Tektronix®
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All references to the SA 501 in this manual now apply to the 067-1090-00 Signature Analyzer.

PLEASE CHECK FOR CHANGE INFORMATION AT THE REAR OF THIS MANUAL.

DM 5010

PROGRAMMABLE DIGITAL MULTIMETER

Francais   Deutsch

INSTRUCTION MANUAL

Tektronix, Inc.
P.O. Box 500
Beaverton, Oregon   97077

070-2994-01
Product Group 76

Serial Number ______________

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INSTRUMENT SERIAL NUMBERS

Each instrument has a serial number on a panel insert, tag, or stamped on the chassis. The first number or letter designates the country of manufacture. The last five digits of the serial number are assigned sequentially and are unique to each instrument. Those manufactured in the United States have six unique digits. The country of manufacture is identified as follows:

B000000	Tektronix, Inc., Beaverton, Oregon, USA
100000	Tektronix Guernsey, Ltd., Channel Islands
200000	Tektronix United Kingdom, Ltd., London
300000	Sony/Tektronix, Japan
700000	Tektronix Holland, NV, Heerenveen, The Netherlands

TABLE OF CONTENTS

TABLE OF CONTENTS (cont)

WARNING

THE FOLLOWING SERVICING INSTRUCTIONS ARE FOR USE BY QUALIFIED PERSONNEL ONLY. TO AVOID PERSONAL INJURY, DO NOT PERFORM ANY SERVICING INSTRUCTIONS UNLESS YOU ARE QUALIFIED TO DO SO.

TABLE OF CONTENTS (cont)

LIST OF ILLUSTRATIONS

NOTE

The following illustrations are located in the diagrams foldout section at the rear of this manual.

LIST OF TABLES

NOTE

The following tables are located in the diagrams foldout section at the rear of this manual.

OPERATORS SAFETY SUMMARY

The general safety information in this part of the summary is for both operating and servicing personnel. Specific warnings and cautions will be found throughout the manual where they apply, but may not appear in this summary.

TERMS

In This Manual

CAUTION statements identify conditions or practices that could result in damage to the equipment or other property.

WARNING statements identify conditions or practices that could result in personal injury or loss of life.

As Marked on Equipment

CAUTION indicates a personal injury hazard not immediately accessible as one reads the marking, or a hazard to property including the equipment itself.

DANGER indicates a personal injury hazard immediately accessible as one reads the marking.

SYMBOLS

In This Manual

⚠ This symbol indicates where applicable cautionary or other information is to be found.

As Marked on Equipment

ϟ DANGER — High voltage.

⏚ Protective ground (earth) terminal.

⚠ ATTENTION — refer to manual.

Power Source

This product is intended to operate from a power module connected to a power source that will not apply more than 250 volts rms between the supply conductors or between either supply conductor and ground. A protective ground connection by way of the grounding conductor in the power cord is essential for safe operation.

Grounding the Product

This product is grounded through the grounding conductor of the power module power cord. To avoid electrical shock, plug the power cord into a properly wired receptacle before connecting to the product input or output terminals. A protective ground connection by way of the grounding conductor in the power module power cord is essential for safe operation.

Danger Arising From Loss of Ground

Upon loss of the protective-ground connection, all accessible conductive parts (including knobs and controls that may appear to be insulating) can render an electric shock.

Use the Proper Fuse

To avoid fire hazard, use only the fuse of correct type, voltage rating and current rating as specified in the parts list for your product.

Refer fuse replacement to qualified service personnel.

Do Not Operate in Explosive Atmospheres

To avoid explosion, do not operate this product in an explosive atmosphere unless it has been specifically certified for such operation.

Do Not Operate Without Covers

To avoid personal injury, do not operate this product without covers or panels installed. Do not apply power to the plug-in via a plug-in extender.

SERVICE SAFETY SUMMARY

FOR QUALIFIED SERVICE PERSONNEL ONLY

Refer also to the preceding Operators Safety Summary

Do Not Service Alone

Do not perform internal service or adjustment of this product unless another person capable of rendering first aid and resuscitation is present.

Use Care When Servicing With Power On

Dangerous voltages may exist at several points in this product. To avoid personal injury, do not touch exposed connections and components while power is on.

Disconnect power before removing protective panels, soldering, or replacing components.

Power Source

This product is intended to operate in a power module connected to a power source that will not apply more than 250 volts rms between the supply conductors or between either supply conductor and ground. A protective ground connection by way of the grounding conductor in the power cord is essential for safe operation.

RECAPITULATIF DES CONSIGNES DE SECURITE

Termes utilisés dans ce manuel

Les paragraphes intitulés ATTENTION identifient les circonstances ou opérations pouvant entraîner la détérioration de l'appareil ou de tout autre équipement.

Les paragraphes intitulés AVERTISSEMENT indiquent les circonstances dangereuses pour l'utilisateur (danger de mort ou risque de blessure).

Repères gravés sur l'appareil

CAUTION (ATTENTION) : ce mot identifie les zones de risque de blessure non perceptibles immédiatement ou un risque éventuel de détérioration de l'appareil.

DANGER (DANGER) : ce mot indique les zones de risque immédiat pouvant entraîner blessures ou mort.

Symboles gravés sur l'équipement

DANGER – Haute tension

Borne de masse de protection (terre)

ATTENTION – se reporter au manuel

Source d'alimentation

L'appareil est conçu pour fonctionner à partir d'une source d'alimentation maximale de 250 V efficaces entre les conducteurs d'alimentation ou entre chaque conducteur d'alimentation et la terre. Pour utiliser l'appareil en toute sécurité, une connexion à la masse, réalisée au moyen d'un conducteur prévu dans le cordon d'alimentation, est indispensable.

Mise à la masse de l'appareil

Une fois installé dans le châssis d'alimentation, l'appareil est relié à la masse à l'aide d'un conducteur du cordon d'alimentation. Pour éviter tout choc électrique, insérer la prise du cordon d'alimentation dans une prise de distribution correspondante avant de connecter l'entrée ou les sorties de l'appareil. Pour utiliser l'appareil en toute sécurité, une connexion à la masse réalisée au moyen d'un conducteur prévu dans le cordon d'alimentation, est indispensable.

Danger provoqué par la coupure de connexion de masse

En cas de coupure de la connexion de masse, tous les éléments conducteurs accessibles (y compris boutons et commandes apparaissant isolants) peuvent provoquer un choc électrique.

Utiliser le cordon d'alimentation approprié

N'utiliser que le cordon d'alimentation et la prise recommandés pour votre appareil. Utiliser un cordon d'alimentation en parfait état. Seul, un personnel qualifié peut procéder à un changement de cordon et prises.

Utiliser le fusible approprié

Pour éviter tout risque d'accident (incendie...) n'utiliser que le fusible recommandé pour votre appareil. Le fusible de remplacement doit toujours correspondre au fusible remplacé : même type, même tension et même courant. Un remplacement de fusible ne doit être effectué que par un personnel qualifié.

Ne pas utiliser l'appareil en atmosphère explosive

Pour éviter toute explosion, ne pas utiliser cet appareil dans une atmosphère de gaz explosifs.

Ne pas démonter les capots

Pour éviter toute blessure, ne pas utiliser cet appareil sans capots ou panneaux. Ne pas alimenter le tiroir à travers un prolongateur.

CONSIGNES DE SECURITE

UNIQUEMENT DESTINEES AU PERSONNEL DE MAINTENANCE

Ne dépannez pas seul

Ces consignes s'adressent exclusivement à un personnel qualifié. Il est également indispensable de se reporter aux consignes de sécurité précédantes. Toute intervention interne ou réglage doit s'effectuer en présence d'une autre personne capable d'assurer les premiers secours en cas de danger.

Agir avec précaution lorsque l'appareil est sous tension

Des potentiels dangereux existent en différents points de l'appareil. Pour éviter toute blessure, ne pas intervenir sur les connexions et les composants alors que l'appareil est sous tension. Débrancher l'alimentation avant le démontage des panneaux, soudure ou remplacement de composants.

Source d'alimentation

Cet appareil est conçu pour fonctionner à partir d'une source d'alimentation qui n'applique pas plus de 250 V efficaces entre les conducteurs d'alimentation ou entre un conducteur et la masse. Pour utiliser l'appareil en toute sécurité, une connexion à la masse réalisée au moyen d'un conducteur prévu dans le cordon d'alimentation est indispensable.

SICHERHEITSANGABEN FÜR DEN ANWENDER

Die allgemeinen Sicherheitsinformationen in diesem Teil der Angaben dienen dem Anwender- und Servicepersonal. Spezielle Warnungen und Hinweise sind überall im Handbuch zu finden, müssen jedoch in diesen Angaben nicht erscheinen.

BEGRIFFE

In diesem Handbuch

VORSICHTSHINWEISE erläutern Bedingungen, die zur Zerstörung des Gerätes oder anderer Gegenstände führen können.

WARNUNGSHINWEISE erläutern Bedingungen, die zu Personenschäden führen können oder lebensgefährlich sind.

Markierungen auf dem Gerät

CAUTION - VORSICHT weist darauf hin, daß durch zufälliges Berühren an einer nicht unmittelbar zugänglichen Stelle Personenschaden entstehen kann, oder Schaden am Gerät selbst.

DANGER - GEFAHR weist darauf hin, daß durch zufälliges Berühren an einer zugänglichen Stelle Personenschaden entstehen kann.

SYMBOLE

In diesem Handbuch

⚠ Dieses Symbol zeigt an, wo Vorsicht walten zu lassen ist, oder wo Informationen zu finden sind.

Markierungen auf dem Gerät

GEFAHR - Hochspannung.

Schutzerdungskontakt.

⚠ ACHTUNG - beziehen Sie sich auf das Handbuch.

Netzspannungsversorgung

Die Betriebsspannung für dieses Gerät darf 250 V_{eff} nicht überschreiten und ist an die Versorgungsleitungen bzw. an eine Versorgungsleitung und Masse anzulegen. Innerhalb des Netzanschlußkabels muß ein Schutzleiter vorhanden sein, der mit Gerätemasse verbunden ist.

Masseanschluß des Gerätes

Dieses Gerät wird über den Schutzleiter der Versorgungseinheit mit Erdpotential verbunden. Zur Vermeidung von elektrischen Schlägen vor der Beschaltung der Ein- und Ausgänge ist der Netzstecker in eine korrekt verdrahtete Steckdose einzustecken. Verwenden Sie den Schutzleiter nicht als einzige Verbindung zwischen zwei oder mehreren Geräten. Zur Vermeidung von elektrischen Schlägen sind die Geräte untereinander mit separaten Leitungen zu verbinden.

Gefahr durch fehlende Schutzerde

Durch eine fehlende Schutzerde können alle berührbaren, leitenden Teile (einschließlich Knöpfe und andere Bedienungselemente, die isoliert sind) einen elektrischen Schlag bei der Berührung auslösen.

Verwendung eines richtigen Netzkabels

Verwenden Sie nur Netzkabel, die für die Versorgungseinheit geeignet sind und die sich in gutem Zustand befinden.

Für detaillierte Informationen über Kabel und Stecker beziehen Sie sich bitte auf Abbildungen innerhalb des Handbuches.

Ein Austausch von Kabeln und Steckern ist nur von geschultem Personal vorzunehmen.

Verwendung einer richtigen Sicherung

Zur Vermeidung von Brandschäden sind nur Sicherungen zu verwenden, die in den Teilelisten dieses Gerätes aufgeführt sind und die in Spannungs- und Stromwert entsprechend sind.

Ersatz von Sicherungen ist nur von geschultem Personal vorzunehmen.

Arbeiten Sie nicht in explosiver Umgebung

Zur Vermeidung von Explosionen ist die Inbetriebnahme dieses Gerätes in explosiver Umgebung zu unterlassen, wenn das Gerät nicht dafür geeignet ist.

Entfernen Sie keine Gehäuseabdeckungen

Zur Vermeidung von Personenschäden sind keine Gehäuseteile zu entfernen. Auch ist das Gerät ohne Gehäuse nicht in Betrieb zu nehmen.

Arbeiten Sie nicht ohne Gehäuseabdeckung

Zur Vermeidung von Personenschäden ist das Gerät nicht ohne Gehäuse in Betrieb zu nehmen. Der Einschub sollte nicht über einen Verlängerungsadapter betrieben werden.

SICHERHEITSANGABEN FÜR DEN SERVICE

NUR FÜR GESCHULTES PERSONAL

Beziehen Sie sich auch auf die vorangehenden Sicherheitsangaben für den Anwender.

Führen Sie keine Servicetätigkeiten alleine durch

Nehmen Sie an dem Gerät keine Service- oder Einstellarbeiten vor, wenn nicht eine andere Person verfügbar ist, um im Bedarfsfall Erste Hilfe oder Wiederbelebungsversuche zu leisten.

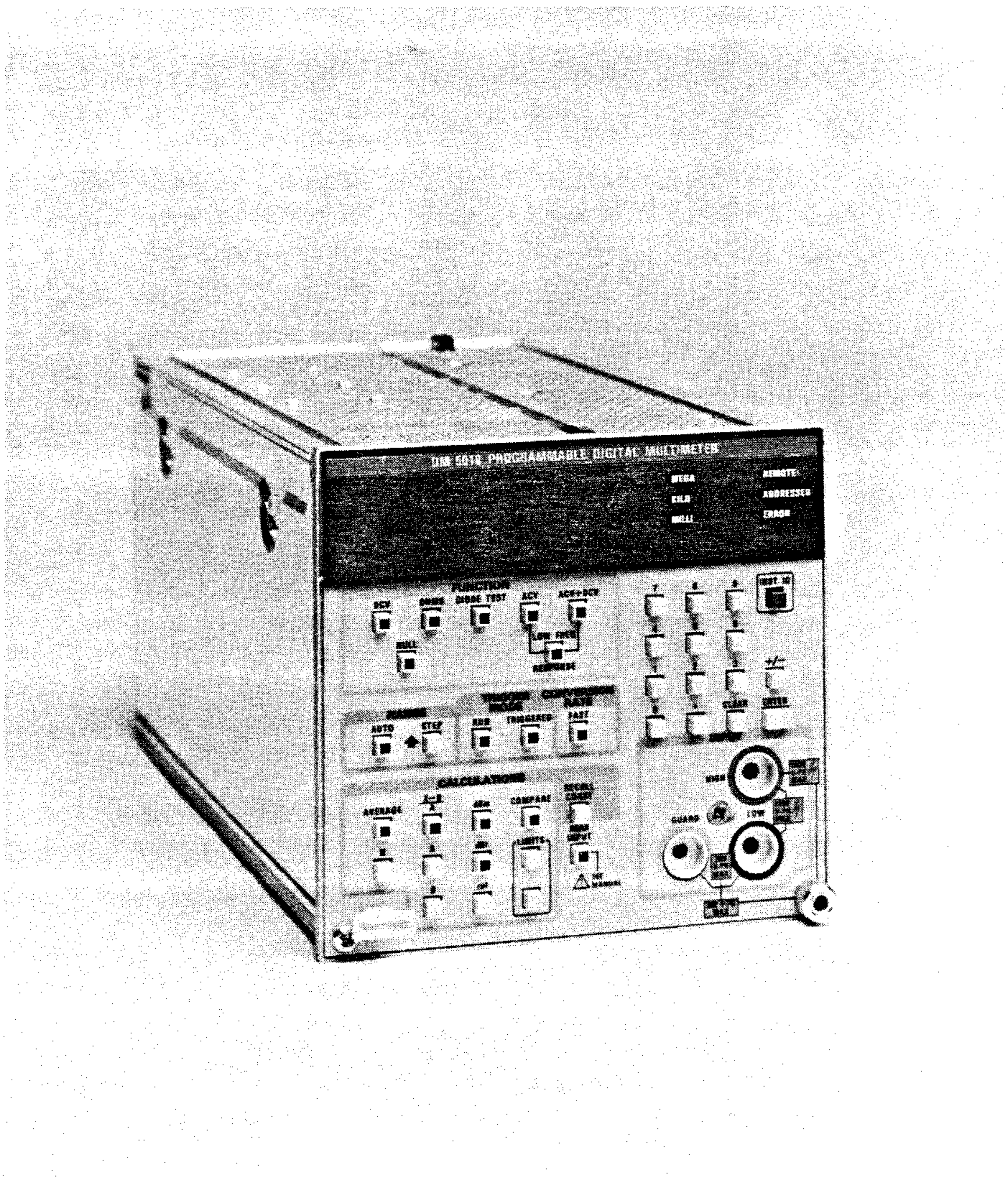
Lassen Sie besondere Vorsicht walten, wenn Sie an einem unter Spannung stehenden Gerät arbeiten

An verschiedenen Stellen im Gerät liegen hohe und damit gefährliche Spannungen. Zur Vermeidung von Personenschäden sind solche Stellen und Bauteile nicht zu berühren, während Betriebsspannung anliegt.

Vor dem Entfernen von Gehäuseteilen, Löten oder Ersetzen von Bauteilen ist immer die Betriebsspannung zu entfernen.

Netzspannungsversorgung

Die Betriebsspannung für dieses Gerät darf 250 V_{eff} nicht überschreiten und ist an die Versorgungsleitungen bzw. an eine Versorgungsleitung und Masse anzulegen. Innerhalb des Netzanschlußkabels muß ein Schutzleiter vorhanden sein, der mit Gerätemasse verbunden ist.



2994-00

DM 5010 Programmable Digital Multimeter.

SPECIFICATION

Introduction

The TEKTRONIX DM 5010 Programmable Digital Multimeter is a TM 5000 plug-in designed to operate in two compartments of a TM 5000-Series power module. The DM 5010 measures and displays dc voltages, resistance, true rms ac voltages, and true rms ac + dc voltages. Range selection is automatic or manually incremented. A diode test function provides a 1 mA current output for diode testing. Measurements are made via front-panel connectors or a rear-interface connector.

The DM 5010 also performs calculations for averaging, scale and offset, conversion to dBm or reference dB, and comparison. Measurements and calculation results are indicated on a signed 4 1/2 digit LED display. The decimal point is automatically positioned and leading zeros are blanked.

The operation of the DM 5010 is programmable via high-level commands (ASCII) sent over the IEEE 488 digital interface. The DM 5010 can send information about front panel control settings, measurements, and calculations via the bus to a GPIB controller. Measurements and calculations are triggered by internal circuitry (at a normal or a fast rate), front-panel push button, GPIB command, or external signal via a rear-interface connector.

This instrument is listed with Underwriters Laboratories, Inc. under U.L. Standard 1244 (Electrical and Electronic Measuring and Testing Equipment).

Standard Accessories

1 Instruction Manual

1 Test Lead Set

1 Reference Guide

Refer to the Accessories page at the back of this manual for part numbers.

IEEE 488 (GPIB) Functions

The DM 5010 can be remotely programmed via the digital interface specified in IEEE Standard 488-1978, *IEEE Standard Digital Interface for Programmable Instrumentation.* In this manual, the digital interface is called the General Purpose Interface Bus (GPIB).

The IEEE standard identifies the interface function repertoire of an instrument on the GPIB in terms of interface function subsets. The subsets are defined in the standard. The subsets listed in Table 1-1 apply to the DM 5010.

Table 1-1
IEEE 488 INTERFACE FUNCTION SUBSETS

Function	Subset	Capability
Source Handshake	SH1	Complete.
Acceptor Handshake	AH1	Complete.
Basic Talker	T5	Responds to Serial Poll. Untalks if My Listen Address (MLA) is received. Talk Only capability.
Basic Listener	L4	Unlistens if My Talk Address (MTA) is received.
Service Request	SR1	Complete.
Remote-Local	RL1	Complete.
Parallel POll	PP0	Does not respond to Parallel Poll.
Device Clear	DC1	Complete.
Device Trigger	DT1	Complete.
Controller	C0	No controller function.

Performance Conditions

The limits stated in the Performance Requirements column of the following tables are valid with the following conditions:

1. The instruments internal adjustments are performed at an ambient temperature between +21 °C and +25 °C.

2. The instrument must be in a non-condensing environment whose limits are described under Environmental.

3. Allow thirty minutes warm-up time for operation to specified accuracy; sixty minutes after exposure to or storage in high-humidity (condensing) environment.

Items listed in the Performance Requirements column of the Electrical Characteristics are verified by completing the

Performance Check in this manual. Information given in the Supplemental Information and Description columns of the following tables is provided for user information only and should not be interpreted to be Performance Check requirements. The information under Electrical Characteristics applies to both front-panel and rear-interface measurements, unless otherwise noted.

NOTE

For measurements to specified accuracy, internal adjustments should be performed after 1000 hours of operation or every six months if used infrequently. Refer to the Adjustment Procedure in this manual.

Table 1-2
ELECTRICAL CHARACTERISTICS

Characteristics	Performance Requirements	Supplemental Information
	DC VOLTS	
ACCURACY for the 200 mV, 2 V, 20 V, 200 V, and 1000 V ranges: Normal Conversion Rate		(3 readings per second)
+18°C to +28°C		
200 mV range	±(0.015% of reading + 0.01% of full scale)	
2 V through 200 V ranges	±(0.015% of reading + 0.005% of full scale)	
1000 V range	±(0.020% of reading + 0.010% of full scale)	
0°C to +18°C, +28°C to +50°C		For the typical accuracy for a given temperature in this range, add to the +18°C to +28°C accuracy, ±(0.002% of reading + 0.001% of full scale)/°C deviation from +28°C or +18°C.
200 mV range	±(0.06% of reading + 0.035% of full scale)	
2 V through 200 V ranges	±(0.06% of reading + 0.03% of full scale)	
1000 V range	±(0.065% of reading + 0.035% of full scale)	
Fast Conversion Rate		(26 readings per second)
+18°C to +28°C		
200 mV to 200 V ranges	±(0.05% of reading + 0.05% of full scale)	
1000 V range	±(0.05% of reading + 0.1% of full scale)	
0°C to +18°C, +28°C to +50°C		
200 mV to 200 V ranges	±(0.1% of reading + 0.1% of full scale)	
1000 V range	±(0.1% of reading + 0.15% of full scale)	

Table 1-2 (cont)

Characteristics	Performance Requirements	Supplemental Information
	DC VOLTS (cont)	
TRUE COMMON MODE REJECTION (CMR)		Verified with 1 kΩ unbalance in either terminal.
Unguarded	≥130 dB at dc. ≥80 dB at 50 to 60 Hz	
Guarded	≥140 dB at dc ≥100 dB at 50 to 60 Hz	
NORMAL MODE REJECTION RATIO (NMRR)		
Normal Conversion Rate	≥40 dB at 50 or 60 Hz, ±0.2 Hz	
Fast Conversion Rate	≥40 dB at 50 Hz, ±0.2 Hz ≥40 dB at 60 Hz, ±0.2 Hz	(50/60 Hz jumper in 50 Hz position) (50/60 Hz jumper in 60 Hz position)
MAXIMUM RESOLUTION		10 μV
INPUT RESISTANCE		
200 mV—20 V ranges		$>10^9$ Ω
200 V—1000 V ranges		10^7 Ω, ±0.25%
STEP RESPONSE TIME (To rated accuracy)		
RUN Mode		
Normal Conversion Rate		≤0.53 sec
Fast Conversion Rate		≤0.08 sec
TRIGGERED Mode		
Normal Conversion Rate		≤0.33 sec
Fast Conversion Rate		≤0.06 sec
MAXIMUM INPUT VOLTAGE		
Front Panel Connectors		
HIGH to LOW or HIGH to Chassis		1000 V peak
LOW to Chassis or GUARD to Chassis		350 V peak
GUARD to LOW		200 V peak
Rear Interface Connector		
Pin 28B (Hi) to pin 28A (Lo)		60 V (dc plus pk ac)

Table 1-2 (cont)

Characteristics	Performance Requirements	Supplemental Information
AC VOLTS—TRUE RMS		
ACCURACY for the 200 mV, 2 V, 20 V, 200 V, and 700 V ranges: (sinewave AC) (Input signal between 5% and 100% of full scale except 700 V range (100 V<V_{in}<700 V)).		
Normal and Fast Conversion Rates		(3 and 26 readings per second)
ACV+DCV Function (DC only or DC component >10% of AC Component.)		
+18°C to +28°C		
200 mV Range	±(.2% of reading + .55% of full scale)	
2 V, 20 V Ranges	±(.2% of reading + .2% of full scale)	
200 V, 700 V Ranges	±(.2% of reading + .5% of full scale)	
0°C to +18°C +28°C to +50°C		For the typical accuracy for a given temperature in this range, add to the +18°C to +28°C accuracy the following tolerance, per degree deviation from +18°C or +28°C.
200 mV Range	±(.45% of reading + 1.3% of full scale)	±(.009% of reading + .025% of full scale)/°C
2 V, 20 V Ranges	±(.45% of reading + .4% of full scale)	±(.009% of reading + .007% of full scale)/°C
200 V, 700 V Ranges	±(.45% of reading + .95% of full scale)	±(.009% of reading + .015% of full scale)/°C
ACV+DCV Function (DC component <10% of AC Component.) 10 Hz to 20 Hz (using LOW FREQ RESPONSE)		
+18°C to +28°C		
200 mV through 200 V Ranges	±(.8% of reading + .3% of full scale)	
700 V Range	±(.8% of reading + .9% of full scale)	
0°C to +18°C +28°C to +50°C		For the typical accuracy for a given temperature in this range, add to the +18°C to +28°C accuracy the following tolerance, per degree deviation from +18°C or +28°C.
200 mV through 200 V Ranges	±(1.25% of reading + .45% of full scale)	±(0.02% of reading + 0.005% of full scale)/°C
700 V Range	±(1.25% of reading + 1.25% of full scale)	±(0.02% of reading + 0.015% of full scale)/°C

Table 1-2 (cont)

Characteristics	Performance Requirements	Supplemental Information
	AC VOLTS—TRUE RMS (cont)	
ACV and ACV+DCV (DC Component <10% of AC Component) +18°C to +28°C		
200 mV through 200 V ranges		
20 Hz to 100 Hz	±(0.8% of reading + 0.2% of full scale)	
100 Hz to 20 kHz	±(0.2% of reading + 0.2% of full scale)	
20 kHz to 100 kHz	±(1.0% of reading + 0.5% of full scale)	Subject to 10^7 V • Hz maximum
700 V range		
20 Hz to 100 Hz	±0.8% of reading + 0.6% of full scale)	
100 Hz to 15 kHz	±(0.2% of reading + 0.6% of full scale)	
0°C to +18°C +28°C to +50°C		For the typical accuracy for a given temperature in this range, add to the +18°C to +28°C accuracy the following tolerance, per degree deviation from +18°C or +28°C.
200 mV through 200 V ranges		
20 Hz to 100 Hz	±(1.25% of reading + 0.35% of full scale)	±(0.02% of reading + 0.005% of full scale)/°C.
100 Hz to 20 kHz	±(0.65% of reading + 0.3% of full scale)	±(0.2% of reading + 0.005% of full scale)/°C.
20 kHz to 100 kHz	±(1.45% of reading + 0.65% of full scale)	±(0.02% of reading + 0.005% of full scale)/°C.
700 V range		
20 Hz to 100 Hz	±(1.25% of reading + 0.95% of full scale)	±(0.02% of reading + 0.015% of full scale)/°C.
100 Hz to 15 kHz	±(0.65% of reading + 0.95% of full scale)	±(0.02% of reading + 0.015% of full scale)/°C.
MAXIMUM RESOLUTION		10 μV
STEP RESPONSE TIME (To rated accuracy)		<1.2 sec, except for LOW FREQ RESPONSE
INPUT IMPEDANCE		2 MΩ, ±0.1% paralleled by <150 pF
MAXIMUM INPUT VOLTAGE		
Front-Panel Connectors		
HIGH to LOW, or HIGH to Chassis		1 kV peak (500 Vdc maximum in ACV mode)
LOW to Chassis, or GUARD to Chassis		350 V peak

Table 1-2 (cont)

Characteristics	Performance Requirements	Supplemental Information
	AC VOLTS—TRUE RMS	
GUARD to LOW		200 V peak
Rear Interface Connector Pin 28B (HI) to pin 28A (LO)		60 V (dc plus pk ac)
CREST FACTOR		4 (subject to maximum peak input voltage)
MAXIMUM VOLT • Hz PRODUCT		10^7 V • Hz
TRUE COMMON MODE REJECTION (CMR) Unguarded		With 1 kΩ unbalance in either terminal Typically ≥80 dB from dc to 60 Hz
Guarded		Typically ≥100 dB from dc to 60 Hz
	OHMS	
ACCURACY for the 200 Ω, 2 KΩ, 20 KΩ, 200 KΩ, 2 MΩ, and 20 MΩ ranges: Normal Conversion Rate		(1.6 readings per second)
+18°C to +28°C 200 Ω range	±(0.015% of reading + 0.015% of full scale)[a]	
2 kΩ to 200 kΩ ranges	±(0.015% of reading + 0.01% of full scale)[b]	
2 MΩ range	±(0.10% of reading + 0.01% of full scale)	
20 MΩ range	±(0.15% of reading + 0.005% of full scale)	
0°C to +18°C, +28°C to +50°C		For the typical accuracy for a given temperature in this range, add to the +18°C to +28°C accuracy the following tolerance, per degree deviation from +18°C or +28°C.
200 Ω range	±(0.06% of reading + 0.06% of full scale)[a]	
2 kΩ to 200 kΩ ranges	±(0.06% of reading + 0.035% of full scale)[b]	±(0.002% of reading + 0.001% of full scale)/°C
2 MΩ range	±(0.54% of reading + 0.035% of full scale)	±(0.02% of reading + 0.001% of full scale)/°C
20 MΩ range	±(0.9% of reading + 0.01% of full scale)	±(0.034% of reading + 0.0001% of full scale)/°C

a. Using NULL
b. Using NULL on 2k OHM range only.
c. Using NULL on 200 OHM range only.
When the NULL function is not used, add ±200 milliohms to all readings.

Table 1-2 (cont)

Characteristics	Performance Requirements	Supplemental Information	
OHMS (cont)			
Fast Conversion Rate		(7.1 readings per second)	
+18°C to +28°C			
200 Ω to 200 kΩ ranges	±(0.05% of reading + 0.05% of full scale)		
2 MΩ range	±(0.10% of reading + 0.05% of full scale)		
20 MΩ range	±(1.0% of reading + 0.05% of full scale)		
0°C to +18°C, +28°C to +50°C			
200 Ω to 200 kΩ ranges	±(0.1% of reading + 0.1% of full scale)		
2 MΩ range	±(0.55% of reading + 0.1% of full scale)		
20 MΩ range	±(1.6% of reading + 0.05% of full scale)		
STEP RESPONSE TIME (To rated accuracy)		Fast Conversion Rate	Normal Conversion Rate
RUN Mode (all ranges)		≤0.33 sec	≤1.24 sec
TRIGGERED Mode (all ranges)		≤0.19 sec	≤0.73 sec
MAXIMUM INPUT VOLTAGE			
Front Panel Connectors			
HIGH to LOW, or HIGH to Chassis		400 V peak, applied continuously	
LOW to Chassis, or GUARD to Chassis		350 V peak	
GUARD to LOW		200 V peak	
Rear Interface Connector			
Pin 28B (Hi) to pin 28A (Lo)		60 V (dc plus pk ac)	
MAXIMUM RESOLUTION		10 MΩ	

[a] Using NULL.

[b] Using NULL on 2k OHM range only.

[c] Using NULL on 200 OHM range only.

When the NULL function is not used, add ±200 milliohms to all readings.

Table 1-2 (cont)

Characteristics	Performance Requirements	Supplemental Information
	OHMS (cont)	
MAXIMUM OPEN CIRCUIT VOLTAGE		<5 volts
MEASURING FULL SCALE VOLTS		
200 Ω through 2 MΩ ranges		0.2 V max
20 MΩ range		0.8 V max
REAR INTERFACE OFFSET		
Ohms offset to rear interface input connector pins	−0.5 Ω to −0 Ω	Subtract offset from measurements, or use NULL feature to eliminate offset for ohms measurements via the rear interface.
	DIODE TEST	
ACCURACY		With a 604 Ω, ±1% resistor connected between the HIGH and LOW input connectors, the display should read between 0.5484 Vdc and 0.6054 Vdc.
MAXIMUM OPEN CIRCUIT VOLTAGE		<5 volts

Table 1-3
MISCELLANEOUS

Characteristics	Description
POWER CONSUMPTION	20 VA or less
RECOMMENDED ADJUSTMENT INTERVAL	1000 hours or 6 months
WARM-UP TIME	30 minutes (60 minutes after storage in high humidity environment)
OVER-RANGE INDICATION	For OHMS or DIODE TEST function, OC is displayed; for ACV, DCV, or ACV+DCV, the display flashes.

Table 1-4
ENVIRONMENTAL[a]

Characteristics	Description	
TEMPERATURE Operating Non-operating	 0°C to +50°C −20°C to +65°C	Meets MIL-T-28800B, class 5. Class 5 non-operating temperature exception due to internal keep-alive battery.
HUMIDITY	95% RH, 0°C to 30°C 75% RH, to 40°C 45% RH, to 50°C	Exceeds MIL-T-28800B, class 5.
ALTITUDE Operating Non-operating	 4.6 km (15,000 ft.) 15 km (50,000 ft.)	Exceeds MIL-T-28800B, class 5.
VIBRATION[b]	0.38 mm (0.015") peak to peak, 5 Hz to 55 Hz, 75 minutes	Meets MIL-T-28800B, class 5, when installed in qualified power module.[c]
SHOCK[b]	30 g's (1/2 sine) 11 ms duration, 3 shocks in each direction along 3 major axes, 18 total shocks.	Meets MIL-T-28800B, class 5, when installed in qualified power module.[c]
BENCH HANDLING[d]	12 drops from 45°, 4" or equilibrium, whichever occurs first.	Meets MIL-T-28800B, class 5, when installed in qualified power module.[c]
TRANSPORTATION[d]	Qualified under National Safe Transit Association Preshipment Test Procedures 1A-B-1 and 1A-B-2.	
EMC[e]	Within limits of F.C.C. Regulations, Part 15, Sub-part J, Class A; VDE 0871; and MIL 461A test RE01, RE02, CE01, CE03, RS01, RS03, CS01, and CS02.	
ELECTRICAL DISCHARGE	20 kV maximum charge applied to instrument case.	

[a]With power module.
[b]Requires retainer clip.
[c]Refer to TM 5000-Series power module specifications.
[d]Without power module.
[e]System performance subject to exceptions of power module or other individual plug-ins.

Table 1-5
PHYSICAL CHARACTERISTICS

Characteristics	Description
FINISH	Plastic-aluminum laminate front panel.
NET WEIGHT	4.5 lbs (2.04 kg)
ENCLOSURE TYPE AND STYLE	MIL-T-28800B, type 3, style E package with power module. (Style F in rackmount power module.)
NOMINAL OVERALL DIMENSIONS	
Height	126.01 mm (4.96 in.)
Width	134.47 mm (5.29 in.)
Length	288.34 mm (11.35 in.)

OPERATING INSTRUCTIONS

Introduction

This section of the manual provides installation and removal instructions and describes the functions of the DM 5010 front-panel controls and connectors. Operators familiarization information is also provided as an aid in understanding how to operate the DM 5010 under local (manual) control only. The information in this section assumes the instrument is not connected to the GPIB via the power module.

Complete information for programming the DM 5010 via the GPIB (General Purpose Interface Bus) is found in the Programming section of this manual.

PREPARATION FOR USE

Installation and Removal

CAUTION

Upon receipt of the instrument, the DM 5010 should be powered up continuously for approximately 24 hours to ensure that its internal keep-alive battery remains sufficiently charged. Failure to do so can result in faulty operation due to loss of calibration factors stored in memory. Calibration factors are restored to memory by performing the Adjustment Procedure in this manual.

NOTE

The DM 5010 is designed to operate only in a TM 5000-Series power module. Refer to the power module instruction manual before installing the DM 5010.

The DM 5010 is calibrated and ready for use when received. Make certain that the line selector block on the power module is positioned correctly. In addition, the DM 5010 contains an internal line frequency select jumper. For best rejection of line frequency related noise when the instrument is operating at the FAST CONVERSION RATE, this jumper position should match the line frequency supplied to the power module. The instrument is shipped with the jumper positioned for a 60 Hz line frequency. For jumper placement, refer qualified service personnel to the Maintenance section of this manual for additional information.

CAUTION

To prevent damage to the DM 5010, turn off the power module before installing or removing the instrument. Do not use excessive force to install or remove.

Check to see that the plastic barriers on the interconnecting jacks of the selected power module compartments match the cutouts in the DM 5010 rear-interface connectors. If they do not match, do not install the DM 5010 until the reason is investigated. When the units are properly matched, align the DM 5010 chassis with the upper and lower guides of the selected compartments (see Fig. 2-1). Push the DM 5010 chassis in and press firmly to seat the rear-interface connectors in the interconnecting jacks. Apply power to the DM 5010 by operating the power switch on the power module.

To remove the DM 5010 from the power module, pull out on the release latch (located in the lower left corner) until the interconnecting jacks disengage and the DM 5010 slides out.

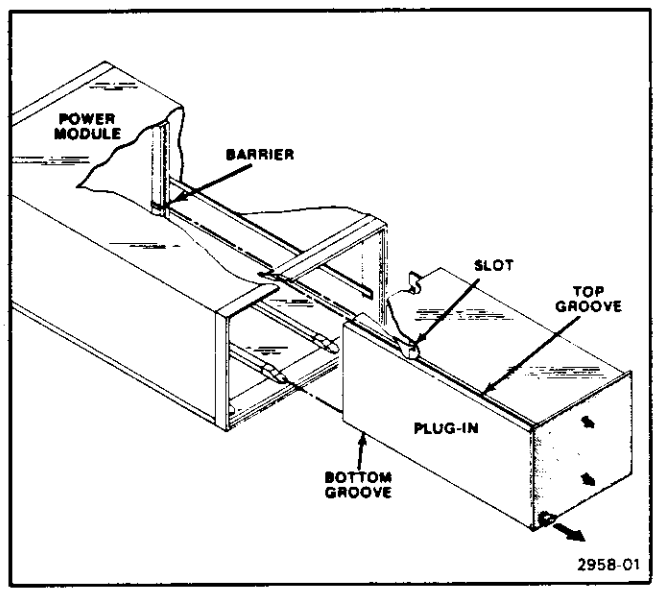


Fig. 2-1. Plug-in installation and removal.

FRONT PANEL CONTROLS AND CONNECTORS

General Information

The seventeen front-panel push buttons listed below enable their functions and illuminate when pressed. The push buttons in the left column are self-cancelling; that is, only one push button is active (illuminated) at a time. The push buttons in the right column illuminate when activated, and remain illuminated and active until pressed again.

DCV	NULL
OHMS	LOW FREQ RESPONSE
DIODE TEST	AUTO
ACV	RUN
ACV+DCV	TRIGGERED
	FAST
	AVERAGE
	$\frac{X-B}{A}$
	dBm
	dBr
	COMPARE
	REAR INPUT

The remaining twenty-three are non-illuminating push buttons that activate their associated functions. Refer to Fig. 2-2.

Display Window

The left side of the window displays measurements and calculation results using signed 4 1/2 digit LEDs. Zeros leading the decimal are suppressed. A flashing display indicates over-range when the voltage measurement functions are active; OC is displayed for OHMS and DIODE TEST.

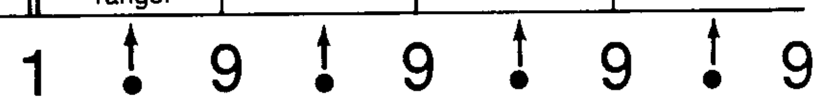
The center area of the window indicates the range multiplier for the displayed reading. Illuminated LED associated with the words MILLI, KILO, and MEGA on the window indicate when the displayed measurement is in milli, kilo, or mega units. The decimal point is fixed for each function range. The multiplier LED and decimal point location indicate the range for both AUTO and manual (STEP) methods of range selection. See Fig. 2-2.

The right area of the display window indicates the operating state of the instrument, as follows:

REMOTE and ADDRESSED illuminate only when the instrument is operating under remote program control via the GPIB.

ERROR illuminates when an internal error, self test error, or operating error occurs. The left area of the window also displays front panel error codes indicating the type of error. See Table 2-2 in Operators Familiarization in this section of the manual.

Function	Illuminated Multiplier	Selected Range			
DCV	• MILLI			200 mV	
DCV		2 V	20 V	200 V	1000 V
ACV and ACV + DCV	• MILLI			200 mV	
ACV and ACV + DCV		2 V	20 V	200 V	700 V
OHMS				200 Ω	
OHMS	• KILO	2 kΩ	20 kΩ	200 kΩ	
OHMS	• MEGA	2 MΩ	20 MΩ		
DIODE TEST		Uses 2 V dc range.			

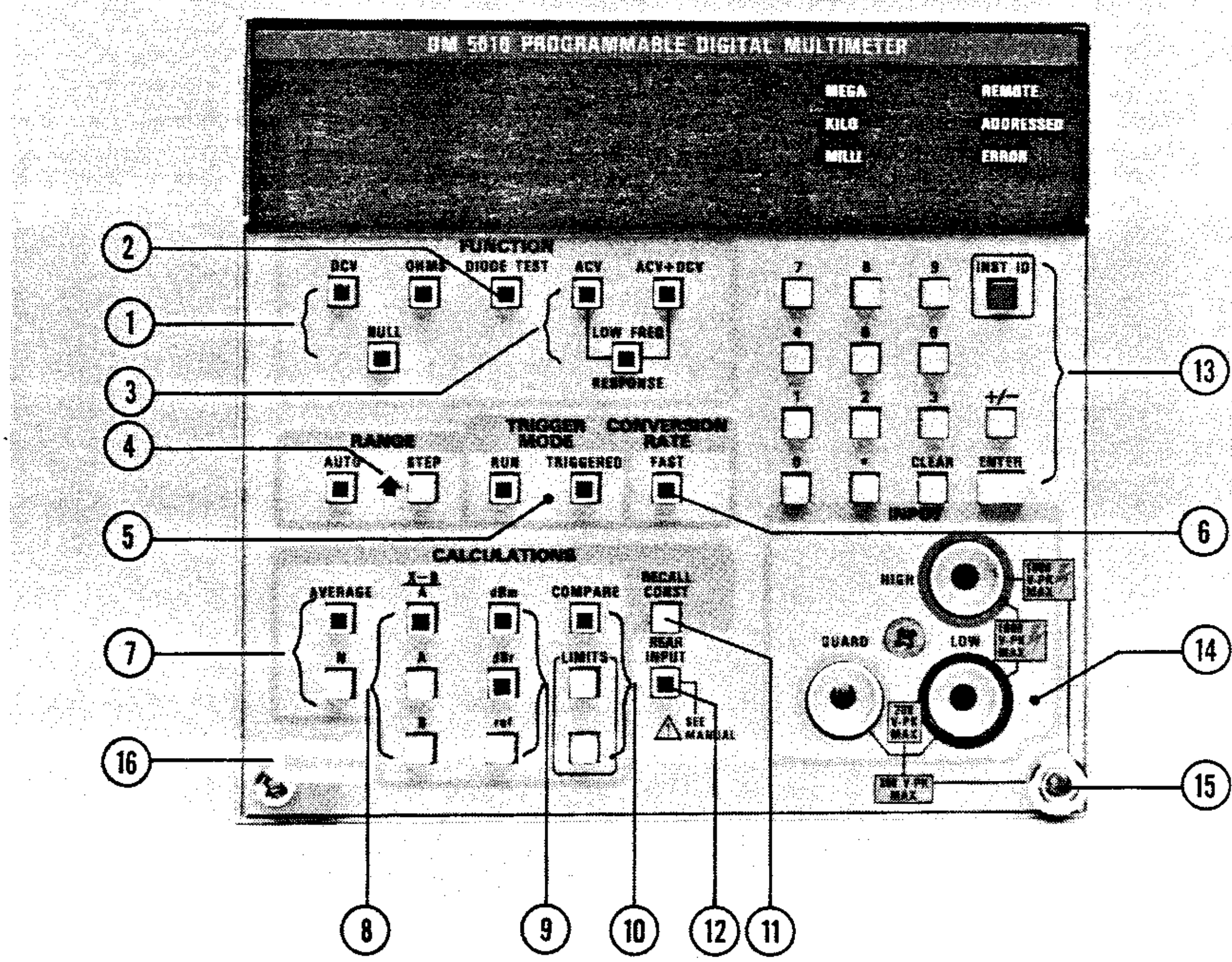


Overrange indication:
Display flashes for voltage functions.
Displays "OC" for OHMS and DIODE TEST functions.

Blank when FAST CONVERSION RATE is enabled. 2994-02

Fig. 2-2. DM 5010 front panel range indication.

@



2994-03

Fig. 2-3. DM 5010 front panel controls and connectors.

Controls and Connectors

The following list describes the functions of the DM 5010 front-panel controls and connectors. See Fig. 2-3.

FUNCTIONS

1 **DCV**
When this button is illuminated, the DM 5010 measures dc voltages applied to the front-panel or rear-interface input connectors. The range used with this function are: 200 mV, 2 V, 20 V, 200 V, and 1000 V.

OHMS
Illuminating this button selects the resistance measurement mode. Resistances applied to the front-panel input connectors or the rear-interface input connections are measured using the 200 Ω, 2 kΩ, 20 kΩ, 200 kΩ, 2 MΩ, and 20 MΩ ranges.

NULL
This function operates with the DM 5010 set to DCV, OHMS, DIODE TEST, ACV, or ACV+DCV (any range). When the NULL button is illuminated,, the instrument measures and stores the value of resistance or voltage across the front-panel or rear-interface input connectors. This stored offset is applied to the subsequent measurements and the results displayed. The value of the offset may be up to ±100% of the range. When the function in use is changed or NULL function disabled (NULL button pressed), the NULL offset is no longer applied. The stored offset is retained until a new offset is set by nulling or until the function in use at the time of nulling is changed.

WARNING

Use caution when the NULL function is enabled, since the displayed measurement may not indicate the value of the voltage applied to the input connectors.

2 **DIODE TEST**
Illuminating this button generates a 1 mA dc current at the front panel or rear interface high input connector. Using conventional current flow, this current flows out the high input connector, through a component connected between the high and low connectors and into the low connector. The voltage developed across the component is measured and displayed using the 2 V dc range.

3 **ACV**
When this button is illuminated, the DM 5010 measures and displays true rms ac voltages. Applied voltages are internally ac coupled to a rms converter. The ranges used with this function are: 200 mV, 2 V, 20 V, 200 V, and 700 V.

ACV+DCV
When this button is illuminated, the DM 5010 measures and displays true rms ac voltages elevated to a dc voltage level. Applied voltages are internally dc coupled to the rms converter. The ranges used are: 200 mV, 2 V, 20 V, 200 V, and 700 V.

LOW FREQ RESPONSE
When this button is illuminated and the ACV or ACV+DCV function is active, the instrument averages 4 measurements and displays the average value of these measurements. This sequence then repeats. The function provides a stable readout when measuring low-frequency ac voltages. It is specified down to 10 Hz; however, it is usable over the entire frequency range specified for the DM 5010.

RANGE

4 **AUTO**
When this button is illuminated, range selection is automatic. At over-range, the DM 5010 switches to the next higher range. If the measured value is less than 9.5% of the range (for most ranges), the instrument switches to the next lower range.

STEP ▲
Activating this button causes the DM 5010 to increment one range. The range is maintained until the AUTO button is pressed to activate automatic range selection or until the range is again incremented. The range is maintained when the function (DCV, OHMS, DIODE TEST, ACV, ACV+DCV) is changed, except a change to the OHMS function selects the highest range. Incrementing while operating in the highest range selects the lowest range.

TRIGGER MODE

5 **RUN**
When this button is illuminated, conversions are free-running at the selected rate. For conversion rate selection, refer to FAST.

TRIGGERED
Illuminating this button triggers and displays one measurement. The next measurement begins when this function is again activated (button is pressed, or EXTRIG trigger signal is received). Use of the EXTRIG triggering requires installation of an internal jumper by qualified service personnel. The TRIGGERED button flashes on briefly when the instrument is triggered.

CONVERSION RATE

(6) **FAST**
With this button illuminated, the conversion (reading) rate is the maximum rate specified for the selected measurement function. At this conversion rate, resolution is 3.5 digits.

When the FAST button is not illuminated, conversions occur at the normal reading rate specified for the selected measurement function. Results are displayed using 4.5 digits.

(7) **AVERAGE**
Illuminating this button causes the DM 5010 to calculate the average of a series of readings. The value of the N constant determines how many readings are averaged in the series. To calculate the average, the instrument sums the measured values for the series of readings and divides the sum by the number of readings in the series. If LOW FREQ RESPONSE is also active, the number of measurements averaged is four times the value of the N constant. When operating in the TRIGGERED mode, only one trigger is required to initiate all the measurements used in the AVERAGE calculation.

N
This button is used to store or recall a constant used in the AVERAGE calculation. The constant determines how many measurements are averaged. At instrument power-up, the value of N is set to 2. This value can be changed to any positive integer ⩾1 and ⩽19999.

(8) $\mathbf{\dfrac{X-B}{A}}$
Illuminating this button causes the DM 5010 to subtract a stored offset constant from a measurement, divide the result by a stored scale constant, and display the result. The offset constant is B, the scale constant is A, and X is the measurement.

A, B
These buttons are used to store or recall constants used in the X-B/A calculation. At instrument power-up, the value of A is set to 1 and the value of B is set to 0. These constants can be changed to any number (integer, decimal, positive or negative) except that the value of A cannot be 0.

(9) **dBm**
When this button is illuminated, the DM 5010 calculates and displays the power ratio of a voltage measurement referenced to 1 mW and 600 Ω (.7746 V), using the formula:

$$\text{dBm} = 20 \log_{10} \left| \frac{x_1}{\sqrt{.6}} \right|$$

where x_1 is the voltage measurement. The logarithm of the absolute value of $x_1/\sqrt{.6}$ is taken.

dBr
When this button is illuminated, the DM 5010 calculates and displays the logarithmic ratio of a measurement to the constant stored for the ref button, using the formula:

$$\text{dBr} = 20 \log_{10} \left| \frac{x_1}{\text{ref}} \right|$$

where x_1 is the measurement. The logarithm of the absolute value of x_1/ref is taken.

ref
This button is used to store or recall a constant used in the dBr calculation. At instrument power-up, the value of ref is set to 1. The value of ref can be any number except 0.

(10) **COMPARE**
Activating this calculation (button illuminated) causes the DM 5010 to compare the next reading with limits set by LIMITS constants. If the compared reading is algebraically less than both constants, the word LO is displayed. The word HI is displayed if the reading is algebraically greater than both constants. PASS is displayed if the reading is equal to or between the constants.

LIMITS (2)
These buttons are used to store or recall constants used as limits in the COMPARE calculation. The values of the constants are set to 0 at instrument power-up.

(11) **RECALL CONST**
Pressing this button and then one of the constant buttons (N, A, B, ref, LIMITS) causes the instrument to display the value stored for that constant.

(12) **REAR INPUT** ⚠
See Rear Interface Measurements under Operators Familiarization in this section of the manual. Illuminating this button selects rear-interface inputs instead of front-panel inputs.

(13) **DIGITS (0 through 9), Decimal Point, and Sign**
These buttons are used for entering numerals, decimals, and polarity for storing constants.

CLEAR
When an error code is displayed in the display window, activating this button clears the displayed error code. Also, when entering a constant, activating the CLEAR button clears from the display window a constant value that has not yet been entered.

ENTER
When entering a constant, activating this button stores the number for the selected constant and displays the stored constant value.

INST ID
Activating this button causes the instrument to display its primary address and, if USEREQ has been enabled, generate a Service Request (SRQ) on the GPIB. Also, the minus sign lights if Talk Only mode is enabled and the far right decimal point lights if LF/EOI message terminator is selected; decimal does not light for EOI ONLY selection.

INPUT

(14) **HIGH Connector**
Isolated analog high connector used with LOW and GUARD connectors for all front panel measurements.

LOW Connector
Isolated analog low connector used with HIGH input connector.

GUARD Connector
Isolated connector connected to a shield that encloses the analog circuitry of the instrument. If a GUARD test lead is not used, the GUARD connector is connected to the LOW connector by an internal switch in the connector assembly. If a GUARD test lead is used, it is normally connected to the LOW test lead at the point of measurement by the user. The GUARD is used to maximize common mode rejection.

(15) **Ground Binding Post**
Chassis ground connector.

(16) **Release Latch**
Pull to remove plug-in.

OPERATORS FAMILIARIZATION

The following discussion describes the use of the DM 5010 front panel controls and connectors under local operation.

Power On Self Test

Upon application of power, the DM 5010 performs a self-test routine. During the self test, all front panel LEDs illuminated. After the self test, the instrument enters the Local State (LOCS) and assumes the power on default settings listed in Table 2-1.

Table 2-1
POWER ON SETTINGS
(FRONT PANEL FUNCTIONS ONLY)

Front-Panel Control	Status
DCV	on
OHMS	off
NULL	(off) Constant set to 0
DIODE TEST	off
ACV	off
ACV+DCV	off
LOW FREQ RESPONSE	off
AUTO	on
STEP	off
RUN	on
TRIGGERED	off
FAST	off
AVERAGE	off
N	Constant set to 2
$\frac{X-B}{A}$	off
A	Constant set to 0
B	Constant set to 1
dBm	off
dBr	off
ref	Constant set to 1
COMPARE	off
LIMITS	Constants set to 0, 0
REAR INPUT	off

If an internal error is detected during self test, the instrument continuously displays a three-digit error code in the display window and the ERROR indicator is lit. See Table 2-2. Refer an error code condition to qualified service personnel.

Table 2-2
FRONT PANEL ERROR CODES

Displayed	Abnormal Event	
	Execution Errors:	
205	Argument out of range.	
231	Not in calibrate mode.	
232	Beyond calibration capability.	
	Internal Errors:	
303	Math pack error.	
311	Converter time-out.	
317	Front panel time-out.	
318	Bad calibration constant.	
340	RAM error (high nibble).	
341	RAM error (low nibble).	
351	Calibration checksum error.	
372	ROM placement error.	C000
373	ROM placement error.	D000
374	ROM placement error.	E000
392	ROM checksum error.	C000
393	ROM checksum error.	D000
394	ROM checksum error.	E000
395	ROM checksum error.	F000

General Operating Information

Allow 30 minutes warmup time for operation to specified accuracy. Over-range for the OHMS and DIODE TEST functions causes the instrument to display OC; for the DCV, ACV, and ACV+DCV functions; over-range is indicated by a flashing display.

CAUTION

Observe the specified maximum input voltage ratings. Instrument damage may occur if the maximum input voltage ratings are exceeded.

For all measurement functions, range selection may be either auto-ranging (AUTO button pressed) or a fixed range may be selected using the STEP button. Refer to the range indication discussion under Display Window. DIODE TEST uses only the 2 V range.

CAUTION

With the instrument in the AUTO range mode, do not repeatedly switch the input voltage between a low value (<200 mV peak) and a higher value (>200 V peak). For repeated measurements alternating between voltage extremes, use the STEP range mode to select an appropriate higher range before increasing the input voltage. Failure to do so may temporarily cause inaccuracy in measurements made using the 200 mV range.

Input Connections

The HIGH, LOW, and GUARD connectors are used for front-panel measurements. The connector assembly contains an internal switch connected between the LOW and GUARD connectors. This switch is closed until a test lead probe is inserted into the GUARD connector; it remains open until the GUARD test lead probe is removed.

Figure 2-4 illustrates three examples of using the front-panel connectors to make measurements. Method A is the most commonly used. It is used when common mode voltage is not a consideration. In this example, only the HIGH and LOW connectors of the DM 5010 are used. Since a test lead probe is not inserted into the GUARD connector, the connector assembly internal switch is closed, shorting the LOW to the GUARD. This allows common mode current to flow through the LOW test lead and the power source ground, introducing some measurement error.

Method B provides the most accurate measurements when common mode voltages are a problem. The DM 5010 GUARD connector is connected to the source low terminal. Common mode current flows through the GUARD test lead and power source ground, not the measurement circuits.

In Method C, the DM 5010 GUARD connects to the source ground. Some measurement error may occur, since common mode current generated between the source low and power source ground flows in the measurement circuit.

WARNING

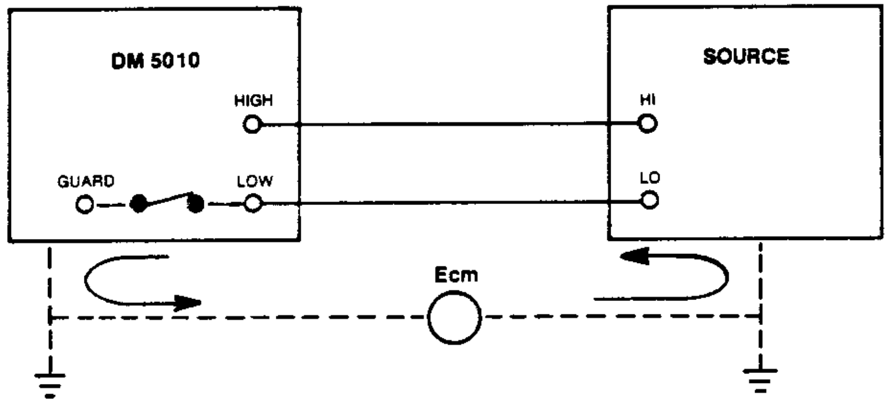
To help eliminate shock hazard from voltages measured by the DM 5010:

1. *Avoid all contact with the voltage source if the measured voltage exceeds 42.4 V peak.*

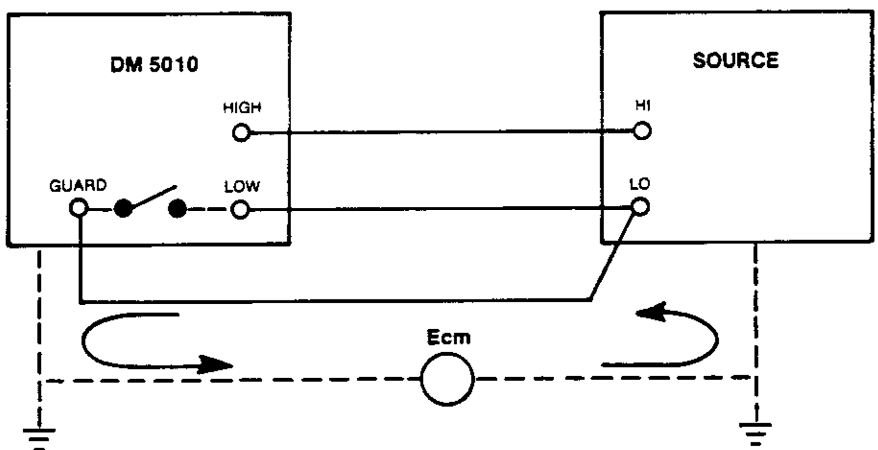
2. *Disconnect test probes from the circuit-under-test before disconnecting probes from the DM 5010, or before removing the DM 5010 from the power module.*

Rear-Interface Measurements ⚠

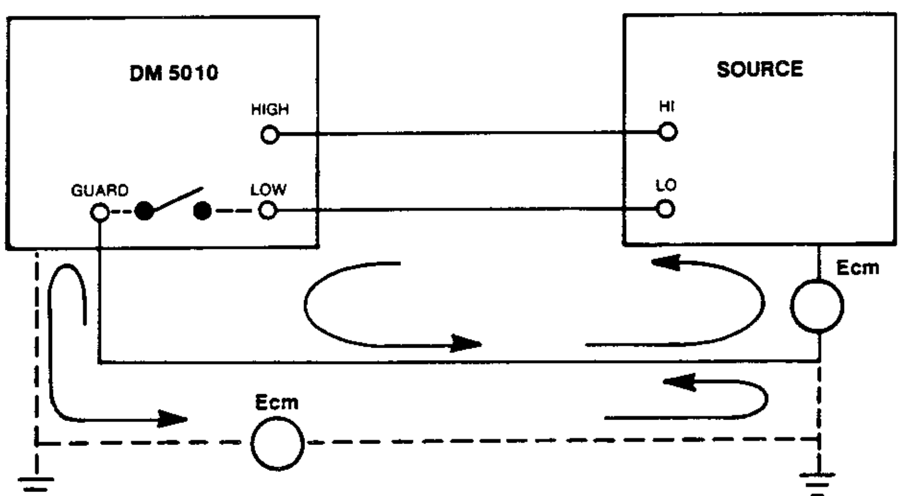
If the REAR INPUT button is pressed (illuminated), signals applied to the rear interface pins 28B (Hi) and 28A (Lo) on the ADC board (A17) are measured. If the button is not illuminated, signals are measured via the front-panel input connectors.



A. Guard connected (internally) to DM 5010 LOW terminal—E_{cm} error present.



B. Guard connected to source Lo terminal—No E_{cm} error.



C. Guard connected to source chassis ground. Low Ecm error, assuming the common error source is mostly between grounds.

2994-04

Fig. 2-4. Examples of front panel input connection methods.

CAUTION

To avoid equipment damage, do not apply a voltage exceeding 42.4 V peak ac or 60 V dc between pins 28B (Hi) and 28A (Lo) of the rear-interface connector P1031 on the ADC board (A17).

CAUTION

Do not switch from front-panel to rear interface input while over 500 V peak is applied to the front panel input connectors. Instrument damage and erratic operation may result.

Dc Voltage Measurements

When the DCV button is pressed, the DM 5010 measures dc voltages using the following ranges: 200 mV, 2 V, 20 V, 200 V, and 1000 V. The readout displays a positive sign when the input to the HIGH connector is positive with respect to the LOW connector. Observe the maximum input voltage ratings.

Resistance Measurements

Pressing the OHMS button enables the DM 5010 to measure resistance using these ranges: 200 Ω, 2 kΩ, 20 kΩ, 200 kΩ, 2 MΩ, and 20 MΩ. Conventional current flow is from the HIGH connector to the LOW connector. Refer to Table 2-3 for the value of current and maximum voltages across the input connectors for full scale display readings (instrument not over-ranged). The maximum (open circuit) voltage available from the HIGH connector referenced to the LOW connector is less than 5 V.

Table 2-3
SOURCE VOLTAGES
(OHMS FUNCTION)

Range	Typical Current (0 Ω to Full Scale)	V Max (Full Scale)
200 Ω	1.02 mA to 1 mA	
2 kΩ	0.12 mA to 0.1 mA	
20 kΩ	9.2 μA to 10 μA	0.2 V
200 kΩ	1.08 μA to 1 μA	
2 MΩ	0.12 μA to 0.1 μA	
20 MΩ	0.12 μA to 0.04 μA	0.8 V

Measuring Diodes

Pressing the DIODE TEST button causes the DM 5010 to generate a 1 mA dc current at the HIGH connector. The forward voltage drop of diode junctions is measured by connecting the diode anode to the HIGH connector and the cathode to the LOW. Devices that can be checked are those having a voltage drop under 1.999 volts. These include most diodes and some LEDs.

To check the reverse voltage drop, reverse the diode connections to the instrument. The display window should display OC.

Ac Voltage Measurements

The DM 5010 provides two ac measurement functions. True rms ac voltages are measured and displayed using the ACV function. True rms ac voltages elevated to a dc level are measured and displayed using the ACV+DCV function. Ranges for both functions are 200 mV, 2 V, 20 V, 200 V, and 700 V. Voltages can be measured with a crest factor up to four at full scale. The crest factor is the ratio of the peak voltage to rms voltage. Observe the maximum input voltage ratings. The LOW FREQ RESPONSE function provides a stable display for low-frequency ac measurements. When activated, this function displays the average of four ac measurements.

Conversion Rates

The DM 5010 operates at either of two conversion rates. The FAST rate (CONVERSION RATE button illuminated) makes measurements at the maximum rate specified for the selected function. Measurements are displayed using 3 1/2 digits. With the button not illuminated, the instrument makes measurements at the normal rate specified for the selected function and uses a 4 1/2 digit display.

Triggering

The DM 5010 has two front-panel trigger modes, RUN and TRIGGERED. When the RUN button is pressed, conversions are free-running at the selected conversion rate. Pressing the TRIGGERED button causes the instrument to trigger one measurement each time the button is pressed.

In addition, conversions may be triggered via the rear interface connector, pin 16A and 16B (Lo) on the Isolation board (A15). Use of this feature requires installation of an internal jumper. Refer qualified service personnel to the Maintenance section of this manual for additional information. Installation of this jumper enables the $\overline{\text{EXTRIG}}$ trigger function in addition to the RUN and TRIGGERED functions. To use the $\overline{\text{EXTRIG}}$ trigger, activate the TRIGGER button to disable the instrument's free-running trigger. The $\overline{\text{EXTRIG}}$ requires a negative-going TTL compatible signal to initiate the internal trigger. To cause a single trigger, this line must be held low between 0.5 and 10 μsec. If held low for a longer time, the instrument triggers multiple measurements.

Calculations

Five front-panel buttons activate calculations on measurements made by the DM 5010. These calculations may be performed singly or in a sequence. A sequence of calculations may be activated (buttons pushed) in any order; however, the DM 5010 executes them in the following order: AVERAGE, X-B/A, dBm or dBr, COMPARE. The instrument performs all activated calculations on the measurement and then displays the result. If active, NULL and then LOW FREQ RESPONSE are executed before any of the calculations. Both of the calculations dBm and dBr cannot be performed in the same sequence. If both buttons are pressed in the same calculation sequence, only the last one pressed will be executed. One trigger begins execution of a single calculation or a calculation sequence. In the RUN trigger mode, an activated calculation or sequence repeats until turned off (calculation button(s) pressed again), or until the trigger mode or measurement function is changed. The display LEDs blank while calculations are being executed. The instrument displays OC to indicate a display overflow for calculation results.

Except for dBm, each calculation uses one or more constants. The numerical value stored in memory for each constant is set to a default value at instrument power up. This value may be changed to any value within the limits specified for each constant. Table 2-4 lists each calculation and associated constant(s), constant default values, and the limits for each constant.

Changing Constant Values

There are two methods for changing constant values in the instrument memory.

1. Using the numeric keyboard:

   a. Press selected constant button.

   b. Press numeric keyboard buttons to display the new constant value (within the limits specified in Table 2-4).

   c. Press ENTER.

2. Using a displayed measurement. (Changes a constant value to the value of the displayed measurement.) Make certain the displayed measurement meets the limits specified in Table 2-4 for the selected constant.

   a. Press selected constant button.

   b. Press ENTER.

Table 2-4
CALCULATION AND CONSTANTS

Calculation	Constants	Default Value	Valid Constant Range
AVERAGE	N	2	+1 to +19999
$\frac{X-B}{A}$	B (offset)	0	+ or −, integer or decimal,
	A (scale)	1	+ or −, integer or decimal, ≠ 0
dBm	-	-	-
dBr	ref	1	+ or −, integer or decimal, ≠ 0
COMPARE	LIMITS (2)	0	

After the ENTER button is pressed, the DM 5010 displays the stored constant value. The displayed value is the new one if the entered value was valid. The previously-stored value is displayed if the entered value was invalid. Each constant value remains stored until a new value is entered or until power is removed from the instrument.

Calculation Examples

The following examples are provided to suggest applications using the DM 5010 calculations.

Example 1: Using X-B/A to display the difference between the nominal and actual zener voltages.

Set the DM 5010 front-panel controls as follows:

DCV	on
NULL	off
LOW FREQ RESPONSE	off
RANGE	AUTO
TRIGGER MODE	RUN
CONVERSION RATE	FAST off
CALCULATIONS	
$\frac{X-B}{A}$	on
all others	off
REAR INPUT	off

Set the constant A to 1.

Set the constant B to 15 (for a 15 V zener diode).

Connect the zener diode, resistor, and power supply to the DM 5010 input connectors as shown in Fig. 2-5. The value of the resistor and the power supply voltage set the zener current.

The displayed voltage initially is unstable until the current through the diode reaches its final value. When the display stabilizes, the displayed voltage is the difference between the nominal zener voltage (15 V) and the actual zener voltage for the zener diode being measured.

To read the voltage difference in percent deviation, change constant A to .15 where A=B (.01).

Example 2: Using dBr to find the point where an audio amplifier is 3 dB down from mid-range.

Set the DM 5010 front-panel controls as follows:

ACV	on
NULL	off
LOW FREQ RESPONSE	off
RANGE	AUTO
TRIGGER MODE	RUN
CONVERSION RATE	FAST off
CALCULATIONS	off
REAR INPUT	off

Set constant ref to 1. Connect a sinewave generator, the audio amplifier, and the DM 5010 as shown in Fig. 2-6.

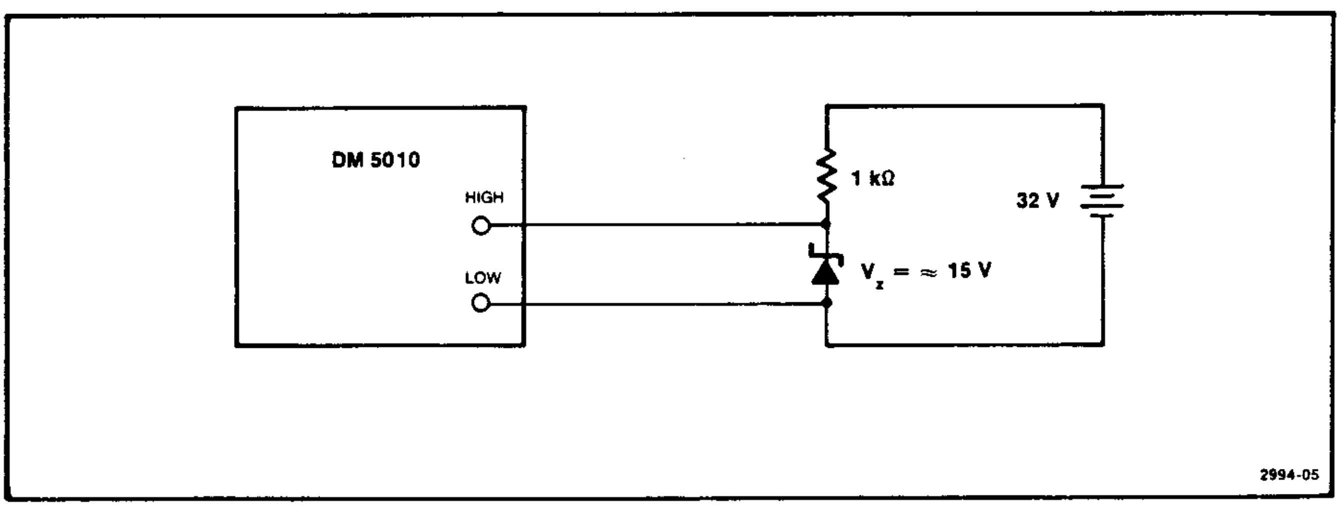


Fig. 2-5. Setup for calculation example 1.

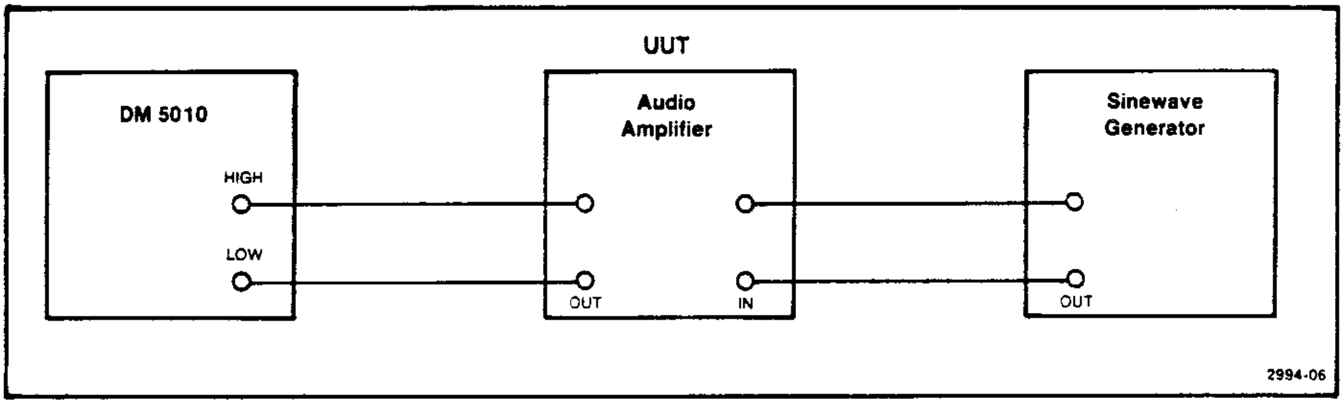


Fig. 2-6. Setup for calculation example 2.

Set the sinewave generator to mid-range (5 kHz in this example); adjust the sinewave generator amplitude for a 1 V reading on the DM 5010.

Press the DM 5010 dBr button. The display reads 0.0.

Reduce the sinewave generator frequency until the DM 5010 display reads −3.00. (Do not readjust amplitude.) The frequency of the generator is the lower −3 dB point of the audio amplifier.

Example 3: Using COMPARE to select resistors within 2% of the nominal value.

Set the DM 5010 front-panel controls as follows:

OHMS	on
NULL	off
LOW FREQ RESPONSE	off
RANGE	AUTO
TRIGGER MODE	RUN
CONVERSION RATE	FAST off
CALCULATIONS	
COMPARE	on
all others	off
REAR INPUT	off

To select 15 kΩ resistors within 2% of the nominal value, set one LIMITS constant to 15300. Set the other LIMITS constant to 14700. Connect the first resistor to the DM 5010 front-panel HIGH and LOW input connectors.The DM 5010 displays HI or LO if the resistor is above or below the 2% tolerance. PASS is displayed if the resistor is between or equal to the limits.

The COMPARE and X-B/A calculations may be combined in the above example. This combination eliminates figuring the highest and lowest in-tolerance values; only the nominal resistance value and the tolerance are used as constants.

Set constant B to 15000 (nominal resistance).

Set constant A to 150 where A=B (.01). This converts the difference between nominal value and actual value to a per cent.

Set one LIMITS constant to 2 (for a 2% tolerance).

Set the other LIMITS constant to −2.

Press X-B/A.

The DM 5010 displays PASS, HI, or LO.

Repackaging Information

If this Tektronix instrument is to be shipped to a Tektronix Service Center for service or repair, attach a tag showing owner (with address) and the name of an individual at your firm that can be contacted. Include the complete instrument serial number and a description of the service required.

Save and re-use the package in which the instrument was shipped. If the original packaging is unfit for use or not available, repackage the instrument as follows:

Surround the instrument with polyethylene sheeting to protect the finish of the instrument. Obtain a carton of corrugated cardboard of the correct carton strength and having inside dimensions of no less than 6 inches more than the instrument dimensions. Cushion the instrument by tightly packing at least 3 inches of dunnage or urethane foam between carton and instrument on all sides. Seal the carton with shipping tape or an industrial stapler.

The carton test strength for this instrument is 200 pounds per square inch.

PROGRAMMING

Introduction

This section of the manual provides information for programming the TEKTRONIX DM 5010 Programmable Digital Multimeter via the IEEE-488 digital interface. The IEEE-488 interface function subsets for the DM 5010 are listed in Section 1. In this manual, the IEEE-488 digital interface is called the General Purpose Interface Bus (GPIB). The following information assumes the reader is knowledgeable in GPIB communication and has some exposure to programming controllers. Message protocol over the GPIB is specified and described in the IEEE Standard 488-1978, *Standard Digital Interface for Programmable Instrumentation*[1]. TM 5000 instruments are designed to communicate with any GPIB-compatible controller that sends and receives ASCII messages (commands) over the GPIB. These commands program the instrument or request information from the instrument.

Commands for TM 5000 programmable instruments are designed for compatibility among instrument types. The same command is used in different instruments to control similar functions. In addition, commands are specified in mnemonics related to the functions they implement. For example, the command INIT initializes instrument settings to their power-up states. For further ease of programming, command mnemonics are similar to front-panel control names.

Instrument commands are presented in three formats:

- A front panel illustration—showing command relationships to front panel operation. See Fig. 3-1.
- Functional Command List—a list divided into functional groups with brief descriptions.
- Detailed Command List—an alphabetical listing of commands with complete descriptions.

[1]Published by the Institute of Electrical and Electronics Engineers, Inc., 345 East 47th Street, New York, N.Y., 10017.

TM 5000 programmable instruments connect to the GPIB through a TM 5000 power module. Refer to the Operating Instructions section of this manual for information on installing the instrument in the power module. Also review this section for instrument caution and warning statements and to become familiar with front-panel and internally selectable instrument functions.

The GPIB primary address for this instrument may be internally changed by qualified service personnel. The DM 5010 is shipped with the address set to decimal 16. The message terminator may also be internally selected by qualified service personnel. Message terminators are discussed in Messages and Communication Protocol (in this section). TM 5000 instruments are shipped with this terminator set to EOI ONLY. Refer qualified service personnel to the Maintenance section of this manual for locations and setting information. Pressing the INST ID button causes the instrument to display its selected GPIB primary address; the far right decimal point lights if the selected message terminator is LF/EOI. The minus sign lights if the Talk Only mode is enabled.

Talk Only Mode

The Talk Only mode enables the DM 5010 to send data under local control over the GPIB to a listener. To initiate this mode, an internal switch is set to the Talk Only position. Refer qualified service personnel to the Maintenance section of this manual for switch setting information.

With the Talk Only mode enabled, the DM 5010 begins sending measurement data when the front panel INST ID button is pressed; it stops sending data when the front panel CLEAR button is pressed. If the instrument is sending a reading when CLEAR is pressed, it completes sending that reading. The ADDRESSED light remains on until transmission of the last reading is complete.

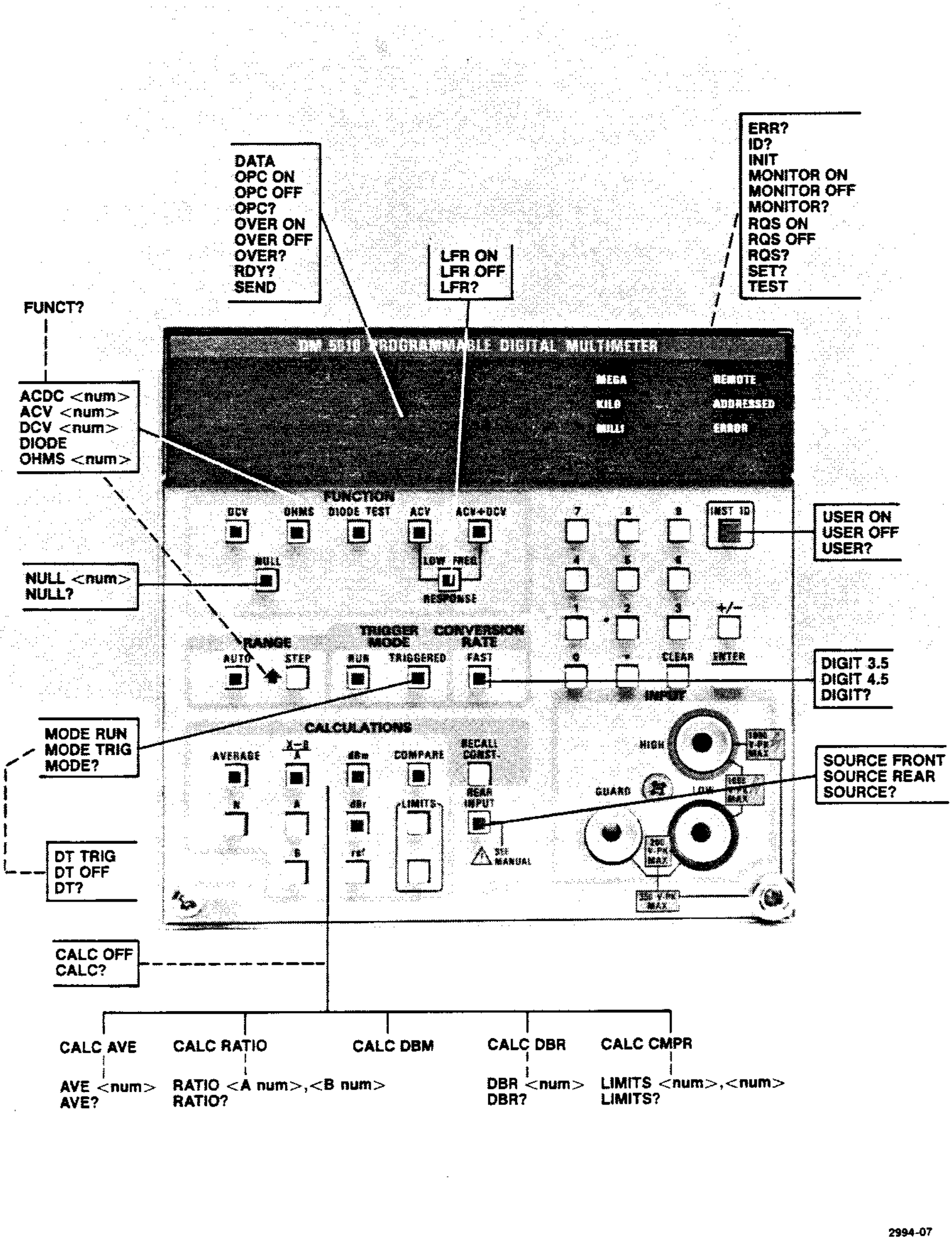


Fig. 3-1. Instrument commands and relationship to front panel controls.

@

COMMANDS

The instrument is controlled by the front panel or via commands received from the controller. These commands are of three types:

Setting commands—control instrument settings.

Query-output commands—ask for data.

Operational commands—cause a particular action.

CAUTION

Using fewer characters than the abbreviated header or argument should be done with caution since erroneous results or damage could result if this data is sent to the wrong instrument.

The instrument responds to and executes all commands when in the remote state. When in the local state, *setting* and *operational commands* generate errors since instrument functions are under front panel control; only *query-output commands* are executed.

Each command begins with a header—a word that describes the function implemented. Many commands require an argument following the header—a word or number that specifies the desired state for the function.

CAUTION

With the instrument in the AUTO range mode, do not repeatedly switch the input voltage between a low value (<200 mV peak) and a higher value (>200 V peak). For repeated measurements alternating between these voltage extremes, use the STEP range mode to select an appropriate higher range before increasing the input voltage. Failure to do so may temporarily cause inaccuracy in measurements made using the 200 mV range.

FUNCTIONAL COMMAND LIST

INSTRUMENT COMMANDS

Function Commands

ACDC <num>—Sets the ACV+DCV function and range.

ACV <num>—Sets the ACV function and range.

DCV <num>—Sets the DCV function and range.

DIODE—Sets the DIODE TEST function.

FUNCT?—Returns present function and range.

LFR ON—Enables the LOW FREQ RESPONSE function.

LFR OFF—Disables the LOW FREQ RESPONSE function.

LFR?—Returns LFR ON or LFR OFF.

NULL <num>—Enables the NULL function and offset value.

NULL?—Returns NULL offset value.

OHMS <num>—Sets the OHMS function and range.

Trigger Mode Commands

MODE RUN—Enables the RUN trigger mode.

MODE TRIG—Enables the TRIGGERED trigger mode.

MODE?—Returns MODE RUN or MODE TRIG.

RDY?—Returns RDY 1 if a measurement is ready; RDY 0 if one is in progress or waiting for trigger.

DIGIT 3.5—Enables FAST conversion rate.

DIGIT 4.5—Enables normal conversion rate.

DIGIT?—Returns DIGIT 3.5 or DIGIT 4.5.

Calculation Commands

AVE <num>—Sets the value of constant N.

AVE?—Returns value of constant N.

CALC AVE—Enables the AVERAGE calculation.

CALC CMPR—Enables the COMPARE calculation.

CALC DBM—Enables the dBm calculation.

CALC DBR—Enables the dBr calculation

CALC RATIO—Enables X-B/A calculation.

CALC OFF—Disables all calculations.

CALC?—Returns CALC OFF or the enabled calculation(s).

DBR <num>—Sets the value of the ref constant.

DBR?—Returns value of ref constant.

LIMITS <num>,<num>—Sets values of LIMITS constants.

LIMITS?—Returns values of LIMITS constants.

MONITOR ON—Enables SRQ when measurement exceeds LIMITS constants.

MONITOR OFF—Disables SRQ when measurement exceeds LIMITS constants.

MONITOR?—Returns MONITOR ON or MONITOR OFF.

RATIO <num>,<num>—Sets values of A and B constants.

RATIO?—Returns values of A and B constants.

INPUT/OUTPUT COMMANDS

DATA—Outputs data saved by MONITOR SRQ.

SEND—Outputs data in Output Buffer; triggers, if necessary.

SOURCE REAR—Selects rear interface connector input.

SOURCE FRONT—Selects front panel connector input.

SOURCE?—Returns SOURCE FRONT or SOURCE REAR.

SYSTEM COMMANDS

DT TRIG—Enables device trigger function. Instrument triggers after <GET> interface message.

DT OFF—Disables device trigger function.

DT?—Returns DT TRIG or DT OFF.

ERR?—Returns error code.

ID?—Returns instrument identification and firmware version.

INIT—Initializes instrument settings.

SET?—Returns instrument settings.

TEST—Returns 0 for correct calibration checksum; 351 for incorrect.

STATUS COMMANDS

OPC ON—Enables operation complete SRQ.

OPC OFF—Disbles operation complete SRQ.

OPC?—Returns OPC ON or OPC OFF.

OVER ON—Enables overrange SRQ.

OVER OFF—Disables overrange SRQ.

OVER?—Returns OVER ON or OVER OFF.

RQS ON—Enables generation of SRQ's.

RQS OFF—Disables generation of SRQ's.

RQS?—Returns RQS ON or RQS OFF.

USER ON—Enables SRQ when ID button is pushed.

USER OFF—Disables SRQ when ID button is pushed.

USER?—Returns USER ON or USER OFF.

DETAILED COMMAND LIST

ACDC (AC with DC Voltage Function)

Type:

Setting

Setting syntax:

ACDC <number>
ACD <number>
ACDC

Examples:	**Range Selected:**
ACDC 2	2 V
ACDC .9	2 V
ACD −200	700 V, auto-range
ACD	700 V, auto-range
ACD 0	700 V, auto-range

Discussion:

The header selects the ACD+DCV function; the argument selects a fixed range or auto-range. The format for numeric arguments is described under Number Format later in this section of the manual. The argument can be any value ≤700; however, the instrument rounds the argument up to the next full scale range. For instance, for an argument of .9, the instrument selects the 2 V range.

If the argument is omitted or its value is 0 or less, the instrument auto-ranges beginning at the highest range.

If the argument is above the highest range, the instrument generates a command error (and asserts SRQ if RQS is on).

Ranges:

200 mV
2 V
20 V
200 V
700 V

ACV (AC Voltage Function)

Type:

Setting

Setting syntax:

ACV <number>
ACV

Examples:	**Range Selected:**
ACV 18	20 V
ACV 2	2 V
ACV −200	700 V, auto-range
ACV	700 V, auto-range

Discussion:

The header selects the ACV function; the argument selects a fixed range or auto-range. The format for numeric arguments is described under Number Format later in this section of the manual. The argument can be any value; however, the instrument rounds the argument up to the first full scale range. For instance, an argument of 18 selects the 20 V range.

If the argument is omitted or its value is 0 or less, the instrument auto-ranges beginning at the highest range.

If the argument is above the highest range, the instrument generates a command error (and asserts SRQ if RQS is on).

Ranges:

200 mV
2 V
20 V
200 V
700 V

AVE (Average)

Type:

Setting or query

Setting syntax:

AVE <number>
AVG <number>

Examples:

AVE 6
AVE 2
AVG 10

Query syntax:

AVE?
AVG?

Query response:

AVE <number>;

Discussion:

This command specifies the number of conversions used in the AVERAGE calculation. (It corresponds to setting the value for the front panel button constant N.) See CALC AVE. The argument may be any number from 1 to 19999. The instrument truncates the argument to integers.

CALC (Calculation Operation)

Type:

Setting or query

Setting syntax:

CALC <argument>
CALC <argument>,. . . . .,<argument>

Arguments:

AVE or AVG
CMPR or COMP
DBM
DBR
RATIO
OFF

Examples:

CALC OFF
CALC AVE
CALC AVE, DBM
CALC RATIO, AVE, DBR

Query syntax:

CALC?

Query response:

CALC OFF; or list of enabled calculation(s).

Discussion:

When the instrument receives a CALC command, it turns off all calculations except those listed after the CALC header. If the result of a calculation exceeds the capabilities of the math pack ($\pm$3.4028E+38), the instrument generates a math pack error (303).

- CALC AVE or CALC AVG enables the AVERAGE calculation. The instrument calculates the average of a series of measurements. The number of measurements in the series is set by the AVE <number> command.

  One trigger generates enough readings for an average result. If over-range occurs for a measurement in a sequence, the AVE calculation is aborted.

  If LFR is also enabled, the number of measurements set by the AVE <number> command is multiplied by 4.

- CALC CMPR or CALC COMP enables the COMPARE calculation. The instrument compares the input to the values set by the LIMITS command. Refer to the text on the following commands, which output comparison results:

  SEND—returns 1., 2., or 3. for LO, PASS, or HI; returns +1E+99; or −1E+99; for over-range.

  DATA—returns out-of-limits measurement value.

- CALC DBM enables the dBm calculation and disables the dBr calculation. The instrument calculates the power ratio of the input voltage, referenced to 1 mW dissipated in 600 Ω (.7746 V).

$$\text{dBm} = 20 \log_{10} \left| \frac{X}{\sqrt{.6}} \right|$$

- CALC DBR enables the dBr calculation and disables the dBm calculation. The DM 5010 computes the logarithmic ratio of the input to the value set by the DBR <number> command.

$$\text{dBr} = 20 \log_{10} \left| \frac{X}{\text{ref}} \right|$$

- CALC RATIO enables the X-B/A calculation, where X is the measurement, B is an offset value, and A is the scale factor. The values of A and B are set by the RATIO command.

- CALC OFF disables all calculations.

DATA

Type:

Output

Syntax:

DATA

Response:

DATA <number>;
or
DATA ±1.E+99; (for over-range)

Discussion:

This command returns one of the responses listed below. It does not trigger a conversion nor wait to return a new reading as the SEND command does.

1. After power on, returns 0 until a reading is available.

2. If a MONITOR SRQ has occurred, DATA returns the measurement causing the SRQ.

3. If neither of the above conditions is true, DATA returns the most recent reading. DATA returns the same reading until the next conversion is triggered and a new reading is available.

DATA may return more digits of resolution for a reading than is displayed on the front panel or returned by the SEND command.

DBR

Type:

Setting or query

Setting syntax:

DBR <number>

Examples:

DBR 1
DBR .707
DBR 2E−3

Query Syntax:

DBR?

Query Response:

DBR <number>;

Discussion:

This command argument sets the value of the constant used by the CALC DBR command. It corresponds to setting the constant value for the front panel button constant ref. The argument can be any number except 0.

DCV (DC Voltage Function)

Type:

Setting

Setting syntax:

DCV <number>
DCV

Examples:	Range selected:
DCV 1.5	2 V
DCV	1000 mV, auto-range
DCV −1.E+3	1000 V, auto-range

Discussion:

The header selects the DCV function; the argument selects a fixed voltage range. The format for numeric arguments is described under Number Format later in this section of the manual. The argument can be any value; however, the instrument rounds the argument up to the first full scale range. For instance, for an argument of 1.5, the instrument selects the 2 V range.

If the argument is omitted or its value is 0 or less, the instrument auto-ranges beginning at the highest range.

If the argument is above the highest range, the instrument generates a command error (and asserts SRQ if RQS is on).

Ranges:

200 mV
2 V
20 V
200 V
1000 V

DIGIT (Digital Resolution)

Type:

Setting or query

Setting syntax:

DIGIT 3.5
DIGIT 4.5
DIG 3.5
DIG 4.5

Query syntax:

DIGIT?
DIG?

Query response:

DIGIT 3.5;
DIGIT 4.5;

Discussion:

This command selects the conversion rate. The argument 3.5 sets the FAST conversion rate (3.5 digit resolution). A reading takes approximately 35 ms in the voltage functions and approximately 130 ms in the OHMS function.

The argument 4.5 sets the normal conversion rate (4.5 digit resolution). A reading takes approximately 310 ms in the voltage functions; 620 ms in the OHMS function.

DIODE (Diode Test Function)

Type:

Setting

Setting syntax:

DIODE
DIO

Discussion:

This command selects the DIODE TEST function. An argument is not accepted.

DT (Device Trigger)

Type:

Setting or query

Setting syntax:

DT TRIG
DT OFF

Query syntax:

DT?

Query response:

DT TRIG:
DT OFF;

Discussion:

This command enables or disables the device trigger function. If Device Trigger is enabled, the <GET> IEEE 488 interface message causes the instrument to trigger a reading.

If <GET> is received while the message processor is busy or when DT is OFF, the instrument generates an error, which indicates the <GET> message was ignored.

ERR? (Error)

Type:

Query

Query syntax:

ERR?

Query response:

$ERR_{sp\ sp}$ <number>

Examples:

$ERR_{sp\ sp}$ 401; (power on)

Discussion:

The ERROR query is used to obtain information about the status of the instrument.

The ERROR query returns a code indicating the event causing SRQ to be asserted. See Status and Error Reporting for more information.

FUNCT? (Function)

Type:

Query

Query syntax:

FUNCT?
FUNC?

Query response example:

DCV 2.;
ACV 20.;
DIODE;
ACDC 200.;
OHMS −2.E+6;

Discussion:

This command returns the measurement function in use. The argument specifies the range currently in use. A negative argument is returned if the instrument is in autorange.

ID?

Type:

Query

Query syntax:

ID?

Query response:

ID TEK/DM5010,V79.1 Fxx;

Discussion:

The ID? query returns the above response.

TEK/DM5010 — Identifies the instrument manufacturer and type.

V79.1 — Identifies the version of Tektronix Codes and Format Standard to which the instrument conforms.

Fxx — Identifies the firmware version of the instrument.

INIT

Type:

Operational

Syntax:

INIT

Discussion:

This command resets instrument functions to their power-on settings. Table 3-3 lists the power-on settings.

LFR (Low Frequency Response)

Type:

Setting or query

Setting syntax:

LFR ON
LFR OFF

Query syntax:

LFR?

Query response:

LFR ON;
LFR OFF;

Discussion:

This command enables or disables the LOW FREQ RESPONSE function (used with ACV and ACV+DCV functions). When enabled, the instrument computes the average of four measurements.

If CALC AVE is also enabled, the number of measurements set by the AVE <num> command is multiplied by 4.

LIMITS

Type:

Setting or query

Setting syntax:

LIMITS <number>,<number>
LIM <number>,<number>

Examples:

LIMITS 3.2, −2
LIMITS −1, −6.5
LIM 6, 1

Query syntax:

LIMITS?
LIM?

Query response:

LIMITS <number>,<number>;

Discussion:

The arguments for this command set the value of the limits used by the COMPARE calculation and the MONITOR SRQ. The first argument sets the value of the limit, which corresponds to the upper front panel LIMITS button; the second argument sets the constant value, which corresponds to the lower LIMITS button.

MODE

Type:

Setting or query

Setting syntax:

MODE RUN
MODE TRIG
MOD RUN
MOD TRIG

Query syntax:

MODE?
MOD?

Query response:

MODE RUN;
MODE TRIG;

Discussion:

This command selects the Trigger Mode. The RUN argument sets the RUN (free-run) Trigger Mode.

The TRIG argument sets the TRIGGERED mode. In this mode, a trigger occurs upon receipt of one of the following:

- A "SEND" command
- A Group Execute Trigger <GET> interface message (only if DT, Device Trigger, is enabled).
- My Talk Address (MTA) with the output unspecified (no query command).
- EXTRIG rear interface trigger (requires internal jumper installation—see Maintenance section). To cause a single trigger, this line must be held low between 0.5 and 10 μsec. If held low for a longer time, the instrument triggers multiple measurements.

If over-range or under-range occurs while MODE TRIG is enabled and the instrument is in auto-range, it will change range and take another reading.

MONITOR

Type:

Setting or query

Setting syntax:

MONITOR ON
MONITOR OFF
MON ON
MON OFF

Query syntax:

MONITOR?
MON?

Query response:

MONITOR ON;
MONITOR OFF:

Discussion:

This command enables or disables the MONITOR SRQ. With the MONITOR SRQ enabled, the instrument saves the first measurement outside the limits (set by LIMITS command) and generates an SRQ. SRQ's are not generated for subsequent measurements (outside the limits) until the SRQ is serviced and the measurement is reported to the controller in response to the DATA command.

If the instrument over-ranges with MON ON, it reports an over-range error even though OVER is OFF.

NULL

Type:

Setting or query

Setting syntax:

NULL <number>

Examples:

NULL .2
NULL 0

Query syntax:

NULL?

Query response:

NULL <number>;

Discussion:

This command enables the NULL function; the argument (in volts or ohms) specifies the value of the offset. This value can be any number up to 100% of the range.

The NULL function is disabled when the measurement function is changed or when the argument is 0. (Changing the measurement function also sets the argument to 0.)

WARNING

Use caution when the NULL function is enabled, since the measurement may not indicate the value of the voltage applied to the input connectors.

OHMS (Ohms Function)

Type:

Setting

Setting syntax:

OHMS <number>
OHMS

Examples:	Range selected:
OHMS	20 MΩ, auto-range
OHMS 100	200 Ω
OHMS −2E+7	20 MΩ, auto-range
OHMS 1E+4	20 kΩ

Discussion:

The header selects the OHMS function; the argument selects the range. The format for numeric arguments is described under Number Format later in this section of the manual. The argument can be any value; however, the instrument rounds the argument up to the first full scale range. For instance, for an argument of 100, the instrument selects the 200 Ω range.

If the argument is omitted or its value is 0 or less, the instrument auto-ranges beginning at the highest range.

If the argument is above the highest range, the instrument generates a command error (and asserts SRQ if RQS is on).

Ranges:

200 Ω
2 kΩ
20 kΩ
200 kΩ
2 MΩ
20 MΩ

OPC (Operation Complete)

Type:

Setting or query

Setting syntax:

OPC ON
OPC OFF

Query syntax:

OPC?

Query response:

OPC ON;
OPC OFF;

Discussion:

This command enables or disables the operation complete service request. If enabled and RQS is ON, the instrument asserts SRQ when a new measurement is available.

OVER (Over-range)

Type:

Setting or query

Setting syntax:

OVER ON
OVER OFF

Query syntax:

OVER?

Query response:

OVER ON;
OVER OFF;

Discussion:

This command enables or disables the over-range service request. If enabled and RQS is ON, the instrument asserts SRQ when it takes an over-range measurement.

When OVER is OFF, the instrument returns ±1.E+99 when talked, to indicate over-range (does not assert SRQ).

RATIO

Type:

Setting or query

Setting syntax:

RATIO <number>,<number>

Examples:

RATIO 100, 15
RATIO 10, 2

Query syntax:

RATIO?

Query response:

RATIO <number>,<number>;

Discussion:

The arguments for this command set the value of the offset and scale factor used in the X-B/A calculation. See CALC RATIO. The first argument sets the value of the scale factor (button A on the front panel); the second sets the offset value (button B on the front panel). The arguments can be any number except that scale factor cannot be 0.

RDY?

Type:

Query

Query syntax:

RDY?

Query response:

RDY $_{sp\ sp}$0;

RDY $_{sp\ sp}$1;

Discussion:

This command returns RDY 0 if a measurement is in progress or if the instrument is waiting for a trigger. RDY 1 indicates data is available.

RQS (Request Service)

Type:

Setting or query

Setting syntax:

RQS ON
RQS OFF

Query syntax:

RQS?

Query response:

RQS ON;
RQS OFF;

Discussion:

This command enables the instrument to generate any service requests. The OFF argument disables all service requests. See Status and Error Reporting for more information.

SEND

Type:

Output

Syntax:

SEND
SEN

Response:

<number>; (no header)

Example:

±1.E+99; (over-range)
+3.2E+3;

Discussion:

This command causes the instrument to output the latest measurement. If no measurement is available, the instrument triggers a measurement and then outputs it.

If the COMPARE calculation is enabled (CALC CMPR) the instrument outputs one of the following numbers which indicate the relationship between the input and the limits set by the LIMITS command:

3.; if the input is above both limits

2.; if the input is between limits or equal to one of the limits

1.; if the input is below both limits

+1.E+99; or −1.E+99; if over-ranged.

SET?

Type:

Query

Query syntax:

SET?

Query response example (power up settings):

DCV −1.E+3;AVE 2; RATIO 1. 0.;DBR 1.;LIMITS 0., 0.;CALC OFF;NULL 0.; DIGIT 4.5;LFR OFF;MODE RUN;SOURCE FRONT;DT OFF;MONITOR OFF;OPC OFF; OVER OFF;USER OFF;RQS ON;

Discussion:

This command returns the present settings of all instrument functions. The longest response is 225 characters.

SOURCE

Type:

Setting or query

Setting syntax:

SOURCE FRONT
SOURCE REAR
SOUR FRONT
SOUR REAR

Query syntax:

SOURCE?
SOUR?

Query response:

SOURCE FRONT;
SOURCE REAR;

Discussion:

SOURCE FRONT selects the front panel input for measurement; SOURCE REAR selects the rear interface input connectors for measurement.

CAUTION

Do not switch from front panel to rear interface input while over 500 V peak is applied to the front panel input connectors. Instrument damage and erratic operation may result.

TEST

Type:

Output

Syntax:

TEST

Response:

TEST 0;
TEST 351;

Discussion:

Returns a number that indicates the status of the calibration checksum. Returns 0 if the checksum is correct; 351 if erroneous.

USER

Type:

Setting or query

Setting syntax:

USER ON
USER OFF

Query syntax:

USER?

Query response:

USER ON;
USER OFF;

Discussion:

This command enables or disables the INST ID button service request. If enabled, the instrument asserts SRQ when the front panel INST ID button is pressed.

MESSAGES AND COMMUNICATION PROTOCOL

Command Separator

A message consists of one command or a series of commands, followed by a message terminator. Messages consisting of multiple commands must have the commands separated by semicolons. A semicolon at the end of a message is optional. For example, each line below is a message.

INIT
TEST;INIT;RQS ON;USER OFF;ID?;SET?
TEST;

Message Terminator

Messages may be terminated with EOI or the ASCII line feed (LF) character. Some controllers assert EOI concurrently with the last data byte; others use only the LF character as a terminator. The instrument can be internally set to accept either terminator. With EOI ONLY selected as the terminator, the instrument interprets a data byte received with EOI asserted as the end of the input message; it also asserts EOI concurrently with the last byte of the output message. With the LF/EOI setting, the instrument interprets the LF character without EOI asserted (or any data byte received with EOI asserted) as the end of an input message; it transmits carriage return (CR) followed by line feed (the LF with EOI asserted) to terminate output messages. Refer service personnel to the Maintenance section of the manual for information on setting the message terminator. TM 5000 instruments are shipped with EOI ONLY selected.

Formatting A Message

Commands sent to TM 5000 instruments must have the proper format (syntax) to be understood; however, this format is flexible in that many variations are acceptable. The following describes this format and the acceptable variations.

The instruments expect all commands to be encoded in ASCII; however, they accept both upper and lower case ASCII characters. All data output is in upper case.

As previously discussed, a command consists of a header followed, if necessary, by arguments. A command with arguments must have a header delimiter that is the space character (SP) between the header and the argument. The space character (SP), carriage return (CR), and line feed (LF) are shown as subscript in the following examples.

$\mathrm{RQS_{SP}ON}$

If extra formatting characters SP, CR, and LF (the LF cannot be used for format in the LF/EOI terminator mode) are added between the header delimiter and the argument, they are ignored by the instrument.

Example 1: $\mathrm{RQS_{SP}ON;}$

Example 2: $\mathrm{RQS_{SP\ SP}ON;}$

Example 3: $\mathrm{RQS_{SP\ CR}LF}$

$\mathrm{_{SP\ SP}ON}$

In general, these formatting characters are ignored after any delimiter and at the beginning and end of a message.

$\mathrm{_{SP}RQS_{SP}ON;_{CR\ LF}}$

$\mathrm{_{SP}USER_{SP}OFF}$

In the command list, some headers and arguments are listed in two forms, a full-length version and an abbreviated version. The instrument accepts any header or argument containing at least the characters listed in the short form; any characters added to the abbreviated version must be those given in the full-length version. For documentation of programs, the user may add alpha characters to the full-length version. Alpha characters may also be added to a query header, provided the question mark is at the end.

USER?
USERE?
USEREQ?
USEREQUEST?

Multiple arguments are separated by commas; however, the instrument will also accept a space or spaces as a delimiter.

2,3
$\mathrm{2_{SP}3}$
$\mathrm{2,_{SP}3}$

NOTE

In the last example, the space is treated as a format character because it follows the comma (the argument delimiter).

Number Formats

The instrument accepts the following kinds of numbers for any of the numeric arguments.

- Signed or unsigned integers (including +0 and −0). Unsigned integers are interpreted as positive. Examples: +1, 2, −1, −10
- Signed or unsigned decimal numbers. Unsigned decimal numbers are interpreted to be positive. Examples: −3.2, +5.0, 1.2

- Floating point numbers expressed in scientific notation. Examples: +1.0E−2, 1.0E−2, 1.E-2, 0.01E+0

The largest acceptable number for an argument is ±3.4028E+38.

Message Protocol

As the instrument receives a message it is stored in the Input Buffer, processed, and executed. Processing a message consists of decoding commands, detecting delimiters, and checking syntax. For *setting commands*, the instrument then stores the indicated changes in the Pending Settings Buffer. If an error is detected during processing, the instrument asserts SRQ, ignores the remainder of the message, and resets the Pending Settings Buffer. Resetting the Pending Settings Buffer avoids undesirable states that could occur if some *setting commands* are executed while others in the same message are not.

Executing a message consists of performing the actions specified by its command(s). For *setting commands*, this involves updating the instrument settings and recording these updates in the Current Settings Buffer. The *setting commands* are executed in groups—that is, a series of *setting commands* is processed and recorded in the Pending Settings Buffer before execution takes place. This allows the user to specify a new instrument state without having to consider whether a particular sequence would be valid. Execution of the settings occurs when the instrument processes the message terminator, a *query-output command*, or an *operational command* in a message.

When the instrument processes a *query-output command* in a message, it executes any preceding *setting commands* to update the state of the instrument. It then executes the *query-output command* by retrieving the appropriate data and putting it in the Output Buffer. Then, processing and execution continue for the remainder of the message. The data are sent to the controller when the instrument is made a talker.

When the instrument processes an *operational command* in a message, it executes any preceding *setting commands* before executing the *operational command*.

Multiple Messages

The Input Buffer has finite capacity and a single message may be long enough to fill it. In this case, a portion of the message is processed before the instrument accepts additional input. During command processing the instrument holds off additional data (by asserting NRFD) until space is available in the buffer.

When space is available, the instrument can accept a second message before the first has been processed. However, it holds off additional messages with NRFD until it completes processing the first.

After the instrument executes a *query-output command* in a message, it holds the response in its Output Buffer until the controller makes the instrument a talker. If the instrument receives a new message before all of the output from the previous message is read, it clears the Output Buffer before executing the new message. This prevents the controller from getting unwanted data from old messages.

One other situation may cause the instrument to delete output. The execution of a long message might cause both the Input and Output buffers to become full. When this occurs, the instrument cannot finish executing the message because it is waiting for the controller to read the data it has generated; but the controller cannot read the data because it is waiting to finish sending its message. Because the instrument's Input buffer is full and it is holding off the rest of the controllers message with NRFD, the system is hung up with the controller and instrument waiting for each other. When the instrument detects this condition, it generates an error, assets SRQ, and deletes the data in the Output buffer. This action allows the controller to transmit the rest of the message and informs the controller that the message was executed and that the output was deleted.

A TM 5000 instrument can be made a talker without having received a message that specifies what it should output. In this case, acquisition instruments (counters and multimeters) return a measurement if one is ready. If no measurement is ready, they return a single byte message with all bits equal to 1 (with message terminator); other TM 5000 instruments will return only this message.

Instrument Response to IEEE-488 Interface Messages

Interface messages and their effects on the instrument's interface functions are defined in IEEE Standard 488-1978. Abbreviations from the standard are used in this discussion, which describes the effects of interface messages on instrument operation.

UNL—Unlisten (63 with ATN)
UNT—Untalk (95 with ATN)

When the UNL command is received, the instrument's listener function goes to its idle state (unaddressed). In the idle state, the instrument will not accept instrument commands from the GPIB.

The talker function goes to its idle state when the instrument receives the UNT command. In this state, the instrument cannot output data via the GPIB.

The ADDRESSED light is off when both the talker and listener functions are idle. If the instrument is either talk addressed or listen addressed, the light is on.

IFC—Interface Clear (GPIB pin 9)

This uniline message has the same effect as both the UNT and UNL messages. The front panel ADDRESSED light is off.

DCL—Device Clear (20 with ATN)

The Device Clear message reinitializes communication between the instrument and controller. In response to DCL, the instrument clears any input and output messages and any unexecuted settings in the Pending Settings Buffer. Also cleared are any errors or events waiting to be reported, except the power-on event. If the SRQ line is asserted for any reason other than power-on when DCL is received, the SRQ is unasserted.

SDC—Selected Device Clear (4 with ATN)

This message performs the same function as DCL; however, only instruments that are listen addressed respond to SDC.

GET—Group Execute Trigger (8 with ATN)

The instrument responds to <GET> only if it is listen addressed and the instrument device trigger function has been enabled by the Device Trigger command (DT). The <GET> message is ignored and an SRQ generated if the DT function is disabled (DT OFF), the instrument is in the local state, or if a message is being processed when <GET> is received.

SPE—Serial Poll Enable (24 with ATN)
SPD—Serial Poll Disable (25 with ATN)

The SPE message enables the instrument to output serial poll status bytes when it is talk addressed. The SPD message switches the instrument back to its normal operation of sending the data from the Output Buffer.

MLA—My Listen Address
MTA—My Talk Address

The primary listen and talk addresses are established by the instruments GPIB address (internally set). The current setting of the GPIB address is displayed on the front panel when the ID button is pressed. When the instrument is addressed to talk or listen, the front panel ADDRESSED indicator is illuminated.

LLO—Local Lockout (17 with ATN)

In response to LLO, the instrument goes to a lockout state—from LOCS to LWLS or from REMS to RWLS.

REN—Remote Enable

If REN is true, the instrument goes to a remote state (from LOCS to REMS or from LWLS to RWLS) when its listen address is received. REN false causes a transition from any state to LOCS; the instrument stays in LOCS as long as REN is false.

A REN transition may occur after message processing has begun. In this case, execution of the message being processed is not affected by a transition.

GTL—Go To Local (1 with ATN)

Only instruments that are listen addressed respond to GTL by going to a local state. Remote-to-local transitions caused by GTL do not affect the execution of the message being processed when GTL was received.

Remote-Local Operation

The preceding discussion of interface messages describes the state transitions caused by GTL and REN. Most front panel controls cause a transition from REMS to LOCS by asserting a message called return-to-local *(rtl)*. This transition may occur during message execution; but in contrast to GTL and REN transitions, a transition initiated by *rtl* does affect message execution. In this case, the instrument generates an error if there are any unexecuted *setting* or *operational commands*. Front panel controls that only change the display (like INST ID) do not affect the remote-local states—only front panel controls that change settings assert *rtl*. The *rtl* message remains asserted while multiple keystroke settings are entered; and it is unasserted after the execution of the settings. Since *rtl* prevents transitions to REMS, the instrument unasserts *rtl* if a multiple button sequence is not completed in a reasonable length of time (approximately 5 to 10 seconds).

The instrument maintains a record of its settings in the Current Settings Buffer and new settings from the front panel or the controller update these recorded settings. In addition, the front panel is updated to reflect setting changes due to commands. Instrument settings are unaffected by transitions between the four remote-local states. The REMOTE indicator is illuminated when the instrument is in REMS or RWLS.

Local State (LOCS)

In LOCS, instrument settings are controlled by the operator via front panel push buttons. When in LOCS, only bus commands that do not change instrument settings are executed (*query-output commands*); all other bus commands (*setting* and *operational)* generate an error since their functions are under front-panel control.

Local With Lockout State (LWLS)

The instrument operates the same as it does in LOCS, except that *rtl* will not inhibit a transition to remote.

Remote State (REMS)

In this state, the instrument executes all instrument commands. For commands having front panel indicators, the front panel is updated when the commands are executed.

Remote With Lockout State (RWLS)

Instrument operation is identical to REMS operation except that the *rtl* message is ignored.

STATUS AND ERROR REPORTING

Through the Service Request function (defined in the IEEE-488 Standard), the instrument may alert the controller that it needs service. This service request is also a means of indicating that an event (a change in status or an error) has occurred. To service a request the controller performs a Serial Poll; in response the instrument returns a Status byte (STB), which indicates whether it was requesting service or not. The STB can also provide a limited amount of information about the request. The format of the information encoded in the STB is given in Fig. 3-2.

When data bit 8 is set, the STB conveys Device Status information that is indicated by bits 1 through 4. Bit 4 is set if the DM 5010 is waiting for a trigger; bit 3 set indicates a reading is available.

Because the STB conveys limited information about an event, the events are divided into classes: the Status Byte reports the class. The classes of events are defined as follows:

COMMAND ERROR Indicates the instrument has received a command that it cannot understand.

EXECUTION ERROR Indicates that the instrument has received a command that it cannot execute. This is caused by arguments out of range or settings that conflict.

INTERNAL ERROR Indicates that the instrument has detected a hardware condition or firmware problem that prevents operation.

SYSTEM EVENTS Events that are common to instruments in a system (e.g., Power on, User Request, etc.).

INTERNAL WARNING Internal warning indicates that the instrument has detected a problem. The instrument remains operational, but the problem should be corrected (e.g., out of calibration).

DEVICE STATUS Device dependent events.

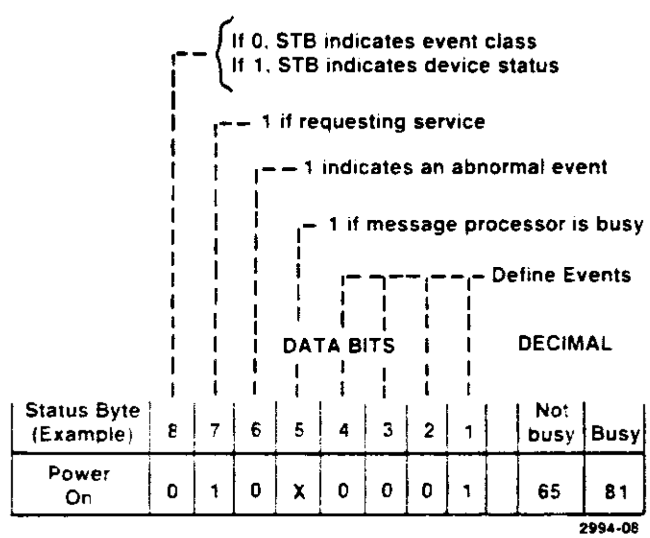


Fig. 3-2. Definition of STB bits.

The instrument can provide additional information about many of the events, particularly the errors reported in the Status Byte. After determining that the instrument requested service (by examining the STB) the controller may request the additional information by sending error query (ERR?). In response, the instrument returns a code which defines the event. These codes are described in Table 3-1.

@

Table 3-1
ERROR QUERY AND STATUS INFORMATION

Abnormal Events	Error Query Response	Serial Poll Response[a]
Command Errors:		
Invalid command header	101	97
Header delimiter error	102	97
Argument error	103	97
Argument delimiter error	104	97
Missing argument	106	97
Invalid message unit delimiter	107	97
Execution Errors:		
Not executable in local mode	201	98
Settings lost due to *rtl*	202	98
Input and output buffers full	203	98
Argument out of range	205	98
Group Execute Trigger ignored	206	98
Not in calibrate mode	231	98
Beyond calibration or null capability	232	98
Internal Errors:		
Interrupt fault	301	99
System error	302	99
Math pack error	303	99
Converter time-out	311	99
Front panel time-out	317	99
Bad ohms calibration constant	318	99
Calibration checksum error	351	99
Normal Events		
System Events:		
Power on	401	65
Operation complete	402	66
ID user request	403	67
Internal Warning:		
Over-range	601	102
Device Status[b]:		
Reading available	0	132
Waiting for trigger	0	136
Reading available and waiting for trigger	0	140
Below limits	701	193
Above limits	703	195
No Errors or Events	0	128

[a]If the instrument is busy, it returns a decimal number 16 higher than the number listed.

[b]The 4050-Series controller POLL command returns 0 for serial poll responses between 128 and 192; the responses listed can be obtained by using WBYTE and RBYTE statements.

Table 3-2
FRONT-PANEL ERROR CODES

Displayed	Abnormal Events	
Execution Errors:		
205	Argument out of range	
231	Not in calibrate mode	
232	Beyond calibration capability	
Internal Errors:		
303	Math pack error	
311	Converter time-out	
317	Front panel time-out	
318	Bad ohms calibration constant	
340	RAM error (high nibble)	
341	RAM error (low nibble)	
351	Calibration checksum error	
372	ROM placement error	C000
373	ROM placement error	D000
374	ROM placement error	E000
392	ROM checksum error	C000
393	ROM checksum error	D000
394	ROM checksum error	E000
395	ROM checksum error	F000
521	Indicates GPIB address switch (Signature Analysis) is enabled	

If there is more than one event to be reported, the instrument re-asserts SRQ until it reports all events. Each event is automatically cleared when it is reported via Serial Poll. The Device Clear (DCL) interface message may be used to clear all events except power-on.

Commands are provided to control the reporting of some individual events and to disable all service requests. For example, the User Request command (USER) provides individual control over the reporting of the user request event, which occurs when the front panel INST ID button is pushed. The Request for Service command (RQS) controls whether the instrument reports any events with SRQ.

RQS OFF inhibits all SRQ's, (except the power-on SRQ) so in this mode the ERR? query allows the controller to find out about events without first performing a Serial Poll. With RQS OFF, the controller may send the ERR? query at any time and the instrument returns an event waiting to be reported. The controller can clear all events by sending the error query until a zero (0) code is returned, or clear all events except power-on through the DCL interface message.

With RQS OFF the controller may perform a Serial Poll, but the Status Byte only contains Device Dependent Status information. With RQS ON, the STB contains the class of the event and a subsequent error query returns additional information about the previous event reported in the STB.

SENDING INTERFACE COMMANDS

The controller commands in the following text are for TEKTRONIX 4050-Series Controllers; they are representative of commands for other controllers.

Instrument commands are sent to the DM 5010 in ASCII using controller PRINT statements. The DM 5010 outputs data in response to INPUT statements from the controller. For example:

```
PRINT @ 16:"SET?"
INPUT @ 16:A$
```

where 16 is the DM 5010 primary GPIB address.

Interface control messages may be sent to the DM 5010 using WBYTE controller commands. In the following examples, A and B are the DM 5010 talk and listen addresses. For A, substitute the instrument primary address plus 32; for B, substitute the instrument primary address plus 64.

Listen (MLA)	WBYTE @ A:
Unlisten (UNL)	WBYTE @ 63:
Talk (MTA)	WBYTE @ B:
Untalk (UNT)	WBYTE @ 95:
Device Clear (DCL)	WBYTE @ 20:
Selected Device Clear (SDC)	WBYTE @ A,4:
Go To Local (GTL)	WBYTE @ A,1:
Remote With Lockout (RWLS)	WBYTE @ A,17:
Local With Lockout (LWLS)	WBYTE @ 17:
Group Execute Trigger <GET>	WBYTE @ A,8:
Serial Poll Enable (SPE)	WBYTE @ 24:
Serial Poll Disable (SPD)	WBYTE @ 25:

Refer to the 4050-Series Controller manual for information on using RBYTE statements.

POWER-ON (INITIAL) CONDITIONS

At power on, the DM 5010 microprocessor performs a diagnostic routine (self-test) to check the functionality of the ROM and RAM. If no error is found, the instrument enters the Local State (LOCS) with the settings listed in Table 3-3. The SRQ line on the GPIB is also asserted.

The DM 5010 also assumes the settings in Table 3-3 when it executes the INIT command. The range setting for the DCV function is valid only for the first reading, since the instrument is in auto-range.

Table 3-3
DM 5010 POWER ON SETTINGS

Header	Argument
AVE	2
CALC	OFF
DBR	1
DCV	−1.E+3
DIGIT	4.5
DT	OFF
LFR	OFF
LIMITS	0,0
MODE	RUN
MONITOR	OFF
NULL	0
OPC	OFF
OVER	OFF
RATIO	1,0
RQS	ON
SOURCE	FRONT
USER	OFF

ASCII & IEEE 488 (GPIB) CODE CHART

BITS B7 B6 B5				Ø Ø Ø	Ø Ø 1	Ø 1 Ø	Ø 1 1	1 Ø Ø	1 Ø 1	1 1 Ø	1 1 1
B4	B3	B2	B1	CONTROL		NUMBERS SYMBOLS		UPPER CASE		LOWER	
Ø	Ø	Ø	Ø	0 NUL 0 (0)	20 DLE 10 (16)	40 SP 20 (32)	60 0 30 (48)	100 @ 40 (64)	120 P 50 (80)	140 ` 60 (96)	160 p 70 (112)
Ø	Ø	Ø	1	1 GTL SOH 1 (1)	21 LLO DC1 11 (17)	41 ! 21 (33)	61 1 31 (49)	101 A 41 (65)	121 Q 51 (81)	141 a 61 (97)	161 q 71 (113)
Ø	Ø	1	Ø	2 STX 2 (2)	22 DC2 12 (18)	42 " 22 (34)	62 2 32 (50)	102 B 42 (66)	122 R 52 (82)	142 b 62 (98)	162 r 72 (114)
Ø	Ø	1	1	3 ETX 3 (3)	23 DC3 13 (19)	43 # 23 (35)	63 3 33 (51)	103 C 43 (67)	123 S 53 (83)	143 c 63 (99)	163 s 73 (115)
Ø	1	Ø	Ø	4 SDC EOT 4 (4)	24 DCL DC4 14 (20)	44 $ 24 (36)	64 4 34 (52)	104 D 44 (68)	124 T 54 (84)	144 d 64 (100)	164 t 74 (116)
Ø	1	Ø	1	5 PPC ENQ 5 (5)	25 PPU NAK 15 (21)	45 % 25 (37)	65 5 35 (53)	105 E 45 (69)	125 U 55 (85)	145 e 65 (101)	165 u 75 (117)
Ø	1	1	Ø	6 ACK 6 (6)	26 SYN 16 (22)	46 & 26 (38)	66 6 36 (54)	106 F 46 (70)	126 V 56 (86)	146 f 66 (102)	166 v 76 (118)
Ø	1	1	1	7 BEL 7 (7)	27 ETB 17 (23)	47 ' 27 (39)	67 7 37 (55)	107 G 47 (71)	127 W 57 (87)	147 g 67 (103)	167 w 77 (119)
1	Ø	Ø	Ø	10 GET BS 8 (8)	30 SPE CAN 18 (24)	50 (28 (40)	70 8 38 (56)	110 H 48 (72)	130 X 58 (88)	150 h 68 (104)	170 x 78 (120)
1	Ø	Ø	1	11 TCT HT 9 (9)	31 SPD EM 19 (25)	51) 29 (41)	71 9 39 (57)	111 I 49 (73)	131 Y 59 (89)	151 i 69 (105)	171 y 79 (121)
1	Ø	1	Ø	12 LF A (10)	32 SUB 1A (26)	52 * 2A (42)	72 : 3A (58)	112 J 4A (74)	132 Z 5A (90)	152 j 6A (106)	172 z 7A (122)
1	Ø	1	1	13 VT B (11)	33 ESC 1B (27)	53 + 2B (43)	73 ; 3B (59)	113 K 4B (75)	133 [5B (91)	153 k 6B (107)	173 { 7B (123)
1	1	Ø	Ø	14 FF C (12)	34 FS 1C (28)	54 , 2C (44)	74 < 3C (60)	114 L 4C (76)	134 \ 5C (92)	154 l 6C (108)	174 | 7C (124)
1	1	Ø	1	15 CR D (13)	35 GS 1D (29)	55 – 2D (45)	75 = 3D (61)	115 M 4D (77)	135] 5D (93)	155 m 6D (109)	175 } 7D (125)
1	1	1	Ø	16 SO E (14)	36 RS 1E (30)	56 . 2E (46)	76 > 3E (62)	116 N 4E (78)	136 ^ 5E (94)	156 n 6E (110)	176 ~ 7E (126)
1	1	1	1	17 SI F (15)	37 US 1F (31)	57 / 2F (47)	77 UNL ? 3F (63)	117 O 4F (79)	137 UNT _ 5F (95)	157 o 6F (111)	177 RUBOUT (DEL) 7F (127)

ADDRESSED COMMANDS

UNIVERSAL COMMANDS

LISTEN ADDRESSES

TALK ADDRESSES

SECONDARY ADDRESSES OR COMMANDS

KEY TO CHART

octal	25
GPIB code	PPU
ASCII character	NAK
hex	15
decimal	(21)

3391-13

Fig. 3-3. ASCII and IEEE 488 (GPIB) Code Chart.

Example Programs

Talker Listener Program For TEKTRONIX 4050-Series Controllers

```
100 REM DM5010 Talker/Listener Program
110 REM DM5010 Primary Address = 16
120 INIT
130 ON SRQ THEN 260
140 DIM A$(200)
150 PRINT "Enter Message(s): ";
160 INPUT C$
170 PRINT @16:C$
180 REM Check for queries
190 IF POS(C$,"?",1)<>0 THEN 220
200 REM Check for 'SEND'
210 IF POS(C$,"SEND",1)=0 THEN 150
220 REM Input from device
230 INPUT @16:A$
240 PRINT A$
250 GO TO 150
260 REM Serial POLL Routine
270 POLL X,Y;16
280 PRINT "Status Byte: ";Y
290 RETURN
```

Talker Listener Program For TEKTRONIX 4040-Series Controllers

```
100 Rem DM5010 TALKER/LISTENER PROGRAM
110 Rem      PRIMARY ADDRESS = 16
120 Init all
130 On srq then gosub srqhdl
140 Enable srq
150 Dim respons$ to 200
160 Input prompt "ENTER MESSAGE(S): ":message$
170 Print #16:message$
180 Rem CHECK FOR QUERIES
190 If pos(message$,"?",1) then goto 280
200 Rem CHECK FOR 'SEND' COMMAND
210 If pos(message$,"SEND",1) then goto 280
220 Rem CHECK FOR 'TEST' COMMAND
230 If pos(message$,"TEST",1) then goto 280
240 Rem CHECK FOR 'DATA' COMMAND
250 If pos(message$,"DATA",1) then goto 280
260 Goto 160
270 Rem INPUT FROM DEVICE
280 Input #16:respons$
290 Print "RESPONSE: ";respons$
300 Goto 160
310 Rem SERIAL POLL ROUTINE
320 Srqhdl: poll stb,pri
330 Print "STATUS BYTE: ";stb
340 Resume
350 End
```

These sample programs allow a user to send instrument commands to the DM 5010 to change instrument settings and to return the data generated.

Additional assistance in developing specific application oriented software is available in the following Tektronix manuals.

070-3985-00—GPIB Programming Guide. This manual is specifically written for applications of this instrument in IEEE-488 systems. It contains programming instructions, tips, and some specific example programs.

070-2270-00—4051 GPIB Hardware Support Manual. This manual gives an in-depth discussion of IEEE-488 bus operation. explanations of bus timing details and early bus interface circuitry.

070-2058-01—Programming in BASIC

070-2059-01—Graphic programming in BASIC

062-5971-01—4050-Series programming aids, T1 (includes software)

062-5972-01—4050-Series programming aids, T2 (includes software)

070-2380-01—4907 File manager operators manual

070-2128-00—4924 Users manual

070-1940-01—4050-Series graphic system operators manual

070-2056-01—4050-Series graphic system reference manual

070-3918-00—4041 Operators manual

061-2546-00—4041 Programming reference manual

PROGRAMMING AIDS

This discussion of programming considerations and the program examples are provided to aid in developing programs to control the DM 5010. The program examples were designed using a TEKTRONIX 4050-Series controller and the DM 5010; some examples also use other TM 5000 programmable instruments.

An initial programming consideration is setting the DM 5010 message terminator, GPIB address, and Talk Only mode switches. To determine their settings, press the INST ID button. The number displayed is the selected GPIB primary address; the far right decimal illuminates if the LF/EOI message terminator is selected; the minus sign illuminates if the Talk Only mode is selected. To change switch settings, refer qualified service personnel to the Maintenance section of this manual.

In the program examples, variable D is assigned to the DM 5010 GPIB primary address, which is assumed to be set to decimal 16. Using a variable name eliminates repeating the address decimal number and allows the address in the program to be easily changed.

Handling Service Requests

At power-on, the DM 5010 asserts SRQ. The power-on SRQ is incorporated to inform the controller if the power source is interrupted during program operation, since it may interfere with proper program execution. The DM 5010 can also assert SRQ for other events, if SRQ is enabled (see Table 3-1, Error Query and Status Information). Some controllers have the capability of ignoring SRQs; the other controllers require servicing all SRQs. If SRQs are to be serviced in the program, be sure to enable its interrupt.

Interrupt Handler—an interrupt driven routine to service SRQs when they occur during program operation. An interrupt handler basically consists of an ON SRQ statement in the beginning of the program, and a serial poll routine somewhere in the program. The ON SRQ statement directs program control to the serial poll routine when an SRQ occurs. See program example 1 or 3, line 110 for ON SRQ statements. When an SRQ interrupt occurs, the controller performs the serial poll routine. In a POLL statement, the first variable returns the instruments position in the list of GPIB addresses; the second variable returns the status byte. A serial poll of one instrument on the bus is illustrated in example 3, line 1000. Line 400 in example 4 polls three instruments on the bus, using the variable names for each instrument address. In each example, the POLL returns the status byte from the instrument asserting SRQ. Program example 9, lines 150, 160, and 170 comprise a serial poll using 4050-Series WBYTE and RBYTE statements.

The serial poll routine can be expanded to decode information about the event causing the SRQ. In example 1, lines 510 and 520 clear the busy bit in the status byte; lines 530 through 560 decode the status byte, and lines 1000 through 7030 print the event class on the controller display.

Program example 7 uses the MONITOR SRQ to detect measurements above or below limits set by the LIMITS command, or overrange. Lines 1020, 1040, and 1045 decode the status byte and initiate the appropriate print out on the controller display.

In program example 2, line 130, the controller polls the instrument at address 16 to clear the power-on SRQ. Line 160 turns SRQ off to inhibit additional SRQs. After SRQ OFF, the ERR? query may be inserted in the program where it is necessary to determine an event state.

Front Panel Lockout

The front panel may be locked out so that only the controller may change instrument settings. To lock out the front panel, first assert REN (true). REN must remain true as long as lock out is desired. For 4050-Series controllers, the RUN statement automatically asserts REN; the END statement unasserts REN. Then send the interface message LLO (decimal 17 with ATN). This is done in the 4050-Series controller with the WBYTE statement. Finally, address the instrument by sending a setting or query command using a PRINT @D: statement or send only the listen address using a WBYTE statement. After these three steps, the front panel is locked out and remains so until REN goes false or a <GTL> message (decimal 1 with ATN) is sent. See program example 4, lines 150 and 190; and example 5, lines 130 and 220.

Using INIT

Using the INIT command simplifies the program because it usually takes fewer commands to set the instrument state than specifying all settings individually. In program example 6, line 150, the DM 5010 receives the INIT command, followed by a series of commands that change the instrument state from the INIT (power-on) settings to the desired state.

Invalidating a Pending Reading

Following a change to the applied input, it may be desirable to invalidate the pending reading since it no longer reflects the current measurement conditions. One way to invalidate a pending reading is to send the instrument a setting command—this causes the instrument to delete data in the output buffer. Another way is to input a reading to the controller and ignore it.

Invalid readings can be avoided by using MODE TRIG to control when readings are taken.

Allowing Settling Time

Settling time may be incorporated in a program to ensure that the reading returned to the controller is valid. Refer to Step Response Time in the Specification section of this manual.

In program example 4, lines 230-250 use a FOR...NEXT loop to input five readings into variable R. At the end of the loop, variable R contains the fifth reading.

In program example 5, lines 290-320, two DM 5010 readings are compared; if the difference is greater than 0.001, another reading is taken for comparison. Comparisons are repeated until the difference indicates two readings are nearly the same.

Triggering Measurements

To trigger a single conversion, use MODE TRIG and initiate a trigger by using one of the following:

1. Talk-address the instrument. See program example 2 line 180.

2. SEND command.

3. Send DT TRIG. Then trigger the DM 5010 by transmitting a Group Execute Trigger (GET) interface message (decimal 8 with ATN). Refer to program example 9, lines 120 and line 5.

4. If the EXTRIG mode is enabled, hold P1031-16A on the Isolation board low for 10 μs or less.

5. Instruct the operator to press the front-panel TRIGGERED button.

For repetitive (free-run) triggering, use the MODE RUN command. If the EXTRIG mode is enabled, hold P1031-16A on the Isolation board low.

Determining Reading AVailability

It is not necessary to determine if a reading is available when the instrument is talk addressed or when the SEND command is used to return data. For either of these retrieval methods, the instrument triggers a conversion if a reading is not pending.

For other retrieval methods, there are several ways to determine if a reading is available.

1. Send the RDY? query command. When the response is 1, a reading is ready. See program example 3, line 140.

2. Set OPC ON and RQS ON. The instrument asserts SRQ when a reading is available. See example 8, line 150.

3. Repeat a serial poll routine using the WBYTE statements until the status byte is 132, 148, 140, or 156. See example 9, lines 150 and 200.

The RDY?, OPC ON and serial poll routine are useful when several tasks are going on at the same time.

Sending Readings to a Listener

To transfer a DM 5010 reading to a GPIB listener, the instrument that is to receive the data must be listen addressed. Then talk address the DM 5010 to transmit readings. When sent to a controller, data can be read into a string or numeric variable. See programming examples 2, line 180, and 3, line 150.

Program Example 1:

```
1 REM INTERACTIVE DRIVER WITH STATUS BYTE DECODER FOR DM5010
99 REM D = ADDRESS OF DM5010
100 D=16
110 ON SRQ THEN 500
120 PRINT @16:"INIT;USER ON;OVER ON"
130 PRINT "ENTER DM5010 COMMAND: ";
140 INPUT A$
150 PRINT @D:A$
159 REM GET QUERY RESPONSE OR READING FROM DM5010
160 INPUT @D:A$
170 PRINT A$
200 GO TO 130
499 REM SERVICE REQUEST INTERRUPT SUBROUTINE
500 POLL X,Y;D
509 REM CLEAR BUSY BIT
510 IF Y/32-INT(Y/32)<0.5 THEN 530
520 Y=Y-16
529 REM DECODE STATUS BYTE
530 IF Y=102 THEN 6010
540 GO TO Y-192 OF 7010,550,7030
550 GO TO Y-64 OF 4010,4020,4030
560 GO TO Y-96 OF 1000,2000,3000
570 PRINT Y;" IS AN INVALID STATUS BYTE FOR DM5010"
580 RETURN
1000 PRINT "COMMAND ERROR"
1009 RETURN
2000 PRINT "EXECUTION ERROR"
2009 RETURN
3000 PRINT "INTERNAL ERROR"
3009 RETURN
4010 PRINT "POWER ON"
4019 RETURN
4020 PRINT "OPERATION COMPLETE"
4029 RETURN
4030 PRINT "USER REQUEST"
4039 RETURN
6010 PRINT "OVER-RANGE"
6019 RETURN
7010 PRINT "BELOW LIMITS"
7019 RETURN
7030 PRINT "ABOVE LIMITS"
7039 RETURN
```

Program Example 2:

```
1 REM PROGRAM TO ECHO READINGS FROM DM5010 ONTO CONTROLLER DISPLAY
2 REM ASSUME USER WILL SET DM5010 TO PROPER FUNCTIONS VIA FRONT PANEL
100 REM D = ADDRESS OF DM5010
110 D=16
120 REM READ SERVICE REQUESTS
130 POLL X,Y;D
140 IF X THEN 130
150 REM DISABLE ALL OTHER SERVICE REQUESTS
160 PRINT @16:"RQS OFF"
170 REM INPUT READING FROM DM5010
180 INPUT @D:R$
190 REM CHECK FOR ERROR
200 PRINT @D:"ERR?"
210 INPUT @D:E$
220 IF E$="ERR  0;" THEN 240
230 PRINT E$;
240 PRINT R$
250 GO TO 180
```

Program Example 3:

```
1 REM READY QUERY
100 REM D = ADDRESS OF DM5010
101 D=16
110 ON SRQ THEN 1000
115 PRINT @D:"INIT"
120 PRINT "WAITING FOR READING"
130 PRINT "KWAITING FOR READING"
140 PRINT @D:"RDY?"
150 INPUT @D:G
160 IF NOT(G) THEN 130
169 REM INPUT READING FROM DM5010
170 INPUT @D:R
180 PRINT "READING IS ";R
190 GO TO 120
999 REM SERVICE REQUEST INTERRUPT SUBROUTINE
1000 POLL X,Y;D
1010 RETURN
```

Program Example 4:

```
1 REM GAIN VS FREQUENCY USING DM5010, FG5010 AND SI5010
100 ON SRQ THEN 400
110 D=16
120 F=24
130 S=26
140 REM SEND LLO (LOCAL LOCKOUT)
150 WBYTE @17:
160 PRINT "FREQUENCY (HZ)     AMPLITUDE (DB)"
170 REM H = FREQUENCY IN HZ
180 H=10
190 PRINT @D:"INIT;ACV"
200 PRINT @F:"INIT;AMPL 1;OUTPUT ON;FREQ ";H
210 PRINT @S:"INIT;CONF 0,8,0,8;CLOSE 4"
220 REM WAIT FOR FG, TEST CIRCUIT AND DM TO SETTLE
230 FOR K=1 TO 5
240 INPUT @D:R
250 NEXT K
260 REM R = INPUT VOLTAGE TO TEST CIRCUIT
270 PRINT @D:"CALC DBR;DBR ";R
280 PRINT @S:"INIT;CLOSE 1,4,5"
290 REM WAIT FOR SI5010 AND DM5010 AC CONVERTER TO SETTLE
300 FOR K=1 TO 5
310 INPUT @D:R1
320 NEXT K
330 REM R1 = TEST CIRCUIT GAIN IN DB
340 PRINT H,R1
350 REM STEP FREQUENCY AND REPEAT MEASUREMENT
360 H=10*H
370 IF H<=100000 THEN 190
380 END
390 REM SERVICE REQUEST INTERRUPT SUBROUTINE
400 POLL X,Y;D;F;S
410 RETURN
```

Program Example 5:

```
1 REM GAIN VS FREQUENCY USING DM5010 AND A MANUAL FG
98 INIT
99 REM D = ADDRESS OF DM5010, S = ADDRESS OF SI5010
100 D=16
105 S=26
110 ON SRQ THEN 480
120 REM SEND LLO (LOCAL LOCKOUT)
130 WBYTE @17:
140 PRINT "PLEASE APPLY THE FOLLOWING FREQUENCY, ";
150 PRINT "THEN PRESS THE INSTRUMENT ID BUTTON ON THE DM5010"
160 PRINT "FREQUENCY (HZ)    AMPLITUDE (DB)"
170 REM H = FREQUENCY IN HZ
180 H=10
190 REM V IS A FLAG THAT IS CLEARED WHEN USER PUSHES ID BUTTON ON DM5010
200 V=1
210 REM FRONT INPUT OF DM IS CONNECTED TO THE FG OUTPUT
220 PRINT @D:"INIT;ACV;USER ON;LFR ON"
230 PRINT @26:"CONF 0,8,0,8;CLOSE 4;RQS OFF"
240 PRINT H,"";
250 REM WAIT FOR USER TO SET FG FREQUENCY AND PUSH DM5010 INST ID BUTTON
260 IF V THEN 250
270 REM WAIT FOR FG, TEST CIRCUIT AND DM5010 TO SETTLE BY TAKING
280 REM READINGS UNTIL TWO READINGS ARE WITHIN 0.1% OF EACH OTHER
290 INPUT @D:R
300 R1=R
310 INPUT @D:R
320 IF ABS(R-R1)>R*1.0E-3 THEN 300
330 REM R HAS VALUE OF INPUT TO TEST CIRCUIT
340 PRINT @26:"CONF 4,4,4,4;CLOSE 1,5"
350 PRINT @D:"CALC DBR;DBR ";R
360 REM WAIT FOR TWO CONSECUTIVE READINGS WITHIN 0.1% OF EACH OTHER
370 INPUT @D:R
380 R1=R
390 INPUT @D:R
400 IF ABS((R-R1)/R)*1.0E-3 THEN 380
410 REM R HAS TEST CURCUIT'S GAIN IN DB
420 PRINT R
430 REM CHANGE FREQUENCY AND REPEAT MEASUREMENT
440 H=10*H
450 IF H<=100000 THEN 200
460 END
470 REM SEVRICE REQUEST INTERRUPT SUBROUTINE
480 POLL X,Y;D;S
490 REM CHECK FOR USER REQUEST INTERRUPT GENERATED BY PUSHING INST ID
500 IF Y=67 OR Y=83 THEN 530
510 RETURN
520 REM CLEAR FLAG TO INDICATE THAT USER HAS PUSHED ID BUTTON
530 V=0
540 RETURN
```

Program Example 6:

```
1 REM DAC TEST USING DM5010 AND MI5010 WITH 50M30 DIGITAL I/O CARD
99 REM D = ADDRESS OF DM5010, M = ADDRESS OF MI5010, C = CARD SLOT
100 D=16
110 M=23
120 C=1
130 ON SRQ THEN 1000
140 DIM R(256)
150 PRINT @D:"INIT;DCV 20;MODE TRIG;DIGIT 3.5"
160 PRINT @M:"INIT;SEL ";C;";CHA 1"
170 FOR K=0 TO 255
179 REM OUTPUT K TO DAC UNDER TEST
180 PRINT @M:"DATA ";K;";DATA?"
189 REM WAIT FOR MI5010 TO SETTLE BY READING RESPONSE TO DATA QUERY
190 INPUT @M:K$
199 REM TRIGGER DM5010 AND READ VOLTAGE FROM DAC UNDER TEST
200 INPUT @D:R(K+1)
210 NEXT K
220 REM DATA IN ARRAY R IS READY FOR PROCESSING
230 END
999 REM SERVICE REQUEST INTERRUPT SUBROUTINE
1000 POLL X,Y;D;M
1010 RETURN
```

Program Example 7:

```
1 REM MONITOR LINE VOLTAGES
99 REM D = ADDRESS OF DM5010
100 D=16
110 ON SRQ THEN 1000
120 PRINT @D:"INIT;ACV;LIMITS 105,120;MONITOR ON"
130 REM PLACE MAIN PROGRAM HERE
150 GO TO 130
160 END
999 REM SERVICE REQUEST INTERRUPT SUBROUTINE
1000 POLL X,Y;D
1005 PRINT Y
1009 REM TEST STATUS BYTE FOR BELOW LIMITS
1010 Z$="BELOW"
1020 IF Y=193 OR Y=209 THEN 1060
1029 REM TEST FOR ABOVE LIMITS
1030 Z$="ABOVE"
1040 IF Y=195 OR Y=211 THEN 1060
1044 REM TEST FOR OVERRANGE
1045 IF Y=102 OR Y=118 THEN 1110
1050 RETURN
1060 PRINT @D:"DATA"
1070 INPUT @D:W
1080 PRINT W;" IS ";Z$;" LIMITS"
1090 RETURN
1110 PRINT "OVER-RANGE"
1120 RETURN
```

Program Example 8:

```
1 REM AN EXAMPLE OF DOING TWO UNRELATED TASKS
2 REM MAIN PROGRAM LISTS A TAPE FILE ONTO A PRINTER AT ADDRESS P
3 REM INTERRUPT SUBROUTINE FINDS MAXIMUM VOLTAGE USING DM5010
100 INIT
109 REM D = ADDRESS OF DM5010, P = ADDRESS OF PRINTER
110 D=16
115 P=40
120 ON SRQ THEN 1000
130 PRINT @D:"INIT"
140 INPUT @D:M
150 PRINT @D:"OPC ON"
160 PRINT "ENTER FILE NUMBER TO BE LISTED"
170 INPUT F
180 FIND F
190 E=1
200 ON EOF (0) THEN 500
210 GO TO 230
220 PRINT @40:A$
230 INPUT @33:A$
240 IF E THEN 220
250 PRINT "DONE WITH FILE ";F
260 PRINT "MAX VOLTAGE IS ";M
270 GO TO 160
499 REM END OF FILE INTERRUPT SUBROUTINE
500 E=0
510 RETURN
999 REM SERVICE REQUEST INTERRUPT SUBROUTINE
1000 POLL X,Y;D
1009 REM TEST FOR OPERATION COMPLETE
1010 IF Y=66 OR Y=82 THEN 1030
1020 RETURN
1029 REM INPUT READING FROM DM AND COMPARE TO PREVIOUS MAXIMUM
1030 INPUT @D:M1
1040 IF M1<=M THEN 1060
1049 REM NEW READING IS NEW MAXIMUM
1050 M=M1
1060 RETURN
```

Program Example 9:

```
1 REM POLL FOR NORMAL DEVICE DEPENDENT STATUS
3 GO TO 100
4 REM USER DEFINABLE KEY #1 SENDS GROUP EXECUTE TRIGGER TO DM5010
5 WBYTE @D+32,8,63:
7 RETURN
19 REM USER DEFINABLE KEY #5 DOES AN ERROR QUERY
20 PRINT @D:"ERR?"
21 INPUT @D:A$
22 PRINT
23 PRINT A$
24 RETURN
99 REM D = ADDRESS OF DM5010
100 D=16
109 REM DO SERIAL POLL TO CLEAR POWER ON SERVICE REQUEST
110 POLL X,Y;D
119 REM DISABLE SERVICE REQUESTS
120 PRINT @D:"INIT;DT TRIG;RQS OFF"
129 REM S = PREVIOUS STATUS, S1 = PRESENT STATUS
130 S=0
140 S1=S
144 REM DO SERIAL POLL WITH WBYTE TO GET DEVICE DEPENDENT STATUS
145 SET NOKEY
150 WBYTE @24,D+64:
160 RBYTE S
170 WBYTE @25,95:
175 SET KEY
178 REM IF NEW STATUS IS SAME AS OLD STATUS THEN PRINT VERTICAL TAB
179 REM SO THAT STATUS MESSAGE WILL APPEAR BRIGHT
180 IF S<>S";THEN 200
190 PRINT "K";
198 REM DECODE STATUS BYTE
199 REM TEST FOR READING READY
200 IF S=132 OR S=148 OR S=140 OR S=156 THEN 300
209 REM TEST FOR WAITING FOR TRIGGER
210 IF S=136 OR S=152 THEN 250
219 REM TEST FOR CONVERSION IN PROGRESS
220 IF S=128 OR S=144 THEN 280
230 PRINT S;" UNEXPECTED STATUS BYTE"
240 GO TO 140
250 PRINT S;" WAITING FOR TRIGGER"
270 GO TO 140
280 PRINT S;" CONVERSION IN PROGRESS"
290 GO TO 140
300 INPUT @D:R
310 PRINT S;" READING IS ";R
320 GO TO 140
```

THEORY OF OPERATION

BLOCK DIAGRAM DESCRIPTION

This discussion is provided to aid in understanding the overall concept of the DM 5010 Programmable Digital Multimeter. The basic block diagram of the DM 5010 in Section 10, Diagrams and Circuit Board Illustrations, should be followed when reading the Block Description.

General Description

The DM 5010 Programmable Digital Multimeter is a microprocessor based GPIB programmable instrument designed to operate in any two adjacent compartments of a TM 5000-Series power module. It has dual-polarity floating-voltage measurement capabilities as well as the ability to offset or null resistance and voltage measurements under user control. It uses a charge balancing technique to convert the analog input signals to digital data for storage and processing.

To understand how the DM 5010 functions, some concepts and techniques implemented in the instrument are explained at this point. These concepts should be understood before proceeding to the block diagram and detailed circuit descriptions in this section.

Isolation

The floating measurement capability allows the DM 5010 to accurately measure voltages referenced to a point other than DMM chassis ground. To accomplish this, the DM 5010 implements an isolation scheme. The TM 5000 power module supplies power to the analog and isolated sections through a transformer to electriclaly isolate it from the chassis ground. The required data and control signals to/from this section are transmitted via opto-isolators, completing the isolation scheme. Isolating the "front-end", where the critical portion of the measurement process occurs, from chassis ground eliminates many problems inherent in ground-related measurement techniques.

Charge Balancing

The DM 5010 Programmable Digital Multimeter operates on the principle that each of its various measurement modes (dc volts, ac volts, Ohms, etc.) may, through proper input conditioning, be translated into a dc voltage representing the conditions present at the instruments inputs. After input conditioning, four major tasks remain:

1. conversion of the representative voltage to a digital form that may be stored and manipulated as necessary;

2. keeping track of measurement specifics (i.e., type, range, etc.);

3. performing any secondary conditioning or algorithms dependent on 2, above, and;

4. presenting the resultant measurement data to the user in a visible display or, if desired, to another device in some intelligent format.

The latter three functions are performed and controlled mostly by microprocessor and GPIB circuitry and are described more fully later in this section. In this instrument, the conversion of step 1 is performed using the charge-balancing A/D conversion technique.

Charge balancing conversion operates on the following principle. An unknown (voltage-dependent) current I_{in} injected into an integrator's input causes the integrator's output to charge away from its initial value at some unknown rate. Similarly, either injecting or removing a known net current $I_{net\ ref\ in}$ or $I_{net\ ref\ out}$ at the input node causes the integrators output to integrate down and up, respectively, at a known rate. If the unknown current and one of the known net currents (either injected or removed) are applied to the node simultaneously, the integrators output charges at a rate determined by the sum of the currents. If the reference currents $I_{net\ ref\ in}$ and $I_{net\ ref\ out}$ are chosen to always be greater in magnitude than any allowed value of I_{in}, the integrators output charges in the direction established by the reference current switched into the summing mode. Charge rate is established by $I_{net\ ref\ (in\ or\ out)} + I_{in}$.

A conversion is accomplished by keeping track of the time required in each of its $I_{net\ ref} + I_{in}$ charge modes to keep the integrators output near a predetermined zero-reference voltage. By attaching a comparator to the zero-reference voltage and to the output of the integrator, it may be determined whether the integrators output is above or below the zero-reference. By adding or subtracting clock pulses to a counter in response to the comparator output, a numerical representation of the net time required by $I_{net\ ref}$ to balance the effect of I_{in} on the integrator capacitor is generated. The system microprocessor translates the numerical results into a meaningful data format for display to the user.

At the beginning of a conversion, an Auto-Zero period is initiated in which a zero-reference voltage is stored by the converter. This voltage is compared to the output of the integrator during actual signal measurement and represents a zero-volt input.

After the zero reference has been established, the input current is switched into the node. This current and $I_{net\ ref\ out}$ cause the integrators output to integrate up toward the zero-reference voltage at a rate determined by $I_{net\ ref\ out} + I_{in}$. For input voltages $\leqslant$ the full scale voltage, the integrator output will cross the zero-reference voltage in less than four measurement intervals. After the zero-reference voltage crossing and a new polarity determination is made, the control logic switches the reference current's direction (and thus the direction of integration).

The measurement interval consists of 18 clock cycles, which allow the integrators output to charge somewhat beyond the zero-reference voltage before charge direction is reversed. During this charging process, each clock is added to or subtracted from the contents of a counter depending on the output state of the comparator.

The integrators output now charges back toward the zero-reference at a rate determined by $I_{net\ ref\ in} + I_{in}$. It may take less than one or up to several hundred measurement intervals for the integrator output to again cross the zero-reference voltage. After the comparator detects the crossing and a new polarity determination is made, charge direction is reversed at the beginning of the next measurement interval. This process of charging toward the threshold, beyond the threshold, and then reversing direction to charge back toward the threshold repeats until the prescribed number of measurement intervals is complete. During this time, the accumulated count in the up/down counter is being added to or subtracted from, depending on the output state of the comparator (ICOMP). When the last measurement interval is complete, the accumulated clocks in the counter are representative of the A/D converters input.

Microprocessor

The implementation of a microprocessor in the DM 5010 substantially reduces its hardware requirements and increases its flexibility and capability. Microprocessor systems use bus-structured architecture. A general description follows.

At any given time in a microprocessor system, many "pieces" of information may be present at various physical locations within the system. This information may include the instructions for the microprocessor to perform some process, constants and algorithms for that process, intermediate and final results for the process, control and switching information, "locations" of certain information, etc. Of these types of information, most are stored (at least temporarily) in the form of "data" at an "address" or as some type of control signal or level.

The microprocessor uses busses to control the flow of data and program execution. A bus is a group of signal lines dedicated to a data transfer or program control function. It is connected to allow bidirectional data transfer or control over two or more devices using the same signal paths for any two of the transfers or control functions.

The data bus is the group of eight signal lines in the DM 5010, dedicated to transferring data in a standard format between the microprocessor and the other devices on the bus.

The address bus is another group of signal lines dedicated solely to "addressing" (selecting) the device that the microprocessor wants to communicate with (data transfer via the data bus). Address-decoding circuitry makes the devices on the data bus respond only to their proper address(es).

The remaining lines associated directly with the microprocessor IC (with the exception of power supply and clock signals) comprise the control bus. These signal lines allow the processor to control certain system functions and allow certain conditions within the system to alter processor operation.

The bus configuration employed in processor-oriented systems allows great flexibility when implementing hardware. Since system operation is under "firmware" control, functions that normally require large amounts of dedicated circuitry may be performed by a general block operating in several different modes.

Another characteristic of processor-oriented systems is the ability to perform calculations. Some parameters may not be measured directly with a multimeter, and a series of calculations must be performed to arrive at the desired result. The DM 5010 has the capability of performing some frequently used calculations, giving the user the ability to "directly" measure these parameters.

GPIB

The GPIB (General Purpose Interface Bus) circuitry of the DM 5010 provides a communication link to other GPIB compatible instruments. This communication link allows the DM 5010 to be programmed to operate in any of its measurement modes and then to transfer the results of that measurement to any other assigned instrument on the GPIB bus. The DM 5010's GPIB circuitry adheres to IEEE Standard 488-1978 and will be described later in this section.

Block Description

The following block description uses the Block Diagram in Section 10 at the rear of this manual. Each major block of circuitry is assigned a name according to its primary function. The diamond numbers within a block represent the diagram(s) on which the complete circuit may be found. Only the basic interconnections between the individual blocks are shown.

As previously mentioned, the circuitry of the DM 5010 is divided into two distinct sections, depending on how the devices within each section receive their power. The block diagram indicates the division between the Grounded Section and the Isolated Section.

The power for the circuitry in the Grounded Section is derived from the Grounded Power Supplies. These supplies are powered from the TM 5000-Series power module and regulated to meet the requirements of the DM 5010.

The power required for the circuitry in the Isolated Section is tranferred from the power module to the Isolated Power Supplies through a transformer. The Transformer Drive circuitry switches the power-module current through the transformer at a frequency synchronized to the analog-to-digital conversion process to minimize the noise error caused by power supply ripple in the Isolated Section.

Power is transferred to the Isolated Power Supplies, and the Isolated Regulators stage regulates the power to the levels required by the rest of the Isolated Section.

The Input Switch stage allows analog signals from either the front panel or the rear interface input to be selected for measurement.

The selected input is applied to either the DCV Signal Conditioner, RMS, or Ohms Converter circuits where the applied input is translated into a representative dc voltage. The Range Control circuitry provides the gain and attenuation switching necessary to accommodate the various ranges of the RMS, DCV Signal Conditioner, and Ohms circuits.

Depending on the mode of operation, the dc output from either the Input switch, RMS Converter, or Ohms Converter is applied to the DCV Signal Conditioner as determined by the Function Switch. The Attenuator and DCV Signal Conditioner provide attenuation or gain factors and scale the input signal to fall within the A/D converters input range. The A/D converter uses a charge balancing conversion technique to convert the applied analog dc input to a corresponding digital equivalent.

As the conversion takes place, the A/D converter generates a count direction control signal defining the input conditions. As this signal is generated, it is transferred via an opto-isolator to the Grounded Section and is used to maintain control of the on-going conversion. The remaining opto-isolators transfer control information from the Grounded Section to the Isolated Section to set up the range switching and to control the A/D conversion process.

The microprocessor is the control center for all activity in the instrument. It is a time-dependent device and most functional blocks are synchronized to it, either directly or indirectly, shortly after power-up. The Timing Logic, together with the Control Logic, develops the proper time-dependent logic signals for the A/D conversion circuitry on both sides of the opto-isolators. The Timing Logic also drives the Transformer Drive circuitry at a rate that makes the A/D conversion most immune to power supply noise.

The Data circuitry consists of a counter that keeps track of clock pulses under the direction of the count-direction control signal generated during an A/D conversion. The signal originates in the A/D Converter in the Isolated Section and is passed through the opto-isolators and the Control Logic to the Data counter where it controls the count direction of an up/down counter. From there, this binary-coded counter data is transferrerd one bit at a time onto the data bus via the block labeled Miscellaneous Buffer. This sequential data string, representing the conditions at the instruments inputs, is read by the Microprocessor. Then the processor performs the manipulations necessary to bring it to the desired format for display or transfer over the GPIB.

With the exception of some front-panel circuitry and a battery circuit, the remainder of the circuitry in the instrument is directly connected to the microprocessor's address or data busses.

The Address Decode and Logic circuits decode certain addresses or groups of addresses output from the processor on its address bus. When output by the processor, they enable specific blocks of circuitry to communicate with the processor. There are many discrete enabling lines involved with the Address Decode; they are shown on the Block Diagram as being returned back onto the address bus. These enable lines may be thought of as an extension of the address bus. Due to the multiplicity of devices requiring microprocessor addressing, an Address Bus Buffer stage is necessary to increase current drive capability.

The Data Bus Buffer serves much the same purpose but is bidirectional; i.e., it buffers data signals both from and to the microprocessor.

The ROM circuitry contains the instruments operational firmware that tells the Microprocessor how to control and perform instrument functions. Many functions the processor performs require some way to temporarily store data and read it back later. The RAM serves this purpose.

A special CMOS RAM is used to store "calibration constants" for the instrument. During adjustment of the instrument, specific signals are applied to its inputs and the microprocessor is "told" what the readings it is receiving from the D/A converter represent. Constants are derived from this data and are stored in the CMOS RAM. This memory may only be changed during the adjustment procedure. The Battery circuit connected to the CMOS RAM ensures that these constants are maintained when instrument power is turned off.

The Front-Panel Control block provides the circuitry necessary for the microprocessor to read information from the user-selectable Front-Panel Switches as well as the ability to present measurement data and some status information back to the user via the Front-Panel Display. The Front-Panel Drive circuitry provides the current drive necessary to illuminate the various devices of the Front-Panel Display.

The GPIB (General Purpose Interface Bus) circuitry enables the DM 5010 to communicate with other GPIB-compatible instruments. By using an external controller, other GPIB instruments may receive measurement information from the DM 5010 or may send measurement related instructions to it. This allows the DM 5010 to change measurement modes and send the measurement results to a desired instrument without operator intervention.

When a GPIB controller addresses an instrument on the GPIB, the microprocessor looks at the DM 5010's Switches block to see if it is supposed to respond. These Switches may be set by the user to define which GPIB address the DM 5010 will recognize.

One of the Switches, when set, stops all normal operation of the DM 5010. This is its signature analysis mode, and signature analysis troubleshooting may be performed on the instrument. By disconnecting the Data Bus Buffer from the Microprocessor and connecting the NOP (no-operation) Buffer in its place, a more rudimentary form of troubleshooting may be performed.

DETAILED CIRCUIT DESCRIPTION

The following description provides detailed information about the circuitry of the DM 5010. The diamond number(s) preceding the individual descriptions indicate the specific diagram(s) being explained by that description.

INPUT SWITCH ◇1

The Input Switch determines whether the analog signal applied to the DM 5010's front-panel inputs or the signal from the analog inputs at its rear interface connector is measured. Depending on the range of the measurement being made, the input is attenuated by an appropriate factor to prescale the signal and protect the various input circuits from overvoltage conditions.

With no current through relay K1631, the front-panel inputs HIGH, LOW, and GUARD are selected for measurement. Guard switch S1731 allows the user to select the guard configuration most suited for his measurement requirements. Resistor R1626 provides a known impedance of 1 MΩ between the GUARD and LOW inputs with the Guard switch open. Refer to the Operating Instructions in Section 2 for specifics concerning use of the GUARD input. The internal Guard is connected to the rear LO when using the rear interface inputs.

With the low (−27 V) applied to K1631-4, indicating that measurements should be taken from the rear interface connector, current to activate the relay flows through both R1613 and CR1621. Once activated, the current path through R1631 is opened and only the smaller current necessary to keep the relay activated flows in the relay via CR1621 and R1615.

ATTENUATOR ⟨1⟩

The input signal to be measured passes through a resistive attenuator network that prescales the analog signal to fall within the input circuitry's dynamic range. Attenuation factors of 1 and 100 are controlled by closing contacts of relays K1527, K1425, and K1525 as shown in Fig. 4-1 and Tables 10-2 and 10-5 in the pull out pages.

OVERVOLTAGE PROTECTION AND FUNCTION SWITCHING ⟨1⟩

All measurement modes of the DM 5010 require that some type of conditioning be performed on the input signal before an A/D conversion is performed. In each case, the input conditions are converted to a representative dc voltage level by the appropriate conditioning circuitry and are then applied to the DCV Signal Conditioner where some range-dependent gain factor is applied to the signal. This resultant prescaled signal is the basis for all A/D conversions and, along with the various mode, attenuation, and gain factors set by the microprocessor, represents the input conditions.

This stage selects the appropriate conditioning circuit output and routes it to the DCV Signal Conditioner input. It also provides overvoltage protection should these signals exceed the specified input range.

A simplified schematic of the Overvoltage Protection and Function Switching stage appears in Fig. 4-2. Each of the FET switches connects either an individual function or the high quality ground reference to the DCV Signal Conditioner when closed. Refer to Tables 10-2 and 10-5 in the pull out pages for mode-dependent function and range switch settings.

Transistors Q1327 and Q1323 connected as diodes prevent the input voltage applied to FET switch Q1319 from exceeding ≈ +23 volts and −23 volts, respectively. Similarly, transistors Q1321 and Q1322 prevent the output voltage of the Ohms Converter from exceeding the same voltages.

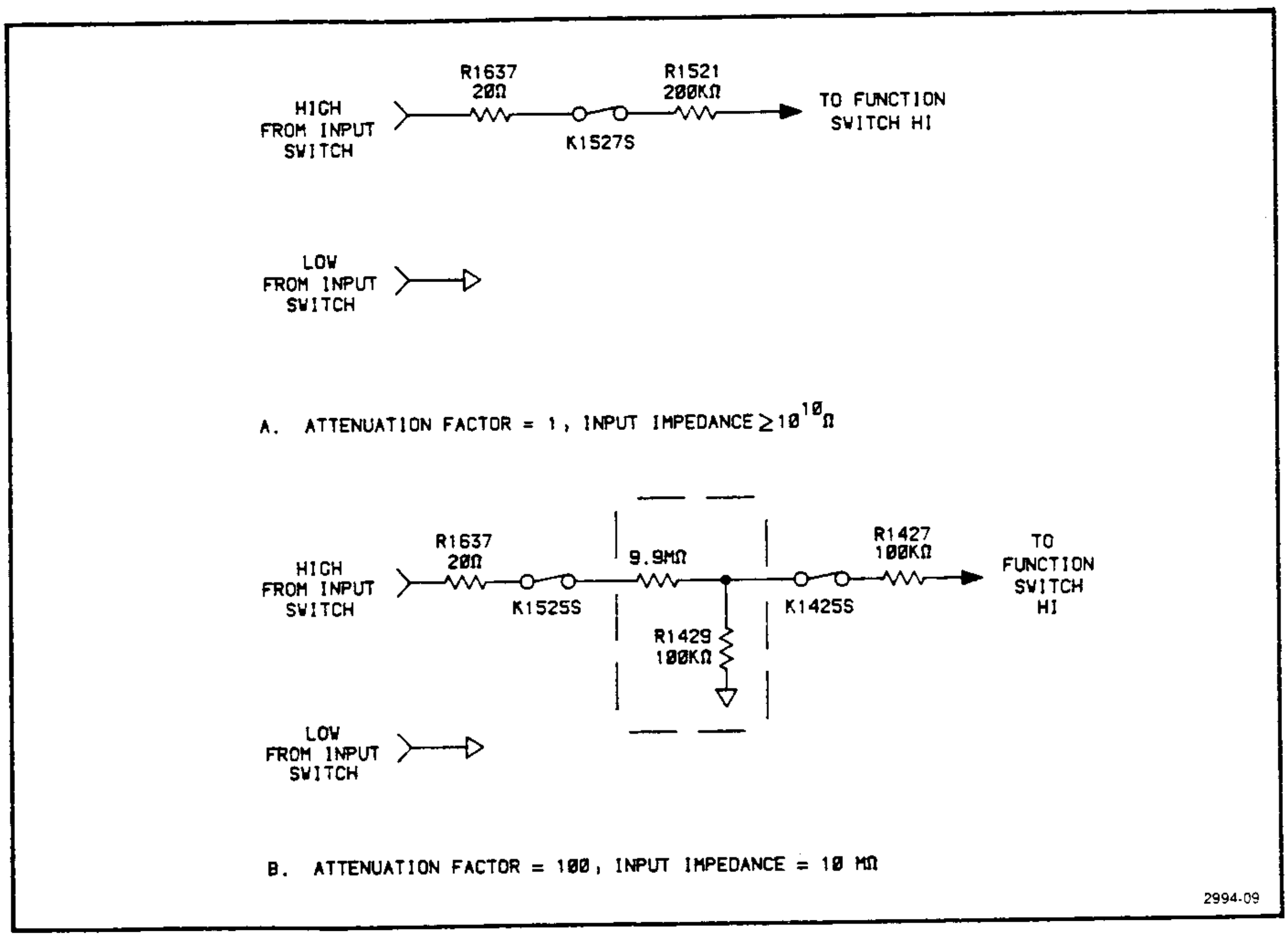


Fig. 4-1. Attenuator.

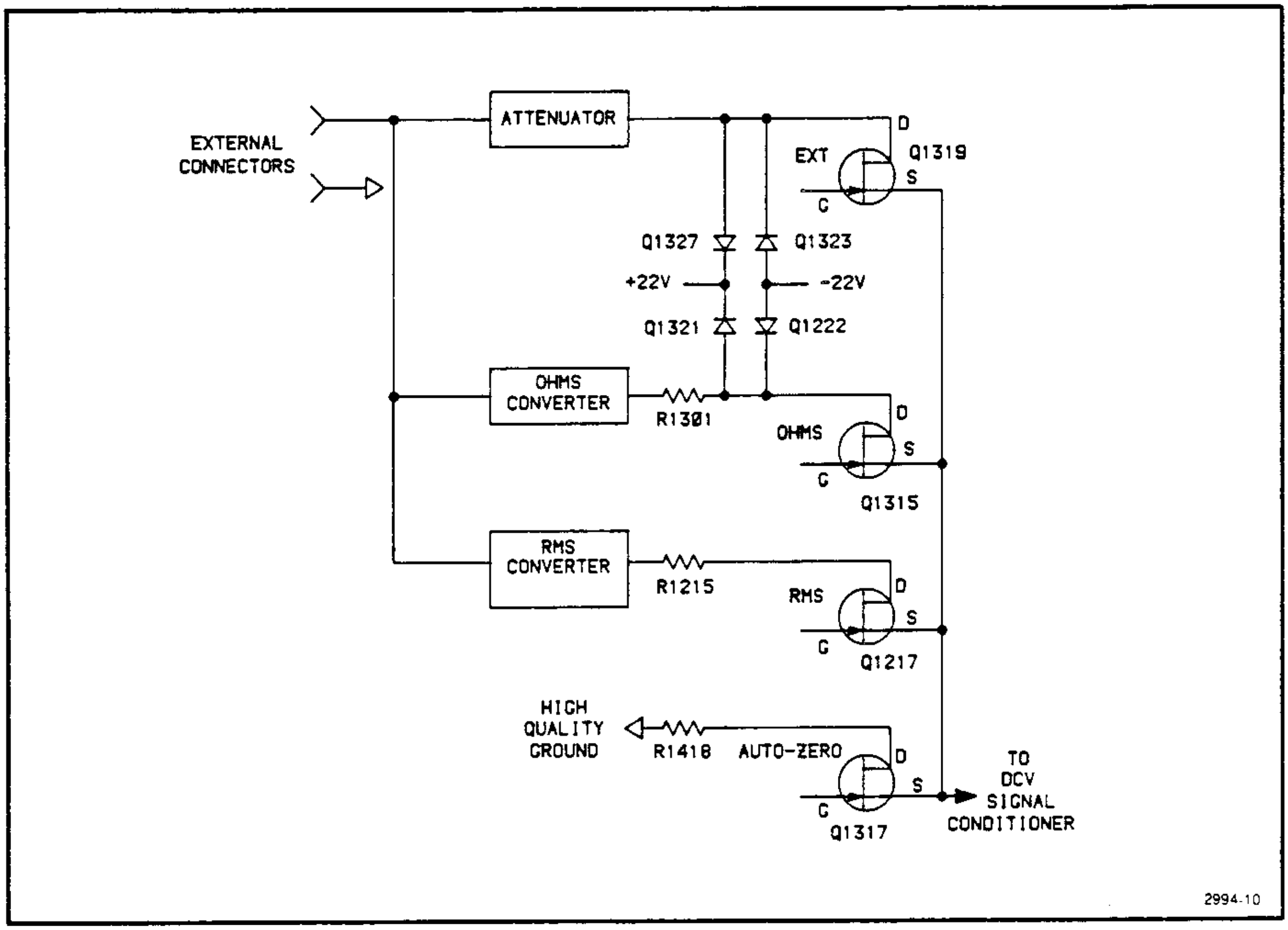


Fig. 4-2. Simplified overvoltage protection and function switching.

DCV SIGNAL CONDITIONER ⟨1⟩

The DCV Signal Conditioner provides range-dependent gain for the various dc mode-dependent signals applied to it. Figure 4-3 shows a simplified diagram of the buffer amplifier Table 4-1 shows the states of the buffer amplifier.

Table 4-1
DCV SIGNAL CONDITIONER GAIN SETTINGS

FET	Gain of the Buffer Amplifier		
Switch	10	1	0.1
Q1105	ON	OFF	OFF
Q1106	OFF	OFF	ON
Q1112	OFF	ON	ON
Q1114	ON	ON	OFF

The Function Switch directs the mode-dependent dc level to the noninverting input of U1210, the buffer amplifier. The gain of the buffer amplifier is set depending on which of the FET switches are turned on by a high at their gates. Feedback to the inverting input of the operational amplifier is through either Q1112 or Q1105 while forward attenuation of the signal to the A/D converter is determined by Q1114 for Q1106. Diodes CR1221 and CR1223 prevent overdriving the buffer amplifier.

To ensure linear response of the buffer amplifier over its input range, a bootstrap buffer is used to make the buffer amplifier supply voltages track its input. This has the effect of making U1210 operate at the middle of its range, avoiding the linearity problems encountered when the output approaches one of the supply voltages. By making the gate bias of the various FET switches also track the input voltage, proper bias is maintained and current leakage through the FETs (and thus the associated error) is minimized. A simplified schematic of the bootstrap buffer is shown in Fig. 4-4.

The input to the bootstrap buffer, pin 3 of U1110, is connected to the inverting input of U1210 and is therefore at the

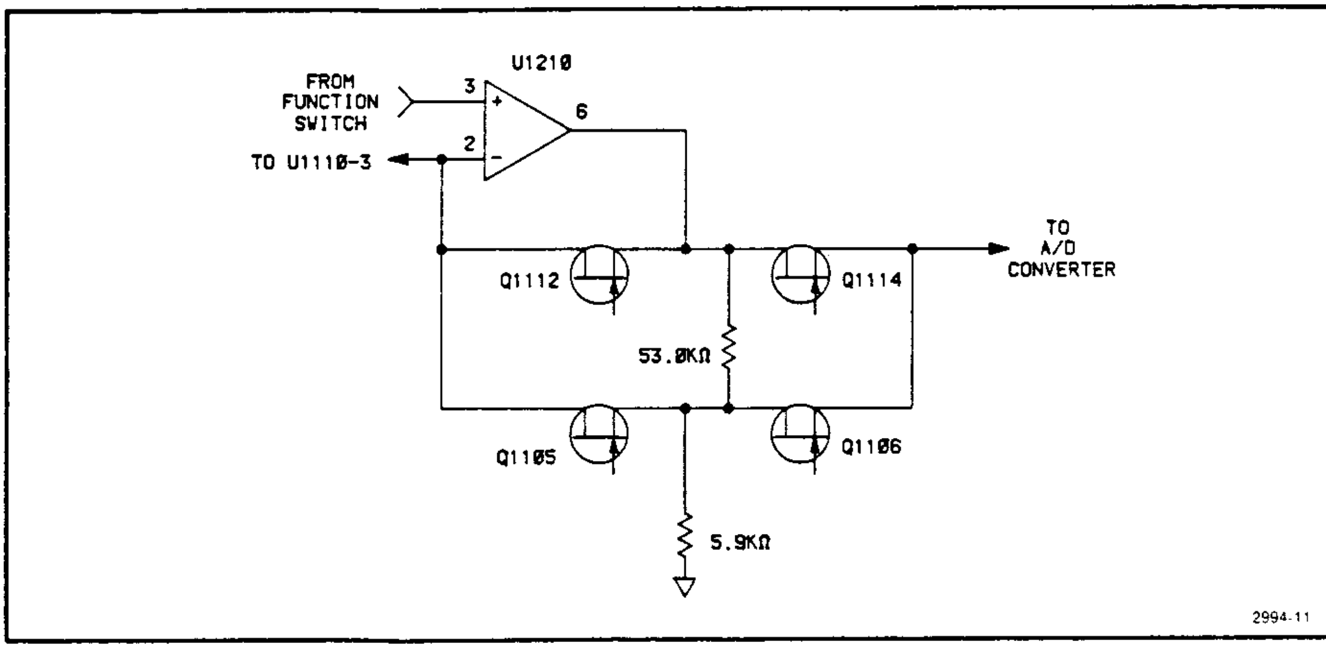


Fig. 4-3. Simplified DCV signal conditioner buffer amplifier.

same voltage as the input of the buffer amplifier. Operational amplifier U1110 and transistors Q1017 and Q1021 form a unity gain, noninverting amplifier that tracks the input of the DCV Signal Conditioner. Hence, the bases of Q1101 and Q1111 follow the input signal (plus and minus 6.2 volts, respectively, as determined by VR1011 and VR1015). The emitters of Q1101 and Q1111 (and thus U1210's supplies) remain +5.5 volts and −5.5 volts away from the input voltage, respectively. Diodes CR1111 and CR1113 allow the operational amplifiers supply pins to follow the buffer amplifier input under transient conditions where Q1101 or Q1111 might become reverse biased.

As an example, let the input to the buffer amplifier start at zero volts. The input to U1110 at pin 3 and, thus, the buffered output at pin 2 must also be at zero volts. Zener diodes VR1001 and VR1013 along with resistor R1011 bias transistors Q1001 and Q1015 on, allowing current to flow in Zener diodes VR1011 and VR1015. This sets the bases of Q1101 and Q1111 at +6.2 volts and −6.2 volts, respectively. Their emitters, and U1210's supplies, are at +5.5 volts and −5.5 volts, respectively.

If the input to the buffer amplifier goes to +15 volts, the input to the bootstrap buffer also goes to +15 volts. The output at the emitters of Q1017 and Q1021 goes positive until the inverting input of U1110 also reaches +15 volts. The bases of Q1101 and Q1111 go to +21.2 volts and +8.8 volts, respectively. The supply voltages at their emitters go to +20.5 volts and +9.5 volts, respectively. The supply voltages are plus and minus 5.5 volts from the input voltage of the buffer amplifier, so it is operating in the middle of its range.

CHARGE-BALANCING CONVERTER ⟨1⟩

The Charge-Balancing Converter is the analog portion of the A/D Converter and, along with the Control Logic, Timing Logic, opto-isolators, and Data stages, changes the analog-dc voltage from the input-conditioning circuits to a digital representation. It derives its name from the fact that, during one conversion cycle, the total current added to and subtracted from the input summing node equals zero. Input buffer U1120 and the charge-balancing IC U1230, along with their associated components, comprise the Charge-Balancing Converter stage. Figure 4-5 shows a diagram of the stage with details of the converter IC added for clarity. The Block Diagram illustrates the major functional interconnections used in this description. The Block Diagram description explains some of the general charge-balancing concepts that should be understood before proceeding with this description.

The A/D conversion process is based upon two main time-dependent periods called Auto-Zero and Measurement. The Auto-Zero period involves setting a zero-reference voltage for the Charge-Balancing Converter. The actual conversion on the selected input is performed during the Measurement period. Both are synchronized to the microprocessor clock by the Timing Logic. Figure 4-6 illustrates some of the critical timing for each period of the conversion process.

Both of the above conversion phases are based on what are known as measurement intervals. The Timing Logic divides the microprocessor 1 MHz clock down to a 250 kHz

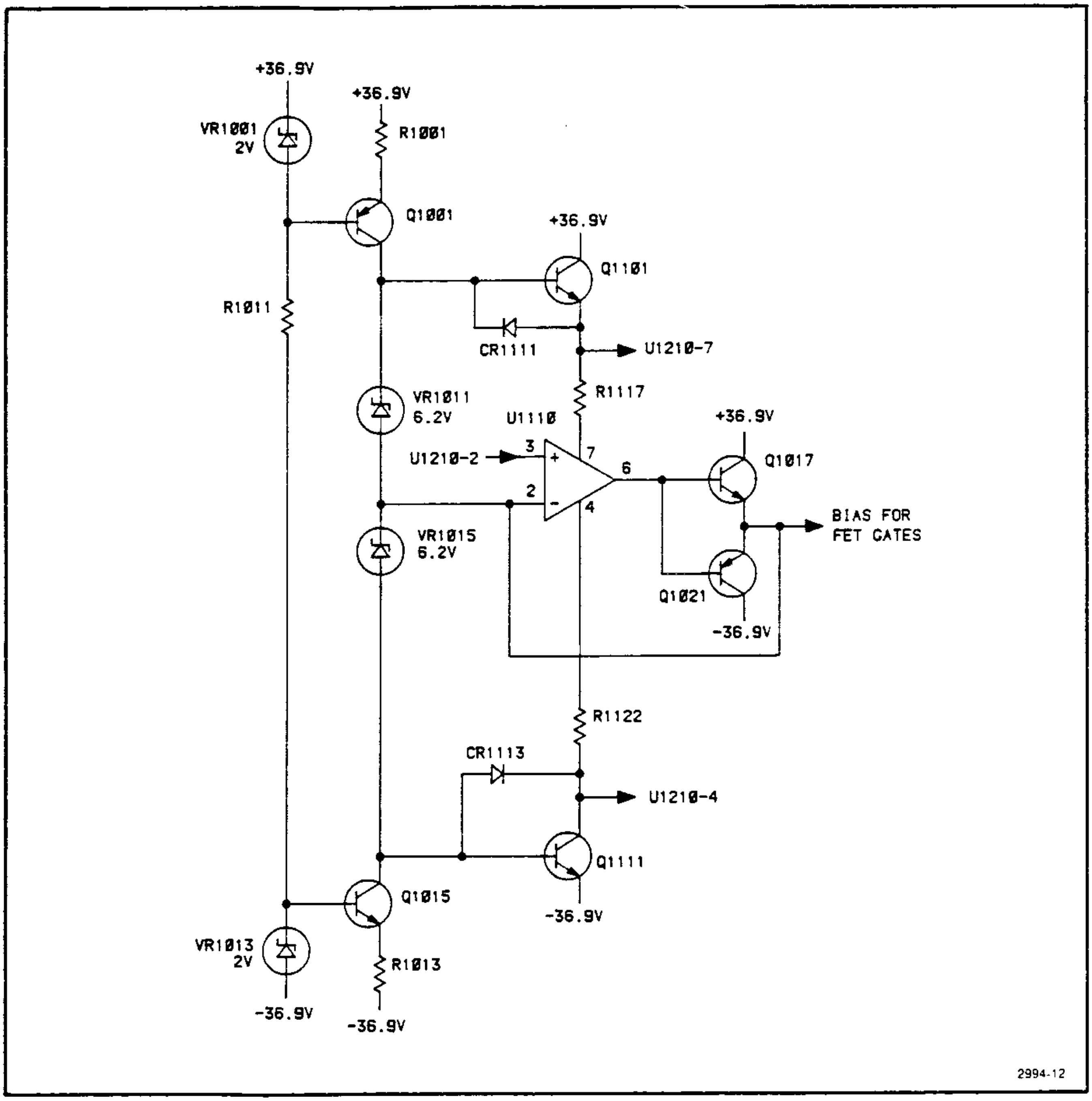


Fig. 4-4. Simplified DCV signal conditioner bootstrap buffer.

rate. Eighteen of these 250 kHz clock pulses in sequence comprise one measurement interval. Some special counters and decoding logic define the beginning, middle, and end of each interval and initiate or terminate certain conversion functions as shown in Fig. 4-6.

Auto-Zero

Before a conversion is performed, an initial zero-reference voltage (≈ -2 V) must be set. The Function Switch, under direction of the Function and Range Control circuitry, switches the input of the DCV Signal Conditioner buffer amplifier to the high quality ground to initiate the Auto-Zero period. The input signal, and the output of input buffer U1120, goes to zero volts.

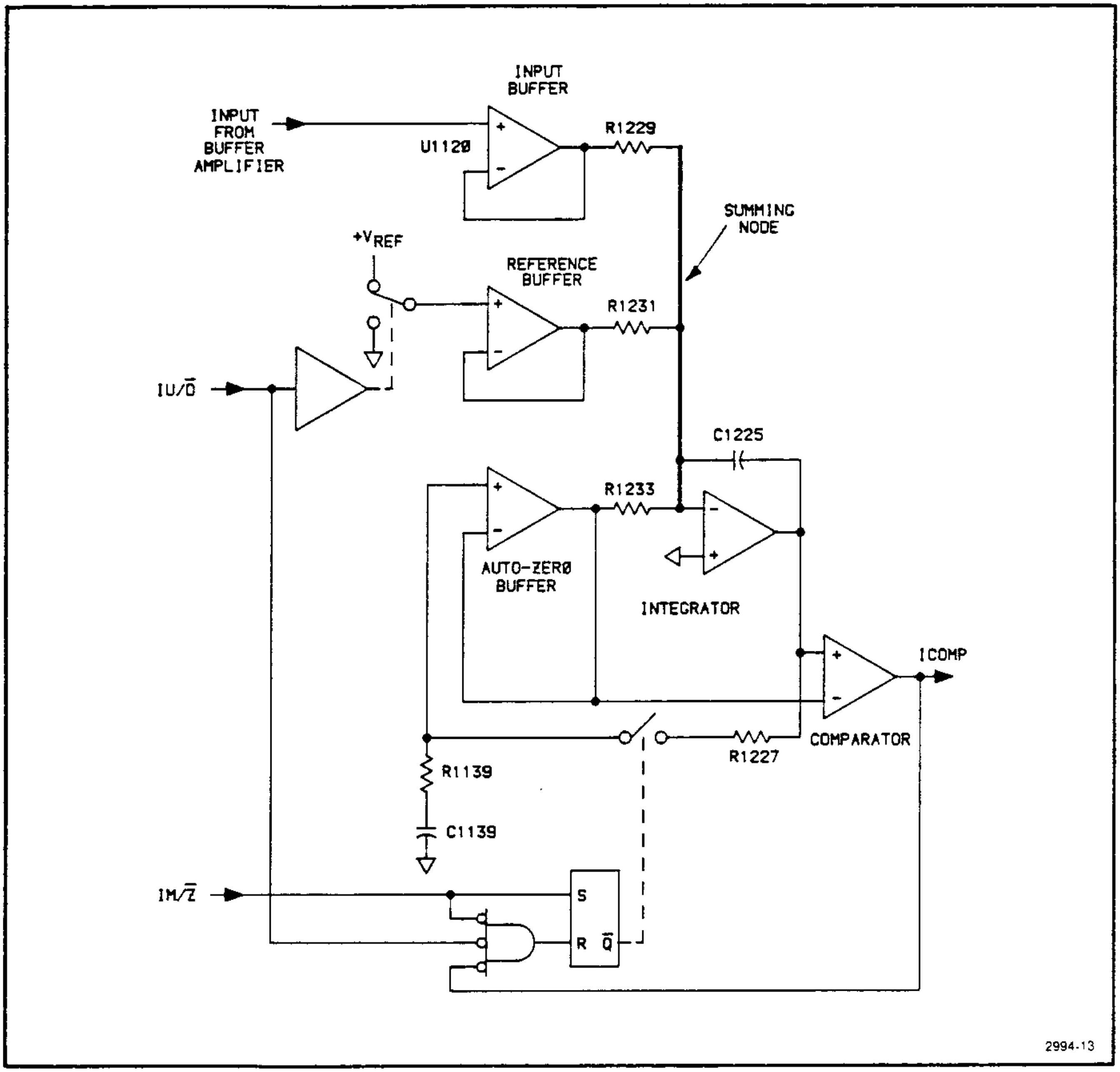


Fig. 4-5. Simplified charge-balancing converter.

Figure 4-7 illustrates the currents at the summing node when the zero-reference is being set. The node current from the Converter Input buffer, U1120, may be ignored since it is very small during the Auto-Zero period.

As the Auto-Zero period begins, a counter in the Timing Logic is set to zero. The Reference Buffer input is then toggled by T0 and T8 with a 50% duty cycle between $+V_{ref}$ and ground, injecting an average current $I_{ref\ in}$ equal to $+V_{ref}/(2 \times R1231)$ into the summing node. The Integrator produces a voltage output to the Auto-Zero Buffer. The Auto-Zero Buffer sinks current, via R1233, of opposite polarity to the current injected by the Reference Buffer until the current removed from the node balances the current being injected. This is the equilibrium state, and the voltage waveform at the input of the Auto-Zero Buffer is that required to precisely track the injected current input. Resistors R1139, R1227, and capacitor C1139 at the Auto-Zero Buffers input integrate the integrator output waveform over a preset number of measure intervals. The negative Auto-Zero Buffer output voltage across R1233 generates a current equal in magnitude but of opposite polarity to the average injected reference current. The averaged voltage at the input of the Auto-Zero Buffer is the zero-reference volt-

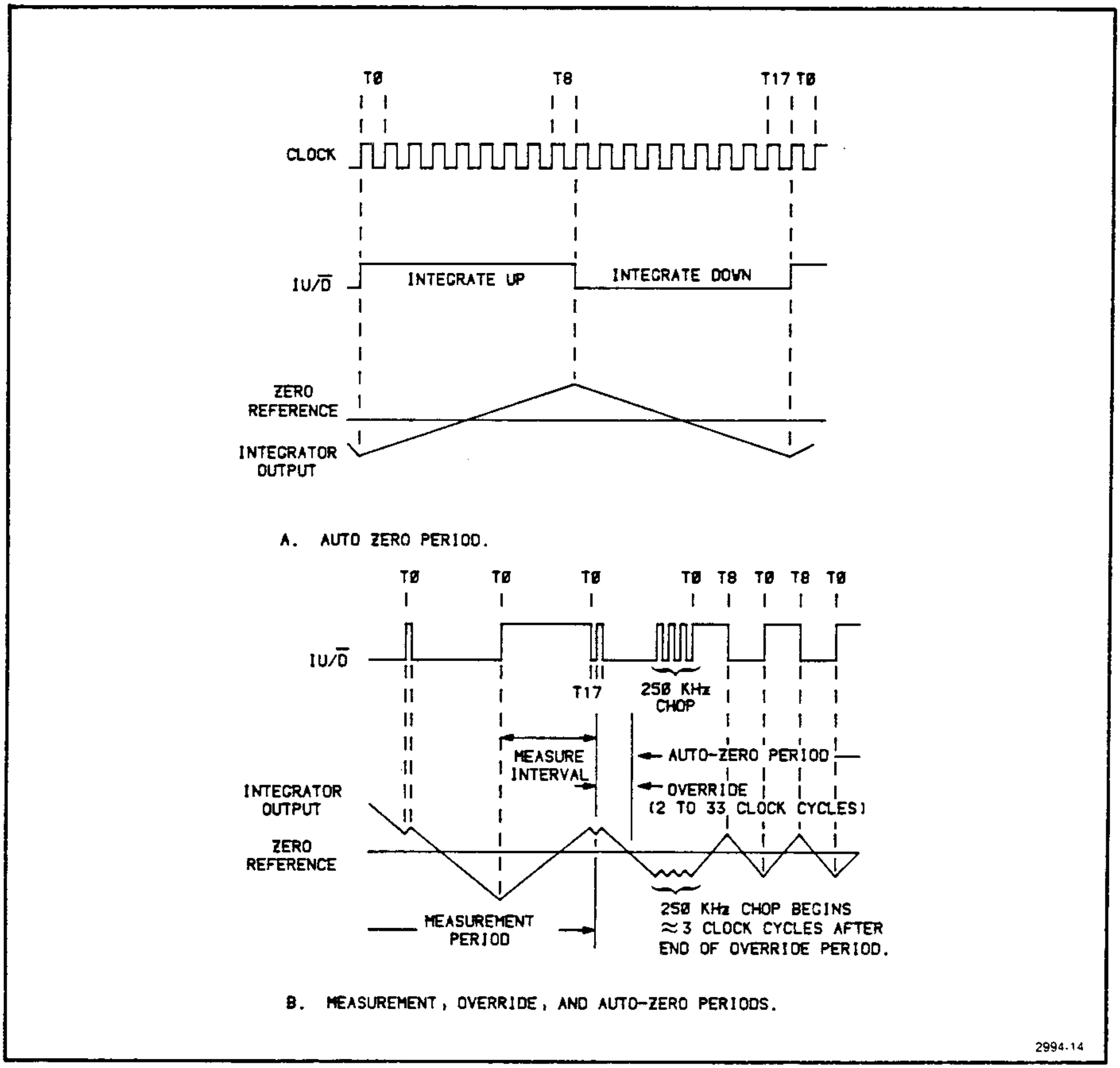


Fig. 4-6. U/D control for the measurement, override, and auto-zero periods.

age. It is stored on C1139 by opening the switch associated with R1227 at the end of the Auto-Zero period. The Integrator output is disconnected from the Auto-Zero Buffer and the zero-reference voltage is buffered to the Comparator.

Measurement

The Measurement period, like the Auto-Zero period, is based on timing signals developed by the Timing Logic. After the Auto-Zero period is complete, the Measurement period begins with T0 of the next measurement interval. As shown in Figs. 4-6 and 4-8, the Integrator's output always charges positive during T0 and negative during T17. The charge direction for the entire T1-T16 period depends on the polarity of the Comparators output at the end of time T0.

As the measurement begins, the input current I_{in} is switched into the summing node along with the negative reference current $I_{ref\,out}$. After a short time, the comparators output ICOMP (isolated comparator) goes high, indicating that the Integrator output is more positive than the zero-reference voltage set during Auto-Zero. At the next T0, the control Logic sets the I U/$\overline{D}$ (isolated up-down) low to

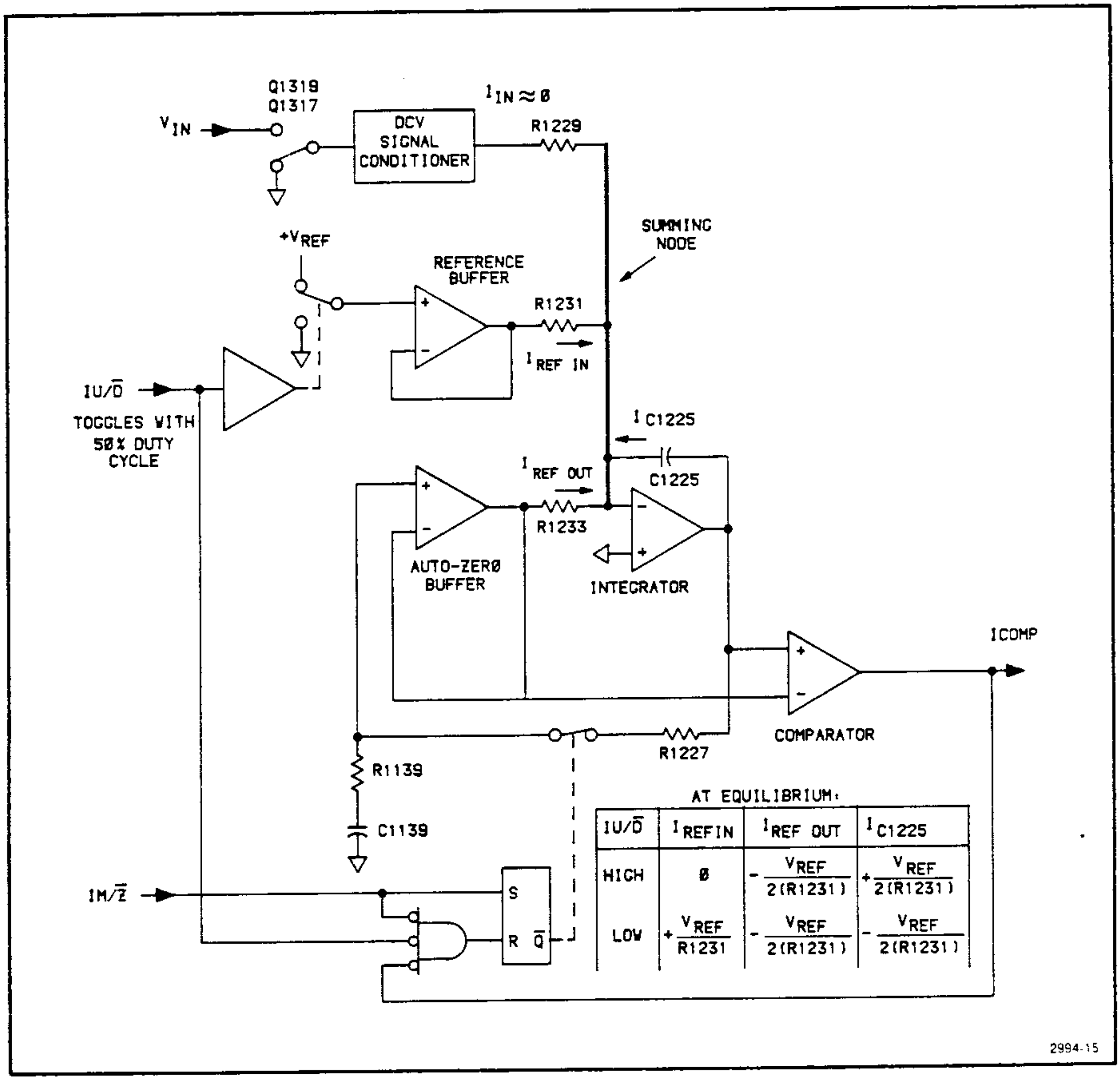


Fig. 4-7. Charge-balancing converter configuration during the auto-zero period.

change charge direction and rate. This is done by switching $I_{ref\ in}$ into the summing node. The Integrator output now charges negatively toward the zero-reference voltage for a complete number of 18-count measurement intervals (except for each T0 as explained above). An up/down counter in the Data stage keeps track of the net time required by the $I_{net\ ref}$ to balance the effect of I_{in} on the integrator capacitor by adding or subtracting a net count of 16 counts for each measure interval to a running total, dependent on the Comparators output state.

After the Measurement Period is completed, an "override" period is entered, in which the integrator is allowed to charge back to the zero-referenced voltage while accumulating counts in the Data counter. During this period the DCV Signal Conditioner input is connected to the high quality ground by Q1317. The $I_{net\ ref}$ balances the remaining charge on the integrator capacitor due to I_{in}.

Figure 4-8 illustrates the override period for measurement periods ending both above and below the zero-reference voltage. As shown in the figure, once the Comparator detects that the Integrator has charged below the zero-referenc voltage, the Data counter is disabled (all counting is complete), and ≈3 clock cycles later the I U/$\overline{D}$ line is chopped at a 250 kHz rate (determined by the Control Logic). Chopping the Reference Buffer input between $+V_{ref}$ and ground at this high rate holds the integrators output close to the zero-reference voltage until the next T0. More information about the charge balancing sequences may be found in the Control Logic description.

MEASUREMENT ENABLE ⟨2⟩

Field effect transistor Q1514, along with R1514 and C1514, holds the I M/$\overline{Z}$ control line low for several hundred milliseconds during power-on, thus allowing the Auto-Zero Buffer Amplifier storage capacitor, C1139, to charge to the zero-reference voltage. Transistors Q1511 and Q1512 comprise a level shifting buffer that shifts the I M/$\overline{Z}$ control line to a level compatible with the isolated logic levels.

ISOLATED REGULATORS ⟨2⟩⟨3⟩

The Isolated Regulators stages on the RMS and ADC boards regulate the power from the Isolated Supply stage to the levels required by the Isolated Section of the instrument. Integrated circuits U1601, U1603, U1605, U1417, U1527, U1525, and U1515 are 3-terminal regulation devices with internal current limiting. Transistor Q1613, VR1514, and their associated components form a series-pass regulator referenced at −36.9 volts.

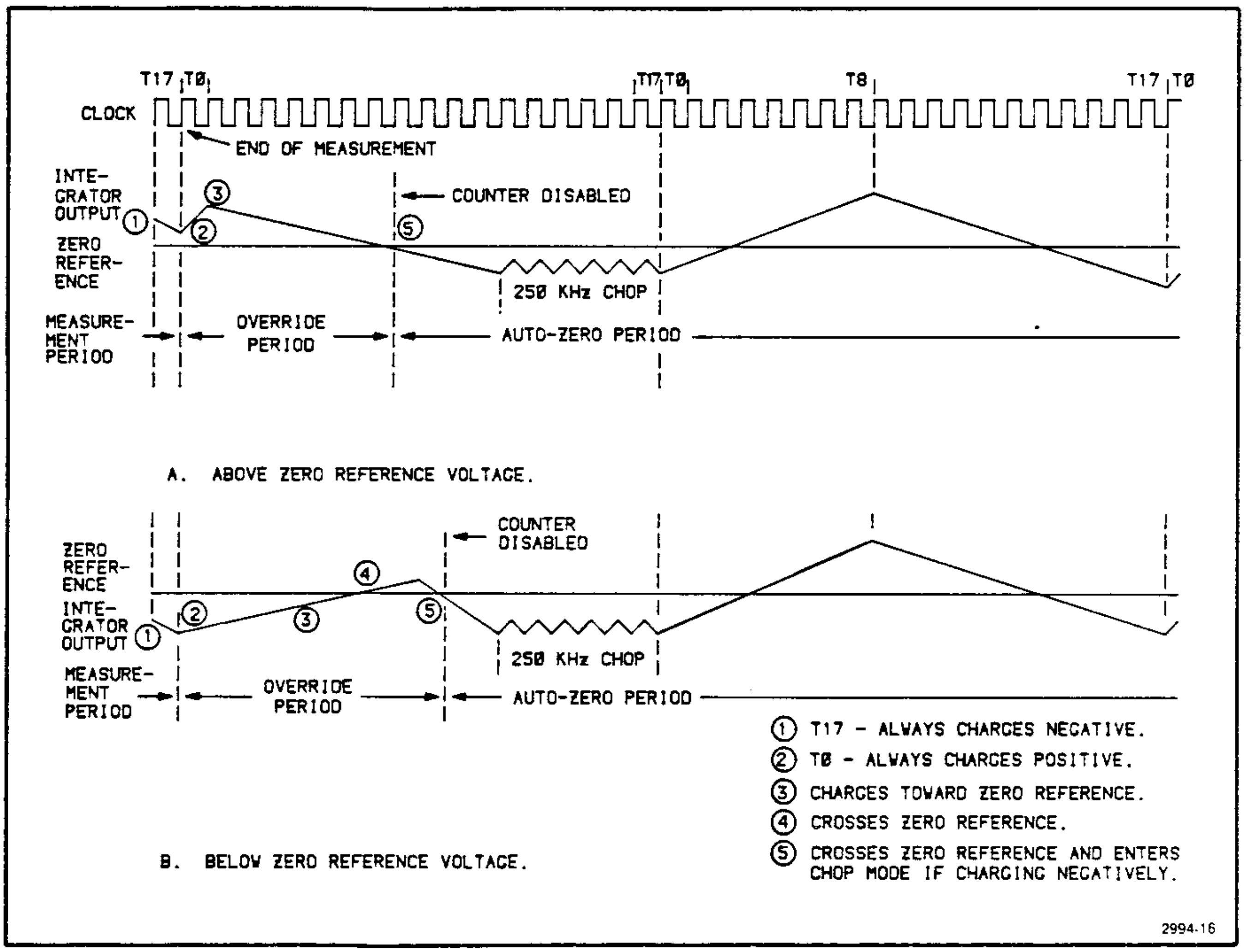


Fig. 4-8. Override and auto-zero timing for measurement period ending.

FUNCTION AND RANGE CONTROL ⟨1⟩⟨2⟩

The purpose of the Function and Range Control circuitry is to convert a string of serial data from the Grounded Section (representing function and range information) into a parallel output configuration for activating transistor and relay switches. The combination of switches activated sets the measurement function and range.

Figure 4-9 is a simplified diagram of the Function and Range Control stages, showing how the two boards interact. Initially, all rgisters are cleared by clocking a series of 32 lows into U1430 from the opto-isolators using the IRD (Isolated Range Data) and IRC (Isolated Range Clock) lines, both of which are under direct microprocessor control. The low IRD levels applied to U1530 hold the STB (strobe) inputs of U1430 and U1330 high, allowing shifting to continue, no matter what serial data is being shifted out of U1300, Now, all registers are clear and are ready to be set with any

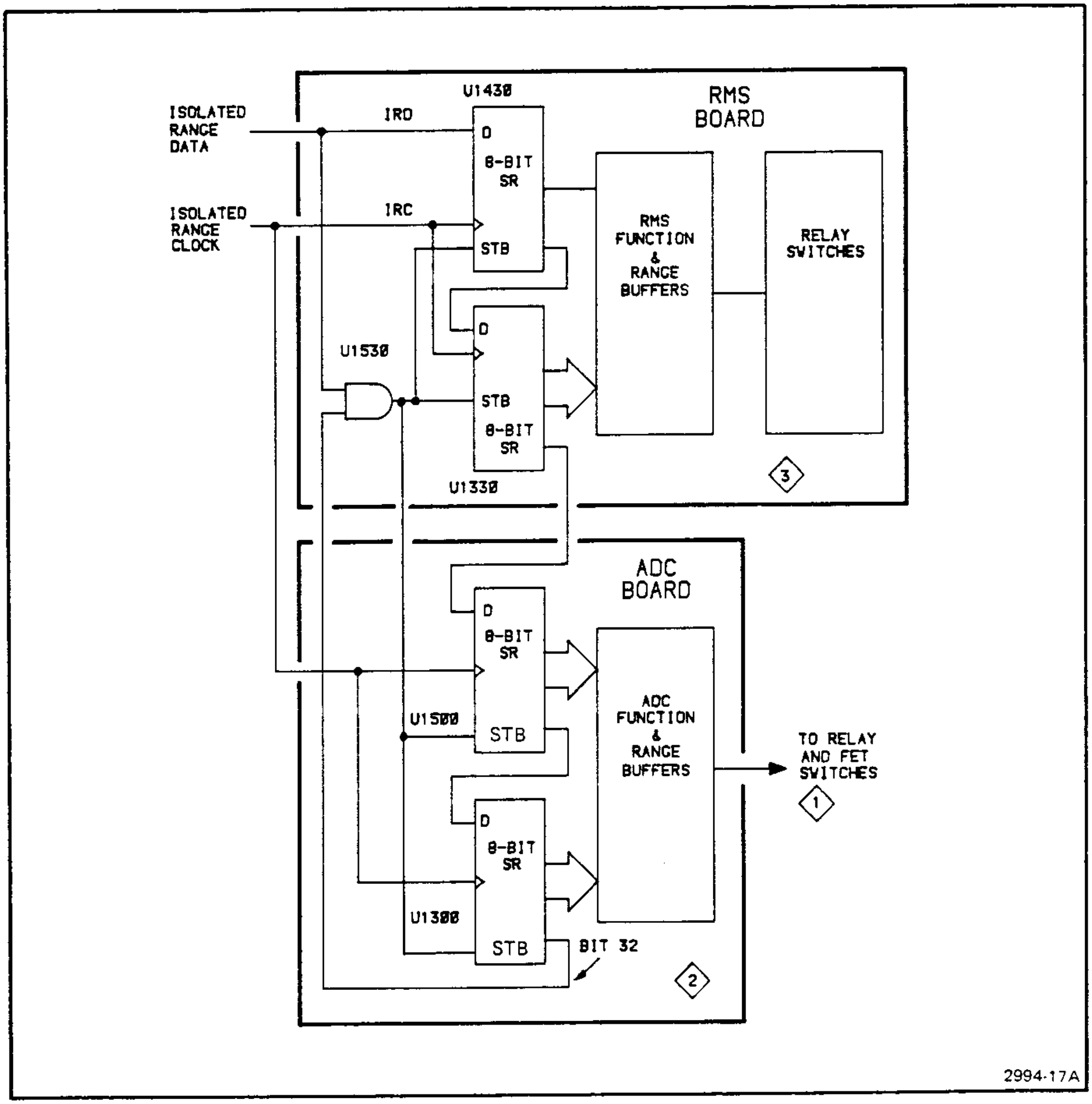


Fig. 4-9. Simplified function and range control circuitry.

new function and range information a new measurement may require.

To set the registers, a new string of serial data must be clocked into the registers. Since the registers have been previously reset, any data clocked into the registers from the IRD line also results in 32 consecutive lows being applied to U1530. This keeps the registers enabled while the new data is clocked into the registers. The first bit of function and range information is always a high signal bit, indicating the beginning of the new data. As the data string is shifted into the registers, this high is eventually clocked into the 32nd position. This, in itself, does nothing; but, another high is applied to the IRD line, signalling the end of the function range information. This causes U1530 to generate a strobe that latches the shifted data into the output registers of U1430, U1330, U1500, and U1300. To change the function and range settings to any new set of conditions, the reset-set sequence must be followed again.

With the exception of U1400, the remainder of the Function and Range Control circuitry consists of current buffering transistors. On the ADC board, U1400, U1500, and the shifted I M/$\overline{Z}$ signal generate the correct timing for the Function Switch FETs Q1319, Q1217, Q1315, and Q1317.

OHMS CONVERTER ③

The Ohms Converter stage supplies a known current that flows through a range-dependent reference resistor, out the front-panel input connectors, and through an unknown resistance. The voltage drop across the unknown resistance V_{ext} is measured, and then the drop across the unknown and reference resistance $V_{\Omega\,out}$ is measured. The ratio $V_{ext}/(VT-V_{ext})$, multiplied by R_{ref}, is calculated by the microprocessor, and the value of the unknown resistance is determined. Figure 4-10 illustrates signal routing for each of the phases of an ohms measurement. Table 4-2 gives the range-dependent switching information.

Operational amplifier U1120 is configured as a voltage source. The noninverting input is referenced at 0.65 V by VR1123 and its associated components. Feedback from the output at the cathode of CR1225 is through the voltage divider R1229, R1321, and R1225. In this configuration, the output voltage is approximately 1.2 V. Depending on the measurement range, R1223 may be switched into the feedback voltage divider, increasing the stages output to approximately 10.2 V.

Transistor Q1021 and its associated components prevent the open circuit output voltage of the DCV Converter from exceeding +5 V.

Table 4-2
OHMS CONVERTER PARAMETERS

RANGE	V_Ω OUT	IR_x	VR_x AT FS	R_{ref}
200	10.2 V	1 mA	0.2 V	10 kΩ
2 k	1.2 V	0.1 mA	0.2 V	10 kΩ
20 k	10.2 V	0.01 mA	0.2 V	1 MΩ
200 k	1.2 V	1.0 μA	0.2 V	1 MΩ
2 M	1.2 V	0.1 μA	0.2 V	10 MΩ
20 M	1.2 V	40 nA	0.8 V	10 MΩ

RMS CONVERTER ③

The RMS Converter stage consists of two selectable gain stages and a true rms-to-dc converter IC. Operational amplifier U1500 is configured as a feedback amplifier with a selectable gain (actually an attenuation) factor. The ampifier is referenced to the rms LOW input applied to its noninverting input. The HIGH input from the front-panel passes through relay contact K1633S to the amplifiers input when an rms measurement is to be taken. The ac signal passes through C1621 to a frequency compensation network and then to the operational amplifiers inverting input. If the dc component of the signal is also to be taken into account, relay K1621 is turned on and C1621 is bypassed. The amplifiers attenuation is set by the various feedback networks. With switches K1405S and K1503S open, the input amplifiers gain is unity. Closing switch K1503S reduces its gain by a factor of 10. Closing switch K1405S by itself results in an attenuation factor of 1000.

The output of U1500 is then applied to R1307, the input of a selectable gain amplifier, also referenced to rms LOW. With relay switch K1201S open, gain of the amplifier is 10 as determined by R1201 and R1307. Closing switch K1201S sets the gain factor to 1. Table 4-3 illustrates the various gain switch configurations for the RMS Converter. Also refer to Tables 10-2 and 10-5 in the pullout pages.

The output of the gain stage, U1200, is applied to a rms converter IC. This converter, referenced to rms LOW, computes the root-mean-square value of the applied ac or ac+dc input signal, and outputs at pin 8 a representative dc level to the Function Switch FET Q1217. Both operational amplifier gain stages have offset adjustments to establish their quiesecent operating points.

GROUNDED POWER SUPPLIES ④

The Grounded Power Supplies regulate the +8 volts supply from the TM 5000-Series power module down to +5 volts for the bulk of the digital circuitry in the Grounded Section.

Table 4-3
RMS CONVERTER PARAMETERS

Range	HI or V_{in}	K1405	K1503	K1201	U1500 Gain	U1200 Gain	U1100-4
200 mV	200 mV	OPEN	OPEN	OPEN	1	10	2 V
2 V	2 V	OPEN	OPEN	CLOSED	1	1	2 V
20 V	20 V	OPEN	CLOSED	CLOSED	0.1	1	2 V
200 V	200 V	CLOSED	OPEN	OPEN	0.001	10	2 V
700 V	700 V	CLOSED	OPEN	CLOSED	0.001	1	0.7 V

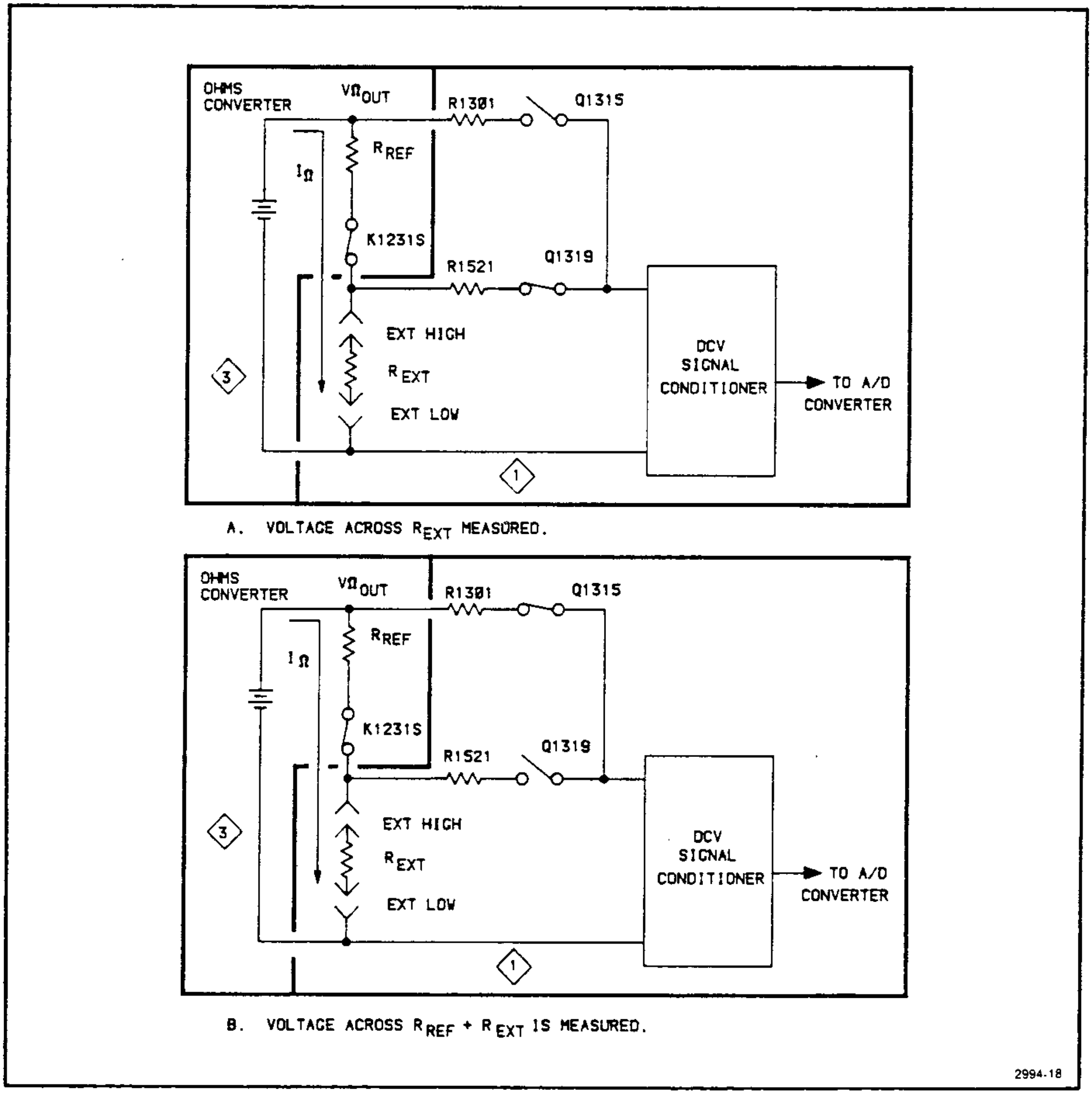


Fig. 4-10. Measurement switching during an Ohms conversion.

Initially, as the power module is turned on, the PWR MDL line is held low for a short time. This keeps Q1105 and Q1104 turned off, holding the output of U1000 high. This keeps Q1101 and the series-pass transistor in the power module turned off.

Then the PWR MDL line goes high and Q1105 is turned on. This forward biases Q1104, allowing current to flow through Zener diode VR1001. The inverting input of U1000 is now held at +5 volts and its output goes negative, turning on Q1101. As Q1101 comes on, base current begins to flow in the series-pass transistor to turn it on.

As its emitter is pulled toward the +8 volt supply, current flows in the voltage-sense network, R1005 and R1033. When the voltage at the noninverting output reaches +5 volts, bias current to Q1001, and thus the series-pass transistor, is reduced. The supply stabilizes at this point and the output closely approximates +5 volts.

Zener diode VR1216, resistor R1217, and the associated power-module transistor provide an overvoltage protection network on the +5 V supply line. If the +5 V line exceeds ≈5.7 V, the transistor becomes forward biased and begins to shunt excess current to ground. This protects the bulk of the circuitry in the Grounded Section of the instrument should a component in the +5 V regulator fail.

TRANSFORMER DRIVE ⟨4⟩

The Transformer Drive circuitry switches current from the TM 5000-Series power module through transformer T1311 to drive the Isolated Supplies. With the center tap of the primary winding connected to the power module's +25 V supply, the ends of the primary coil are alternately switched to ground at an approximate 27.78 kHz rate. This rate is synchronized to the A/D conversion process and minimizes any converter error caused by power supply ripple in the Isolated Section.

Flip-flop U1325B and inverter U1520B convert the unsymmetrical 27.78 kHz timing signal from the Timing logic to a pair of symmetrical and complementary signals to drive the transformer switching amplifiers. Figure 4-11 illustrates the timing relationships of the symmetry conversion.

The complementary squarewaves at the outputs of U1325B drive two identical current-switching amplifiers to control current flow in isolation transformer T1311. A pair of transistors in each amplifier are driven in a push-pull configuration to provide the large base currents and fast switching times required for efficient power transfer.

ISOLATED POWER SUPPLIES ⟨4⟩

The Isolated Supplies provide rectification and initial filtering for the power transferred from the power module to the Isolated Section via the Isolation transformer. Capcitor network C1301, C1401, C1403, and C1404 provide noise cancellation by summing out-of-phase currents until cancellation occurs.

CONTROL LOGIC ⟨5⟩

The Control Logic generates the control signals that control the A/D conversion process. It uses time-related signals

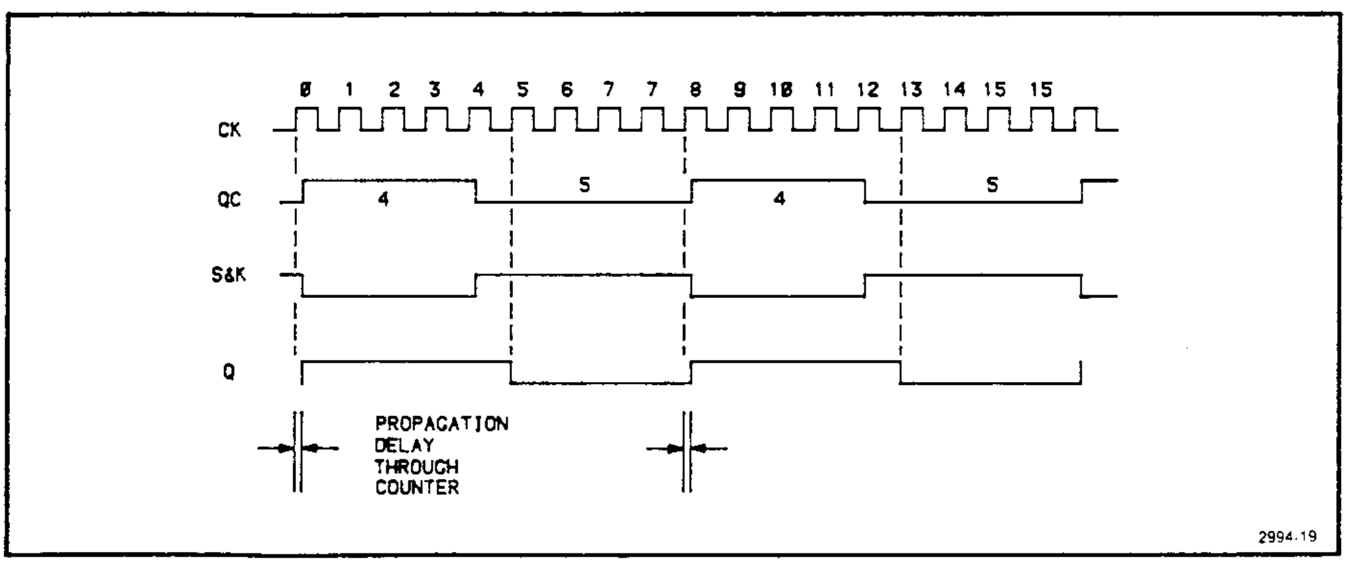


Fig. 4-11. Transformer drive timing.

generated by the Timing Logic and the comparison data from the Charge-Balancing Converter to automatically sequence through the complex and varied measurement functions.

To initiate a measurement, the microprocessor generates a low $\overline{TRIG}$ via the Address Decode circuitry. This TRIG pulse is latched by U1530A and U1530B and sets the IN PROGRESS line high, telling the microprocessor that the conversion is in progress and valid data is not available. The J input of U1425A is set high via U1435C and, at the beginning of the next measurement interval (falling edge of T17), the M/$\overline{Z}$ (measure-zero) level is set high. This signal is trans mitted to the Charge-Balancing Converter via the opto-isolators and initiates its measurement sequence. The $\overline{Q}$ output of U1425A sets the J input of U1230A high via U1530C and, on the next 250 kHz clock (T0), the UP clock and DOWN clock logic, U1135A and U1135C, is enabled.

The up/down counter now accumulates clock pulses as described in the Charge-Balancing Converter description until the Timing Logic generates an EOC (end of count) pulse to U1435A, signalling that the proper number of measurement intervals have been completed. This applies a high to the J input of the override flip-flop U1330A and the next clock pulse (T0) sets its $\overline{Q}$ output low. This low is applied to U1425B and keeps any subsequent trigger from passing through U1435C that might re-initiate the measurement sequence before it is completed.

The measure-zero flip-flop is reset on the next clock (the falling edge of T17 coincides with rising T1). The low input to U1530C from U1330A keeps the UP counter and DOWN counter logic enabled during the override period by keeping U1230A's J input held high. This enables the data counter to keep counting while the Charge-Balancing Converters integrator makes its final charge back to the zero-reference voltage as explained in the Charge-Balancing Converter description. Integrated circuits U1430C and U1435B reset the override flip-flop when integrating down (pin 9 of U1330B high) and the zero-reference voltage is crossed (COMP goes low).

The next clock pulse after the override flip-flop is reset disables the UP clock and DOWN clock logic by clocking U1230A's Q output low. This clocks chop flip-flop U1230B and the 250 kHz clock is enabled through U1435D. The low Q output of the chop flip-flop holds U1330B in its set state, and the cathode of opto-isolator U1710's transmitter LED is held low. This results in the 250 kHz chopping of the I U/$\overline{D}$ line, keeping the Charge-Balancing Converters integrator output very close to the zero-reference voltage as explained in that description.

At the end of the next T17, $\overline{T17}$ sets U1230B to disable the chopping clock and allow U1330B to distribute clocks in its usual manner.

The clock enable provided by U1230A to U1135A and U1135C allows clock pulses to be passed to the data counter whenever the A/D converter is in its measurement or override modes. During this time, generation of either an UP clock or a DOWN clock is controlled by U1330B. T17, applied to U1330B's K input, always sets $\overline{Q}$ high, enabling UP clocks to the data counter on the next clock (T0).

Any of four gates OR'd together by U1335A have the ability to generate a DOWN clock enable, depending on the converters operating mode.

When generating the squarewave I U/$\overline{D}$ required for Auto-Zero, T17 initiates a series of UP clocks, starting at T0 as mentioned above. Integrated circuit U1430A detects T8 when operating in the Auto-Zero mode and applies a high to U1330B's J input via U1335A. The next clock to U1330B (T9) initiates a series of 9 DOWN clocks. At T17, the cycle repeats itself.

When in the measurement mode, clock pulses between T1 and T16 may be either high or low, as described in the Charge-Balancing Converter description, but all must be the same. This determination is made at the end of T0 by U1335B. When measuring, the M/$\overline{Z}$ level at pin 12 is high. Pin 13 is high during all of T0, the time when the decision about T1-T16 must be made. If the COMP (comparator output) level from the A/D converter is high at the end of T0 (indicating the integrators output is above the zero-reference voltage), a high is applied to the J input of U1330B via U1335B and U1335A. The next clock pulse (T1) sets U1330's Q output high and T1-T17 are DOWN clocks to the Data counter. If the COMP level were low at clock T1, all of the T1-T16 clocks would be UP clocks, since U1330B did not change.

In either case, T17 is always a DOWN clock as determined by U1430D. During T16 when in the measurement mode, a high is applied to pin 11 of U1330B via U1430D and U1335A. The next clock (T17) clocks a high to U1330B's Q output and produces a DOWN clock whether T1-T16 are DOWN clocks or not.

During the override period, clocks must be enabled to the Data counter, but only until the integrators output charges beyond the zero-reference voltage, going negative (COMP goes high to low). Integrated circuit U1430B detects when this occurs and, along with U1430C, U1435B, and U1330A, completely disables all clocks to the data counter while the remainder of the override period chops the I U/$\overline{D}$ line.

At the end of the measurement and override periods, U1420C generates a $\overline{CLR2}$ pulse to reset trigger latch U1530A and U1530B. This sets the IN PROGRESS line low and tells the microprocessor that the A/D conversion is over and valid data is available. It also sets the Data stage to address the first bit (LSB) of data for transfer onto the Data Bus.

During the time the data is read, the Control Logic automatically initiates an Auto-Zero period after the end of override. Then U1420A clears the interval timer and Auto-Zero intervals are counted. At the end of the Auto-Zero period, the Timing Logic generates an EDAZ (End Of Auto-Zero) to U1425B. This enables further measurement sequences to be initiated by the microprocessor $\overline{TRIG}$ line from the Address Decode block.

As the next measurement cycle is initiated, U1420D resets the contents of the data counter to zero, and U1420A resets the Timing Logic's interval counter so measurement intervals may be counted. The cycle repeats itself as often as initiated by the microprocessor.

OPTO-ISOLATORS ⑤

The opto-isolators couple digital control and data signals between the Grounded and Isolated Sections of the DM 5010 while maintaining electrical isolation between the two. Each isolator consists of a light-emitting diode that is turned either on or off by the drive circuitry, and a photodetector diode and buffer to sense and buffer the transmitted signal. Each isolator buffer has an open collector output and pullup resistors are required. Integrated circuits U1605 and U1613 are three-terminal regulators used to provide the correct output levels for the various isolators. Transistor Q1615 and R1615 set the ON current for U1510's LED.

TIMING LOGIC ⑥

The Timing Logic stage generates the time-dependent signals for the A/D conversion process as well as the timing signals to sync the Transformer Drive circuitry to the conversion process (to minimize error caused by power supply noise). The stage is essentially a series of counters and some decoding logic that determines when certain phases of the mode-dependent conversion process should be initiated or have been completed.

Flip-flops U1535A and U1535B comprise a ÷4 counter that divides the 1 MHz microprocessor clock down to a 250 kHz rate. From there, the 250 kHz clock is divided by 18 to generate the intervals for the charge-balancing conversion by U1730, U1630A, U1630B, U1320B, U1635B, U1635C, and U1530B. Refer to the timing diagram in Fig. 4-12 for the following description.

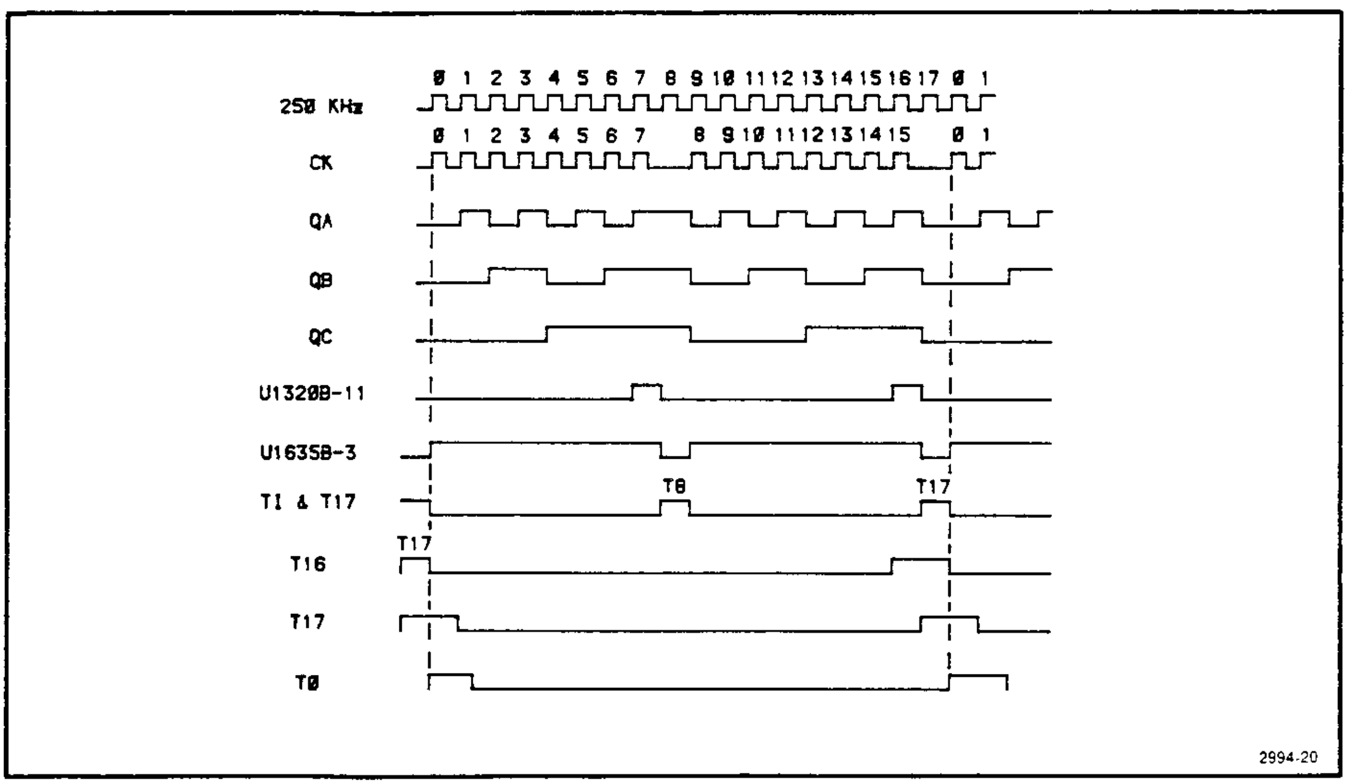


Fig. 4-12. Timing of the divide by eighteen counter.

Initially, pin 3 of U1635B is high. As the 250 kHz clock is applied to U1730, counting begins. When U1730's binary outputs equal 7, a high is applied to the J input of U1320B via U1635C and U1530B. The falling edge of the 250 kHz clock (actually rising $\overline{Q}$) clocks the high to the Q output (T8) of the U1320B. The complementary low at its Q output is applied to U1635B and disables the next clock to U1730. The J input of U1320B is high (U1730's count is still 7) and the K input is latched high by the Q output. The T8 interval line at the Q output of U1320B is toggled low by the next 250 kHz clock, re-enabling the clock to U1730 ($\overline{Q}$ goes high). Once again U1730 counts normally until its binary output equals 15. On the falling edge of the 250 kHz clock, a high is clocked to the Q output of U1320B and the complementary low at its $\overline{Q}$ output disables the next clock through U1635B.

Line T16 at pin 15 of U1730 goes high when its binary output equals 15 (actually count 16 because one clock is skipped). The next clock (17th) sets the T17 output at pin 5 of U1630A high and, on its falling edge, clocks to U1730 are re-enabled. The rising edge of the next 250 kHz clock sets the binary outputs of U1730 back to zero and intiates the T0 pulse at the terminal of flip-flop U1630B. Although generation of a T0 pulse is actually dependent on the presence of a T17 pulse, the instrument considers T17 to be the last pulse of the sequence and T0 to be the beginning of the next sequence.

Integrated circuit U1525 is a negative-edge-triggered binary counter that counts the number of 18-count charge-balancing intervals completed. As U1525 requires a negative clock, $\overline{T17}$ is applied to its clock input to signal the end of an 18-count interval.

The NAND gates connected to the binary outputs of U1525 generate two time-dependent control signals required by the Control Logic to perform an A/D conversion. During normal 4 1/2 digit operation, U1520C detects when 1536 measure intervals have occurred during the Auto-Zero period and causes a high EOAZ (End Of Auto-Zero) at pin 3 of U1520A, signalling that the Auto-Zero process should stop. At this time, the zero-reference voltage in the charge-balancing converter stage has been set. The counter is reset by CLR1 and the actual A/D measurement begins.

A measurement requiring 4 1/2 digit acuracy requires that the integrator integrate over 12 or 10 periods of the power line frequency for 60 or 50 Hz operation, respectively. Referring to Fig. 4-13, it can be seen that any noise at the instruments input affects the charge and discharge rates at the A/D Converters summing node (and thus the time at which the node voltage crosses the zero-reference voltage).

In the DM 5010's charge-balancing A/D conversion, the time (number of counts) that the Integrators output voltage is above the zero-reference voltage is subtracted from the time below the zero-reference voltage, and is representative of the input voltage. Though the magnitude of the ripple and the charge rates are extremely exaggerated in Fig. 4-13, a principle may be demonstrated.

If, for example, a measurement is taken over time interval A, the noise (at power line frequency) added to the summing node of the "antenna effect" of the test leads, results in a conversion more positive than the actual signal being measured. Similarly, a measurement taken over time interval B results in a conversion more negative than the actual signal.

By making the A/D conversion over a complete number of power-line cycles (A + B), these measurement errors cancel and the actual signal is accurately resolved. Since the DM 5010 will be used in environments where either 50 Hz or 60 Hz power is in use, the chosen time frame results in "complete-cycle" measurements for either line frequency.

For normal 4 1/2 digit measurements, U1620 detects when 2778 measurement intervals have occurred. This is equivalent to 200.02 ms of time or, in terms of "complete cycles", 12 cycles at 60 Hz or 10 cycles at 50 Hz. After the instrument measures for 200.02 ms, U1620 applies a low at U1635A, generating an EOC (End Of Count) pulse at its output. This EOC signals the Control Logic stage that the Measure Period of the measurement is over.

The DM 5010 also has the capability to perform 3 1/2 digit measurements at a faster rate. If the microprocessor determines that a 3 1/2 digit measurement should be initiated, it sets the 3 1/2 line high. This enables U1520B to generate the EOAZ pulse after 256 measure intervals have occurred during Auto-Zero. Integrated circuit U1525 is reset and begins to count measurement intervals for a 3 1/2 digit conversion.

Once again, because of the power-line noise picked up by the measurement leads, the A/D conversion must be performed over a number of complete power-line cycles. Adequate resolution for a 3 1/2 digit measurement may be obtained by performing the A/D conversion over just one power-line cycle at either 50 Hz or 60 Hz. Both U1625 and U1720 are enabled by the high 3 1/2 line and, if operating from a 60 Hz power line, the 50/60 mode-select-enable to U1720 is also high (this is set by an internal jumper to match the power-line frequency).

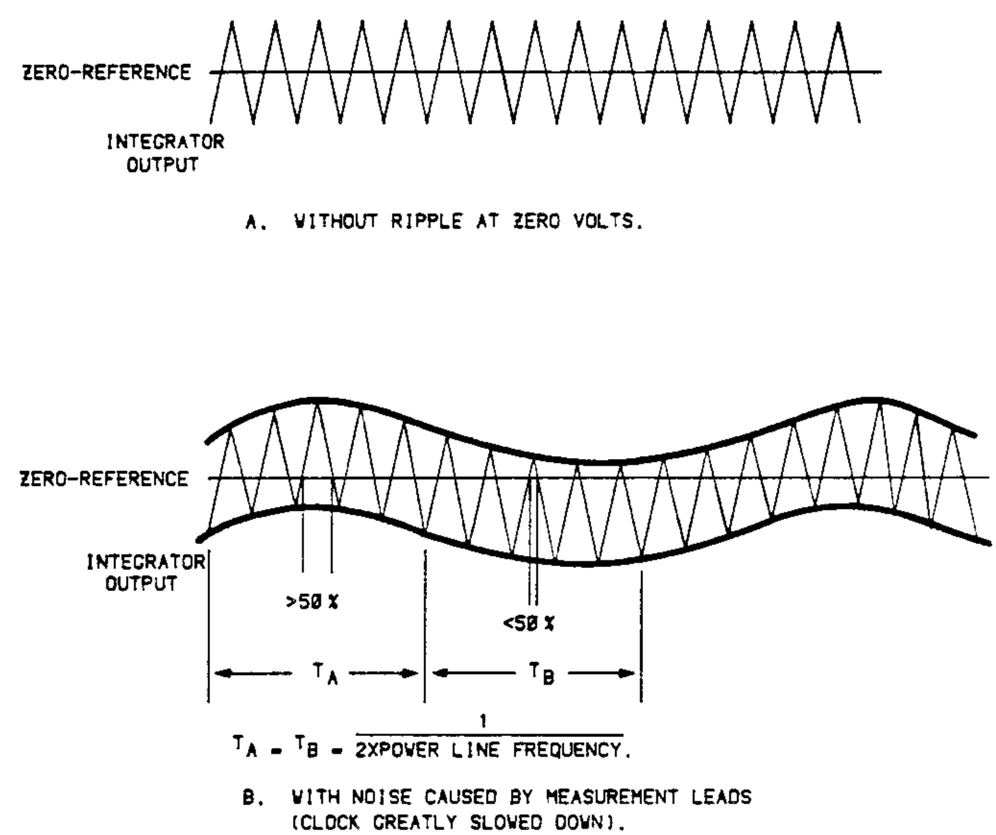


Fig. 4-13. Influence of power line frequency on A/D conversion.

When operating in a 60 Hz environment, U1720 detects when 231 measurement intervals have occurred. This is equivalent to 16.63 ms or one complete cycle at 60 Hz. At this time, U1720 causes an EOC to be generated at the output of U1635A, stopping the A/D conversion.

When operating in a 50 Hz environment, the 50/60 line to U1720 should be set low. This disables U1720 and U1525 counts up to 278 before the EOC is generated by U1625 and U1635A. This equates to 20.02 ms or one complete cycle at 50 Hz. As can be seen, in all cases the A/D conversion takes place over a complete number of power-line cycles, minimizing conversion errors caused by noise.

DATA ⑥

As described earlier, the result of a charge-balancing A/D conversion is a sequence of pulses. The number of pulses generated during the conversion directly represents the conditions at the converters input. The Data stage counts these pulses and later transfers the accumulated results to the microprocessor data bus as required by the processor.

The counter circuitry consists of four 4-bit up-down counters cascaded together along with a discrete-gate flip-flop to form a 17-bit up-down counter. The counter is reset at the beginning of a measurement cycle and then counts either up or down, depending on the polarity of the Integrators output with respect to the Comparators zero-reference voltage. At the end of the measurement period, the number of clocks accumulated (T_{below}-T_{above}) by the 17-bit counter is representative of the input conditions to the A/D converter.

When the conversion is complete and the results are stored in the counter, the Control Logic signals that conversion data is available to the microprocessor. This data is transferred from the counter to the Data Bus one bit at a time, starting with the least significant bit.

At the time the processor is told that the data is available, U1235 and U1230 are cleared by the Control Logic pulsing the $\overline{CLR}$ line low. This sets the Q output of U1320 high to enable data to be passed through U1030A. Since the Q output of U1320A is low, the data path through U1030D is disabled and the resulting high at its output enables U1030B.

Counter U1235, set to binary zero by the $\overline{\text{CLR}}$ pulse at the end of the measurement period, selects the least significant bit of data (at the E_0 input of U1125) to be output to the data bus via U1030A, U1030B, and the Miscellaneous buffer (diagram 9). As the processor beings its reading sequence, it reads this bit of data, and then generates an $\overline{\text{ADVANCE}}$ pulse via the Address Decode circuitry (diagram 7) to increment the counter U1235. The next LSB of data (E_1) is now selected by U1125 and is applied to the data bus. The processor continues reading data and advancing counter U1235 in this fashion until all 16 bits of data selectable by U1125 have been read. The next ADVANCE pulse generated by the processor causes a ripple-carry at pin 15 of U1235, and U1320 changes state. U1030A is disabled and the 17th bit of conversion data stored in the discrete flip-flop (U1135C and U1030C) is passed on to the data bus via U1030D, U1030B and the Miscellaneous buffer.

MICROPROCESSOR ⟨7⟩

The Microprocessor is the control center for all instrument operations. Operating under firmware control, the various types of data in the System are moved about and manipulated by the microprocessor. By addressing (selecting) the various devices or memory locations in the proper sequence (firmware control) and by properly manipulating and transferring the data associated with these addresses, each portion of the instrument performs its correct function at the correct time.

The DM 5010, as do all microprocessor systems, requires a system clock. The 4 MHz crystal, Y1221, provides a stable and accurate timing element for the microprocessor's internal clock oscillator. All other critical timing signals in the instrument are derived from the internally-divided $\phi 2$ (1 MHz) clock.

The VMA (Valid Memory Access) and R/$\overline{\text{W}}$ (read/$\overline{\text{write}}$) lines control the enabling of devices on the data bus as well as the flow of data on the bus. The $\overline{\text{IRQ}}$ line (interrupt re quest) is used in conjunction with GPIB data transfers, which are explained in the Handshake Process. The remaining processor control lines, with the exception of the $\overline{\text{RESET}}$, are not used. The function of the $\overline{\text{RESET}}$ line is explained in the following description.

POWER-ON LOGIC ⟨7⟩

The Power-On Logic holds the DM 5010 circuitry in a reset condition for a short time after power up, or when a momentary power supply fault occurs. This ensures that the +5 V supply has settled and that all instrument functions begin from a known state.

As instrument power is turned on, the +5 V supply comes up from 0 V to +5 V over some finite time period. During most of this time, the inverting input of U1230B is more positive than the noninverting input, keeping the output, at pin 7 low, and thus the system reset ($\overline{\text{PON}}$ at pin 1 of U1230A) at ground potential. As the supply voltage reaches approximately +4.7 V, the noninverting input at pin 5 goes more positive than the input at pin 6. As this occurs, the output transistor of comparator U1230B (an open collector device) is turned off.

Capacitor C1223 now charges toward +5 V through R1227. As the voltage across C1223 charges beyond +2.75 V, the inputs to comparator U1230A change relative polarity and the system reset ($\overline{\text{PON}}$) level at output pin 1 goes high. As previously mentioned, the time delay incorporated in this circuitry ensures that the +5 V supply has had time to settle before any operation is attempted.

ADDRESS BUS BUFFER ⟨7⟩

The Address Buffer stage consists of U1235 and U1420A. This stage provides the increased current drive required to address the many devices on the Address Bus.

ADDRESS DECODE ⟨7⟩

The Address Decode circuitry may be thought of as an extension of the address bus. This stage looks at the six most-significant bits of the address bus along with two function-dependent signals produced by the microprocesor to generate many of the required enable and control signals for specific devices within the instrument.

A high VMA (Valid Memory Access) signal, as does its inverted counterpart (low BVMA), indicates that the information on the address bus is pointing to a valid memory location. When these signals are present, decoders U1510, U1520, and U1620 along with U1720A, U1720B, U1730A, and U1730B in the logic state, generate the enable and control signals as shown in Table 4-4. The memory map shown in Table 4-5 further illustrates address decoding. Those signals associated with U1620 are all synchronized to the microprocessor by the $\phi 2$ clock.

Table 4-4
ADDRESS DECODING

Address Bit							Generated Output	Equivalent Addresses	Size
φ2	10	11	12	13	14	15			
X	X	X	L	L	H	H	EROMC	CXXX	4k
X	X	X	H	L	H	H	EROMD	DXXX	4k
X	X	X	L	H	H	H	EROME	EXXX	4k
X	X	X	H	H	H	H	EROMF	FXXX	4k
X	X	X	X	X	L	H	Not Decoded	8000-BFFF	16k
X	X	X	X	X	H	L	Not Decoded	4000-7FFF	16k
L	L	L	L	H	L	L	EGPIB	2000-23FF	1k
L	L	L	H	H	L	L	ADVANCE	3000-33FF	1k
L	L	H	L	H	L	L	Set RD low	2800-2BFF	1k
L	L	H	H	H	L	L	Set 3 1/2	3800-3BFF	1k
L	H	L	L	H	L	L	SA STOP	2400-27FF	1k
L	H	L	H	H	L	L	Set 4 1/2	3400-37FF	1k
L	H	H	L	H	L	L	Set RD high	2C00-2FFF	1k
L	H	H	H	H	L	L	TRIG	3C00-3FFF	1k
X	L	L	L	L	L	L	ERAM	0000-03FF	1k
X	L	L	H	L	L	L	NC	1000-13FF	1k
X	L	H	L	L	L	L	EMISC	0800-0BFF	1k
X	L	H	H	L	L	L	ECMOS	1800-1BFF	1k
X	H	L	L	L	L	L	ESW	0400-07FF	1k
X	H	L	H	L	L	L	NC	1400-17FF	1k
X	H	H	L	L	L	L	EFP	0C00-0FFF	1k
X	H	H	H	L	L	L	RC	1C00-1FFF	1k

Table 4-5
ADDRESS DECODE MEMORY MAP

Starting Hexadecimal Address	Signal or Enable	Size (Decimal)
0000	$\overline{\text{ERAM}}$	1k
0400	$\overline{\text{ESW}}$	1k
0800	$\overline{\text{EMISC}}$	1k
0C00	$\overline{\text{EFP}}$	1k
1000	1000-17FF NOT USED	2k
1B00	$\overline{\text{ECMOS}}$	1k
1C00	RC	1k
2000	$\overline{\text{EGPIB}}$	1k
2400	SA $\overline{\text{STOP}}$	1k
2800	1 $\overline{\text{RD}}$	1k
2C00	0 $\overline{\text{RD}}$	1k
3000	$\overline{\text{ADVANCE}}$	1k
3400	3 1/2	1k
3800	4 1/2	1k
3C00	$\overline{\text{TRIG}}$	1k
4000	4000-BFFF NOT USED	32k
C000	$\overline{\text{EPROMC}}$	4k
D000	$\overline{\text{EPROMD}}$	4k
E000	$\overline{\text{EPROME}}$	4k
F000	$\overline{\text{EPROMF}}$	4k

LOGIC

The Logic stage works in conjunction with the Address Decode circuitry to generate process control signals required by the A/D conversion circuitry.

The set-reset latches, U1720A and U1720B, allow the microprocessor to set signal levels simply by addressing the function via the Address Decode circuitry. Table 4-4 shows the block of addresses that the microprocessor uses to set or reset the RD (Range Data) or 3 1/2 (measurement resolution) signal lines.

DATA BUS BUFFER ⟨7⟩

The Data Bus Buffer, U1435, provides bidirectional buffering of instructions and data on the data bus. Depending on the instruction being executed, the microprocessor either outputs data onto the data bus or reads from the bus by controlling buffer direction via its R/$\overline{\text{W}}$ (read-$\overline{\text{write}}$) control line.

NOP BUFFER ⟨7⟩

By making the microprocessor execute a continuous series of NOP (no-operation) instructions, much of the microprocessor kernel may be exercised and verified apart from devices that may be malfunctioning on the Data Bus. Moving P1425 to its NOP position tri-states (disables) the normal Data Bus Buffer U1435 and, in its place, enables the NOP Buffer U1430. This device inverts its hardwired inputs and forces a NOP instruction (00000001) into the processor with each clock to make the processor "do nothing". In reality, the microprocessor sequentially increments through its entire address field, exercising many devices connected to the address bus in a repeatable and predictable fashion. This allows for verification of the kernel and may be used as an aid in distinguishing data-related problems from hardware problems when troubleshooting.

ROM ⟨8⟩

The ROM contains the operational firmware for the DM 5010. Data is read from the ROM stage one byte at a time from any of 16k locations as addressed by the microprocessor. The Address Decode stage described earlier enables only one of the four ROM IC's when the ROM is to be read. The 12 LSBs of the buffered address bus select one of the possible 4k bytes stored in the enabled IC to be output to the Data Bus where it is read by the microprocessor.

RAM ⟨8⟩

The RAM stage, U1600 and U1505, consists of two 1k X 4-bit RAM ICs and a small amount of enable logic. When the Address Decode circuitry detects an address within the alotted RAM space, it sets the $\overline{\text{ERAM}}$ line connected to the RAM $\overline{\text{CS}}$ (Chip Select) inputs low. This enables data to be read from or written to RAM, depending on the level of the $\overline{\text{WE}}$ (Write Enable) pins.

The RAM outputs the data addressed by the buffered address bits BA0-BA9 when $\overline{\text{ERAM}}$ is low and $\overline{\text{WE}}$ is high. Data may be written to the addressed location only when the RAM block is enabled by $\overline{ERAM}$ low and when the write enable WE is also low. The write-to-RAM may only occur on a Valid Memory Access (VMA) writing B $\overline{R}$/W to the RAM after the Data Bus is known to be valid (B ϕ2) as determined by U1630A.

CMOS RAM ⟨8⟩

The CMOS RAM stage, U1220, contains the calibration constants for the DM 5010. These constants, along with various algorithms stored in the firmware ROM, are used by the microprocessor to calculate measurement results. These constants are stored, as described below, at the time of initial instrument adjustment. During normal instrument operation, the CMOS RAM looks like ROM to the microprocessor.

On power up, transistor Q1123 is turned on and the CMOS RAM may be enabled by a low $\overline{ECMOS}$ from the Address Decode stage.

During normal instrument operation, jumper P1132 is in the NORM position and data may only be read from the CMOS RAM when $\overline{ECMOS}$ is low; R/W is always high. During instrument adjustment, however, new calibration constants must be written into the CMOS RAM. Jumper P1132 is moved to its CAL position and the $\overline{VW}$ (Valid Write) signal enables writing to the CMOS RAM in much the same way as writing to the normal RAM.

To store calibration constants, a specified signal is applied to the DM 5010 input and an A/D conversion is performed. The processor is then told to store this data as a calibration constant when the user presses the front-panel ENTER key. This routine is repeated until all calibration constants have been stored. Jumper P1132 is then returned to its NORM position and, for all practical purposes, the CMOS RAM functions as a ROM.

When instrument power is turned off, transistor Q1123 is turned off and the CS (Chip Select) input of U1220 is pulled high through R1133 up to the battery supply voltage. This tri-states the busses of U1220 to minimize power drain from the Battery circuit.

BATTERY ⟨8⟩

A Battery circuit is employed in the DM 5010 to maintain the calibration contents of the CMOS RAM when the instrument is not connected to a line-power source via the power module. When not driving the data bus (as when the instrument is off), the CMOS RAM requires very little power and a small battery will maintain the calibration constants for the extended periods between instrument use.

In normal operation with power applied, power for U1220 comes from the +8 V supply through R1135 and CR1133. Diode CR1235 holds the anode voltage of CR1133 at +5.6 V. This results in +5 V being applied to pin 16 of U1220, the positive supply input. This +5 V is also applied to R1131, charging battery BT1121 when the instrument is operating. With power removed, U1220 is disabled, as described earlier, and the current to maintain the contents of the CMOS RAM flows through R1131 from battery BT1121.

MISCELLANEOUS BUFFER ⟨9⟩

This stage buffers three of the one-wide status bits and the serial conversion data onto the data bus so the processor may read them when required.

The $\overline{EMISC}$ (Enable Miscellaneous) signal from the Address Decode circuitry turns on buffer U1420B. This enables the microprocessor to read the data on the four most-significant bits of the data bus and make decisions based on these status and data bits.

Three of the four bits buffered onto the bus comprise status-type information. These bits affect the way in which the microprocessor performs its various control functions.

Since the A/D conversion process operates in either 50 or 60 Hz environment, the microprocessor must know which environment it is operating in. The 50/60 Hz jumper, P1723, is set to match the line frequency of the power source. This status bit may be read from data bus bit 5 as the processor requires.

The microprocessor continually checks the output of the set/reset latch, U1720C, which is buffered onto the data bus. If the Extrigger jumper, P1721, is in the enable position, a signal applied to the rear interface $\overline{EXTRIG}$ connector pin may be used to initiate triggering. In normal front-panel operation, jumper P1721 is in its disable position and a low is buffered onto Data Bus bit 4 when status information is read. With the Extrigger jumper in its Enable position, a low $\overline{EXTRIG}$ from the rear interface connector pin sets the output of U1720C high and the microprocessor stops its conversion process after it performs one more complete conversion. After the conversion is complete and the results are properly stored or transferred, the processor sets $\overline{ESW}$ (Enable Switch) low via the Address Decode circuitry and the output of U1720C is reset low. Normal front-panel operation resumes until another $\overline{EXTRIG}$ occurs to initiate another triggered conversion.

The In Progress bit, when set high, informs the microprocessor that an A/D conversion is in process. The processor, when controlling the conversion process, monitors this data bit and, when it returns low, knows that the A/D conversion is complete and that the serial data may be read onto the bus via the Data line.

The 17-bit serial data representing an A/D conversion is buffered one bit at a time onto bit 7 of the buffered data bus. The microprocessor, by executing a sequence of read, shift, and store commands, re-assembles this serial data into the parallel format it uses most efficiently.

SWITCHES ⟨9⟩

The primary function of the $\overline{\text{ESW}}$ (Enable Switches) signal is to enable the microprocessor to read the settings of the eight user-definable switches defining the GPIB and SA (Signature Analysis) configuration of the DM 5010.

Though also used to reset the $\overline{\text{EXTRIG}}$ status bit as previously described, a low $\overline{\text{ESW}}$ from the Address Decode circuitry turns on buffer U1610. This buffers eight bits onto the data bus corresponding to the switch closures of S1515, as defined by the user. Switches S1515-2 through 8 define GPIB address and mode data and will be further discussed in the GPIB description that follows. Switch S1515-1, when closed, causes the microprocessor to stop normal DMM operation and execute a special SA stimulation routine.

GPIB ⟨9⟩

The GPIB provides a communication and control link so that multiple instruments may interface with each other under the direction of a system controller. The TM 5000-Series power module provides the external GPIB connector as well as the internal interconnection to tie a GPIB-compatible plug-in to the GPIB. All GPIB interface and control functions of the DM 5010 and the TM 5000-Series power modules adhere to IEEE Standard 488-1978.

The IEEE 488-1978 Standard

The IEEE 488-1978 Standard defines a byte-serial, bit-parallel interface system electrically, functionally, and mechanically as well as specifying terminology and system limitations. This system implements a three-wire handshake system with each data transfer from a "talker" to one or more "listeners". A "talker" is a GPIB device sending data while a "listener" is one that receives data from a "talker". All GPIB information is transferred at standard TTL levels using negative logic (i.e., 0 = true).

The power module's external GPIB interface has 16 connections that are used for three separate types of functions. Each of these signal lines is connected directly to the DM 5010 and function as described by the IEEE 488-1978 Standard. One additional signal line TE (talk enable), is provided for future use.

Inputs DI01 through DI08 (data input/output) are used specifically for transfer of data between GPIB devices.

Five other lines are used to manage the flow of information over the interface lines. The ATN (Attention) line, when active, disables the current talker and listeners and makes all devices listen to the controller. IFC (Interface Clear) line is used to put the interface system into a known quiescent state. The SRQ (Service Request) line is used to indicate to the controller that a device on the bus is in need of service and an interrupt is requested (the controller determines which devices may talk or listen at any time). The REN (Remote Enable) command selects either a remote or local source of device programming. The EOI (End Or Identify) line is used to signal the end of a multiple byte transfer.

The three remaining lines are associated with the handshake process and are the DAV (Data Valid), NRFD (Not Ready For Data) and NDAC (Data Not Accepted) lines. Their timing relationships during the handshake process are shown in Fig. 4-14. Each data byte transferred by the interface system uses the handshake process to exchange data between source (typically a talker) and acceptor (typically a listener). The following list of events is related by number to the state changes shown in Fig. 4-14 and the flowchart shown in Fig. 4-15.

The Handshake Process

1. The source (talker) initializes the active low DAV (Data Valid) to a high level, indicating that data is not valid.

2. The acceptors (listeners) initialize the active low NRFD (Not Ready For Data) level to a low (none are ready for data) and set the active low NDAC (Data Not Accepted) level to low (none have accepted data).

3. The source checks for an error condition (both NRFD and NDAC at a high level) and then sets a data byte on the DIO (Data In/Out) lines. After the data has been placed on the DIO lines, the source delays to allow the data to settle on these lines.

4. When the acceptors have all indicated readiness to accept the first data byte, the NRFD level goes high.

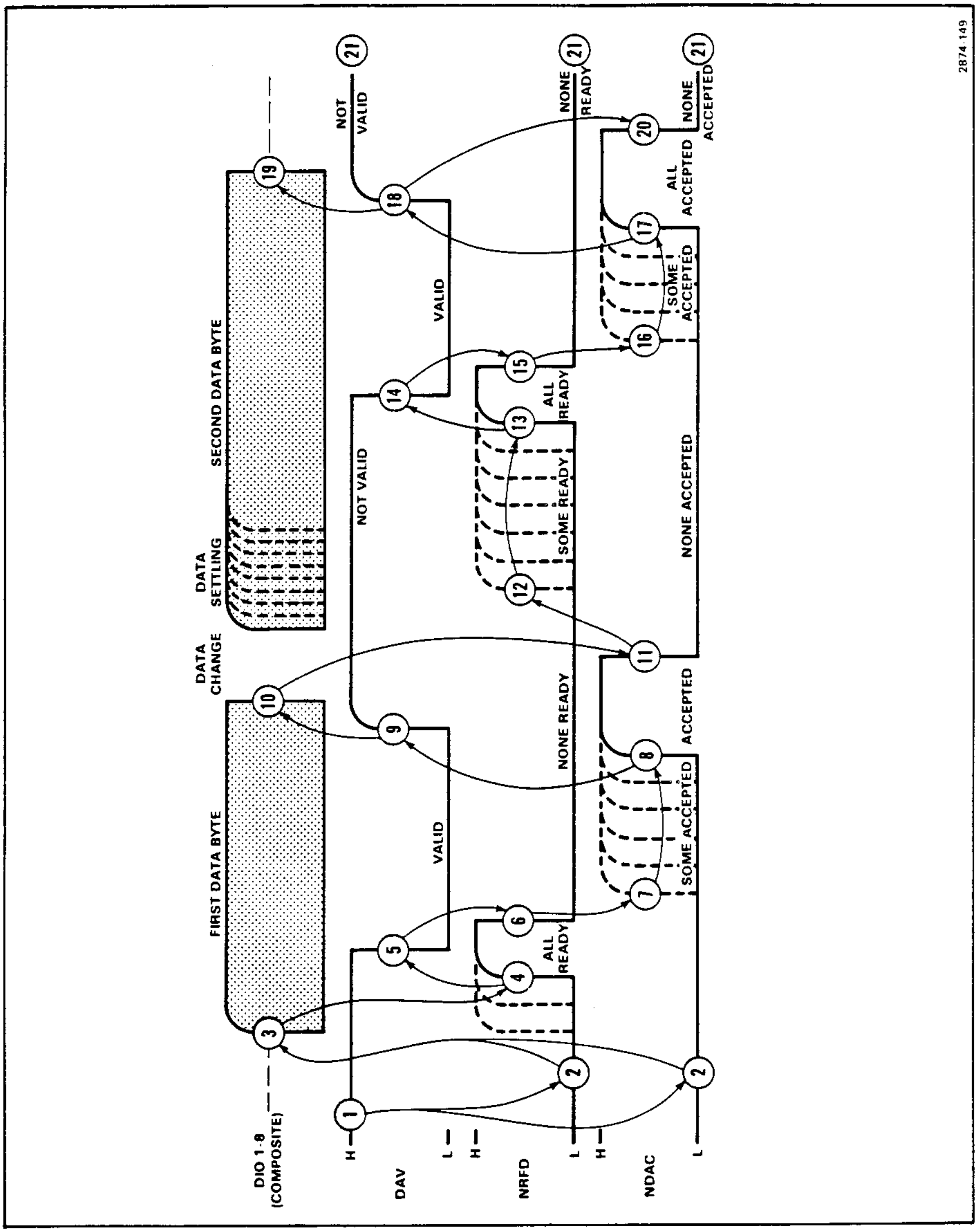


Fig. 4-14. GPIB three wire handshake state diagram.

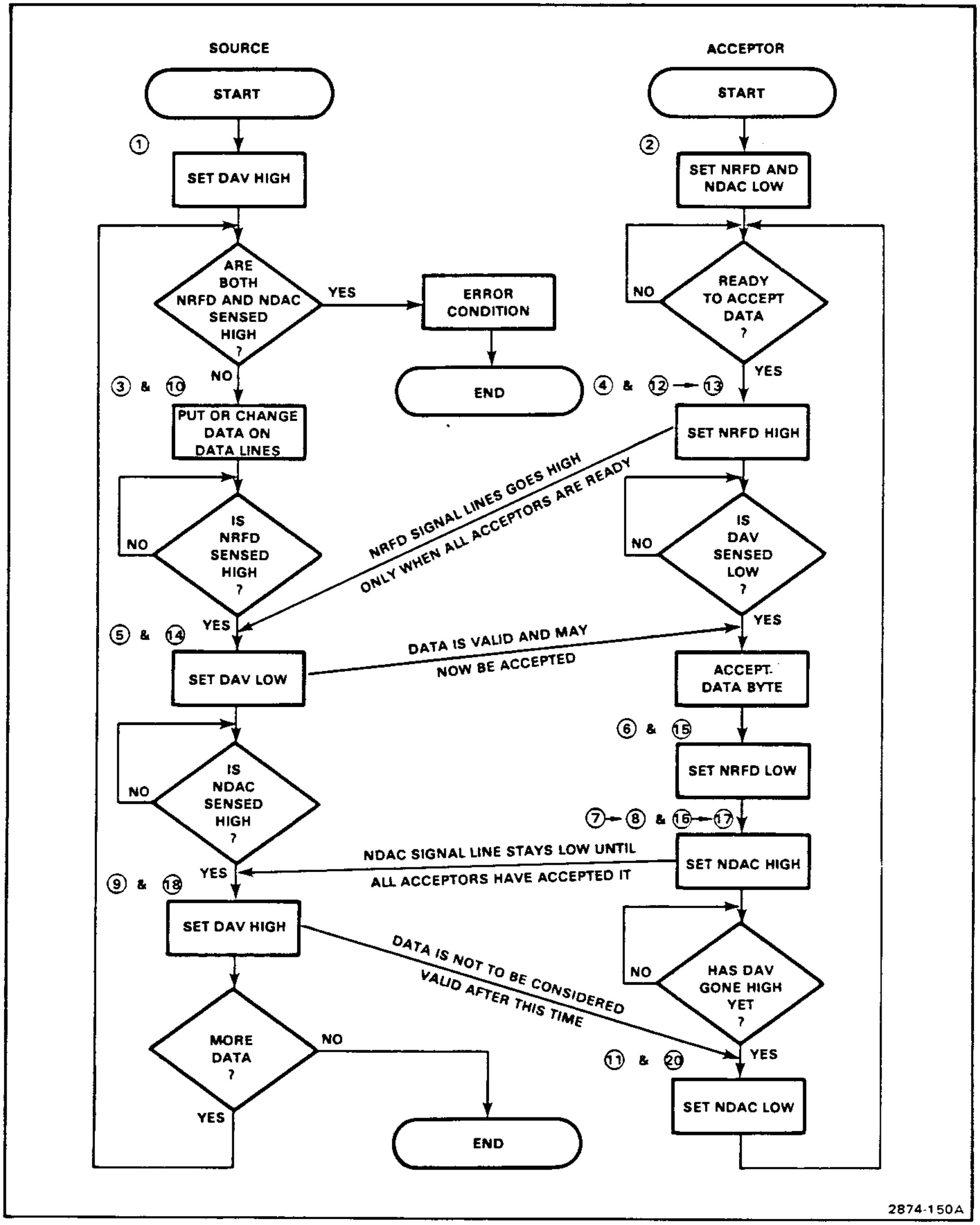


Fig. 4-15. GPIB Handshake flowchart.

5. The source, upon sensing the high NRFD level, sets the DAV level to a low, indicating that the data on the DIO lines has settled and is valid.

6. The first (fastest) acceptor sets the NRFD level low, indicating that it is no longer ready for new data, and accepts the present data. The remaining acceptors follow at their own rates.

7. The first acceptor sets its NDAC level to a (passive) high, indicating that it has accepted the data. (NDAC remains low due to the other acceptors actively driving NDAC low. The term "passive" means that if any other device is "actively" driving this line to the opposite state, the passive level is overridden.)

8. As the last (slowest) acceptor accepts the present data, the NDAC level goes to a (passive) high, indicating that all acceptors have accepted the data.

9. The source, having sensed the high NDAC level, sets DAV high. This indicates to the acceptors that the data on the DIO lines must now be considered invalid.

10. The source may change the data on the DIO lines at this time, and now delays to allow this data to settle if changed.

11. The acceptors, upon sensing the high DAV level (step 9, above), set the NDAC level low in preparation for the next cycle. The NDAC line goes low when set by the first acceptor.

12. The first acceptor indicates that it is now ready for the next data byte by setting its NRFD level to a (passive) high. (NRFD remains low due to other acceptors actively driving it low.)

13. When the last acceptor indicates that it is ready for the next data byte, the NRFD level goes (passive) high.

14. The source, sensing that NRFD is high, sets the DAV level low, indicating that the new data on the DIO lines has settled and is valid.

15. The first acceptor sets the NRFD level low, indicating that it is not ready to accept any change of data, then accepts the present data. The other acceptors follow at their own rate.

16. The first acceptor sets its NDAC level to a (passive) high, indicating that it has accepted the data (as in step 7 above).

17. The last acceptor sets the NDAC level (passive) high, indicating that it has accepted the data (as in step 8 above).

18. The source, having sensed that NDAC is high, sets DAV high (as in 9).

19. The source removes the data byte from the DIO signal lines after setting DAV high.

20. The acceptors, upon sensing the high DAV level, set NDAC to a low level in preparation for the next cycle.

21. Note that all three handshake lines are at their initial states (as in steps 1 and 2 above).

GPIB Interface

The purpose of the GPIB Interface is to provide interface between the IEEE 488-1978 Standard bus and the DM 5010 microprocessor. The DM 5010 GPIB Interface consists primarily of a 40-pin IC designed specifically for GPIB applications and two bidirectional current buffer ICs.

On the bus side of the GPIB IC, U1105, 16 pins are related directly to the 16 signal lines defined in the IEEE 488-1978 Standard description above. These data, control, and handshake signals are buffered by U1100 and U1110 either from U1105 to the GPIB or vice versa, depending on the T/R (Transmit-Receive) direction control signal. This $T/\overline{R}$ is also inverted by Q1121 and is provided to the TM 5000-Series power module for future use.

The GPIB IC is a register-oriented device; i.e., its function depends on how its various internal registers have been set. The various control and addressing signals that determine the setting of these registers are applied to the microprocessor side of the IC.

At power up, the negative $\overline{PON}$ pulse sets all internal registers of the GPIB IC to predefined states. When the Address Decode circuitry detects that a GPIB function is to be performed, it sets $\overline{EGPIB}$ (Enable GPIB) low and the GPIB IC is enabled.

There are 16 register locations accessible to the microprocessor via the address bus and data bus. These registers store and transfer the control information for the various IC functions as well as IC status and data transfer information. The 16 registers (eight read-only and eight write-only) are addressed by the $R/\overline{W}$ line along with buffered address bits BA0-BA2. Data is written into the write registers or read from the read registers via the data bus coincident with the Bϕ2 clock.

The GPIB IC can execute instructions from both the microprocessor data bus and from the General Purpose Interface Bus. As these commands are executed, the various GPIB control and handshake sequences are automatically performed by the GPIB IC, including the proper direction of data transfer on the GPIB (controlled by $T/\overline{R}$).

Command sequences received via the GPIB usually require that normal microprocessor operation be interrupted. An $\overline{IRQ}$ (Interrupt Request) to the microprocessor is generated by the GPIB IC when such conditions arise.

FRONT-PANEL CONTROL ⟨9⟩

The Front-Panel Control stage consists primarily of U1605, a specialized IC designed to scan the Front-Panel Switches and control the Front-Panel Display. It provides scanning and reading functions for the various Front-Panel Switches as well as the storage and multiplexing functions required for the Front-Panel Display.

After the PON reset at power up, a scanning sequence begins that checks the Front-Panel Switches for closures.The SC1-SC3 (Scan Column 1-3) lines are the outputs of a free-running binary counter and are later decoded by the Front-Panel Drive circuitry (diagram 11) to scan the eight columns of the Front-Panel Switches matrix. As each column of the matrix is set low (one at a time), the five rows of the matrix are checked to see if a closure is present at the corresponding switch. If a closure is detected, a unique address identifying the switch is written into a temporary storage register within U1605. When the microprocessor executes its front-panel read routine, the register is read via the data bus and the instrument function is changed under firmware control to reflect the depressed switch. All time relationships for the front-panel scanning are derived from the Bϕ2 clock.

Data to be displayed by the Front-Panel Display is written from the microprocessor into eight 8-bit storage registers internal to U1605 via the data bus. Each bit, when low, corresponds to an illuminated LED, either in the seven segment displays or the individual status LEDs. The microprocessor formats all numeric and status information before writing it to U1605 so that meaningful displays will result.

The Display is scanned in a manner similar to that of the switch matrix described above. As U1605 performs its continuous scanning functions, each of the seven-segment displays or columns of status LEDs are enabled one at a time, as determined by the SC1-SC3 output lines from U1605 and the Front-Panel Drive circuitry on diagram 11. As each new column or digit is enabled, the contents of the corresponding display register are output onto the CD1-CD8 (cathode drive 1-8) lines. This is the display information previously stored by the microprocessor. The appropriate LEDs are turned on to form either a decimal digit or to light the status indicators.

All front-panel related data transfers occur via the Data Bus and are enabled by a low $\overline{EFP}$ (Enable Front Panel) from the Address Decode circuitry. Writing display information to U1605 is enabled by a low $\overline{VW}$ (Valid Write) to the IC and occurs coincident with the Bϕ2 clock. Integrated circuit U1630 controls the reading of the Front-Panel Switches registers. Reading occurs coincident with the Bϕ2 clock and one of two registers may be read as selected by BA0, the least significant bit of the address bus.

MAIN INTERCONNECT ⟨10⟩

The Main Interconnect is a printed circuit board that provides most of the interconnection for the various boards of the DM 5010. Signal origin is indicated by an arrow pointing away from the board connector on which the signal is generated. The Main Interconnect also provides guard and ground shielding.

FRONT-PANEL DRIVE ⟨11⟩

The Front-Panel Drive stage consists of a 1-of-8 decoder, current buffering circuitry, and a front-panel regulator. The front-panel regulator, U1720, and its associated components regulate the +8 V supply from the power module down to +5 V to provide power for the front-panel circuitry. By using a separate +5 V supply for the front-panel circuitry, switching noise and transients generated by Front-Panel Switches do not affect operation of the rest of the instrument.

The decoder, U1040, converts the binary scanning code from the Front-Panel Control IC to the eight individual lines required to scan the Front-Panel Switches and the Front-Panel Display, as explained in the Front-Panel Control description. The buffering provides current drive levels as required by the switch matrix and LED displays.

FRONT-PANEL SWITCHES ⟨12⟩

The Front-Panel Switches provide a way for the user to control the operation of the DM 5010.

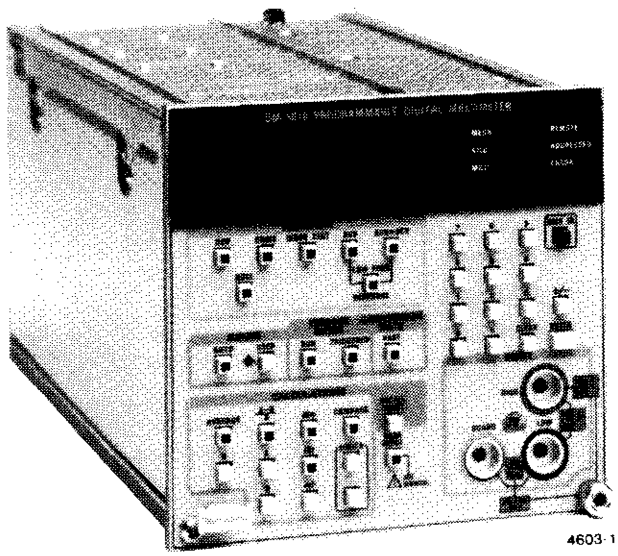
Forty push button switches are arranged in a 5 X 8 matrix and are continuously scanned under control of the special Front-Panel Control IC and the 1-of-8 decoder in the Front-Panel Drive stage. The 1-of-8 decoder sets each of the eight columns of the matrix low, one at a time, and then each of the five rows are sequentially checked by the Front-Panel Control IC to see if a switch closure is present. After all five rows have been scanned, the next column is set low by the decoder and the sequence is repeated. Switch closure data is stored by the Front-Panel Control IC and is further explained in that description.

FRONT-PANEL DISPLAY ⟨12⟩

The Front-Panel Display provides a visual indication of instrument status and measurement results to the user. It is comprised of multi-segment displays and individual light-emitting diodes arranged in a matrix configuration. The display is generated in much the same way as when the Front-Panel Switches are scanned.

The Front-Panel Control IC, along with the 1-of-8 decoder in the Front-Panel Drive circuitry, enables one of the mult-segment displays or one of the columns of status LEDs by pulling the associated anodes high through the buffering circuitry on diagram 11. As each group of anodes is enabled, an 8-bit display word associated with the particular column enabled is output from the Front-Panel Control IC on lines CD0-CD7 (Cathode Data 0-Cathode Data 7). This is the data stored earlier by the microprocessor representing the LEDs that should be turned on in any given display digit or status column. The data is buffered by the Front-Panel Drive circuitry and applied to the eight cathode rows. Any cathode that is low when its respective anode is held high will illuminate.

DM 5010 Instrument Interfacing Guide



4603-1

This interfacing guide is designed to help you get started using the DM 5010 Programmable Digital Multimeter with a GPIB controller as quickly and easily as possible. This guide tells you how to set DM 5010 switches for GPIB operation and explains how to communicate with the DM 5010 with a variety of controllers. Sample measurement programs for these controllers are also included.

This guide does not take the place of the operators manual or other documentation supplied with the DM 5010 and your system controller. More complete information in this other documentation will help you get the full benefit of the DM 5010's programmable capabilities.

Setting Up the DM 5010 for GPIB Operation

Connect the TM 5000 power module to your controller with a GPIB cable. The program examples in this guide assume that the DM 5010 and controller are the only instruments on the bus.

Checking the GPIB Address and Terminator. The DM 5010 primary address is displayed when you press the INST ID button. A decimal point in the display indicates the message terminator switch is set for EOI or LF (no decimal point indicates EOI-only). A minus sign in the display indicates talk-only mode.

The DM 5010 is supplied from the factory set to an address of 16 and to EOI-only for the message terminator.

Setting the Address and Terminator Switches. The switches that select the GPIB address and terminator are located on a circuit board on the left side of the DM 5010. Because the DM 5010 side cover must be removed, allowing hazardous voltages to be exposed, refer address and terminator selection to qualified personnel only. Both a sticker on the inside of the side cover and Fig. 1 identify the switches and illustrate their meanings. Other switch or strap-selectable options in the DM 5010 are explained in the Operators Manual.

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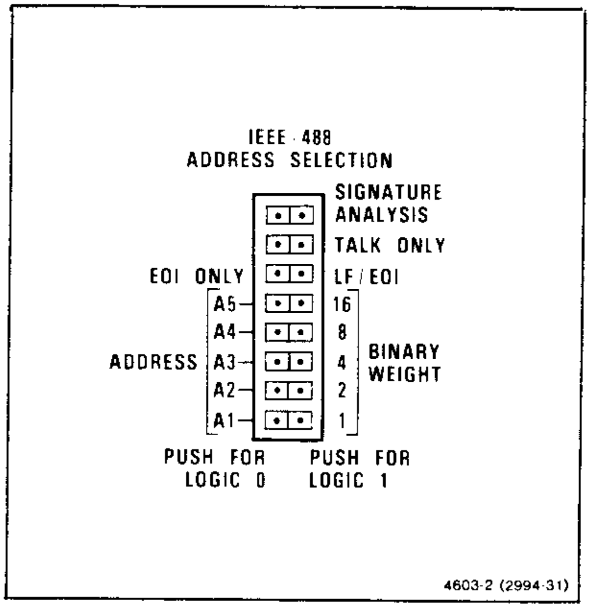

Fig 1. *The address and message terminator switches are located on the circuit board on the left side of the DM 5010.*

WARNING

Hazardous voltages exist inside the DM 5010. The DM 5010 should be removed and disconnected from the TM 5000 power module (after turning power off) before opening the instrument covers. Internal settings should only be made by qualified personnel.

Valid primary addresses include the range of 0 to 30. (31 effectively disables the DM 5010 from communicating on the GPIB.) If your controller reserves an address for itself, do not set the DM 5010 to that address. This is true of Tektronix 4050-Series controllers, which reserve address 0 for themselves. The Tektronix 4041 defaults to address 30 on power-on, but may be programmed to use any primary address. The DM 5010 ignores secondary addresses.

EOI-only is recommended as the message terminator for use with Tektronix controllers. EOI-or-LF is recommended for use with Hewlett-Packard controllers. (In the latter position, the DM 5010 still recognizes EOI as a terminator and transmits EOI concurrently with the LF character to terminate a message.)

Neither signature analysis nor talk-only modes are used in normal operation with a GPIB controller, so those switches should be set to a logic 0.

Programming The DM 5010

DM 5010 Power-On

The DM 5010 performs a self-test and goes to its default settings on power-on.

Self-Test. During the self-test, all front-panel indicators are lighted. If an internal error is detected, the DM 5010 continuously displays a three-digit error code and turns on the ERROR indicator. See the operators manual for the meaning of any code displayed.

Power-On Settings. Following a successful self-test, the DM 5010 goes to local state with the default settings shown in Table 1 (and defined in Table 2). These settings are restored any time the INIT command is executed.

Power-On SRQ. The DM 5010 asserts SRQ to report power-on status after completing the self-test. This can be handled with a serial poll, although the DM 5010 communicates normally on the GPIB and executes the commands it receives whether or not the SRQ is serviced. Some controllers, such as the 4051 and 4052 when used without the 405XR14 GPIB rompack, require that the program contain an SRQ handler and begin by enabling the handler; otherwise the power-on SRQ will cause the program to halt with the error 'NO SRQ ON UNIT.'

Table 1
DM 5010 POWER ON SETTINGS

Header	Argument
AVE	2
CALC	OFF
DBR	1
DCV	−1.E+3
DIGIT	4.5
DT	OFF
LFR	OFF
LIMITS	0,0
MODE	RUN
MONITOR	OFF
NULL	0
OPC	OFF
OVER	OFF
RATIO	1,0
RQS	ON
SOURCE	FRONT
USER	OFF

DM 5010 Messages

Commands are provided to control DM 5010 settings, cause DM 5010 actions, or request status or measurement data. These commands are listed in Table 2. DM 5010 commands begin with a header—a word or abbreviation that describes the function implemented. The command may include one or more arguments, which are delimited from the header by a space; multiple arguments are delimited by a comma. DM 5010 commands can be combined in a message by separating the commands with the message unit delimiter (semicolon). Either upper or lower-case ASCII characters are accepted.

Table 2
DM 5010 COMMANDS AND DESCRIPTIONS
( ) = Optional

Header	Argument	Description
ACDC (ACD)	<num>	Selects the ACV+DCV function. Argument selects range. Negative or omitted argument selects auto-range.
ACV	<num>	Selects the ACV function. Argument selects range. Negative or omitted argument selects auto-range.
AVE (AVG)	<num>	Sets the number of conversions used in CALC AVE program. Argument is truncated to integers.
AVE? (AVG?)		Returns "AVE <num>;".
CALC	AVE (AVG)	Calculates the average of the next "N" readings. AVE command sets the value of "N".
CALC	CMPR (COMP)	Compares input to limits set by LIMITS command. SEND command returns: "3.;" if input is above both limits. "2.;" if input is between or equal to both limits. "1.;" if input is below both limits. "±1.E+99;" for overrange. DATA returns the out-of-limits measurement.
CALC	DBM	Calculates power ratio, referenced to 1 mV dissipated in 600 Ω. Disables CALC DBR.
CALC	DBR	Calculates logarithmic ratio of measurement to value of DBR command. Disables CALC DBM.
CALC	RATIO	Subtracts offset and divides by scale factor set by RATIO command.
CALC	OFF	Disables all calculations.
CALC?		Returns "CALC OFF;" or list of enabled calculations.
DATA		Returns the out-of-limits measurement saved by the MONITOR command.
DBR	<num>	Numeric sets value of reference used in CALC DBR command.
DBR?		Returns "DBR <num>;".
DCV	<num>	Selects the DCV function. Argument selects range. Negative or omitted argument selects auto-range.
DIGIT (DIG)	3.5	Selects FAST CONVERSION RATE (3.5 digit resolution).
DIGIT (DIG)	4.5	Selects normal CONVERSION RATE (4.5 digit resolution).
DIGIT? (DIG?)		Returns "DIGIT 3.5;" or "DIGIT 4.5;".
DIODE (DIO)		Selects DIODE TEST function. No argument.
DT	TRIG	Instrument responds to Group Execute Trigger <GET>.
DT	OFF	Disables DT TRIG. Instrument will not respond to Group Execute Trigger <GET>.
DT?		Returns "DT TRIG;" or "DT OFF;".

Table 2 (cont)

Header	Argument	Description
ERR?		Returns error code for most recent event reported by serial poll when RQS is ON; with RQS OFF it returns the highest priority status.
FUNCT? (FUNC?)		Returns the current function (DCV, OHMS, DIODE, ACV, ACDC) and range. Negative argument indicates autorange.
ID?		Returns "ID TEK/ DM 5010,V79.1 FXX;", where XX is the firmware version number.
INIT		Initializes all instrument settings to their power-on settings. See Power On Settings.
LFR	ON	Enables the LOW FREQ RESPONSE function. Instrument computes the average of four ACV or ACV+DCV measurements.
LFR	OFF	Disables the LOW FREQ RESPONSE function.
LFR?		Returns "LFR OFF;" or "LFR ON;".
LIMITS (LIM)	<num>, <num>	Sets limits used in CALC CMPR program.
LIMITS? (LIM?)		Returns "LIMITS <num>, <num>;".
MODE	RUN	Selects the free-run (RUN) trigger mode.
MODE	TRIG	Selects TRIGGERED trigger mode. Triggers a conversion only upon receipt of one of the following. • SEND command • Group Execute Trigger <GET>, only if device trigger (DT) is enabled. • My Talk Address (MTA) with the output unspecified (no query command). • Rear interface trigger (EXTRIG). Requires internal jumper installation. To cause a single trigger, this line must remain low between 0.5 and 10 μsec. Holding this line low longer causes multiple readings.
MODE?		Returns "MODE RUN;" or "MODE TRIG;".
MONITOR (MON)	ON	Enables monitor SRQ. Saves the measurement outside the limits set by the LIMITS command and generates an SRQ. Returns this measurement in response to DATA. Subsequent out-of-limits measurements are not reported until the SRQ is serviced and measurement is returned via DATA command.
MONITOR (MON)	OFF	Disables the monitor SRQ.
MONITOR? (MON?)		Returns "MONITOR ON;" or "MONITOR OFF;".
NULL	<num>	Sets an offset value and applies it to subsequent measurements. Argument may be any value up to 100% of range. Disable NULL by setting argument to 0, or changing measurement function.
NULL?		Returns "NULL <num>;".
OHMS	<num>	Selects OHMS function. Argument selects range. Negative or omitted argument selects auto-range.
OPC	ON	Enables operation complete SRQ. DM 5010 asserts SRQ whenever a new measurement is available.
OPC	OFF	Disables operation complete SRQ.
OPC?		Returns "OPC OFF;" or "OPC ON;".

Table 2 (cont)

Header	Argument	Description
OVER	OFF	Disables overrange SRQ (OVER ON). If overranged when talked, returns "1.E+99;" and does not generate an SRQ.
OVER	ON	Enables overrange SRQ. If overranged when talked, returns "1.E+99;" and generates an SRQ.
OVER?		Returns "OVER ON;" or "OVER OFF;".
RATIO (RAT)	<num>, <num>	Sets values for offset and scale used in CALC RATIO command. First argument is for scale, second for offset.
RATIO? (RAT?)		Returns "RATIO <num>, <num>;".
RDY?		Returns "RDY 0;" if a measurement is in progress or if the instrument is waiting for a trigger. Returns "RDY 1;" if a measurement is available. Also see OPC ON.
RQS	ON	Enables instrument to generate service requests.
RQS	OFF	Disables all SRQ's. Instrument responds to ERR? without first being serial polled.
RQS?		Returns "RQS OFF;" or "RQS ON;".
SEND (SEN)		Returns latest measurement. If no measurement is available, the instrument triggers a measurement and then outputs it. If CALC CMPR is enabled, returns 1, 2, or 3 to indicate relationship of measurement to LIMITS. See CALC CMPR.
SET?		Returns all instrument settings that may be queried. See Power On Settings.
SOURCE (SOUR)	FRONT	Connects front panel connector inputs.
SOURCE (SOUR)	REAR	Connects rear interface connector inputs.
SOURCE? (SOUR?)		Returns "SOURCE FRONT;" or "SOURCE REAR;".
TEST		Returns 0 if calculation checksum is correct; 351 if erroneous.
USER	ON	Enables INST ID button service request.
USER	OFF	Disables INST ID button service request.
USER?		Returns "USER ON;" or "USER OFF;".

Sending Messages to the DM 5010

Most GPIB controllers provide a high-level statement that allows you to transfer device-dependent messages to the DM 5010. In the 4050-Series and the 4041, it's the PRINT statement.

4050-Series:

```
170 PRINT @16:"ACV;LFR ON"
```

4041:

```
170 Print #16:"ACV;LFR ON"
```

A useful variation assigns the DM 5010 address to a variable and inserts that variable in the PRINT statement in place of the number for the address. This works with either the 4050-Series or 4041 and allows you to change the program to work with the DM 5010 set to other addresses by changing only the statement that assigns the variable.

4050:

```
200 D=16
210 PRINT @D:"ACV;LFR ON"
```

4041:

```
200 Dmm=16
210 Print #dmm:"ACV;LFR ON"
```

Notice that the DM 5010 message (what's inside the quote marks) is the same in all of the above examples. The rest of each example varies to match the PRINT statement syntax designed into each controller as illustrated in Fig. 2. This suggests that once you understand your controller's output and input statements, it's just a matter of plugging in the DM 5010 commands you need.

4050-Series BASIC	**PRINT @5:"RQS ON"**
4041 BASIC	**PRINT #5:"RQS ON"**
HP-85 BASIC	**OUTPUT 705 ; "RQS ON"**
FLUKE 1720A BASIC	**PRINT @5%,"RQS ON"**
HP 9826 BASIC	**OUTPUT 705;"RQS ON"**

4603-5

Fig. 2. *A message to a GPIB device is contained within the controller's GPIB output statement. The statement is composed of three parts: the keyword, the address or logical unit number, and the device-dependent message. All the statements shown send the same standard Tektronix Codes & Formats message (RQS ON) that enables SRQ interrupts. All send the message to an instrument with primary address 5. The difference lies in the syntax of the statement required for a particular controller.*

Getting DM 5010 Current Settings

DM 5010 queries or output commands (such as FUNCT?, MODE?, or SEND) prepare the instrument for output, but do not start such output. The DM 5010 waits until it sees its talk address to begin sending the requested data. This is accomplished by the INPUT statement.

4050-Series:

```
280 PRINT @16:"FUNC?"
290 INPUT @16:F$
```

4041:

```
290 Input #16 prompt "FUNC?":fnction$
```

All instrument settings can be obtained in one message. Just dimension a string large enough (300 characters is plenty) and input the settings string.

4050-Series:

```
330 DIM S$(300)
340 PRINT @16:"SET?"
350 INPUT @16:S$
```

4041:

```
330 Dim settings$ to 300
340 Input #16 prompt "SET?":settings$
```

You can restore the settings you input from the DM 5010 by sending back the settings string.

4050-Series:

```
380 PRINT @16:S$
```

4041:

```
380 Print #16:settings$
```

Getting DM 5010 Measurements

Getting measurements from the DM 5010 is even easier than getting settings data. Sending the DM 5010 talk address, which INPUT does, is enough to cause the DM 5010 to output a reading. (The DM 5010 responds with a reading if it has not been told by a query command to respond with some other output.) The DM 5010 sends the reading as ASCII numeric characters, which may be input into a character string or numeric variable. The variable and its type are specified after the colon in the INPUT statement.

4050-Series:

```
430 INPUT @16:R
```

4041:

```
430 Input #16:reading
```

If a reading is not available, say the DM 5010 was set to triggered mode but no reading was triggered, the INPUT statement causes the DM 5010 to trigger a reading and output it as soon as it is available. Meanwhile, it holds off further GPIB activity by halting the handshake. This may be undesirable if the DM 5010 is set to average many readings before it can output a response. The SEND command is provided for this reason. Its use is illustrated in the sample measurement program later in this guide. SEND allows the program to handle other events or do other processing while many readings are averaged. It also avoids a timeout, which occurs if the DM 5010 is talked but cannot supply output within five seconds.

If the program does request a long averaging operation, does not use SEND, and attempts to INPUT the reading before it is ready, it can cause the DM 5010 to time out. If a time out occurs, the DM 5010 does not hold up bus traffic any longer; it outputs a byte with all bits set to one (FF hex) and asserts EOI concurrently. This does not change the value stored in the INPUT target variable. If the variable was undefined, it remains undefined. This causes an error if the variable is numeric and it is subsequently used in an output statement or a calculation.

Because the DM 5010 returns a very large number (1.E+99) to indicate an overrange condition, it is necessary to define variables used for readings in the 4041 as long floating point. Such a variable is used in the 4041 sample measurement program.

Using DM 5010 Interrupts

Programmable interrupts are provided in the DM 5010 to inform the controller of asynchronous events, such as operation complete, command errors, overranging, or out-of-limits reading in the compare mode. If the DM 5010 is set to report an event, it asserts SRQ when it detects that event and sets its status byte and error code appropriately. The status byte returned in response to a serial poll and the error code returned in response to an error query (ERR?) correspond to the events shown in Table 3. The error query obtains more detail in the case of abnormal events and some normal events. For instance, in the case of a command error, was it a problem with a header, argument, or delimiter? You can find out from the error code.

Here are typical SRQ handlers that alert you to a reporting instrument's address, status, and error code with a message on your console. The error code is helpful during debugging because it identifies the specific command or execution problem should one occur. To use an SRQ handler, you must link it and enable it as shown in the statements at lines 120 and 130. The sample measurement program does not use the error query because the information that is needed (operation complete) is available from the status byte. It prints the status byte as a failsafe measure only if it is other than the one expected.

4050-Series with 405XR14 Rompack:

```
120 ON SRQ THEN 470
130 CALL "SRQON"
140 REM
150 REM
450 REM
460 STOP
465 REM SERIAL POLL OF ADDRESS 16 ONLY
470 POLL A,S;16
475 PRINT @16:"ERR?"
480 INPUT @16:E
490 PRINT "STATUS=";S,"ERROR=";E
500 RETURN
```

4041:

```
120 On srq then gosub dopoll
130 Enable srq
140 !
150 !
450 !
460 Stop "End of 4041 example program statements."
470 Dopoll: poll stabyt,addr;16.
480 Input #addr prompt "ERR?":errnum
490 Print "STATUS=";stabyt,"ADDRESS=";addr,"ERROR=";errnum
500 Resume
```

Table 3
ERROR QUERY AND STATUS INFORMATION

Abnormal Events	**Error Query Response**	**Serial Poll Response***
Command Errors:		
Invalid command header	101	97
Header delimiter error	102	97
Argument error	103	97
Argument delimiter error	104	97
Missing argument	106	97
Invalid message unit delimiter	107	97
Execution Errors:		
Not executable in local mode	201	98
Settings lost due to *rtl*	202	98
Input and output buffers full	203	98
Argument out of range	205	98
Group Execute Trigger ignored	206	98
Not in calibrate mode	231	98
Beyond calibration or null capability	232	98
Internal Errors:		
Interrupt fault	301	99
System error	302	99
Math pack error	303	99
Converter time-out	311	99
Front panel time-out	317	99
Bad ohms calibration constant	318	99
Calibration checksum error	351	99
Normal Events		
System Events:		
Power on	401	65
Operation complete	402	66
ID user request	403	67
Internal Warning:		
Over-range	601	102
Device Status:		
Reading available	0	132
Waiting for trigger	0	136
Reading available and waiting for trigger	0	140
Below limits	701	193
Above limits	703	195
No Errors or Events	0	128

***If the instrument is busy, it returns a decimal number 16 higher than the number listed.**

DM 5010 Data Processing

Functions built into the DM 5010 allow you to obtain answers that are already processed or corrected in a number of ways. For instance, ohms readings can be offset by NULL to take into account lead resistance. Any reading can be scaled according to the formula (x-b)/a; this converts a voltage reading across a resistor to current if b is set to zero and a to the resistor's ohms value. Voltage readings can be returned in dB or dBr (dB compared to a reference). Just insert the processing command selected from the command table in this guide into set-up messages sent to the DM 5010. An example using the averaging function is shown in the sample measurement program.

DM 5010 Response to Interface Messages

The following program sequences show various interface messages transmitted to the DM 5010.

The DM 5010 responds to DCL (and SDC if listen addressed) by clearing its Input and Output Buffers and any unexecuted setting commands in its Pending Settings Buffer, along with any errors or events waiting to be reported (except power-on).

GET triggers a reading in device trigger mode if the instrument receives the message while listen addressed. It is used with the MODE TRIG and DT TRIG commands.

LLO locks out the operator from restoring local (front-panel) control when the instrument is under remote control.

GTL restores local control if the instrument receives the message while listen addressed.

See the DM 5010 Operators Manual for a full discussion of how the instrument responds to interface messages.

405XR14:

```
100 REM
110 REM
120 REM
130 REM
140 A=16
150 REM
160 REM                Send Listen Address (MLA)
170 CALL "LISTEN";A
180 REM                Send Unlisten (UNL)
190 CALL "UNL"
200 REM                Send Talk Address
210 CALL "TALK";A
220 REM                Send Untalk
230 CALL "UNT"
240 REM                Send Device Clear
250 CALL "DCL"
260 REM                Send MLA, Selected Device Clear, UNL
270 CALL "SDC";A
280 REM                Send Local Lockout
290 CALL "LLO"
300 REM                Send MLA, Go to Local, UNL
310 CALL "GTL";A
320 REM                Send MLA, Group Execute Trigger, UNL
330 CALL "GET";A
340 REM                Unassert REN
350 CALL "LOCS"
```

4041:

```
130      Pri_addr=16 !       primary bus address
140    !
150    !
160 Listen:      wbyte atn(pri_addr+32) !    Send Listen Address (MLA)
170    !
180 Unlisten:      wbyte atn(unl) !          Send Unlisten (UNL)
190    !
200 Talk:      wbyte atn(pri_addr+64) !      Send Talk Address
210    !
220 Untalk:      wbyte atn(unt) !            Send Untalk
230    !
240 Devclear:      wbyte dcl !               Send Device Clear
250    !
260 Selctclr:      wbyte sdc(pri_addr),atn(unl) ! Send MLA, Selected Device
270    !                                          Clear, UNL
280 Lockout:      wbyte llo !                Send Local Lockout
290    !
300 Gtlocal:      wbyte gtl(pri_addr),atn(unl) ! Send MLA, Go to Local, UNL
310    !
320 Trigger:      wbyte get(pri_addr),atn(unl) ! Send MLA, Group Execute
330    !                                         Trigger, UNL
340 Loclstat:      wbyte ren(0),ren(1) !     Pulse unassert REN line
```

Sample Measurement Program

The following program makes a series of DM 5010 measurements to illustrate command i/o and various measurement triggering modes.

Figs. 3 and 4 are typical output from the programs.

405XR14:

```
100 REM +::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::+
110 REM ::::::::::: DM 5010/4050-SERIES MEASUREMENT PROGRAM :::::::::::
120 REM ::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::
130 REM
140 REM BY Jim Kimball, GPI Marketing, 10/15/82, update 11/17/82
150 REM
160 REM Copyright (c) 1982, Tektronix, Inc.  All rights reserved.  This
170 REM software is provided on an "as is" basis without warranty of any
180 REM kind.  It is not supported.
190 REM
200 REM This software may be reproduced without prior permission, in
210 REM whole or in part.  Copies must include the above copyright
220 REM and warranty notice.
230 REM
240 REM REQUIRED EQUIPMENT
250 REM DM 5010 in TM 5000 mainframe.
260 REM Program assumes no other instruments on the bus.
270 REM 4050-Series controller with R14 GPIB Enhancement rompack
280 REM
290 REM PURPOSE:
300 REM Inputs four readings, using four different DM 5010 acquisition
310 REM modes.  Prints readings on screen.
320 REM
330 REM OPERATING PROCEDURE:
340 REM Connect 4050 Controller and TM 5000 mainframe with GPIB cable.
350 REM DM 5010 must be set for primary address of 16 or
360 REM   change line that assigns d=16.
370 REM Enter and run program (no other program segment required).
380 REM
390 REM PROGRAM FUNCTIONS:
400 REM
410 REM Prepares DM 5010 for measurement and queries id
420 REM Reads whatever measurement is available
430 REM Triggers a reading with the INPUT statement
440 REM Reads after GET trigger in device trigger mode
450 REM Gets average of 20 DM 5010 readings using SEND
460 REM General-purpose SRQ handler
470 REM
480 REM -::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::-
490 INIT
500 PAGE
510 PRINT "GDM 5010 MAKING MEASUREMENTS."
520 REM              Assign DM 5010 factory-set address of 16
530 D=16
540 ON SRQ THEN 950
550 CALL "SRQON"
560 REM
570 REM Setup DM 5010; expand as needed
580 PRINT @D:"init"
```

```
590 REM              Query id
600 PRINT @D:"id?"
610 INPUT @D:I$
620 PRINT I$
630 REM
640 REM              Get continuous mode reading
650 PRINT @D:"mode run"
660 INPUT @D:M
670 PRINT "Continuous Mode:  ";M
680 REM
690 REM               Get triggered reading
700 PRINT @D:"mode trig"
710 INPUT @D:M
720 PRINT "Triggered Mode:  ";M
730 REM
740 REM              Get triggered reading using device trigger
750 PRINT @D:"dt trig"
760 REM Allow DM to set up for GET
770 CALL "WAIT",0.4
780 CALL "get";D
790 INPUT @D:M
800 PRINT @D:"dt off"
810 PRINT "Device Trigger Mode:  ";M
820 REM
830 REM              Get averaged reading
840 REM              Inform operator of delay
850 PRINT "GWaiting for average..."
860 PRINT @D:"ave 20;calc ave;opc on;send"
870 WAIT
880 IF NOT(S=66 OR S=82) THEN 870
890 INPUT @D:M
900 PRINT @D:"opc off"
910 PRINT "Average of 20 readings:  ";M
920 PRINT "Program complete."
930 END
940 REM              SRQ handler
950 POLL A,S;D
960 IF S=66 OR S=82 THEN 980
970 PRINT "Status=";S
980 RETURN
```

```
DM 5010 MAKING MEASUREMENTS.
ID TEK/DM5010,V79.1,F00;
Continuous Mode:  0.18635
Triggered Mode:  -0.0413
Device Trigger Mode:  -0.13415
Waiting for average...
Average of 20 readings:  -0.19933
Program complete.
```
4603-3

Fig. 3. *Screen output from 4050-Series sample measurement program.*

4041:

```
100    !+::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::+
110    ! :::::::::::::::    DM 5010/4041 MEASUREMENT PROGRAM    ::::::::::::::::::
120    ! :::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::
130    !
140    ! By Jim Kimball, GPI Marketing, 9/24/82, revised 11/18/82
150    !
160    ! Copyright (c) 1982, Tektronix, Inc.  All rights reserved.  This
170    ! software is provided on an "as is" basis without warranty of any
180    ! kind.  It is not supported.
190    !
200    ! This software may be reproduced without prior permission, in whole or
210    ! in part.  Copies must include the above copyright and warranty notice.
220    !
230    ! REQUIRED EQUIPMENT:
240    ! DM 5010 in TM 5000 mainframe.
250    ! Program assumes no other instruments on the GPIB.
260    ! 4041 (V1.1) -- console may be either front panel or terminal (comm:).
270    !
280    ! PURPOSE:
290    ! Inputs four readings, using four different DM 5010 acquisition modes.
300    ! Prints readings on 4041 printer.
310    !
320    ! OPERATING PROCEDURE:
330    ! Connect 4041 and TM 5000 mainframe with GPIB cable.
340    ! DM 5010 must be set for primary address of 16 or change line Addr_set
350    ! Enter and type run (no other program segment required; contains main  program)
360    ! Console may be either "FRTP:" or "COMM:"
370    !
380    ! PROGRAM LABELS:
390    !
400    !     Initset:  prepares DM 5010 for measurement and queries id
410    !     Runmode:  reads whatever measurement is available
420    !     Trigread:  triggers a reading with the INPUT statement
430    !     Dtread:  reads on GET trigger in device trigger mode
440    !     Average:  gets average of 20 DM 5010 readings using SEND
450    !     Polldm:  general purpose srq handler
460    !
470    !-:::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::-
480      Init var all
490      Print "^GDM 5010 making measurements."
500 Addr_set:      dmm=16 !                     This is factory-set primary address
510      Open #101:"prin:" !                    Open LU for 4041 printer
520      Long measure !    Long floating point handles 1.E+99 if DMM overranges
530      Integer dmm,status,address
540      On srq then gosub polldm !      Links srq handler
550      Enable srq !                    Enables srq interrupt
560    !
570 Initset:      print #dmm:"init" !      Expand to cover measurement needs
580      Input #dmm prompt "id?":id$ !          Query DM id
590      Print #101:id$ !                       Print response on 4041 printer
600    !
610 Runmode:      print #dmm:"mode run"
620      Input #dmm:measure !                   Get whatever reading is available
630      Print #101:"Continuous Mode",measure
640    !
650 Trigread:      print #dmm:"mode trig"
660      Input #dmm:measure !          INPUT statement talks DMM, triggers reading
670      Print #101:"Triggered Mode",measure
680    !
690 Dtread:      print #dmm:"dt trig"
700      Wait 0.4 !                    Let DM set up for GET
710      Wbyte get(dmm),atn(unl) !     Send GET to DM 5010 to start reading
720      Input #dmm:measure !          Gets reading as soon as ready
```

```
730     Print #dmm:"dt off"
740     Print #101:"Device Trigger Mode";measure
750   !
760 Average:     print "^GWaiting for average" !      Inform operator of delay
770     Status=0 !                Clear variable so set only by next serial poll
780     Print #dmm:"ave 20;calc ave;opc on;send"
790     Wait ! for OPC
800     If not(status=66 or status=82) then goto 790
810     Input #dmm:measure
820     Print #dmm:"opc off"
830     Print #101:"Average of 20";measure
840   !
850     Stop "Program complete"
860   !
870 Polldm:     poll status,address
880     If not(status=66 or status=82) then print "Status=";status
890     Resume
900     End
```

```
ID TEK/DM5010,V79.1,
  F00;
Continuous Mode 0.06
  93200
Triggered Mode -0.07
  49500
Device Trigger Mode
  -0.1003200
Average of 20 -0.122
  5400
```

4603-4

Fig. 4. *Printer output from 4041 sample measurement program.*

ASCII & GPIB CODE CHART

B7 B6 B5 BITS / B4 B3 B2 B1	0 0 0	0 0 1	0 1 0	0 1 1	1 0 0	1 0 1	1 1 0	1 1 1
	CONTROL		NUMBERS SYMBOLS		UPPER CASE		LOWER CASE	
0 0 0 0	0 **NUL** 0 0	20 **DLE** 10 16	40 0 **SP** 20 32	60 16 **0** 30 48	100 0 **@** 40 64	120 16 **P** 50 80	140 0 **`** 60 96	160 16 **p** 70 112
0 0 0 1	1 GTL **SOH** 1 1	21 LLO **DC1** 11 17	41 1 **!** 21 33	61 17 **1** 31 49	101 1 **A** 41 65	121 17 **Q** 51 81	141 1 **a** 61 97	161 17 **q** 71 113
0 0 1 0	2 **STX** 2 2	22 **DC2** 12 18	42 2 **"** 22 34	62 18 **2** 32 50	102 2 **B** 42 66	122 18 **R** 52 82	142 2 **b** 62 98	162 18 **r** 72 114
0 0 1 1	3 **ETX** 3 3	23 **DC3** 13 19	43 3 **#** 23 35	63 19 **3** 33 51	103 3 **C** 43 67	123 19 **S** 53 83	143 3 **c** 63 99	163 19 **s** 73 115
0 1 0 0	4 SDC **EOT** 4 4	24 DCL **DC4** 14 20	44 4 **$** 24 36	64 20 **4** 34 52	104 4 **D** 44 68	124 20 **T** 54 84	144 4 **d** 64 100	164 20 **t** 74 116
0 1 0 1	5 PPC **ENQ** 5 5	25 PPU **NAK** 15 21	45 5 **%** 25 37	65 21 **5** 35 53	105 5 **E** 45 69	125 21 **U** 55 85	145 5 **e** 65 101	165 21 **u** 75 117
0 1 1 0	6 **ACK** 6 6	26 **SYN** 16 22	46 6 **&** 26 38	66 22 **6** 36 54	106 6 **F** 46 70	126 22 **V** 56 86	146 6 **f** 66 102	166 22 **v** 76 118
0 1 1 1	7 **BEL** 7 7	27 **ETB** 17 23	47 7 **'** 27 39	67 23 **7** 37 55	107 7 **G** 47 71	127 23 **W** 57 87	147 7 **g** 67 103	167 23 **w** 77 119
1 0 0 0	10 GET **BS** 8 8	30 SPE **CAN** 18 24	50 8 **(** 28 40	70 24 **8** 38 56	110 8 **H** 48 72	130 24 **X** 58 88	150 8 **h** 68 104	170 24 **x** 78 120
1 0 0 1	11 TCT **HT** 9 9	31 SPD **EM** 19 25	51 9 **)** 29 41	71 25 **9** 39 57	111 9 **I** 49 73	131 25 **Y** 59 89	151 9 **i** 69 105	171 25 **y** 79 121
1 0 1 0	12 **LF** A 10	32 **SUB** 1A 26	52 10 ***** 2A 42	72 26 **:** 3A 58	112 10 **J** 4A 74	132 26 **Z** 5A 90	152 10 **j** 6A 106	172 26 **z** 7A 122
1 0 1 1	13 **VT** B 11	33 **ESC** 1B 27	53 11 **+** 2B 43	73 27 **;** 3B 59	113 11 **K** 4B 75	133 27 **[** 5B 91	153 11 **k** 6B 107	173 27 **{** 7B 123
1 1 0 0	14 **FF** C 12	34 **FS** 1C 28	54 12 **,** 2C 44	74 28 **<** 3C 60	114 12 **L** 4C 76	134 28 **** 5C 92	154 12 **l** 6C 108	174 28 **|*** 7C 124
1 1 0 1	15 **CR** D 13	35 **GS** 1D 29	55 13 **−** 2D 45	75 29 **=** 3D 61	115 13 **M** 4D 77	135 29 **]** 5D 93	155 13 **m** 6D 109	175 29 **}** 7D 125
1 1 1 0	16 **SO** E 14	36 **RS** 1E 30	56 14 **.** 2E 46	76 30 **>** 3E 62	116 14 **N** 4E 78	136 30 **^** 5E 94	156 14 **n** 6E 110	176 30 **~** 7E 126
1 1 1 1	17 **SI** F 15	37 **US** 1F 31	57 15 **/** 2F 47	77 UNL **?** 3F 63	117 15 **O** 4F 79	137 UNT **_** 5F 95	157 15 **o** 6F 111	177 **DEL (RUBOUT)** 7F 127
	ADDRESSED COMMANDS	UNIVERSAL COMMANDS	LISTEN ADDRESSES		TALK ADDRESSES		SECONDARY ADDRESSES OR COMMANDS (PPE)	(PPD)

* ¦ on some keyboards or systems

KEY

octal	25 PPU	GPIB code
	NAK	ASCII character
hex	15 21	decimal

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COMMITTED TO EXCELLENCE

REF: ANSI STD X3. 4-1977
IEEE STD 488-1978
ISO STD 646-1973

TEKTRONIX STD 062-5435-00 4 SEP 80

TEKTRONIX INSTRUMENTATION SOFTWARE LIBRARY

Utility Software for TM 5000 Instruments

Utility Software is available from Tektronix, Inc. for TM 5000 Instruments. This software consists of a set of subroutines and subprograms that perform common instrument functions over the GPIB such as data acquisition, front-panel set-up, etc. These routines are designed to be easily integrated into your application programs. And since they are small and well documented, the routines are easy to modify to suit your particular applications. Refer to the current Tektronix Instrumentation Software Library Catalog for instrument options, ROM packs, and other required equipment.

The following Utility Software was available when this Instrument Interfacing Guide was printed. Other software may be available; contact your local Tektronix Field Office for further information.

Description	Tektronix Part No.
TM 5000/4041 Utility Software (DC-100 tape)	062-6958-01
TM 5000/4052A Utility Software (DC-300 tape)	062-6957-01

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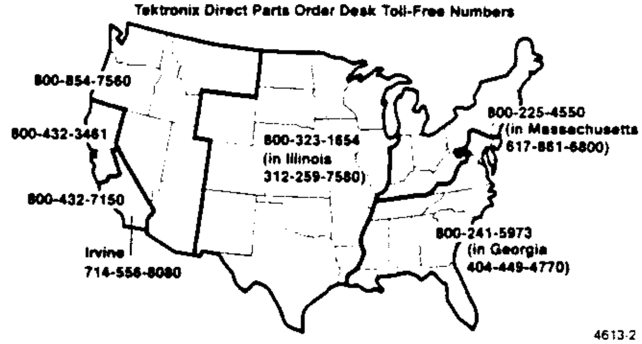

4613-2

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Tektronix Instrumentation Software Library
Tektronix Australia Pty. Limited
Sydney
80 Waterloo Road
North Ryde, N.S.W. 2113

Canada

Tektronix Instrumentation Software Library
Tektronix Canada Ltd.
P.O. Box 6500
Barrie, Ontario
Canada L4M 4V3

Caribbean, Latin America, and Far East (except Japan)

Tektronix Instrumentation Software Library
Export Marketing
Tektronix, Inc.
P.O. Box 500
Beaverton, OR 97077
U.S.A.

Japan

Tektronix Instrumentation Software Library
Sony/Tektronix Corporation
9-31 Kitashinagawa-5
Tokyo 141 Japan

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To contribute a program, submit a copy of the program on media along with a listing and a Tektronix Instrument Software Library release form (see current library catalog). If the program was created as part of your employment, the release must be signed by an authorized representative of your employer. Acceptance of the program is subject to review of the Tektronix Instrumentation Software Library staff.

For further information on submitting a program or for information about coding and documentation standards, contact:

Tektronix Instrumentation Software Library
Tektronix, Inc.
Group 157, 54-016
P.O. Box 500
Beaverton, OR 97077

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Tek Lit. No. 76W-5235

INSTRUCTIONS D'UTILISATION

Introduction

Ce chapitre fournit des indications sur l'installation et le retrait du DM 5010 dans un châssis d'alimentation de la série TM 5000 et décrit les fonctions des commandes et connecteurs de la face avant. Le paragraphe Familiarisation est destiné à faciliter l'utilisation de l'appareil en mode Local (commande manuelle), celui-ci n'étant pas connecté au Bus Interface Général GPIB via le module d'alimentation.

Des informations détaillées sur la programmation du DM 5010 par l'intermédiaire du Bus GPIB sont données au chapitre Programmation.

PREPARATION

Installation et retrait de l'appareil

ATTENTION

A la livraison, le DM 5010 doit être mis sous tension durant 24 heures environ, de façon à ce que sa batterie interne soit suffisamment chargée. Sinon, il pourrait en résulter un fonctionnement défectueux de l'appareil, dû à la perte des facteurs d'étalonnage mémorisés. Pour rappeler de la mémoire ces facteurs d'étalonnage, se référer à la Procédure de Réglage de ce manuel.

NOTE

Le DM 5010 est conçu pour être utilisé dans un Module d'Alimentation de la Série TM 5000. Se référer au manuel d'utilisation du module d'alimentation avant de procéder à l'installation du DM 5010.

Le DM 5010 est étalonné et prêt à l'emploi dés la livraison. S'assurer que le sélecteur de tension réseau du module d'alimentation est correctement positionné. De plus, le DM 5010 contient un cavalier interne de sélection de fréquence réseau. Pour une meilleure réjection du bruit associé à la fréquence du réseau en mode Vitesse de Conversion Rapide (FAST CONVERSION RATE), la position de ce cavalier doit correspondre à la fréquence du réseau. A la livraison, ce cavalier est positionné sur 60 Hz. Des informations supplémentaires sont données au chapitre Maintenance de ce manuel.

ATTENTION

En vue de prévenir toute détérioration de cet instrument, couper l'alimentation du module d'alimentation avant l'installation ou le retrait de tout tiroir. Installer et ôter le tiroir avec précaution.

Veiller à ce que les détrompeurs (du connecteur du compartiment sélectionné du module d'alimentation) coïncident avec les encoches du connecteur du tiroir. Si ce n'est pas le cas, ne pas installer le DM 5010 avant d'en découvrir la raison. Une fois cette condition satisfaite, aligner les rainures supérieures et inférieures du tiroir avec les guides du compartiment sélectionné (voir Fig. 2.1). Insérer le Multimètre dans le châssis et le pousser à fond pour que le circuit imprimé se place correctement. Mettre le module en marche (commutateur POWER).

Pour extraire le multimètre du module d'alimentation, couper l'alimentation (commutateur POWER), tirer le bouton de déverrouillage (coin gauche à l'avant du tiroir). Tirer l'instrument hors du compartiment en le maintenant dans la position horizontale.

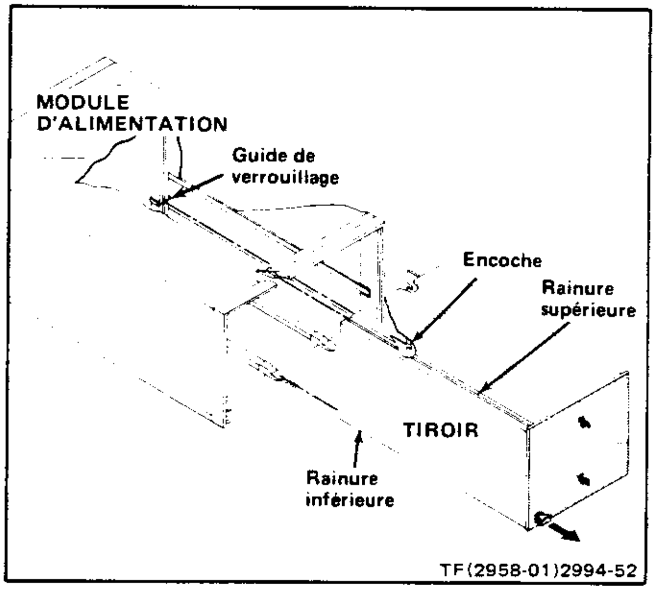


Fig. 2.1. Installation et retrait du tiroir.

COMMANDES ET CONNECTEURS DE LA FACE AVANT

Informations générales

Les 17 boutons poussoirs de la face avant indiqués ci-dessous correspondent chacun à une fonction de l'instrument. Ils s'allument une fois enfoncés. Les boutons de la colonne de gauche s'annulent respectivement : un seul bouton est allumé à la fois. Les boutons de la colonne de droite restent allumés jusqu'à ce qu'on les enfonce de nouveau.

DCV	NULL
OHMS	LOW FREQ RESPONSE
DIODE TEST	AUTO
ACV	RUN
ACV + DCV	TRIGGERED
	FAST
	AVERAGE
	$\frac{X-B}{A}$
	dBm
	dBr
	COMPARE
	REAR INPUT

Les boutons poussoirs restants (23) ne s'allument pas. Voir figure 2.2.

Fenêtre d'affichage

La partie gauche de la fenêtre contient les mesures et les résultats des calculs affichés sur 4 chiffres et demi (DELs). Les zéros à gauche du point décimal sont supprimés. Un clignotement indique un dépassement de gamme au cours d'une mesure de tension. "OC" est affiché pour les fonctions OHMS et DIODE TEST.

La partie centrale indique la gamme de mesure sélectionnée. Une DEL allumée en vis-à-vis de l'un des mots MILLI, KILO et MEGA indique l'unité de mesure affichée en milli, kilo, ou mega. Le point décimal est fixe à l'intérieur d'une même gamme de mesure. La DEL et l'emplacement du point décimal indiquent la gamme sélectionnée en modes Sélection Automatique (AUTO) et Sélection Manuelle (par incréments - STEP). Voir figure 2.2.

La partie droite de la fenêtre d'affichage indique le mode d'utilisation de l'instrument, à savoir :

REMOTE et ADDRESSED s'allument lorsque l'instrument fonctionne sous contrôle de programme à distance via le Bus GPIB.

ERROR s'allume pour une erreur interne, une erreur décelée au cours d'un auto-test, ou une erreur d'utilisation. La partie gauche de la fenêtre affiche également les codes d'erreurs indiquant le type d'erreur. Se référer au tableau 2.2 du paragraphe Familiarisation de ce même chapitre.

Fonction	Multiplicateur éclairé	Gamme sélectionnée			
DCV	• MILLI			200 mV	
		2 V	20 V	200 V	1000 V
ACV et ACV + DCV	• MILLI			200 mV	
		2 V	20 V	200 V	700 V
OHMS				200 Ω	
	• KILO	2 kΩ	20 kΩ	200 kΩ	
	• MEGA	2 MΩ	20 MΩ		
DIODE TEST		Utilise la gamme 2 V continus			

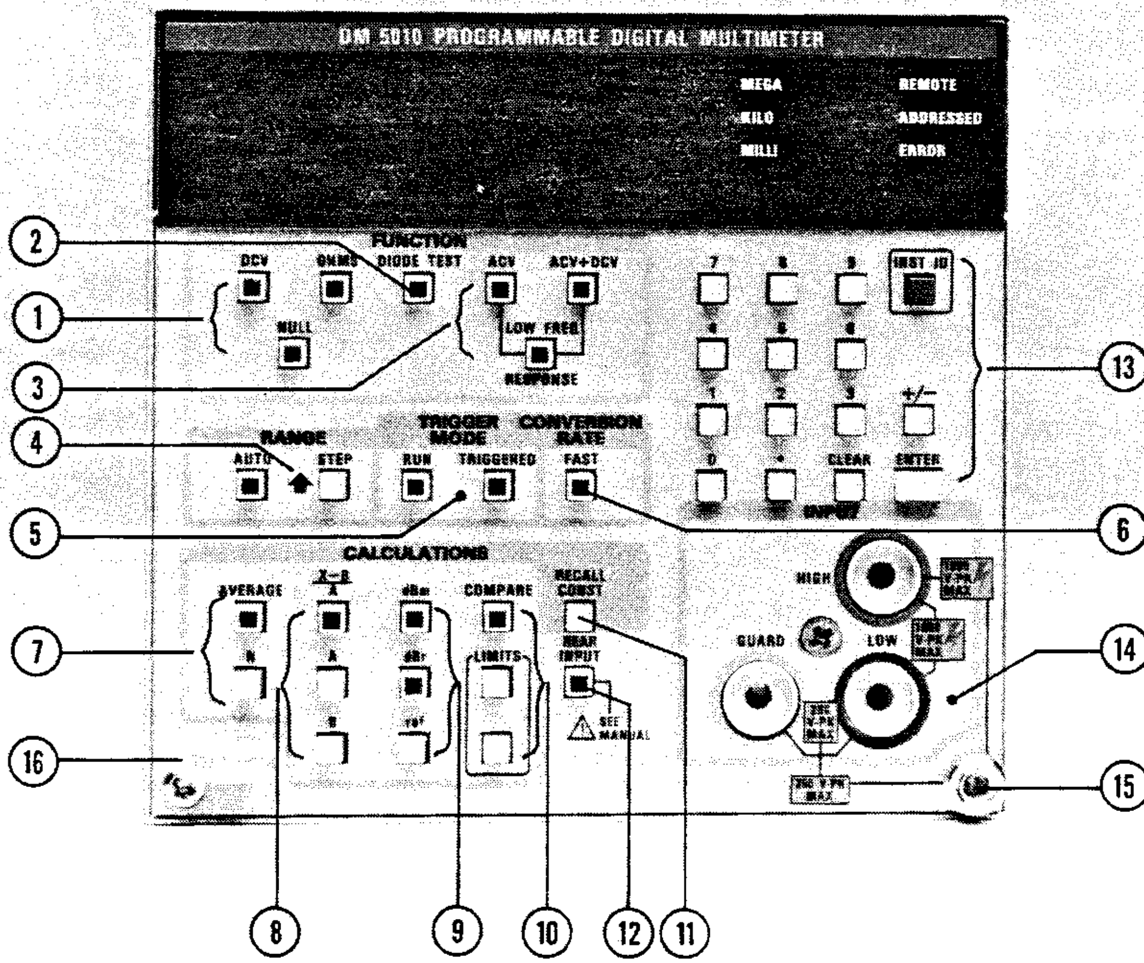
1 . 9 . 9 . 9 . 9

Indication "hors-gamme" :
Clignotement pour les mesures de tension
"OC" affiché pour les fonctions OHMS et DIODE TEST

Noir quand la commande FAST CONVERSION RATE est inhibée

TF2994-02

Fig. 2.2. Indications des gammes de mesure.



2994-03

Fig. 2.3. Commandes et connecteurs de la face avant du DM 5010.

Commandes et connecteurs

La liste suivante décrit les commandes et connecteurs de la face avant du DM 5010. Voir figure 2.3.

FONCTIONS

1 **DCV**
Bouton allumé - le DM 5010 mesure les tensions continues appliquées aux connecteurs de la face avant ou de l'interface arrière. Les gammes de mesure utilisées avec cette fonction sont : 200 mV, 2V, 20V, 200V, et 1000V.

OHMS
Bouton allumé - Sélectionne le mode Mesure de Résistances. Les résistances appliquées aux connecteurs de la face avant ou de l'interface arrière sont mesurées dans les gammes 200 Ω, 2 KΩ, 20 KΩ, 200 KΩ, 2 MΩ et 20 MΩ.

NULL
Opère en mode DCV (tension continue), OHMS, DIODE TEST, ACV (tension alternative) et ACV + DCV (quelle que soit la gamme sélectionnée). Bouton allumé - mesure et mémorise la valeur de la résistance ou de la tension existant aux bornes des connecteurs de la face avant ou de l'interface arrière. Le décalage mémorisé est appliqué aux mesures suivantes et aux résultats affichés. Cette valeur peut représenter jusqu'à ± 100 % de la gamme. Lorsqu'on passe à une autre fonction ou que l'on inhibe la fonction NULL (appuyer sur le bouton NULL), ce décalage n'est plus appliqué. La valeur mémorisée est conservée en mémoire jusqu'à un autre décalage (NULL) ou jusqu'à la sélection d'une autre fonction de mesure.

AVERTISSEMENT

En mode NULL, la mesure affichée peut ne pas indiquer la valeur de la tension appliquée aux connecteurs d'entrée.

2 **DIODE TEST**
Bouton allumé - génère un courant continu de 1 mA, disponible sur le connecteur HIGH de la face avant ou de l'interface arrière. Celui-ci passe normalement du connecteur HIGH au connecteur LOW via un composant connecté entre les deux. La tension développée à travers ce composant est mesurée et affichée (gamme 2 V continus).

3 **ACV**
Bouton allumé - Le DM 5010 mesure et affiche des tensions alternatives efficaces vraies. Les tensions appliquées sont couplées intérieurement (couplage alternatif) au convertisseur de tension efficace. Les gammes utilisées sont : 200 mV, 2 V, 20 V, 200 V et 700 V.

ACV + DCV
Bouton allumé - Le DM 5010 mesure et affiche des tensions alternatives vraies élevées à un niveau de tension continu. Les tensions appliquées sont couplées intérieurement (couplage continu) au convertisseur de tension efficace. Les gammes utilisées sont : 200 mV, 2 V, 20 V, 200 V et 700 V.

LOW FREQ RESPONSE
Bouton allumé et en mode ACV ou ACV + DCV - L'instrument moyenne quatre mesures et affiche la valeur moyenne de ces mesures, puis répète cette séquence d'opérations. Cette fonction permet d'effectuer des mesures stables de tensions alternatives basse fréquence. La limite de fréquence spécifiée est 10 Hz. Toutefois, cette fonction est utilisable sur toute la plage de fréquences du DM 5010.

GAMME

4 **AUTO**
Bouton allumé - La sélection de gamme est automatique. A la limite supérieure d'une gamme, le DM 5010 sélectionne automatiquement la gamme supérieure. Si la valeur mesurée est inférieure à 9,5 % de la gamme (pour la plupart des gammes), le DM 5010 sélectionne la gamme inférieure.

STEP ⬆
Incrémente d'une gamme de mesure ; cette gamme est maintenue jusqu'à ce qu'on appuie sur la touche AUTO (Sélection de Gammes Automatique) ou de nouveau sur la touche STEP. Elle ne varie pas si l'on sélectionne une autre fonction de mesure (DCV, OHMS, DIODE TEST, ACV, ACV + DCV), sauf si la commutation dans la fonction OHMS fait passer dans la gamme maximale. Une incrémentation de la gamme maximale fait passer dans la gamme minimale.

MODE DE DECLENCHEMENT

5 **RUN**
Bouton allumé - Les conversions sont déclenchées librement à la vitesse sélectionnée. Pour la sélection de la Vitesse de Conversion, se référer à FAST.

TRIGGERED
Bouton allumé - Déclenche et affiche une mesure. Une nouvelle pression sur ce bouton déclenche la mesure suivante (ou la réception du signal de déclenchement EXTRIG). L'utilisation du signal EXTRIG nécessite l'installation d'un cavalier interne par un personnel de maintenance qualifié. Le bouton TRIGGERED clignote rapidement lors d'un déclenchement correct.

PLAGE DE CONVERSION

6 **FAST**
Bouton allumé - La vitesse de conversion (affichée) est la vitesse maximale spécifiée pour la fonction de mesure sélectionnée. La résolution pour cette vitesse de conversion est 3,5 chiffres.
Non allumé - La conversion a lieu à la vitesse normale spécifiée pour la fonction de mesure sélectionnée. Les résultats sont affichés sur 4,5 chiffres.

7 **AVERAGE**
Bouton allumé - Le DM 5010 calcule la moyenne d'une série de mesures. La valeur de la constante N détermine le nombre de mesures moyennées. Pour calculer la moyenne, l'instrument accumule les valeurs mesurées et divise la somme par le nombre de moyennes effectuées. Si l'on se trouve également en mode LOW FREQ RESPONSE (Réponse en Basse Fréquence), le nombre de mesures moyennées est quatre fois supérieur à la valeur de la constante N. En mode TRIGGERED, un seul déclenchement est nécessaire pour initialiser toutes les mesures utilisées dans le calcul de la Moyenne.

N
Ce bouton est utilisé pour mémoriser une constante ou rappeler une constante utilisée précedemment pour le calcul de la Moyenne (AVERAGE). Cette constante détermine le nombre de mesures moyennées. A la mise en service, la valeur de N est 2. On peut lui substituer tout nombre entier positif entre ≥ 1 et ≤ 19999.

8 $\mathbf{\frac{X-B}{A}}$
Bouton allumé - Le DM 5010 soustrait d'une mesure une constante de décalage mémorisée, divise le résultat par une constante Facteur d'échelle mémorisée, et affiche le résultat. La constante Décalage est B, la constante Facteur d'échelle est A et la mesure est X.

A,B
Ces boutons sont utilisés pour mémoriser ou rappeler les constantes utilisées dans le calcul de X-B/A. A la mise en service, la valeur de A est 1, la valeur de B est 0. Il est possible de substituer n'importe quel nombre à ces constantes (entier, décimal, positif ou négatif), excepté la valeur 0 pour A.

9 **dBm**
Bouton allumé - Le DM 5010 calcule et affiche le rapport de deux puissances. La référence est 1 mW dans une résistance de 600 Ω.
En appliquant la formule :

$$dBm = 20 \log_{10} \left| \frac{X_1}{\sqrt{.6}} \right|$$

X_1 étant la mesure de tension. Le logarithme de la valeur absolue de $X_1/\sqrt{0{,}6}$ est calculé.

dBr
Bouton allumé - Le DM 5010 calcule et affiche le rapport logarithmique d'une mesure sur la constante de référence mémorisée (bouton ref), en utilisant la formule :

$$dBr = 20 \log_{10} \left| \frac{X_1}{ref} \right|$$

X_1 étant la mesure. Le logarithme de la valeur absolue de X_1/ref est calculé.

ref
Ce bouton est utilisé pour mémoriser une constante, ou rappeler une constante utilisée, dans le calcul de dBr. A la mise sous tension, la valeur de ref est 1. Cette valeur peut être tout autre nombre différent de 0.

10 **COMPARE**
Bouton allumé - Le DM 5010 compare la mesure suivante avec les limites définies par les constantes LIMITS. Si la mesure comparée est : - algébriquement inférieure aux deux constantes, le mot LO est affiché ; - algébriquement supérieure aux deux constantes, le mot HI est affiché ; - égale à l'une des constantes ou comprise entre les deux constantes, le mot PASS est affiché.

LIMITS (2)
Boutons utilisés pour mémoriser ou rappeler les constantes utilisées comme limites dans le calcul de la comparaison (COMPARE). Les valeurs des constantes sont égales à 0 à la mise en service.

11 **RECALL CONST**
Une pression sur ce bouton, puis sur l'un des boutons d'entrée/rappel d'une constante (N, A, B, ref, LIMITS) provoque l'affichage de la constante mémorisée correspondante.

12 **REAR INPUT** ⚠
Voir au paragraphe Familiarisation de ce manuel les mesures via l'interface arrière.
Bouton allumé - Sélectionne les entrées sur l'interface arrière au lieu des entrées en face avant.

13 **Chiffres (0 à 9), point décimal et signe.**
Ces boutons sont utilisés pour entrer les valeurs numériques, décimales et la polarité des constantes.

CLEAR
Lorsqu'un code d'erreur est affiché (dans la fenêtre d'affichage), une pression sur ce bouton efface ce code d'erreur. Lors de l'entrée d'une constante, efface la valeur d'une constante non encore entrée (par la touche ENTER).

ENTER
Lors de l'entrée d'une constante, mémorise cette constante et affiche la valeur mémorisée.

INST ID
Provoque l'affichage de l'adresse primaire de l'instrument et, si la commande Requête de l'Utilisateur (USEREQ) a été validée, génère une Demande de Service (SRQ) sur le Bus GPIB. Le signe "moins" est éclairé en mode Emetteur Seulement et le point décimal droit s'allume si la fin de message sélectionnée est LF/EOI (et non EOI ONLY).

ENTREES

14 **Connecteur HIGH**
Entrée analogique flottante haute utilisée avec les connecteurs LOW et GUARD pour toutes les mesures en face avant.

Connecteur LOW
Entrée analogique flottante basse utilisée avec le connecteur HIGH.

Connecteur GUARD
Entrée isolée reliée à un écran entourant le circuit analogique de l'instrument. Utilisé avec un conducteur de garde (GUARD), cette entrée est normalement connectée au conducteur de test LOW par l'utilisateur au point de mesure. Sinon, le connecteur GUARD est relié au connecteur LOW par un contact interne monté dans le connecteur. Ce connecteur permet d'augmenter la réjection en mode Commun.

15 **Connecteur à la masse du châssis.**

16 **Tirette de déverrouillage. Tirer pour ôter le tiroir.**

FAMILIARISATION

Voici une description des commandes et connecteurs de la face avant du DM 5010 utilisés en mode Local.

Auto-test à la mise en service

A la mise en service, le DM 5010 exécute un programme d'auto-test. Durant l'auto-test, toutes les DELs de la face avant sont allumées. Après l'auto-test, l'instrument passe à l'état Local (LOCS) ; les réglages (par défaut) à la mise en service sont indiqués au tableau 2.1.

Tableau 2.1
Réglages à la mise en service
(Fonctions en face avant seulement)

Commandes en face avant	Etat
DCV	Enfoncée
OHMS	Sortie
NULL	(Sortie) Constante = 0
DIODE TEST	Sortie
ACV	Sortie
ACV+DCV	Sortie
LOW FREQ RESPONSE	Sortie
AUTO	Enfoncée
STEP	Sortie
RUN	Enfoncée
TRIGGERED	Sortie
FAST	Sortie
AVERAGE	Sortie
N	Constante = 2
$\frac{X-B}{A}$	Sortie
A	Constante = 0
B	Constante = 1
dBm	Sortie
dBr	Sortie
ref	Constante = 1
COMPARE	Sortie
LIMITS	Constantes = 0,0
REAR INPUT	Sortie

En cas de détection d'une erreur interne durant l'auto-test, l'instrument affiche continûment un code d'erreur sur 3 chiffres dans la fenêtre d'affichage et l'indicateur ERROR est éclairé. Voir tableau 2.2. Pour découvrir l'origine d'une erreur, s'adresser à un personnel de maintenance qualifié.

Tableau 2.2
CODES D'ERREURS AFFICHES EN FACE AVANT

Code affiché	Condition anormale
	Erreurs d'exécution :
205	Argument hors-gamme
231	L'instrument n'est pas en position étalonnée
232	Hors des limites étalonnées
	Erreurs internes :
303	Erreur dans le bloc mathématique
311	Temps de conversion erroné
317	Temps de réponse en face avant erroné
318	Constante d'étalonnage erronée
340	RAM erronée
341	RAM erronée
351	Checksum d'étalonnage erronée
372	ROM C000 mal positionnée
373	ROM D000 mal positionnée
374	ROM E000 mal positionnée
392	Checksum de la ROM C000 erroné
393	Checksum de la ROM D000 erroné
394	Checksum de la ROM E000 erroné
395	Checksum de la ROM F000 erroné

Instructions générales d'utilisation

Laisser l'instrument chauffer 30 minutes, pour obtenir la précision spécifiée. Dans les fonctions OHMS et DIODE TEST, un dépassement de gamme provoque l'affichage de "OC". Dans les fonctions DCV, ACV et ACV + DCV, un dépassement de gamme est indiqué par un affichage clignotant.

ATTENTION

Veiller à ne pas dépasser la tension d'entrée maximale.

Pour toutes les fonctions de mesure, la sélection de gammes peut être automatique (AUTO) ou manuelle (STEP). Voir au paragraphe Fenêtre d'affichage l'indication de la gamme utilisée. La fonction DIODE TEST n'utilise que la gamme 2V.

ATTENTION

En mode Sélection de Gamme Automatique, ne pas passer de manière répétitive d'une tension basse (< 200 mV crête) à une tension haute (> 200 V crête). Dans le cas d'alternances répétées de tensions extrêmes, utiliser la commande STEP pour sélectionner la gamme supérieure appropriée avant d'augmenter la tension d'entrée. Le risque est d'obtenir des mesures temporaires erronées en utilisant la gamme 200 mV.

Connexions d'entrée

Les bornes HIGH, LOW et GUARD sont utilisées pour les mesures en face avant. Un contact interne (dans la borne GUARD) relie les bornes LOW et GUARD. Ce contact est fermé jusqu'à ce qu'un cordon de mesure soit inséré dans la borne GUARD. Il reste ouvert jusqu'au retrait de ce cordon.

La figure 2.4 illustre trois exemples d'utilisation des connecteurs de la face avant. La méthode la plus couramment utilisée est la méthode A lorsqu'on néglige la tension de mode commun. Dans cet exemple, seules les bornes LOW et HIGH du DM 5010 sont utilisées. Aucun cordon n'étant inséré dans la borne GUARD, le contact interne (dans la borne) est fermé et relie les bornes LOW et GUARD. Ceci entraîne le passage du courant de mode commun à travers le cordon LOW et la masse de la source d'alimentation, provoquant une erreur de mesure.

La méthode B permet d'obtenir une précision optimale, lorsqu'on désire éliminer la tension de mode commun. La borne GUARD du DM 5010 est reliée à la borne LO de la source. Le courant de mode commun circule à travers le conducteur de garde (GUARD) et la masse de la source d'alimentation mais non à travers le circuit de mesure (cordon LOW).

Méthode C - La borne GUARD du DM 5010 est reliée à la masse de la source. Ceci peut produire une erreur de mesure, du fait que le courant de mode commun circule dans le circuit de mesure.

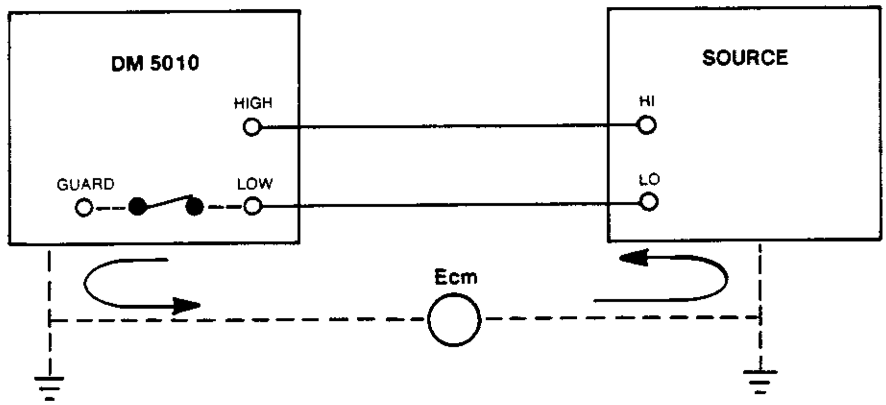
AVERTISSEMENT

Pour éliminer tout risque d'électrocution par les tensions mesurées :

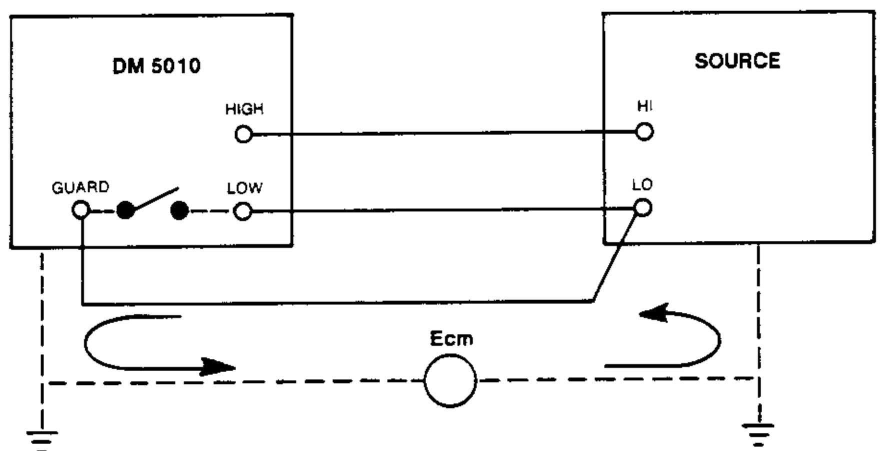
1. *Eviter tout contact avec la source de tension, si la tension mesurée dépasse 42,4 V crête.*
2. *Déconnecter les cordons du circuit sous test avant de les débrancher du DM 5010 ou avant d'ôter le DM 5010 du module d'alimentation.*

Mesures sur l'interface arrière ⚠

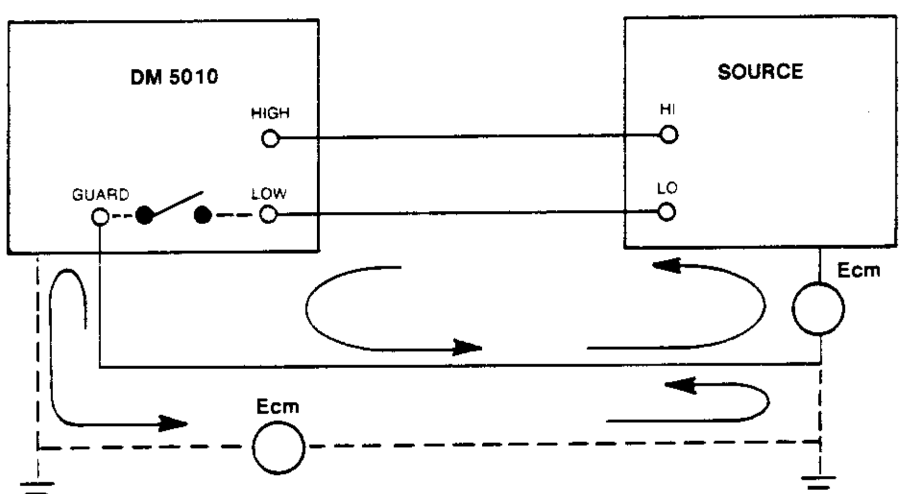
Si le bouton REAR INPUT est enfoncé (allumé), les signaux appliqués aux broches 28B (HI) et 28A (LO) de l'interface arrière sont mesurés. Si ce bouton est sorti (éteint), les signaux mesurés sont ceux appliqués aux bornes de la face avant.



A. Connexion (interne) entre la borne GUARD et la borne LOW du DM 5010. Erreur de mesure due à la tension de mode commun (Emc).



B. Connexion entre la borne GUARD et la borne basse (LO) de la source. Pas d'erreur due à la tension de mode commun.



C. Connexion entre la borne GUARD et la masse du châssis d'alimentation. Erreur minime due à la tension de mode commun, la tension de mode commun se situant au niveau des deux masses.

TF2994-04

Fig. 2.4. Exemples de méthodes de connexion en face avant.

ATTENTION

Pour ne pas endommager l'appareil, ne pas appliquer de tension supérieure à 42,4 V alternatifs crête ou à 60 V continus entre les broches 28B (HI) et 28A (LO) du connecteur de l'interface arrière P1031 de la carte ADC (A17).

ATTENTION

Si une tension supérieure à 500 V crête est appliquée sur les bornes de la face avant, ne pas valider les entrées de l'interface arrière, pour éviter tout risque de détérioration de l'instrument ou de fonctionnement erroné.

Mesures de tensions continues

Une pression sur le bouton DCV valide des mesures de tensions continues dans les gammes : 200 mV, 2 V, 20 V, 200 V et 1000 V. Lorsque l'entrée HIGH est positive par rapport à l'entrée LOW, le signe "+" est affiché. Ne pas dépasser les tensions maximales autorisées en entrée.

Mesures de résistances

Une pression sur le bouton OHMS valide des mesures de résistances dans les gammes : 200 Ω, 2 KΩ, 20 KΩ, 200 KΩ, 2 MΩ et 20 MΩ. Le courant passe normalement de la borne HIGH vers la borne LOW. Les courants et tensions maximaux entre bornes et à pleine échelle (sans dépassement de gamme) sont indiqués au tableau 2.3. La tension maximale (en circuit ouvert) disponible entre la borne HIGH et la borne LOW est inférieure à 5 V.

Tableau 2.3
TENSIONS DE SOURCE
(FONCTION OHMS)

Gamme	Courant typique (0 Ω à la pleine échelle)	Tension max. (pleine échelle)
200 Ω	de 1,02 mA à 1 mA	
2 K Ω	de 0,12 mA à 0,1 mA	
20 KΩ	de 9,2 μA à 10 μA	0,2 V
200 KΩ	de 1,08 μA à 1 μA	
2 MΩ	de 0,12 μA à 0,1 μA	
20 MΩ	de 0,12 μA à 0,04 μA	0,8 V

Mesure de diodes

Une pression sur le bouton DIODE TEST valide la génération d'un courant de 1 mA continus sur la borne HIGH. La variation de tension aux jonctions de la diode se mesure en connectant l'anode de la diode à la borne HIGH et la cathode à la borne LOW. Les diodes doivent, pour être testées, présenter une variation de tension inférieure à 1,999 volt. C'est le cas de la plupart des diodes et DELs.

Pour tester la tension inverse, inverser les connexions. "OC" doit apparaître dans la fenêtre d'affichage.

Mesures de tensions alternatives

Il existe deux fonctions de mesure de tensions alternatives :
1. Mesure de tensions alternatives efficaces vraies (ACV)
2. Mesure de tensions alternatives efficaces vraies superposées à un niveau continu (ACV + DCV).

Les gammes de mesure pour ces deux fonctions sont 200 mV, 2 V, 20 V, 200 V et 700 V. Les tensions peuvent être mesurées avec un facteur de crête maximal de 4 pour la pleine échelle. Le facteur de crête est le rapport tension crête sur tension efficace. Veiller à ne pas dépasser la tension maximale autorisée en entrée. La fonction LOW FREQ RESPONSE permet d'effectuer des mesures stables de tensions alternative en basse fréquence. Cette fonction effectue la moyenne de 4 mesures de tensions alternatives.

Vitesses de conversion

Le DM 5010 utilise deux vitesses de conversion. La vitesse FAST (bouton CONVERSION RATE allumé) permet d'effectuer des mesures à la vitesse maximale spécifiée pour la fonction sélectionnée. La résolution de l'affichage est de 3,5 chiffres. Lorsque le bouton CONVERSION RATE est éteint, les mesures sont effectuées à la vitesse normale spécifiée pour la fonction sélectionnée avec une résolution d'affichage de 4,5 chiffres.

Déclenchement

Le DM 5010 possède deux modes de déclenchement, les modes RUN et TRIGGERED. Une pression sur le bouton RUN valide des conversions en mode relaxé à la vitesse de conversion sélectionnée. Une pression sur le bouton TRIGGERED valide une mesure à la fois.

En outre, les conversions peuvent être déclenchées via le connecteur de l'interface arrière, broches 16A et 16B (LO) sur la carte Isolation (A15). Ceci nécessite l'installation d'un cavalier (se référer au chapitre Maintenance). L'installation de ce cavalier valide la fonction de déclenchement EXTRIG (en plus de RUN et TRIGGERED). Pour utiliser cette fonction, appuyer sur le bouton TRIGGER pour mettre fin au déclenchement relaxé. La fonction EXTRIG nécessite un signal de déclenchement interne compatible TTL, flanc négatif. Pour un déclenchement unique, cette ligne doit être maintenue à l'état bas pendant 0,5 μs (10 μs max.) . Son maintien prolongé à l'état bas provoquerait le déclenchement de plusieurs mesures consécutives.

Calculs

Cinq boutons en face avant permettent d'effectuer des calculs sur les mesures effectuées par le DM 5010. Ces calculs peuvent être exécutés individuellement ou séquentiellement. Une séquence de calculs peut être entrée dans n'importe quel ordre (boutons enfoncés). Toutefois, le DM 5010 les exécute dans l'ordre suivant : AVERAGE, X-B/A, dBm ou dBr, COMPARE. L'instrument affiche le résultat de chaque calcul. Les fonctions NULL et LOW FREQ, si elles ont été validées, sont exécutées en priorité. Les calculs dBm et dBr ne peuvent être effectués dans la même séquence. Seule la dernière fonction validée (dBm ou dBr) est exécutée. Un déclenchement démarre l'exécution d'un calcul unique, ou d'une séquence de calculs. En mode RUN (Déclenchement Relaxé), tout calcul ou séquence de calculs est répété jusqu'à ce qu'il soit inhibé (bouton correspondant enfoncé de nouveau), ou jusqu'à ce que la sélection d'un autre mode de déclenchement ou d'une autre fonction de mesure soit effectuée. Les DELs d'affichage sont éteintes pendant l'exécution du calcul. L'instrument affiche "OC" pour signaler un dépassement de gamme pour un résultat de calcul.

A l'exception de la fonction dBm, chaque calcul utilise une constante ou plus. La valeur numérique de chaque constante mémorisée prend une valeur par défaut à la mise en service. Cette valeur peut être remplacée par toute autre à l'intérieur des limites spécifiées. Le tableau 2.4 contient la liste de chaque calcul et constante(s) associée(s), des valeurs par défaut des constantes, et des limites associées à chaque constante.

Modification des valeurs des constantes

Deux méthodes permettent de changer la valeur d'une constante en mémoire.

1. Utilisation du clavier numérique :

   a. Appuyer sur le bouton de la constante sélectionnée.

   b. Appuyer sur les touches de clavier numériques pour afficher la nouvelle valeur de la constante (dans les limites spécifiées tableau 2.4).

   c. Appuyer sur la touche ENTER.

2. Utilisation d'une mesure affichée. (Remplace la valeur d'une constante par la valeur de la mesure affichée). S'assurer que la mesure affichée correspond aux limites spécifiées pour cette constante (tableau 2.4).

   a. Appuyer sur le bouton de la constante sélectionnée.

   b. Appuyer sur la touche ENTER.

TABLEAU 2.4
FONCTIONS CALCUL ET CONSTANTES ASSOCIEES

Calcul	Constante	Valeur par défaut	Plage de constantes valides
AVERAGE	N	2	+1 à +19999
X-B / A	B (décalage) A (facteur d'échelle)	0 1	nombre entier ou décimal, + ou -, nombre entier ou décimal, ≠ 0, + ou -
dBm			
dBr	ref	1	nombre entier ou décimal, ≠ 0, + ou -,
COMPARE	LIMITS (2)	0	

Après toute pression sur la touche ENTER, le DM 5010 affiche la valeur de la constante mémorisée. Toute nouvelle valeur valide est affichée. Sinon, la valeur affichée est la valeur précédemment entrée. Chaque valeur d'une constante est conservée en mémoire jusqu'à l'entrée d'une nouvelle valeur, ou jusqu'à ce que l'alimentation du DM 5010 soit coupée.

Exemples de calculs

Voici quelques exemples d'application des fonctions de calcul du DM 5010.

Exemple 1 : Utilisation de la fonction X-B/A pour afficher la différence entre la tension nominale et la tension Zener mesurée.

Régler les commandes en face avant de la façon suivante :

DCV	enfoncée
NULL	sortie
LOW FREQ RESPONSE	sortie
RANGE	sur la position AUTO
TRIGGER MODE	sur la position RUN
CONVERSION RATE	commande FAST sortie
CALCULATIONS	
$\frac{X-B}{A}$	enfoncée
Toutes les autres	sorties
REAR INPUT	sortie

Entrer "1" pour la constante A.

Entrer "15" pour la constante B (pour une diode Zener de 15V).

Connecter la diode Zener, la résistance et l'alimentation aux entrées du DM 5010, comme indiqué figure 2.5. La valeur de la résistance et de l'alimentation déterminent le courant Zener.

La tension affichée est instable jusqu'à ce que le courant traversant la diode prenne sa valeur finale. Lorsque l'affichage devient stable, la tension affichée est la différence entre la tension Zener nominale (15V) et la tension Zener mesurée.

Pour obtenir le pourcentage correspondant à la différence de tension, remplacer la constante A par 0,15, A étant égale à B (0,01).

Exemple 2 : Utilisation de la fonction dBr pour découvrir le point d'un amplificateur audiofréquence -3dB (par rapport à la valeur milieu).

Régler les commandes de la face avant de la façon suivante :

ACV	enfoncée
NULL	sortie
LOW FREQ RESPONSE	sortie
RANGE	sur la position AUTO
TRIGGER MODE	sur la position RUN
CONVERSION RATE	commande FAST sortie
CALCULATIONS	sortie
REAR INPUT	sortie

Entrer "1" pour la constante de référence (ref). Connecter le générateur sinusoïdal, l'amplificateur audiofréquence et le DM 5010 comme indiqué figure 2.6.

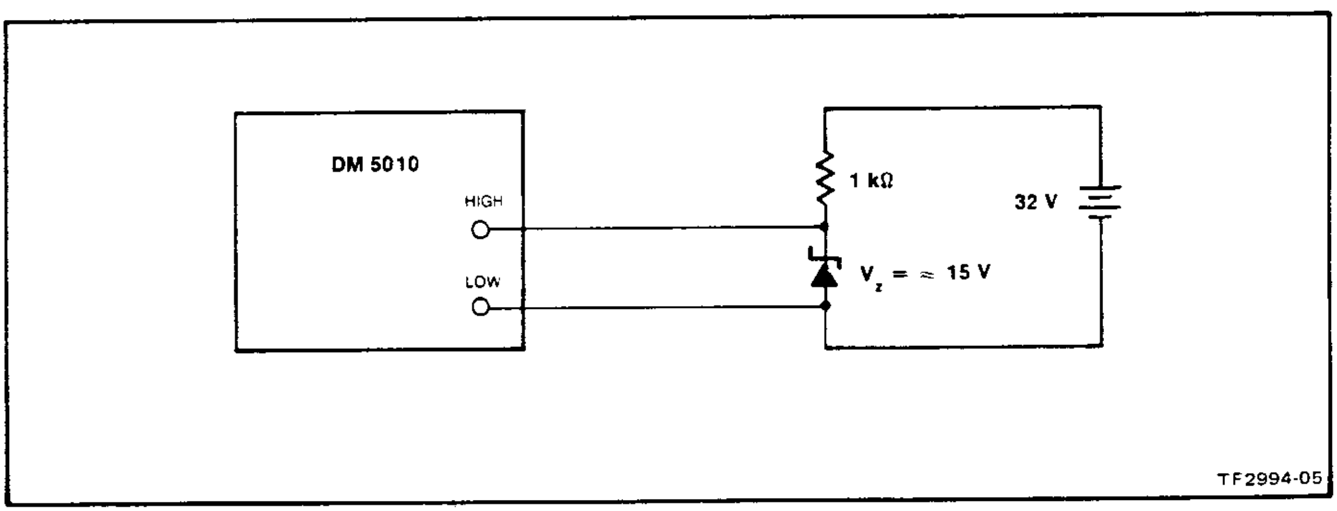


Fig. 2.5. Installation nécessaire au calcul de l'exemple 1

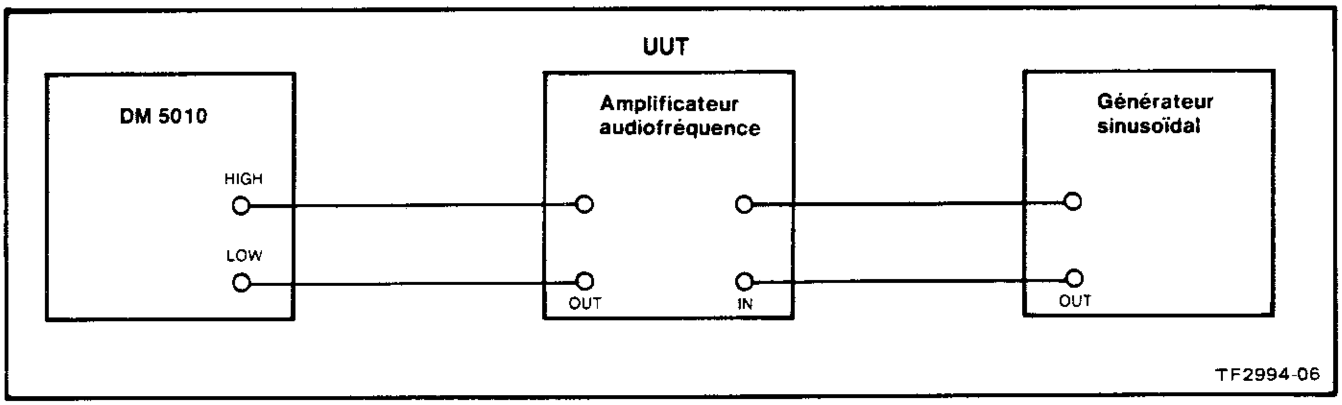


Fig. 2.6. Installation nécessaire au calcul de l'exemple 2.

Régler le générateur sinusoïdal à mi-bande (dans cet exemple 5 KHz) ; régler son amplitude de façon à lire 1 V sur le DM 5010.

Appuyer sur le bouton dBr. La valeur "0.0" est affichée.

Réduire la fréquence du générateur jusqu'à ce que la valeur "-3.00." soit affichée sur le DM 5010 (ne pas retoucher l'amplitude). La fréquence du générateur correspond au point -3dB de l'amplificateur audiofréquence.

Exemple 3 : Utilisation de la fonction COMPARE pour sélectionner des résistances différant de ± 2 % de la valeur nominale.

Régler les commandes de la face avant du DM 5010 de la façon suivante :

OHMS	enfoncée
NULL	sortie
LOW FREQ RESPONSE	sortie
RANGE	sur la position AUTO
TRIGGER MODE	sur la position RUN
CONVERSION RATE	commande FAST sortie
CALCULATIONS	
COMPARE	enfoncée
Toutes les autres	sorties
REAR INPUT	sortie

Pour sélectionner des résistances 15 KΩ à ± 2 % de la valeur nominale, entrer "15300" pour l'une des limites (LIMITS) et "14700" pour l'autre. Connecter la première résistance à trier aux bornes HIGH et LOW du DM 5010. Le DM 5010 affiche "HI" ou "LO" pour indiquer le dépassement de la tolérance 2 % ou l'infériorité à cette tolérance. Si la résistance est comprise dans les limites ou égale aux limites, le DM 5010 affiche "PASS".

Les fonctions de calcul COMPARE et X-B/A peuvent être combinées dans l'exemple ci-dessus. Ceci élimine la nécessité d'afficher les valeurs de tolérance. Seule la valeur nominale de la résistance et la tolérance sont utilisées comme constantes.

Entrer "15000" dans B (résistance nominale).

Entrer "150" dans A, A étant égale à B (.01). Ceci convertit la différence entre la valeur nominale et la valeur réelle en "1 %".

Entrer "2" pour une limite (LIMITS) (tolérance de 2 %).

Entrer "-2" pour l'autre.

Appuyer sur la touche X-B/A.

Le DM 5010 affiche PASS, HI, ou LO.

Instructions de réemballage

Si le DM 5010 doit être renvoyé à un centre de maintenance Tektronix pour une révision ou une réparation, y apposer une étiquette portant le nom (et l'adresse) de la société utilisatrice et le nom de la personne à y contacter, ainsi que le numéro de série complet de l'instrument et la description du défaut constaté.

Si l'emballage d'origine n'est plus disponible, emballer l'appareil de la façon suivante :

Se procurer un carton résistant dont les dimensions internes soient supérieures de 15 cm aux dimensions de l'appareil. La résistance de l'emballage doit être de 90 kg/cm.

Entourer l'instrument d'une feuille de polyethylène.

Tapisser le fond et les bords de mousse d'urethane sur une épaisseur de 7,5 cm.

Fermer le carton au moyen d'une bande adhésive.

BEDIENUNGSANLEITUNG

Einführung

Dieser Abschnitt des Handbuches gibt Hinweise zum Ein- und Ausbau des Gerätes und beschreibt die Funktionen der Bedienungselemente und Anschlüsse auf der Frontplatte des DM 5010. Diese Informationen dienen nur als Hilfe zum Verständnis der manuellen Bedienung des DM 5010. Es wird dabei vorausgesetzt, daß das DM 5010 nicht über die Versorgungseinheit mit dem GPIB verbunden ist.

Vollständige Informationen zur Programmierung des DM 5010 über den GPIB (General Purpose Interface Bus) enthält der Abschnitt „Programmierung".

VORBEREITENDE ARBEITEN

Ein- und Ausbau

VORSICHT

Nach Erhalt des Gerätes sollte das DM 5010 etwa 24 Stunden lang an das Stromnetz angeschlossen und eingeschaltet werden, um die eingebauten Pufferbatterien aufzuladen. Wird dies nicht gemacht, kann das durch Verlust der im Speicher enthaltenen Kalibrierfaktoren zu fehlerhaftem Betrieb führen. Mit dem in diesem Handbuch enthaltenen „Justierungsvorgang" können die Kalibirierfaktoren neu in den Speicher eingegeben werden.

ANMERKUNG

Das DM 5010 ist nur für den Betrieb in einer Versorgungseinheit der Serie TM 5000 ausgelegt. Beachten Sie vor dem Einbau des DM 5010 die Bedienungsanleitung der Versorgungseinheit.

Das DM 5010 kommt kalibriert und betriebsbereit zum Versand. Achten Sie darauf, daß der Spannungswahlschalter der Versorgungseinheit richtig eingestellt ist. Das DM 5010 besitzt einen internen Netzfrequenzwähler. Zur bestmöglichen Unterdrückung des Netzfrequenzrauschens sollte bei Betrieb in FAST CONVERSION RATE die richtige Netzfrequenz eingestellt sein. Bei Versand ist das Gerät auf eine Netzfrequenz von 60 Hz eingestellt. Überlassen Sie die Einstellung der Netzfrequenz dem qualifizierten Servicepersonal.

VORSICHT

Um Beschädigungen zu vermeiden ist vor Einbau des DM 5010 die Spannungsversorgung der Versorgungseinheit abzuschalten. Ein- oder Ausbau dürfen nicht mit Gewalt erfolgen.

Prüfen Sie ob die Plastiksperren an den Verbindungssteckern der ausgewählten Fächer der Versorgungseinheit mit den Ausschnitten an den Steckerleisten des DM 5010 übereinstimmen. Ist das nicht der Fall, darf das DM 5010 nicht eingebaut werden bevor der Grund dafür festgestellt wurde. Stimmen Sie überein, halten Sie das Chassis des DM 5010 an die oberen und unteren Führungsschienen der gewählten Fächer der Versorgungseinheit und drücken es fest ein, bis die rückseitigen Steckverbindungen einrasten (siehe Bild 2-1). Schalten Sie die Versorgungseinheit ein.

Zum Ausbau des DM 5010 ziehen Sie den Entriegelungshebel (an der unteren linken Ecke) bis die Steckverbindung ausrastet und das Gerät aus der Versorgungseinheit herausgleitet.

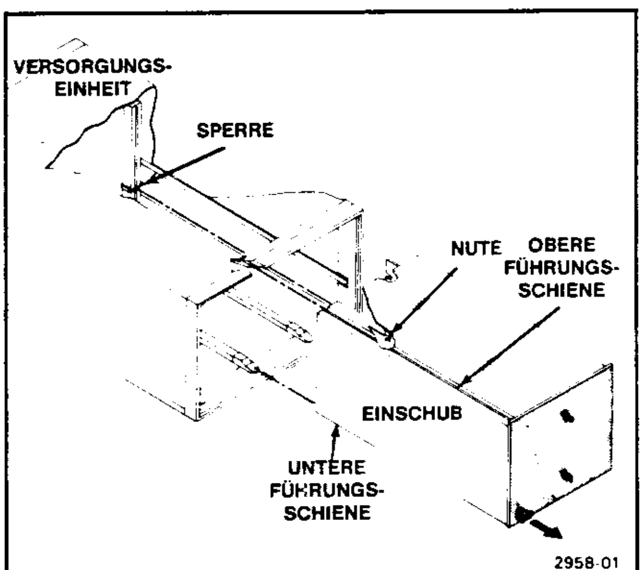


Bild 2-1. Ein- und Ausbau.

BEDIENUNGSELEMENTE UND ANSCHLÜSSE AUF DER FRONTPLATTE

Allgemeine Hinweise

Die nachstehend aufgelisteten siebzehn Druckschalter auf der Frontplatte aktivieren nach Eindrücken die jeweilige Funktion und leuchten auf. Die Druckschalter im linken Teil schließen sich gegenseitig aus; d. h. es ist immer nur ein Druckschalter aktiviert (erleuchtet). Die Druckschalter im rechten Teil leuchten auf wenn sie aktiviert werden und bleiben aktiviert und erleuchtet bis sie nochmals gedrückt werden.

DCV	NULL
OHMS	LOW FREQ RESPONSE
DIODE TEST	AUTO
ACV	RUN
ACV + DCV	TRIGGERED
	FAST
	AVERAGE
	$\frac{X-B}{A}$
	dBm
	dBr
	COMPARE
	REAR INPUT

Anzeigefenster

Im linken Teil der Anzeige werden Meß- und Berechnungsergebnisse durch eine 4 1/2stellige LED angezeigt. Nullen vor Dezimalzahlen werden nicht angezeigt. In den Spannungsmeßfunktionen wird durch Flackern ein Überlaufen angezeigt; für OHMS und DIODE TEST wird OC dargestellt.

Im mittleren Teil der Anzeige werden die Bereichsmultiplikatoren für die dargestellte Anzeige angegeben. Eine den Aufschriften MILLI, KILO und MEGA zugeordnete LED zeigt an, ob es sich bei der dargestellten Messung um Milli-, Kilo- oder Megaeinheiten handelt. Der Dezimalpunkt ist für jeden Funktionsbereich fixiert. Die Multiplikator-LED und die Position des Dezimalpunktes zeigen bei den Bereichswahlmethoden AUTO und manuell (STEP) den Bereich an. Siehe Bild 2–2.

Der rechte Teil des Anzeigefensters zeigt den Betriebszustand des Gerätes wie folgt an:

REMOTE und ADRESSED leuchten nur auf, wenn das Gerät ferngesteuert über den GPIB arbeitet.

ERROR leuchtet auf, wenn ein interner, ein Selbst-Test-, oder ein Betriebsfehler auftritt. Im linken Teil der Anzeige werden auch Fehlercodes dargestellt, welche die Art des Fehlers anzeigen. Siehe Tabelle 2–2 im Abschnitt „Bedienungshinweise".

Function	Illuminated Multiplier	Selected Range			
DCV	• MILLI			200 mV	
		2 V	20 V	200 V	1000 V
ACV and ACV + DCV	• MILLI			200 mV	
		2 V	20 V	200 V	700 V
OHMS				200 Ω	
	• KILO	2 kΩ	20 kΩ	200 kΩ	
	• MEGA	2 MΩ	20 MΩ		
DIODE TEST		Uses 2 V dc range.			

1 . 9 . 9 . 9 . 9

Overrange indication:
Display flashes for voltage functions.
Displays "OC" for OHMS and DIODE TEST functions.

Blank when FAST CONVERSION RATE is enabled.

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Bild 2–2. DM 5010 Bereichsanzeige auf der Frontplatte.

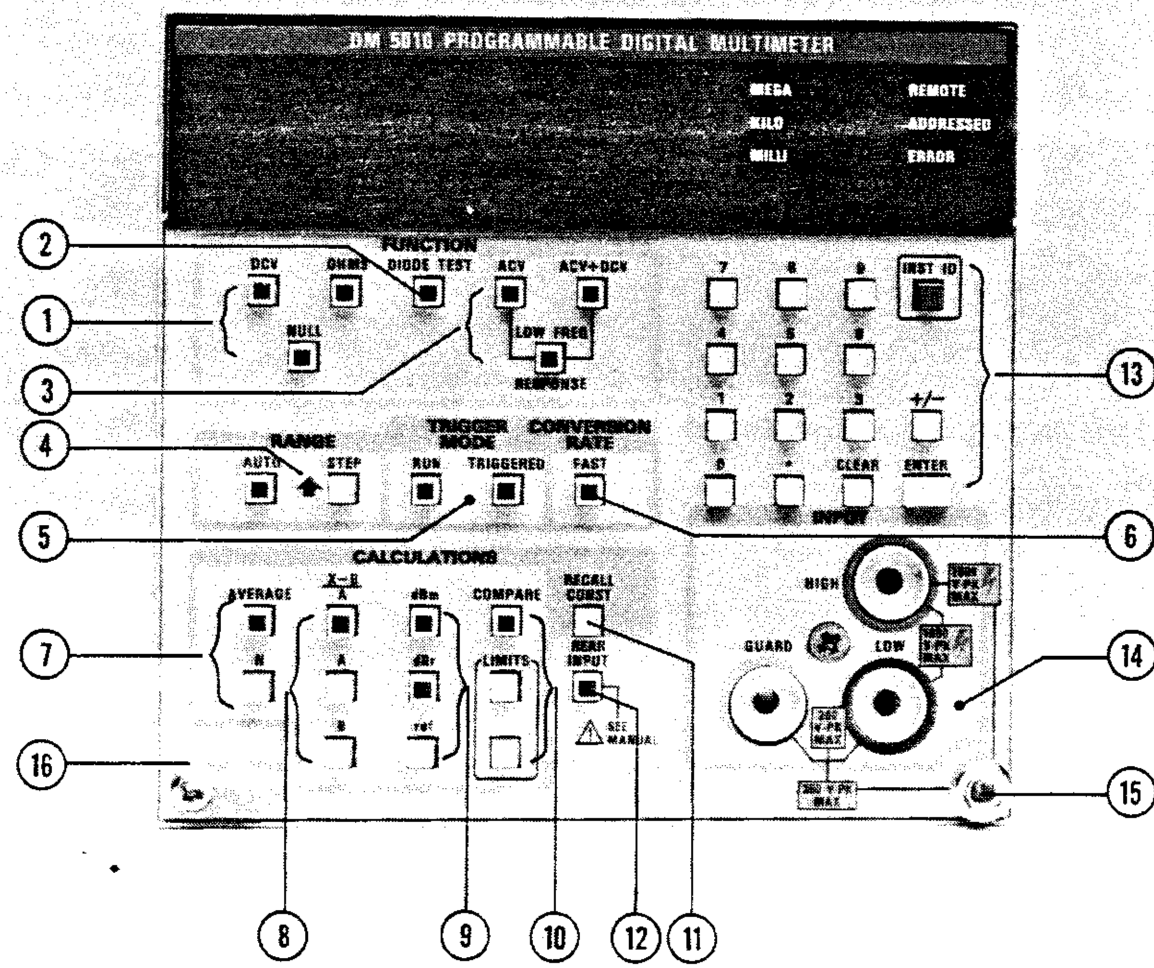


Bild 2–3. DM 5010 Bedienungselemente und Anschlüsse auf der Frontplatte.

Bedienungslemente und Anschlüsse

Nachstehend werden die Bedienungselemente und Anschlüsse auf der Frontplatte des DM 5010 beschrieben. Siehe Bild 2–3.

FUNKTIONEN

(1) **DCV**
Wenn diese Drucktaste erleuchtet ist, mißt das DM 5010 die an die Eingangsanschlüsse auf der Frontplatte oder der Rückseite angelegten Gleichspannungen. Die Meßbereiche sind: 200 mV, 2 V, 20 V, 200 V und 1000 V.

OHMS
Diese Drucktaste ist in der Betriebsart Widerstandsmessung erleuchtet. An den Anschluß auf der Frontplatte oder den rückseitigen Schnittstellenanschluß angelegte Widerstände werden in den Bereichen 200 Ω, 2 kΩ, 20 kΩ, 200 kΩ, 2 MΩ und 20 mΩ gemessen.

NULL
Diese Funktion arbeitet, wenn das DM 5010 auf DCV, OHMS, DIODE TEST, ACV + DCV eingestellt ist (in allen Bereichen). Wenn der Tastkopf NULL erleuchtet ist, mißt und speichert das Gerät den an einen der Eingangsanschlüsse angelegten Widerstands- oder Spannungswert. Dieser gespeicherte Offset wird den folgenden Messungen hinzugefügt und die Ergebnisse werden dargestellt. Der Wert des Offset kann bis zu ±100% des Bereichs betragen. Wird die derzeitige Funktion geändert oder die NULL Funktion abgeschaltet (NULL Taste gedrückt), wird der NULL Offset nicht mehr hinzugefügt. Der gespeicherte Offset bleibt erhalten, bis ein neuer Offset durch Nullung eingestellt oder die während der Nullung eingeschaltete Funktion verändert wird.

WARNUNG

Bei eingeschalteter NULL Funktion kann es vorkommen, daß die dargestellte Messung nicht den Wert der an den Eingangsanschlüssen angelegten Spannung anzeigt.

(2) **DIODE TEST**
Wenn diese Taste erleuchtet ist, wird an den positiven Eingangsanschlüssen auf der Frontplatte und der Rückseite ein Gleichstrom von 1 mA erzeugt. Dieser Strom fließt durch ein Bauelement zum negativen Anschluß. Die dabei am Bauelement entstehende Spannung wird im 2 V Gleichspannungsbereich gemessen und dargestellt.

(3) **ACV**
Wenn diese Drucktaste erleuchtet ist, werden vom DM 5010 echte effektive Wechselspannungen gemessen und dargestellt. Die angelegten Spannungen werden intern an einen Effektivwandler gekoppelt. Die Meßbereiche sind: 200 mV, 2 V, 20 V, 200 V und 700 V.

ACV + DCV
Ist diese Taste erleuchtet, werden vom DM 5010 echte effektive Wechselspannungen gemessen und dargestellt, die auf einen Gleichspannungspegel angehoben worden sind. Die angelegten Spannungen werden intern wechselspannungsmäßig an den Effektivwandler angekoppelt. Die Bereiche sind: 200 mV, 2 V, 20 V, 200 V und 700 V.

LOW FREQ RESPONSE
Wenn diese Drucktaste erleuchtet und die Funktion ACV oder ACV + DCV aktiviert ist, wird aus 4 Messungen der Mittelwert berechnet und dargestellt. Dieser Vorgang wird danach wiederholt. Diese Funktion bietet eine stabile Anzeige bei der Messung von niederfrequenten Wechselspannungen und ist bis 10 Hz spezifiziert. Sie kann jedoch über den gesamten für das DM 5010 spezifizierten Frequenzbereich angewendet werden.

BEREICH

(4) **AUTO**
Wenn diese Taste erleuchtet ist erfolgt die Bereichswahl automatisch. Wird der jeweilige Bereich überschritten, schaltet das DM 5010 in den nächst höheren Bereich um. Beträgt der gemessene Wert weniger als 9,5% des Bereichs, schaltet das Gerät in den nächst niedrigeren Bereich um.

STEP ⬆
Bei Aktivierung dieser Drucktaste schaltet das DM 5010 in den nächsthöheren Bereich um. Dieser Bereich wird beibehalten, bis für die automatische Bereichswahl die Taste AUTO gedrückt oder der Bereich nochmals erhöht wird. Bei Änderung der Funktion (DCV, OHMS, DIODE TEST, ACV, ACV + DCV) bleibt der Bereich. Nur bei Wahl der Funktion OHMS wird in den höchsten Bereich umgeschaltet. Bei Drücken der Taste während der Arbeit im höchsten Bereich erfolgt Umschaltung in den niedrigsten Bereich.

TRIGGERUNG

(5) **RUN**
Wenn diese Taste erleuchtet ist, läuft die Konversion frei mit der gewählten Rate. Für die Wahl der Wandelrate siehe FAST.

TRIGGERED
Nach Drücken dieser Taste wird eine Messung getriggert und dargestellt. Die nächste Messung beginnt, wenn diese Funktion wieder aktiviert wird (Taste gedrückt, oder ein EXTRIG Triggersignal empfangen wird). Für die Anwendung der EXTRIG Triggerung muß von qualifiziertem Servicepersonal ein interner Anschluß eingebaut werden. Wenn das Gerät getriggert wird, leuchtet die Taste TRIGGERED kurz auf.

WANDELRATE

⑥ **FAST**
Ist diese Taste erleuchtet, entspricht die Wandel- (Meß-) Rate der für die gewählte Meßfunktion spezifizierten maximalen Rate. Bei dieser Wandelrate beträgt die Auflösung 3,5 Stellen.

Wenn die Taste FAST nicht erleuchtet ist, erfolgt die Wandlung mit der für die gewählte Meßfunktion spezifizierten normalen Meßrate. Die Ergebnisse werden 4,5 stellig dargestellt.

⑦ **AVERAGE**
Wenn diese Taste erleuchtet ist, berechnet das DM 5010 den Mittelwert aus einer Serie von Messungen. Der Wert der Konstanten N bestimmt aus wie vielen Messungen der Mittelwert gebildet wird. Zur Berechnung des Mittelwertes summiert das Gerät die gemessenen Werte und dividiert die Summe durch die Anzahl der Messungen. Ist LOW FREQ RESPONSE ebenfalls aktiviert, entspricht die Anzahl der Messungen aus denen der Mittelwert gebildet wird dem vierfachen Wert der Konstante N. In der Betriebsart TRIGGERED wird zum Start aller für die AVERAGE Berechnung verwendeten Messungen nur eine Triggerung benötigt.

N
Diese Taste wird zum Speichern oder Abrufen einer bei der AVERAGE Berechnung verwendeten Konstanten benutzt. Die Konstante bestimmt, aus wie vielen Messungen der Mittelwert gebildet wird. Beim Einschalten des Gerätes wird der Wert N auf 2 eingestellt. Dieser Wert kann auf jede positive ganze Zahl von 1 bis 19999 eingestellt werden.

⑧ $\mathbf{\frac{X-B}{A}}$
Wird diese Taste gedrückt, subtrahiert das DM 5010 eine gespeicherte Offsetkonstante von einer Messung, dividiert das Ergebnis durch eine gespeicherte Skalierungskonstante und stellt das Ergebnis dar. B ist die Offsetkonstante, A die Skalierungskonstante und X die Messung.

A, B
Diese Tasten werden zum Speichern oder Abrufen von Konstanten verwendet, die zur Berechnung von X-A/B benutzt wurden. Beim Einschalten des Gerätes wird der Wert A auf 1 und der Wert B auf 0 eingestellt. Diese Konstanten können auf jede Zahl (ganze, Dezimal-, positive oder negative Zahl) eingestellt werden, nur der Wert A kann nicht 0 sein.

⑨ **dBm**
Wenn diese Taste erleuchtet ist, wird das Verhältnis einer Spannungsmessung, bezogen auf 1 mW und 600 Ohm nach folgender Formel berechnet:

$$dBm = 20 \log_{10} \left| \frac{x_1}{\sqrt{.6}} \right|$$

dabei ist x_1 die Spannungsmessung. Es wird der Logarithmus des absoluten Wertes von $x_1/\sqrt{.6}$ genommen.

dBr
Ist diese Taste erleuchtet, berechnet das DM 5010 mit der nachstehende Formel das logarithmische Verhältnis einer Messung zu einer gespeicherten Bezugskonstanten (Taste ref):

$$dBr = 20 \log_{10} \left| \frac{x_1}{ref} \right|$$

wobei x_1 die Messung ist. Es wird der Logarithmus des absoluten Wertes von x_1/ref genommen.

ref
Diese Taste wird zum Speichern oder Abrufen einer für die dBr Berechnung benutzten Konstanten verwendet. Beim Einschalten wird der Wert ref auf 1 eingestellt. Der Wert von ref kann jede Zahl außer 0 sein.

⑩ **COMPARE**
Die Aktivierung dieser Berechnung (Taste erleuchtet) veranlaßt das DM 5010 die nächste Messung mit den durch die Konstanten LIMITS gesetzten Grenzwerten zu vergleichen. Wenn die verglichene Messung algebraisch unter den beiden Konstanten liegt, wird das Wort LO dargestellt. Ist sie algebraisch größer als die beiden Konstanten wird HI dargestellt. PASS wird dargestellt, wenn die Messung gleich ist oder zwischen den Konstanten liegt.

LIMITS (2)
Diese Tasten werden zum Speichern oder Abrufen von Konstanten verwendet, die als Grenzwerte in der Berechnung COMPARE benutzt wurden. Beim Einschaltvorgang werden die Werte der Konstanten auf 0 eingestellt.

⑪ **RECALL CONST**
Drücken dieser Taste und dann eine der Konstantentasten (N, A, B, ref, LIMITS) veranlaßt das Gerät, den für diese Konstante gespeicherten Wert darzustellen.

⑫ **REAR INPUT!** ⚠
Siehe „Messungen an der rückseitigen Schnittstelle" im Abschnitt „Betriebshinweise". Wenn diese Taste erleuchtet ist, werden statt der Eingänge auf der Frontplatte die Eingänge der rückseitigen Schnittstelle gewählt.

⑬ **DIGITS (0 bis 9), Dezimalpunkt und Zeichen**
Diese Tasten werden für die Eingabe von Zahlen, Dezimalstellen und der Polarität für die Speicherung von Konstanten verwendet.

CLEAR
Wenn im Anzeigefenster ein Fehlercode dargestellt wird, löscht diese Taste den dargestellten Fehlercode. Wird die Taste CLEAR während der Eingabe einer Konstanten gedrückt, wird ein Konstantenwert, der noch nicht eingegeben worden ist, auf der Anzeige gelöscht.

ENTER
Durch Drücken dieser Taste bei der Eingabe einer Konstanten wird die Zahl der Konstanten gespeichert und der gespeicherte Konstantenwert dargestellt.

INST ID
Die Aktivierung dieser Taste veranlaßt das Gerät seine Primäradresse darzustellen und, wenn USEREQ freigegeben ist, eine Serviceabfrage (SRQ) am GPIB zu erzeugen. Ferner leuchtet in der Betriebsart Talk Only das Minuszeichen auf und der ganz rechts stehende Dezimalpunkt leuchtet auf, wenn als Endezeichen LF/EOI gewählt wurde; der Dezimalpunkt leuchtet nicht, wenn das Endezeichen EOI ONLY ist.

INPUT

(14) **HIGH Anschluß**
Isolierter analoger positiver Anschluß, der mit den LOW und GUARD Anschlüssen für alle Messungen auf der Frontplatte verwendet wird.

LOW Anschluß
Isolierter analoger Anschluß, der mit dem HIGH Eingangsanschluß verwendet wird.

GUARD Anschluß
Isolierter Anschluß, der mit der Abschirmung der Analogschaltkreise verbunden ist. Wird keine GUARD Prüfleitung verwendet, ist GUARD über einen internen Schalter mit dem LOW Anschluß verbunden. Wird eine GUARD Prüfleitung benutzt, wird sie normalerweise vom Anwender mit der LOW Prüfleitung am Meßpunkt angeschlossen. Der Anschluß GUARD wird zur Maximierung der Gleichtaktunterdrückung verwendet.

(15) **Masse-Anschluß**
Chassis Masseanschluß.

(16) **Entriegelungshebel**
Beim Herausnehmen des Einschubs ziehen.

BEDIENUNGSHINWEISE

Nachstehend werden die Bedienungselemente und Anschlüsse auf der Frontplatte des DM 5010 bei Eigenbedienung beschrieben.

Selbst-Test

Nach dem Einschalten durchläuft das DM 5010 eine Selbsttest-Routine. Während des Selbsttests sind alle LED's auf der Frontplatte erleuchtet. Nach dem Selbsttest schaltet das Gerät auf Eigenbedienung (LOCS) und nimmt die in Tabelle 2–1 enthaltenen Einstellungen an.

Tabelle 2–1
EINSCHALT-EINSTELLUNGEN
(NUR FUNKTIONEN AUF DER FRONTPLATTE)

Funktion	Status
DCV	on
OHMS	off
NULL	(off) Konstante auf 0 eingestellt
DIODE TEST	off
ACV	off
ACV + DCV	off
LOW FREQ RESPONSE	off
AUTO	on
STEP	off
RUN	on
TRIGGERED	off
FAST	off
AVERAGE	off
N	Konstante auf 2 eingestellt
$\frac{X-B}{A}$	off
A	Konstante auf 0 eingestellt
B	Konstante auf 1 eingestellt
dBm	off
dBr	off
ref	Konstante auf 1 eingestellt
COMPARE	off
LIMITS	Konstante auf 0, 0 eingestellt
REAR INPUT	off

Wird während des Selbsttests ein interner Fehler entdeckt, zeigt das Gerät im Anzeigefenster kontinuierlich einen 3-stelligen Fehlercode an und das Lämpchen ERROR leuchtet auf. Siehe Tabelle 2–2. Überlassen Sie Fehlerzustände dem qualifizierten Fachpersonal.

Tabelle 2-2
FEHLERCODES

Anzeige	Fehler	
	Ausführungsfehler:	
205	Argument außerhalb des Bereichs	
231	Nicht kalibrierte Betriebsart	
232	Nicht kalibrierbar	
	Interne Fehler:	
303	Rechenfehler	
311	Konverterausfall	
317	Frontplattenausfall	
318	Schlechte Kalibrierkonstante	
340	RAM Fehler	
341	RAM Fehler	
351	Kalibrier-Prüfsummenfehler	
372	ROM Plazierungsfehler	C000
373	ROM Plazierungsfehler	D000
374	ROM Plazierungsfehler	E000
392	ROM Prüfsummenfehler	C000
393	ROM Prüfsummenfehler	D000
394	ROM Prüfsummenfehler	E000
395	ROM Prüfsummenfehler	F000

Allgemeine Betriebshinweise

Das Gerät erreicht seine spezifizierte Genauigkeit nach 30 Minuten Aufwärmzeit. Bei Bereichsüberschreitung der Funktionen OHMS und DIODE TEST zeigt das Gerät OC an; Bereichsüberschreitung bei den Funktionen DCV, ACV und ACV + DCV wird durch eine blinkende Darstellung angezeigt.

VORSICHT

Beachten Sie die spezifizierten Maximalwerte für die Eingangsspannung. Überschreiten der Maximalwerte kann zu Schäden am Gerät führen.

Für alle Meßfunktionen erfolgt die Bereichswahl entweder automatisch (Taste AUTO eingedrückt) oder es wird mit der Taste STEP ein fixierter Bereich ausgewählt. Siehe auch Abschnitt „Anzeigefenster". Für DIODE TEST wird nur der Bereich 2 V verwendet.

VORSICHT

Bei der AUTO Bereichswahl darf die Eingangsspannung nicht wiederholt zwischen einem niedrigen Wert (< 200 mV$_S$) und einem höheren Wert (> 200 V$_S$) hin und her geschaltet werden. Verwenden Sie für wiederholte Messungen zwischen den Spannungsextremen vor Erhöhung der Eingangsspannung mit der Bereichswahl STEP einen entsprechend höheren Bereich, da sonst ungenaue Messungen im 200 mV Bereich vorkommen können.

Eingangs-Anschlüsse

Die Anschlüsse HIGH, LOW und GUARD werden für Messungen auf der Frontplatte verwendet. Diese Anschlüsse besitzen zwischen dem LOW und GUARD Anschluß einen internen Schalter. Der Schalter ist geschlossen, bis eine Prüfleitung am Anschluß GUARD eingesteckt wird; er bleibt offen, bis die Prüfleitung entfernt wird.

Bild 2-4 zeigt drei Beispiele für Messungen mit den Anschlüssen auf der Frontplatte. Methode A zeigt die am meisten verwendete Art. Sie wird benutzt, wenn Gleichtaktspannung nicht in Betracht kommt. In diesem Beispiel werden nur die HIGH und LOW Anschlüsse des DM 5010 benutzt. Da am GUARD Anschluß keine Prüfleitung eingesteckt ist bleibt der interne Schalter geschlossen und schließt LOW und GUARD kurz. Dadurch kann der Gleichtaktstrom durch die LOW Prüfleitung und die Erdung der Spannungsversorgung fließen und zu Meßfehlern führen.

Wenn Gleichtaktspannungen ein Problem sind, liefert Methode B die genauesten Messungen. Der Anschluß GUARD am DM 5010 ist mit dem negativen Anschluß der Signalquelle verbunden. Der Gleichtaktstrom fließt durch die GUARD Prüfleitung und die Erdung der Quelle, aber nicht durch den Meßkreis.

Bei Methode C ist der GUARD Anschluß am DM 5010 mit der Erdung der Quelle verbunden. Da der zwischen dem negativen Anschluß der Quelle und der Erdung erzeugte Gleichtaktstrom in den Meßkreis fließt, können Meßfehler auftreten.

WARNUNG

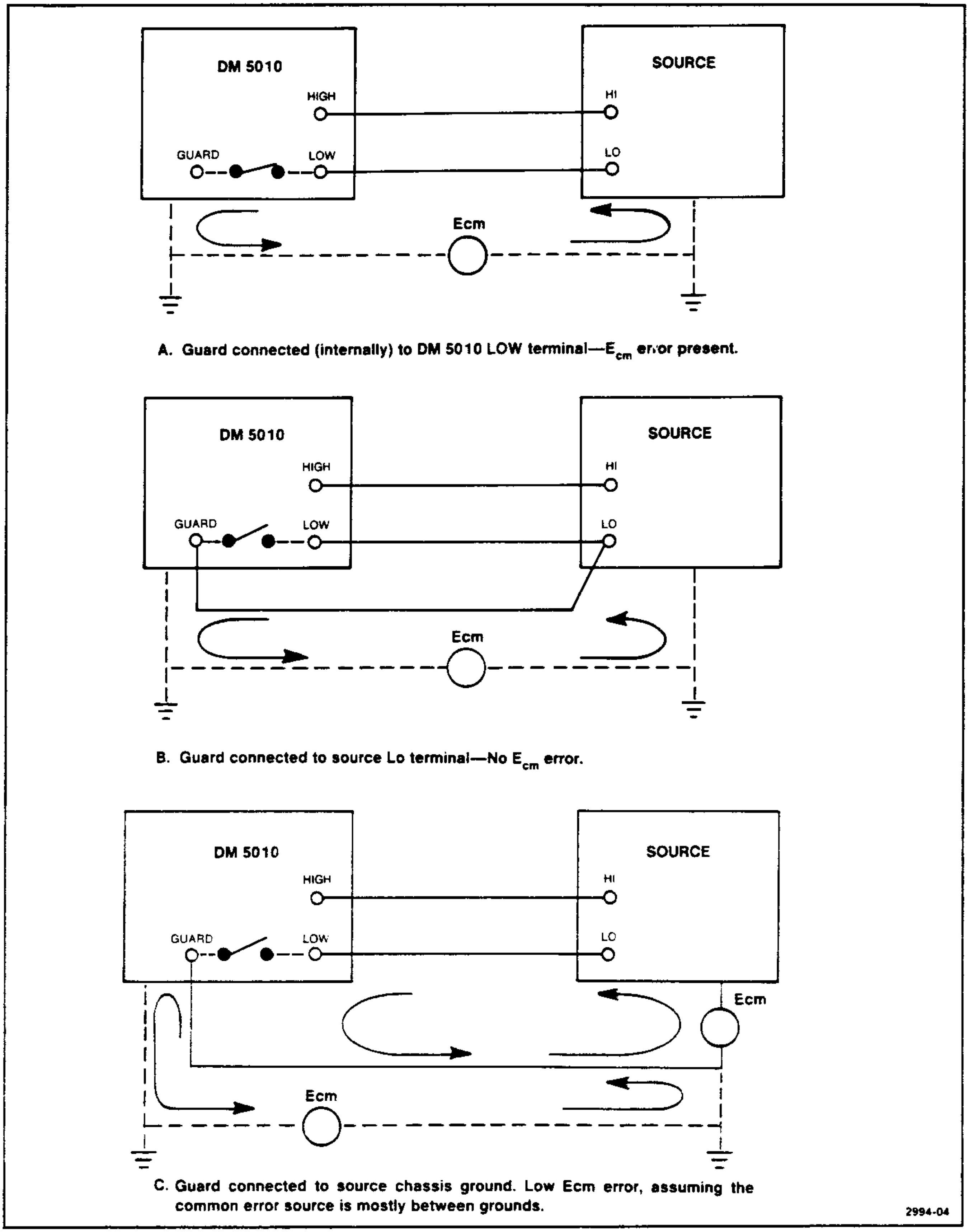
Um die Gefahr von Stromschlägen bei Spannungsmessungen zu vermeiden:

1. Vermeiden Sie den Kontakt mit der Spannungsquelle wenn die gemessene Spannung 42,4 V$_S$ übersteigt.

2. Trennen Sie die Prüfleitungen von dem zu prüfenden Schaltkreis bevor Sie die Leitungen am DM 5010 entfernen und bevor Sie das DM 5010 aus der Versorgungseinheit herausnehmen.

Messungen an den rückseitigen Interface-Anschlüssen! ⚠

Wenn die Taste REAR INPUT gedrückt ist (erleuchtet) werden Signale gemessen, die an die rückseitigen Interface-Stifte 28B (Hi) und 28A (Lo) auf der ADC Platine (A17) angelegt sind. Ist die Taste nicht erleuchtet, werden die Signale über die Eingangsanschlüsse auf der Frontplatte gemessen.



A. Guard connected (internally) to DM 5010 LOW terminal—E_{cm} error present.

B. Guard connected to source Lo terminal—No E_{cm} error.

C. Guard connected to source chassis ground. Low Ecm error, assuming the common error source is mostly between grounds.

Bild 2–4. Beispiele für Anschlußarten auf der Frontplatte.

VORSICHT

Um Beschädigung des Gerätes zu vermeiden, darf zwischen den Stiften 28B (Hi) und 28A (Lo) am rückseitigen Interface-Anschluß P1031 auf der ADC Platine (A17) keine Spannung angelegt werden, die 42,4 V_S AC oder 60 V DC übersteigt.

VORSICHT

Schalten Sie nicht zwischen der Frontplatte und dem rückseitigen Interface-Anschluß um, während an den Eingangsanschlüssen auf der Frontplatte eine Spannung von über 500 V_S angelegt ist. Betriebsfehler und eine Beschädigung des Gerätes können die Folge sein.

Gleichspannungs- (DC) Messungen

Wenn die Taste DCV gedrückt ist, mißt das DM 5010 Gleichspannungen in den Bereichen: 200 mV, 2 V, 20 V, 200 V und 1000 V. Die Darstellung zeigt ein positives Zeichen an wenn der Eingang am HIGH Anschluß mit Bezug auf den LOW Anschluß positiv ist. Beachten Sie die Maximalwerte für die Eingangsspannung.

Widerstandsmessungen

Drücken der Taste OHMS gibt das DM 5010 frei für die Messung von Widerständen in den Bereichen: 200 Ω, 2 kΩ, 20 kΩ, 200 kΩ, 2 MΩ und 20 MΩ. Der normale Stromfluß geht vom Anschluß HIGH zum Anschluß LOW. Tabelle 2-3 enthält die Strom- und maximalen Spannungswerte an den Eingangsanschlüssen (innerhalb der Bereiche). Die maximale Spannung am Anschluß HIGH bezogen auf Anschluß LOW liegt unter 5 V.

Tabelle 2-3
Funktion OHMS

Bereich	Typischer Strom	V max.
200 Ω	1,02 mA bis 1 mA	
2 kΩ	0,12 mA bis 0,1 mA	
20 kΩ	9,2 µA bis 10 µA	0,2 V
200 kΩ	1,08 µA bis 1 µA	
2 MΩ	0,12 µA bis 0,1 µA	
20 MΩ	0,12 µA bis 0,04 µA	0,8 V

Messung von Dioden

Wird die Taste DIODE TEST gedrückt, erzeugt das DM 5010 am Anschluß HIGH einen Gleichstrom von 1 mA. Zur Messung des Spannungsabfalls wird die Diode mit der Anode an HIGH und der Kathode an LOW angeschlossen. Es können Geräte mit einem Spannungsabfall unter 1,999 V geprüft werden. Das sind die meisten Dioden und einige LED's.

Zur Prüfung des umgekehrten Spannungsabfalls vertauschen Sie die Anschlüsse der Diode am Gerät. Die Darstellung sollte OC anzeigen.

Meßgeschwindigkeiten

Das DM 5010 arbeitet mit einer von zwei Meßgeschwindigkeiten. Bei der Geschwindigkeit FAST (Taste CONVERSION RATE erleuchtet) führt es Messungen mit der maximalen, für die gewählte Funktion spezifizierten, Geschwindigkeit durch. Die Meßergebnisse werden 3 1/2-stellig angezeigt. Ist die Taste nicht erleuchtet erfolgen die Messungen mit der normalen für die gewählte Funktion spezifizierten Geschwindigkeit und die Ergebnisse werden 4 1/2-stellig angezeigt.

Triggerung

Das DM 5010 verfügt von der Frontplatte aus über zwei Triggerbetriebsarten RUN und TRIGGERED. Wenn die Taste RUN gedrückt ist erfolgen die Messungen frei laufend mit der gewählten Meßgeschwindigkeit. Bei jedem Drücken der Taste TRIGGERED wird eine Messung ausgelöst.

Ferner können Messungen über den rückseitigen Interface-Anschluß, Stifte 16A und 16B (Lo) am Isolation Board (A15) getriggert werden. Dazu muß eine interne Überbrückung installiert werden. Hinweise dazu findet qualifiziertes Servicepersonal im Abschnitt „Wartung". Durch Einbau dieser Brücke wird die Triggerfunktion EXTRIG freigegeben. Zur Anwendung der EXTRIG Triggerung drücken Sie die Taste TRIGGER und sperren damit die frei laufende Triggerung des Gerätes. Für die Auslösung der internen Triggerung wird bei EXTRIG ein negatives, TTL kompatibles Signal benötigt. Für eine einzelne Triggerung muß diese Leitung zwischen 0,5 und 10 µs gehalten werden. Wird sie längere Zeit niedrig gehalten, triggert das Gerät Mehrfachmessungen.

Berechnungen

Berechnungen von Messungen des DM 5010 werden mit fünf Tasten auf der Frontplatte aktiviert. Diese Berechnungen können einzeln oder in Folge durchgeführt werden. Eine Folge von Berechnungen kann in beliebiger Reihenfolge aktiviert (Tasten gedrückt) werden; das DM 5010 führt sie jedoch in nachstehender Reihenfolge durch: AVERAGE, X-B/A, dBm oder dBr, COMPARE. Das Gerät führt alle aktivierten Berechnungen der Messung durch und stellt dann das Ergebnis dar. Wenn aktiviert, werden NULL und LOW FREQ RESPONSE vor jeder anderen Berechnung ausgeführt. Die Berechnungen dBm und dBr können nicht in der gleichen Folge durchgeführt werden. Wenn beide Tasten in der gleichen Berechnungsfolge gedrückt werden, wird nur die zuletzt gedrückte Berechnung ausgeführt. Eine Triggerung löst die Durchführung einer einzelnen Berechnung oder einer Berechnungsfolge aus. In der Triggerbetriebsart RUN wird eine aktivierte Berechnung oder Berechnungsfolge wiederholt bis sie abgeschaltet wird (Berechnungstasten nochmals gedrückt), oder bis Triggerart oder Meßfunktion geändert werden. Während der Berechnung bleiben die Anzeige-LED's dunkel. Bei Überfließen der Berechnungsergebnisse zeigt das Gerät OC an.

Außer für dBm werden für jede Berechnung eine oder mehrere Konstanten verwendet. Der für jede Konstante im Speicher enthaltene numerische Wert wird beim Einschalten auf einen Anfangswert eingestellt. Dieser Wert kann auf jeden Wert, innerhalb der für jede Konstante spezifizierten Grenzwerte eingestellt werden. Tabelle 2–4 enthält jede Berechnung und die zugeordneten Konstanten, den Konstanten-Anfangswert und die Grenzwerte für jede Konstante.

Änderung der Konstantenwerte

Es gibt zwei Methoden zur Änderung von Konstantenwerten im Gerätespeicher:

1. Mit dem numerischen Tastenfeld:

   a. Drücken Sie die Taste der gewählten Konstanten.

   b. Drücken Sie die numerischen Tasten zur Darstellung des neuen Konstantenwertes (innerhalb der in Tabelle 2–4 spezifizierten Grenzwerte).

   c. Drücken Sie ENTER.

2. Mit einer angezeigten Messung (ändert den Konstantenwert auf den Wert der angezeigten Messung). Achten Sie darauf, daß der angezeigte Meßwert innerhalb der in Tabelle 2–4 für die gewählte Konstante spezifizierten Grenzwerte liegt.

   a. Drücken Sie die Taste der gewählten Konstanten.

   b. Drücken Sie ENTER.

Tabelle 2–4
BERECHNUNG UND KONSTANTEN

Berechnung	Konstanten	Anfangswert	gültiger Konstantenbereich
AVERAGE	N	2	+ 1 bis + 19999
$\frac{X-B}{A}$	B (Offset) A	0 1	+ oder –, ganze Zahl oder dezimal, + oder –, ganze Zahl oder dezimal, ≠ 0
dBm	–	–	–
dBr	ref	1	+ oder –, ganze Zahl oder dezimal, ≠ 0
COMPARE	LIMITS (2)	0	

Nachdem die Taste ENTER gedrückt wurde, zeigt das DM 5010 den gespeicherten Konstantenwert an. Das ist der neue Wert, wenn der eingegebene Wert gültig ist. Der vorher gespeicherte Wert wird angezeigt, wenn der eingegebene Wert ungültig war. Jeder Konstantenwert bleibt gespeichert bis ein neuer Wert eingegeben oder das Gerät abgeschaltet wird.

Berechnungsbeispiele

Die nachstehenden Beispiele sind Anwendungsvorschläge für Berechnungen mit dem DM 5010.

Beispiel 1: Verwendung von X-B/A zur Darstellung der Differenz zwischen den nominalen und aktuellen Zenerspannungen.

Stellen Sie die Bedienungselemente auf der Frontplatte des DM 5010 wie folgt ein:

DCV	on
NULL	off
LOW FREQ RESPONSE	off
RANGE	AUTO
TRIGGER MODE	RUN
CONVERSION RATE	FAST off
CALCULATIONS	
$\frac{X-B}{A}$	on
alle anderen	off
REAR INPUT	off

Stellen Sie die Konstante A auf 1.

Stellen Sie die Konstante B auf 15 (für eine 15 V Zenerdiode).

Verbinden Sie die Zenerdiode, Widerstand und Spannungsquelle wie in Bild 2-5 gezeigt mit den Eingangsanschlüssen des DM 5010. Der Wert des Widerstandes und die Spannung stellen den Zenerstrom ein.

Die angezeigte Spannung ist zuerst unstabil bis der Strom durch die Diode den Endwert ereicht. Wenn sich die Anzeige stabilisiert, zeigt die Spannung die Differenz zwischen der nominalen Zenerspannung (15 V/ und der aktuellen Zenerspannung an.

Zur Ablesung der Spannungsdifferenz in Abweichungsprozenten, ändern Sie die Konstante A auf .15, wobei A – B (.01) ist.

Beispiel 2: Verwendung von dBr zum Finden des Punktes an dem ein Audioverstärker 3 dB unterhalb des mittleren Bereiches liegt.

Stellen Sie die Bedienungslemente wie folgt ein:

ACV	on
NULL	off
LOW FREQ RESPONSE	off
RANGE	AUTO
TRIGGER MODE	RUN
CONVERSATION RATE	FAST off
CALCULATIONS	off
REAR INPUT	off

Stellen Sie die Konstante ref auf 1. Verbinden Sie einen Sinusgenerator, den Audioverstärker und das DM 5010 wie in Bild 2-6 gezeigt.

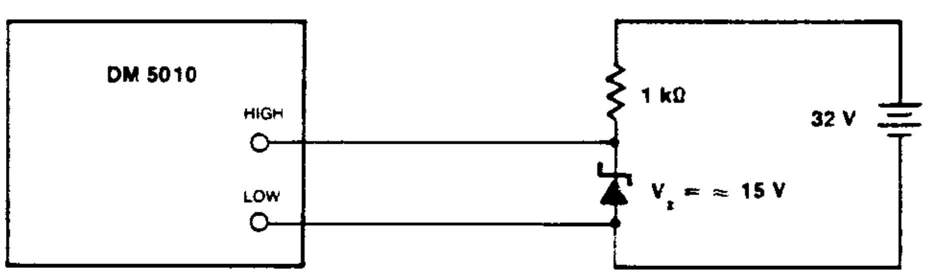


Bild 2-5. Anordnung für Berechnungsbeispiel 1.

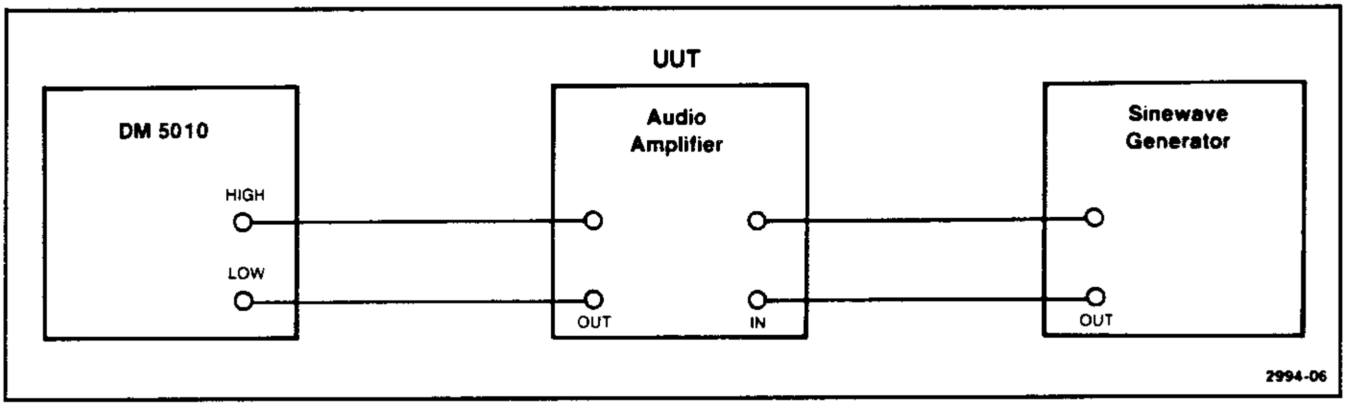


Bild 2-6. Anordnung für Berechnungsbeispiel 2.

Stellen Sie den Sinusgenerator auf Mitte Bereich (in diesem Beispiel 5 kHz) ein. Stellen Sie die Amplitude des Sinusgenerators für eine 1 V Anzeige am DM 5010 ein.

Drücken Sie am DM 5010 die Taste dBr. Das Gerät zeigt 0.0 an.

Reduzieren Sie die Frequenz des Sinusgenerators bis das DM 5010 - 3.00 anzeigt. (Ändern Sie nicht die Amplitude). Die Frequenz des Generators ist der niedrigere - 3 dB Punkt des Audioverstärkers.

Beispiel 3: Die Verwendung von COMPARE zur Auswahl von Widerständen, die innerhalb von 2% des Nennwertes liegen.

Stellen Sie die Bedienungselemente wie folgt ein:

OHMS	on
NULL	off
LOW FREQ RESPONSE	off
RANGE	AUTO
TRIGGER MODE	RUN
CONVERSION RATE	FAST off
CALCULATIONS	
COMPARE	on
alle anderen	off
REAR INPUT	off

Zur Auswahl von 15 kΩ Widerständen, die innerhalb von 2% des Nennwertes liegen stellen Sie eine LIMITS Konstante auf 15300. Die andere LIMITS Konstante stellen Sie auf 14700. Verbinden Sie den ersten Widerstand mit den HIGH und LOW Eingangsanschlüssen auf der Frontplatte des DM 5010. Das DM 5010 zeigt HI oder LO an, wenn der Widerstand oberhalb oder unterhalb der 2% Toleranz liegt. PASS wird angezeigt wenn der Widerstand innerhalb der Grenzwerte liegt.

Die Berechnungsarten COMPARE und X-B/A können in dem vorstehenden Beispiel auch kombiniert verwendet werden. Dabei müssen die höchsten und niedrigsten Toleranzwerte nicht angegeben werden; nur der Nennwert des Widerstandes und der Toleranzwert werden als Konstanten benutzt.

Stellen Sie die Konstante B auf 15000 (Nennwiderstand).

Stellen Sie die Konstante A auf 150 wobei A = B (.01) ist. Dadurch wird die Differenz zwischen Nennwert und tatsächlichem Wert in einen Prozentsatz umgewandelt.

Stellen Sie eine LIMITS Konstante auf 2 (für 2% Toleranz).

Stellen Sie die andere LIMITS Konstante auf -2.

Drücken Sie X-B/A.

Das DM 5010 zeigt PASS, HI oder LO an.

PROGRAMMATION

Introduction

Ce chapitre est relatif à la programmation du Multimètre Numérique Programmable DM 5010, par l'intermédiaire de l'interface numérique IEEE-488. Les fonctions de l'interface relatives au DM 5010 sont indiquées au chapitre 1. L'interface numérique IEEE-488 est appelée dans ce manuel Bus d'Interface Général (GPIB). Les informations qui suivent s'adressent à un lecteur déjà familiarisé avec les communications sur le GPIB et la programmation des contrôleurs. Le protocole des messages transmis sur le GPIB est spécifié et décrit dans les normes IEEE 488-1978, "Interface Numérique Standard pour Instruments Programmables"[1]. Les instruments de la série TM 5000 sont conçus pour communiquer avec tout contrôleur compatible GPIB transmettant et recevant des messages ASCII (commandes) sur le bus GPIB. Ces messages sont constitués de commandes de programmation de l'instrument ou de demandes d'informations issues de l'instrument.

Les commandes des instruments programmables de la série TM 5000 sont compatibles avec d'autres types d'instruments. La même commande peut être utilisée par différents instruments pour le contrôle de fonctions similaires. En outre, chaque commande se présente sous forme d'un mnémonique décrivant sa fonction. Par exemple, la commande INIT réinitialise les réglages d'un instrument en restaurant les conditions de mise en service. De plus, les mnémoniques de commande coïncident avec les appellations en face avant (programmation simplifiée).

Les commandes de l'instrument sont présentées dans ce manuel sous trois formes :

- Une illustration de la face avant - et les commandes ayant trait aux différents modes d'utilisation (v. fig. 3.1).
- Une liste des commandes fonctionnelles - réparties par groupes. Chaque fonction est décrite brièvement.
- Une liste de commandes détaillées - liste alphabétique des commandes. Chaque commande est suivie de sa description complète.

[1] Institute of Electrical and Electronic Engineers, New York

Les instruments programmables de la série TM 5000 sont connectés sur le Bus GPIB par l'intermédiaire d'un module d'alimentation TM 5003 ou TM 5006. Des informations sur l'installation de l'instrument dans le module d'alimentation, ainsi que la description des diverses fonctions en face avant et des fonctions sélectionnables (internes) sont données au chapitre Instructions d'Utilisation.

L'adresse primaire du DM 5010 (16) peut être modifiée par un personnel de maintenance qualifié, ainsi que la Fin de Message (v. dans ce même chapitre le paragraphe Messages et Protocole de Communication). Cette Fin de Message est réglée sur EOI ONLY (à la livraison). Pour toute information sur une localisation ou un réglage interne, se référer au chapitre Maintenance. Une pression sur le bouton INST ID entraîne l'affichage de l'adresse primaire ; le point décimal droit s'allume si la Fin de Message sélectionnée est LF/EOI. Le signe "moins" s'allume si le mode Emetteur Seulement est validé.

Mode Emetteur Seulement (Talk Only)

Ce mode valide l'envoi de données sur le GPIB par le DM 5010 à un Récepteur, sous contrôle local. Pour cela, le commutateur interne correspondant doit être placé sur la position Talk Only. Pour modifier la position de ce commutateur s'adresser à un personnel de maintenance qualifié (v. Chapitre Maintenance).

En mode Emetteur Seulement, le DM 5010 commence à transmettre les résultats de la mesure lorsque l'utilisateur appuie sur le bouton INST ID. Une pression sur la touche CLEAR met fin à l'envoi de données. Si, à cet instant, l'instrument est en train de transmettre une mesure, il termine l'opération en cours. Le voyant ADDRESSED demeure allumé jusqu'à ce que la dernière mesure ait été transmise.

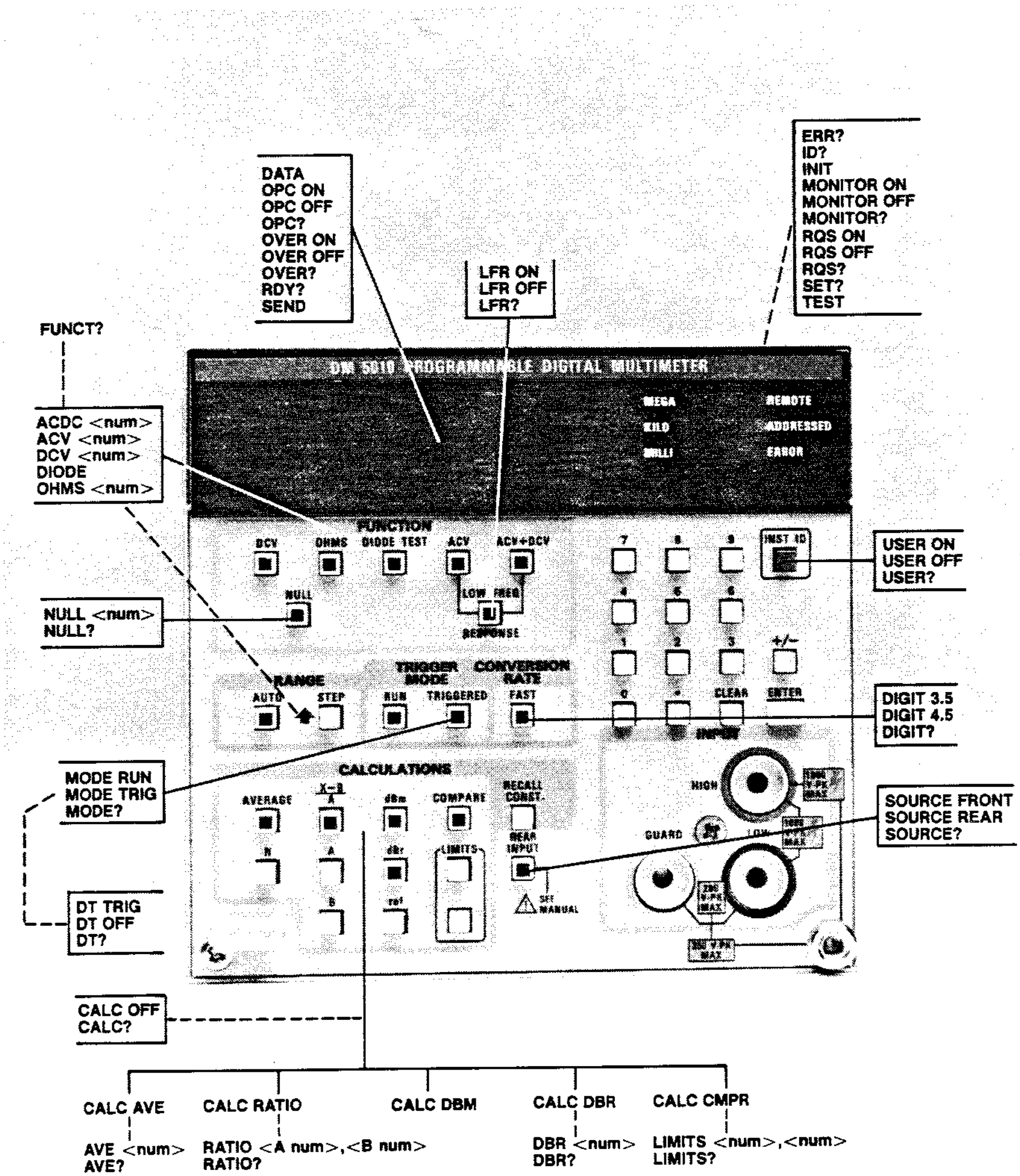


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Fig. 3.1. Commandes du DM 5010 et relations avec les commandes de la face avant.

COMMANDES

L'instrument est contrôlé soit par la face avant, soit par les commandes reçues (envoyées par le contrôleur). Ces commandes sont de trois types :

Commandes de réglage - permettent de régler l'instrument

Demandes d'informations - requièrent des données

Commandes d'utilisation - provoquent une opération spécifique.

ATTENTION

Veiller à ne pas transmettre un nombre de caractères inférieur à ceux du mnémonique ou de l'argument abrégé. Toute transmission à un appareil non concerné pourrait entraîner un risque d'erreur ou de détérioration de l'appareil.

Le DM 5010 répond à et exécute toute commande lorsqu'il est dans le mode Commande à Distance. En mode Local, les fonctions du DM 5010 étant sous le contrôle de la face avant, toute commande de réglage et de fonction transmise par le contrôleur donne lieu à un message d'erreur. Seules les demandes d'informations sont exécutées.

Chaque commande débute par un mnémonique - préfixe décrivant la fonction exécutée. De nombreuses commandes nécessitent un argument à la suite du préfixe, pour décrire l'état désiré de la fonction concernée.

ATTENTION

En mode Sélection Automatique de Gammes, ne pas passer de manière répétitive d'une tension basse (< 200 mV crête) à une tension élevée (> 200 V crête). Dans ce cas, utiliser le mode Sélection de gammes par incréments (STEP) pour sélectionner la gamme supérieure appropriée avant d'augmenter la tension d'entrée. En travaillant directement dans la gamme 200 mV on risque d'obtenir des mesures erronées.

LISTE DE COMMANDES FONCTIONNELLES

COMMANDES DE L'INSTRUMENT

Commandes de fonctions

ACDC <nombre> - valide la fonction Mesure d'une tension alternative efficace vraie superposée à un niveau continu (ACV + DCV) et définit la gamme de mesure.

ACV <nombre> - valide la fonction Mesure d'une tension alternative efficace vraie (ACV) et définit la gamme de mesure.

DCV <nombre> - valide la fonction Mesure d'une tension continue (DCV) et définit la gamme de mesure.

DIODE - valide la fonction DIODE TEST.

FUNCT? - renvoie la fonction et la gamme actuelles.

LFR ON - valide la fonction Réponse en basse fréquence (LOW FREQ RESPONSE).

LFR OFF - inhibe la fonction Réponse en basse fréquence (LOW FREQ RESPONSE).

LFR? - renvoie LFR ON ou LFR OFF.

NULL <nombre> - valide la fonction Annulation (NULL) et la valeur de décalage utilisée.

NULL ? - renvoie la valeur de décalage utilisée par la fonction NULL.

OHMS <nombre> - valide la fonction Mesure de résistances (OHMS) et la gamme utilisée.

Commandes du mode de déclenchement

MODE RUN - valide le mode Déclenchement relaxé (RUN).

MODE TRIG - valide le mode Déclenché (TRIGGERED).

MODE? - renvoie MODE RUN ou MODE TRIG.

RDY? - renvoie RDY 1 si une mesure est prête ; RDY 0 si une mesure est en cours ou en attente de déclenchement.

DIGIT 3.5 - valide la vitesse de conversion rapide (FAST)

DIGIT 4.5 - valide la vitesse de conversion normale.

DIGIT? - renvoie DIGIT 3.5 ou DIGIT 4.5.

Commandes de calcul

AVE <nombre> - définit la valeur de la constante N.

AVE? - renvoie la valeur de la constante N.

CALC AVE - valide le calcul de la Moyenne (AVERAGE).

CALC CMPR - valide la fonction Comparaison (COMPARE).

CALC DBM - valide la conversion en dBm.

CALC DBR - valide la conversion en dBr.

CALC RATIO - valide le calcul de X-B/A.

CALC OFF - inhibe tous les calculs.

CALC ? - renvoie CALC OFF ou le(s) calcul(s) à effectuer.

DBR 8Anombre8F - définit la valeur de la constante de référence (ref).

DBR ? - renvoie la valeur de la constante de référence (ref).

LIMITS <nombre>,<nombre> - définit la valeur des constantes limites (LIMITS).

LIMITS ? - renvoie la valeur des constantes limites.

MONITOR ON - valide une Demande de Service lorsque la mesure excède les constantes limites (LIMITS).

MONITOR OFF - inhibe la Demande de Service lorsque la mesure excède les constantes limites (LIMITS).

MONITOR ? - renvoie MONITOR ON ou MONITOR OFF.

RATIO <nombre>,<nombre> - définit la valeur des constantes A et B.

RATIO ? - renvoie la valeur des constantes A et B.

Commandes d'entrée/sortie

DATA - valide la sortie des données sauvegardées par la commande MONITOR SRQ.

SEND - valide la sortie des données contenues dans la mémoire tampon de sortie. Génère un déclenchement si nécessaire.

SOURCE REAR - sélectionne les entrées de l'interface arrière.

SOURCE FRONT - sélectionne les entrées de la face avant.

SOURCE ? - renvoie SOURCE REAR ou SOURCE FRONT.

Commandes du système

DT TRIG - valide la fonction Déclenchement de l'Instrument. L'instrument est déclenché après le message d'interface <GET8F.

DT OFF - inhibe la fonction Déclenchement de l'Instrument.

DT ? - renvoie DT TRIG ou DT OFF.

ERR ? - renvoie le code d'erreur approprié.

ID ? - renvoie l'identification de l'instrument et le numéro de la version logicielle.

INIT - initialise les réglages de l'instrument.

SET ? - renvoie les réglages de l'instrument.

TEST - renvoie 0 si le contrôle de l'étalonnage est correct ; 1 si le checksum de l'étalonnage est erroné.

Commandes d'état

OPC ON - valide la Demande de Service après une Opération Complète.

OPC OFF - inhibe la Demande de Service après une Opération Complète.

OPC ? - renvoie OPC ON ou OPC OFF.

OVER ON - valide la Demande de Service lors d'un dépassement de gamme.

OVER OFF - inhibe la Demande de Service lors d'un dépassement de gamme.

OVER ? - renvoie OVER ON ou OVER OFF.

RQS ON - valide la génération de demandes de service (SRQ).

RQS OFF - inhibe la génération de demandes de service (SRQ).

RQS ? - renvoie RQS ON ou RQS OFF.

USER ON - valide la Demande de Service lorsque le bouton ID est enfoncé.

USER OFF - inhibe la Demande de Service lorsque le bouton ID est enfoncé.

USER ? - renvoie USER ON ou USER OFF.

LISTE DES COMMANDES DETAILLEES

ACDC (AC + DC)
(Mesure d'une tension alternative efficace vraie superposée à une tension continue)

Type :

Réglage

Syntaxe de réglage :

ACDC <nombre>
ACD <nombre>
ACDC

Exemples :	**Gamme sélectionnée :**
ACDC 2	2 V
ACDC .9	2 V
ACD -200	700 V, Sélection Automatique
ACD	700 V, Sélection Automatique
ACD 0	700 V, Sélection Automatique

Explication :

Le préfixe sélectionne la fonction ACV + DCV. L'argument sélectionne une gamme déterminée ou la Sélection Automatique de Gammes. Le format des arguments numériques est décrit au paragraphe Format de l'argument numérique de ce chapitre. L'argument peut être toute valeur ≤ 700. Toutefois, l'instrument arrondit l'argument à la gamme supérieure. Par exemple, si l'argument est 0.9, l'instrument sélectionne la gamme 2 V.

Un argument absent, ou égal à 0 (ou moins) valide le mode Sélection Automatique de Gammes (à partir de la gamme maximale).

Si l'argument est supérieur à la gamme maximale, l'instrument génère une "erreur" de commande (et valide la ligne SRQ si la commande RQS est validée (RQS ON)).

Gammes :

200 mV   2 V
20 V
200 V
700 V

ACV
(Mesure d'une tension alternative efficace vraie)

Type :

Réglage

Syntaxe de réglage :

ACV <nombre>
ACV

Exemples :	**Gamme sélectionnée :**
ACV 18	20 V
ACV 2	2 V
ACV -200	700 V, Sélection Automatique de Gammes
ACV	700 V, Sélection Automatique de Gammes

Explication :

Le préfixe sélectionne la fonction ACV. L'argument sélectionne une gamme déterminée ou la Sélection de Gammes Automatique. Le format des arguments numériques est décrit au paragraphe Format de l'argument numérique de ce chapitre. L'argument peut prendre toute valeur. Toutefois, l'instrument arrondit l'argument à la gamme supérieure. Par exemple, si l'argument est 18, l'instrument sélectionne la gamme 20 V.

Un argument absent, ou égal à 0 (ou moins) valide le mode Sélection Automatique de Gammes (à partir de la gamme supérieure).

Si l'argument est supérieur à la gamme maximale, l'instrument génère une "erreur" de commande (et valide la ligne SRQ si la commande RQS est validée (RQS ON)).

Gammes :

200 mV   2 V
20 V
200 V
700 V

AVE
(AVERAGE (Moyenne))

Type :

Réglage ou interrogation

Syntaxe de réglage

AVE <nombre>
AVG <nombre>

Exemples :

AVE 6
AVE 2
AVG 10

Syntaxe d'interrogation :

AVE?
AVG?

Réponse à l'interrogation :

AVE <nombre>

Explication :

Cette commande spécifie le nombre de conversions utilisées dans le calcul de la Moyenne. (Ceci équivaut à définir la valeur de la constante N en face avant). Voir CALC AVE. L'argument peut prendre n'importe quelle valeur de 1 à 19999. L'instrument arrondit cet argument à un nombre entier.

CALC
(Calculs)

Type :

Réglage ou interrogation

Syntaxe de réglage :

CALC <argument>
CALC <argument>,......,<argument>

Arguments :

AVE ou AVG
CMPR ou COMP
DBM
DBR
RATIO
OFF

Exemples :

CALC OFF
CALC AVE
CALC AVE,DBM
CALC RATIO,AVE,DBR

Syntaxe d'interrogation :

CALC?

Réponse à l'interrogation :

CALC OFF ; ou le(s) calcul(s) à effectuer.

Explication :

Lorsque l'instrument reçoit une commande CALC, il inhibe tous les calculs exceptés ceux indiqués à la suite du préfixe. Si le résultat d'un calcul excède les capacités du bloc mathématique ($\pm$3.4028E+38), l'instrument génère une erreur concernant le Bloc mathématique (erreur 303).

- CALC AVE ou CALC AVG valide le calcul de la Moyenne. L'instrument calcule la moyenne d'une série de mesures. Le nombre de mesures moyennées est défini par la commande AVE <nombre>.

  Un déclenchement génère un nombre suffisant de lectures pour effectuer une moyenne. Un dépassement de gamme d'une mesure dans une séquence met fin à la fonction AVE.

  Si la commande LFR est également validée, le nombre de mesures défini par la commande AVE <nombre> est multiplié par 4.

- CALC CMPR ou CALC COMP valide la fonction COMPARE. L'instrument compare la valeur en entrée aux valeurs définies par la commande LIMITS. Les commandes suivantes valident la sortie du résultat de la comparaison :

  SEND - renvoie 1., 2. ou 3. équivalant à LO (inférieure), PASS (égale) ou HI (supérieure) ; renvoie +1E+99; ou -1E+99; pour un dépassement de gamme.

  DATA - renvoie la valeur de la mesure hors-limites.

- CALC DBM valide la conversion en dBm et inhibe la conversion en dBr. L'instrument calcule le rapport de la puissance du signal d'entrée par rapport à une puissance de 1 mW dissipée dans une résistance de 600 Ω (0,7446 V).

- CALC DBR valide la conversion en dBr et inhibe la fonction CALC DBM. Le DM 5010 calcule le rapport logarithmique d'une entrée sur la valeur de référence définie par la commande DBR <nombre>.

- CALC RATIO valide la calcul de X-B/A, X étant la mesure, B une valeur de décalage et A le facteur d'échelle. Les valeurs de A et B sont définies par la commande RATIO.

- CALC OFF inhibe tous les calculs.

DATA
(Données)

Type :

Commande de sortie

Syntaxe :

DATA

Réponse :

DATA <nombre>;
ou
DATA ± 1.E+99; *(indication "hors-gamme")*

Explication :

Cette commande renvoie l'une des réponses indiquées ci-dessous. Elle ne déclenche pas une conversion et n'attend pas pour renvoyer une nouvelle mesure, comme la commande SEND.

1. Après la mise en service, renvoie 0 jusqu'à ce qu'une mesure soit disponible.

2. Si une Demande de Service a été générée par la commande MONITOR SRQ, DATA renvoie la mesure à l'origine de la Demande de Service.

3. Si aucune des conditions ci-dessus n'est vraie, DATA renvoie la lecture la plus récente. DATA renvoie la même mesure jusqu'à ce qu'une nouvelle conversion soit déclenchée et qu'une nouvelle mesure soit disponible.

DATA peut renvoyer un nombre de chiffres supérieur (résolution supérieure) au nombre de chiffres affichés en face avant ou renvoyés par la commande SEND.

DBR
(dB par rapport à une référence)

Type :

Réglage ou interrogation

Syntaxe de réglage :

DBR <nombre>

Exemples :

DBR 1
DBR .707
DBR 2E-3

Syntaxe d'interrogation :

DBR?

Réponse à l'interrogation :

DBR <nombre>;

Explication :

L'argument de cette commande définit la valeur de la constante utilisée par la commande CALC DBR. Cette fonction est équivalente à la commande ref en face avant. L'argument peut être tout nombre différent de 0.

DCV
(Mesure d'une tension continue)

Type :

Réglage

Syntaxe de réglage :

DCV <nombre>
DCV

Exemples :	Gamme sélectionnée :
DCV 1.5	2 V
DCV	1000 V, Sélection Automatique de Gammes
DCV -1.E+3	1000 V, Sélection Automatique de Gammes

Explication :

Le préfixe sélectionne la fonction DCV. L'argument sélectionne une gamme de tension déterminée. Le format de l'argument est décrit dans ce chapitre au paragraphe Format de l'argument numérique. L'argument peut être n'importe quelle valeur. Toutefois, l'instrument arrondit l'argument à la gamme immédiatement supérieure. Par exemple, si l'argument est 1,5, l'instrument choisit la gamme 2V.

Un argument manquant ou égal à 0 (ou moins) valide la Sélection de Gammes Automatique (à partir de la gamme maximale).

Si l'argument est supérieur à la gamme maximale, l'instrument génère une erreur de commande (et une Demande de Service si la commande RQS a été validée (RQS ON)).

Gammes :

200 mV
2 V
20 V
200 V
1000 V

DIGIT
(Résolution numérique)

Type :

Réglage ou interrogation

Syntaxe de réglage :

DIGIT 3.5
DIGIT 4.5
DIG 3.5
DIG 4.5

Syntaxe d'interrogation :

DIGIT?
DIG?

Réponse à l'interrogation :

DIGIT 3.5;
DIGIT 4.5;

Explication :

Cette commande sélectionne la vitesse de conversion. L'argument 3.5 valide la Vitesse de Conversion Rapide (FAST) (résolution d'affichage de 3,5 chiffres). Une mesure de tension dure environ 35 ms. Une mesure de résistance dure environ 130 ms.

L'argument 4.5 valide la Vitesse de Conversion Normale (résolution d'affichage de 4,5 chiffres). Une mesure de tension dure environ 310 ms. Une mesure de résistance dure environ 620 ms.

DIODE
(Test de diode)

Type :

Réglage

Syntaxe de réglage :

DIODE
DIO

Explication :

Cette commande sélectionne la fonction DIODE TEST. Elle n'accepte pas d'argument.

DT
(Déclenchement de l'instrument)

Type :

Réglage ou interrogation

Syntaxe de réglage :

DT TRIG
DT OFF

Syntaxe d'interrogation :

DT?

Réponse à l'interrogation :

DT TRIG;
DT OFF;

Explication :

Cette commande valide ou inhibe la fonction Déclenchement de l'instrument. Cette commande provoque une mesure à l'arrivée du message <GET> de l'interface IEEE 488.

Si <GET> est reçu alors que le processeur de messages est occupé (ou si la commande DT n'a pas été validée), l'instrument génère une "erreur", qui indique que le message <GET> est ignoré.

ERR?
(Erreur)

Type :

Interrogation

Syntaxe d'interrogation :

ERR?

Réponse à l'interrogation :

$ERR_{SP\,SP}$ <nombre>

Exemple :

$ERR_{SP\,SP}$401;

Explication :

L'interrogation ERROR est utilisée pour s'informer de l'état de l'instrument.

L'interrogation ERROR renvoie un code indiquant l'évènement à l'origine de la Demande de Service. Se référer au paragraphe Indications d'erreurs et d'états.

FUNCT?
(Fonction)

Type :

Interrogation

Syntaxe d'interrogation :

FUNCT?
FUNC?

Exemples de réponse à l'interrogation :

DCV 2.;
ACV 20.;
DIODE;
ACDC 200.;
OHMS -2.E+6;

Explication :

Cette commande renvoie la fonction de mesure utilisée. L'argument spécifie la gamme. Si l'instrument est en mode Sélection Automatique de Gammes, un argument négatif est renvoyé.

ID?
(Identification)

Type :

Interrogation

Syntaxe d'interrogation :

ID?

Réponse à l'interrogation :

ID TEK/DM5010,V79.1 Fxx;

Explication :

L'interrogation ID? renvoie la réponse ci-dessus.

TEK/DM5010	Identifie le Constructeur et le type de l'Instrument.
V79.1	Identifie la version des Codes et Formats Standard Tektronix à laquelle l'instrument est conforme.
Fxx	Identifie la version logicielle de l'instrument.

INIT
(Initialisation)

Type :

Commande d'utilisation

Syntaxe :

INIT

Explication :

Cette commande restaure les conditions de réglage de l'instrument à la mise en service. Ces réglages sont indiqués au tableau 3.3.

LFR
(Réponse en Basse Fréquence)

Type :

Réglage ou interrogation

Syntaxe de réglage :

LFR ON
LFR OFF

Syntaxe d'interrogation :

LFR?

Réponse à l'interrogation :

LFR ON;
LFR OFF;

Explication :

Cette commande valide ou inhibe la fonction LOW FREQ RESPONSE (utilisée avec les fonctions ACV et ACV+DCV). Lorsque cette fonction est validée, l'instrument calcule la moyenne de quatre mesures.

Si la fonction CALC AVE est également validée, le nombre de mesures défini par la commande AVE <nombre> est multiplié par 4.

LIMITS
(Limites)

Type :

Réglage ou interrogation

Syntaxe de réglage :

LIMITS <nombre>,<nombre>
LIM <nombre>,<nombre>

Exemples :

LIMITS 3.2, -2
LIMITS -1, -6.5
LIM 6,1

Syntaxe d'interrogation :

LIMITS?
LIM?

Réponse à l'interrogation :

LIMITS <nombre>,<nombre>;

Explication :

L'argument de cette commande définit la valeur des limites utilisées par la fonction COMPARE et la Demande de Service du moniteur. Le premier argument définit la valeur de la limite qui correspond au bouton LIMITS du haut (face avant). Le deuxième argument définit la valeur de la limite qui correspond au bouton LIMITS du bas.

MODE

Type :

Réglage ou interrogation

Syntaxe de réglage :

MODE RUN
MODE TRIG
MOD RUN
MOD TRIG

Syntaxe d'interrogation :

MODE?
MOD?

Réponse à l'interrogation :

MODE RUN;
MODE TRIG;

Explication :

Cette commande sélectionne le mode de déclenchement. L'argument RUN définit le mode Déclenchement Relaxé.

L'argument TRIG définit le mode Déclenché. Dans ce mode, un déclenchement se produit à la réception de :

- une commande SEND
- un message <GET> (Déclenchement simultané de tous les instruments) de l'interface (seulement si le Déclenchement de l'instrument (DT) a été validé)
- Mon adresse en tant qu'Emetteur (MTA), la sortie n'étant pas spécifiée (pas de commande d'interrogation)
- un déclenchement par l'interface arrière (EXTRIG) (nécessite l'installation d'un cavalier interne - voir chapitre Maintenance). Pour l'obtention d'un déclenchement unique, cette ligne doit être maintenue à l'état bas entre 0,5 et 10 μsec. Son maintien prolongé à l'état bas entraîne le déclenchement de mesures multiples.

Si le signal mesuré est excessif ou insuffisant, en modes Déclenché (MOD TRIG) et Sélection Automatique de Gammes, l'instrument change de gamme et effectue une autre mesure.

MONITOR
(Moniteur)

Type :

Réglage ou interrogation

Syntaxe de réglage :

MONITOR ON
MONITOR OFF
MON ON
MON OFF

Syntaxe d'interrogation :

MONITOR?
MON?

Réponse à l'interrogation :

MONITOR ON;
MONITOR OFF;

Explication :

Cette commande valide ou inhibe la Demande de Service du moniteur. Si celle-ci est validée, l'instrument sauvegarde la première mesure hors-limites (cf. commande LIMITS) et génère une Demande de Service (SRQ). Ceci est valable pour la première mesure hors-limites mais non pour les autres jusqu'à ce que la Demande de Service ait été exécutée, et que la mesure ait été renvoyée au contrôleur en réponse à la commande DATA.

Si l'instrument effectue un dépassement de gamme alors que la commande MON ON a été générée, il renvoie une erreur "hors-gamme", même si OVER n'est pas validé (OVER OFF).

NULL
(Annulation)

Type :

Réglage ou interrogation

Syntaxe de réglage :

NULL <nombre>

Exemples :

NULL .2
NULL 0

Syntaxe d'interrogation :

NULL ?

Réponse à l'interrogation :

NULL <nombre>;

Explication :

Cette commande valide la fonction NULL. L'argument (en volts ou en ohms) spécifie la valeur du décalage. Cette valeur peut être toute valeur jusqu'à 100 % de la gamme.

La fonction NULL est inhibée à la sélection d'une autre fonction de mesure ou avec l'argument 0. (La sélection d'une autre fonction met également l'argument à 0).

AVERTISSEMENT

Lorsque la fonction NULL est validée, la mesure peut ne pas indiquer la valeur de la tension appliquée aux connecteurs d'entrée.

OHMS
(Mesure d'une résistance)

Type :

Réglage

Syntaxe de réglage :

OHMS <nombre>
OHMS

Exemples :	**Gamme sélectionnée :**
OHMS	20 MΩ, sélection automatique de gammes
OHMS 100	200 Ω
OHMS -2E+7	20 MΩ, sélection automatique de gammes
OHMS 1E+4	20 KΩ

Explication :

Le préfixe sélectionne la fonction OHMS. L'argument sélectionne la gamme. Se référer au paragraphe Format des arguments numériques de ce chapitre. L'argument peut être n'importe quelle valeur. Toutefois, l'instrument arrondit l'argument à la gamme immédiatement supérieure.

Par exemple, si l'argument est 100, l'instrument sélectionne la gamme 200 Ω.

Un argument manquant, ou égal à 0 (ou moins) valide la Sélection Automatique de Gammes (à partir de la gamme maximale).

Si l'argument est supérieur à la gamme maximale, l'instrument génère une "erreur" de commande (et valide la ligne SRQ si la commande RQS est validée (RQS ON)).

Gammes :

200 Ω
2 KΩ
20 KΩ
200 KΩ
2 MΩ
20 MΩ

OPC
Operation Complète)

Type :

Réglage ou interrogation

Syntaxe de réglage :

OPC ON
OPC OFF

Syntaxe d'interrogation :

OPC?

Réponse à l'interrogation :

OPC ON;
OPC OFF;

Explication :

Cette commande valide ou inhibe la Demande de Service Operation Complète. L'instrument valide la ligne SRQ lorsqu'une nouvelle mesure est disponible si OPC et RQS sont validées (RQS ON)).

OVER
(Hors-gamme)

Type :

Réglage ou interrogation

Syntaxe de réglage :

OVER ON
OVER OFF

Syntaxe d'interrogation :

OVER?

Réponse à l'interrogation :

OVER ON;
OVER OFF;

Explication :

Cette commande valide ou inhibe la Demande de Service lors d'un dépassement de gamme. L'instrument valide la ligne SRQ lors d'une mesure hors-gamme (si OVER et RQS sont validées (RQS ON)).

Si la Demande de Service est inhibée, l'instrument renvoie °1.E+99 lorsqu'il est Emetteur, pour indiquer un dépassement de gamme (et ne valide pas la ligne SRQ).

RATIO
(Rapport de mesures)

Type :

Réglage ou interrogation

Syntaxe de réglage :

RATIO <nombre>,<nombre>

Exemples :

RATIO 100,15
RATIO 10,2

Syntaxe d'interrogation :

RATIO?

Réponse à l'interrogation :

RATIO <nombre>,<nombre>;

Explication :

Les arguments de cette commande définissent la valeur du décalage et le facteur d'échelle utilisé dans le calcul de X-B/A. Se référer à la commande CALC RATIO. Le premier argument définit la valeur du facteur d'échelle (bouton A en face avant). Le second définit la valeur du décalage (bouton B). Les arguments peuvent prendre n'importe quelle valeur, à l'exception de 0 pour le facteur d'échelle.

RDY?
(Prêt)

Type :

Interrogation

Syntaxe d'interrogation :

RDY?

Réponse à l'interrogation :

$\mathrm{RDY}_{\mathrm{SP\,SP}}0;$
$\mathrm{RDY}_{\mathrm{SP\,SP}}1;$

Explication :

Cette commande renvoie RDY 0 si une mesure est en cours ou si l'instrument attend un déclenchement ; RDY 1 indique qu'une donnée est disponible.

RQS
(Demande de Service)

Type :

Réglage ou interrogation

Syntaxe de réglage :

RQS ON
RQS OFF

Syntaxe d'interrogation :

RQS?

Réponse à l'interrogation :

RQS ON;
RQS OFF;

Explication :

Cette commande valide la génération de Demandes de Service. L'argument OFF inhibe toutes les Demandes de Service. Se référer au paragraphe Indications d'états et d'erreurs.

SEND
(Envoi)

Type :

Commande de sortie

Syntaxe :

SEND
SEN

Réponse :

<nombre>; (pas de préfixe)

Exemple :

±1.E+99;
±3.2E+3; (dépassement de gamme)

Explication :

Cette commande valide la sortie de la mesure la plus récente. Si aucune mesure n'est disponible, l'instrument déclenche une mesure puis affiche celle-ci.

Si la fonction COMPARE est validée (CALC CMPR), l'instrument affiche l'un des nombres suivants, qui indiquent la relation entre la valeur entrée et la limite définie par la commande LIMITS.

3.; si l'entrée est supérieure aux limites.

2.; si l'entrée est comprise entre les limites ou égale à l'une des deux limites.

1.; si l'entrée est inférieure aux limites.

+1.E+99; ou -1.E+99; dans le cas d'un dépassement de gamme

SET?
(Réglages?)

Type :

Interrogation

Syntaxe d'interrogation :

SET?

Exemple de réponse à l'interrogation (réglages à la mise en service) :

DCV -1.E+3;AVE 2;RATIO 1.0.; DBR 1.;LIMITS 0.,0.;CALC OFF;NULL 0.;DIGIT 4.5;LFR OFF;MODE RUN;SOURCE FRONT;DT OFF;MONITOR OFF;OPC OFF;OVER OFF;USER OFF;RQS ON;

Explication :

Cette commande renvoie les réglages actuels de toutes les commandes.
La réponse la plus longue comprend 225 caractères.

SOURCE

Type :

Réglage ou interrogation

Syntaxe de réglage :

SOURCE FRONT
SOURCE REAR
SOUR FRONT
SOUR REAR

Syntaxe d'interrogation :

SOURCE?
SOUR?

Réponse à l'interrogation :

SOURCE FRONT;
SOURCE REAR;

Explication :

SOURCE FRONT sélectionne les entrées de la face avant pour la mesure. SOURCE REAR sélectionne les entrées de l'interface arrière.

ATTENTION

Si une tension supérieure à 500 V crête est appliquée sur les connecteurs de la face avant, ne pas valider les entrées de l'interface arrière, pour éviter tout risque de détérioration ou de fonctionnement erroné de l'instrument.

TEST

Type :

Commande de sortie

Syntaxe :

TEST

Réponse :

TEST 0;
TEST 351;

Explication :

Renvoie un nombre indiquant l'état du checksum (test d'erreur) d'étalonnage : 0 si celui-ci est correct ; 1 si celui-ci est erroné.

USER
(Utilisateur)

Type :

Réglage ou interrogation

Syntaxe de réglage :

USER ON
USER OFF

Syntaxe d'interrogation :

USER?

Réponse à l'interrogation :

USER ON;
USER OFF;

Explication :

Cette commande valide ou inhibe la Demande de Service associée au bouton INST ID. Si celle-ci est validée, l'instrument valide la ligne SRQ lorsque le bouton INST ID en face avant est enfoncé.

MESSAGES ET PROTOCOLE DE COMMUNICATION

Délimiteur de commande

Un message consiste en une commande ou une série de commandes, suivies d'une fin de message. Dans le cas de messages constitués de plusieurs commandes, celles-ci doivent être séparées par des points virgules. Un point virgule n'est pas obligatoire en fin de message. Chacune des lignes ci-dessous est un message :

INIT
TEST;INIT;RQS ON;USER OFF;ID?;SET?
TEST;

Fin de message

Les messages peuvent être terminés par EOI ou le caractère ASCII de saut de ligne (LF). Certains contrôleurs valident la ligne EOI concurremment avec la transmission du dernier octet de données ; d'autres n'utilisent que le caractère LF comme fin de message. L'un ou l'autre peut être sélectionné à l'intérieur du DM 5010. Si EOI ONLY est sélectionné, l'instrument interprète comme fin du message entré tout octet de données reçu. De même, il valide la ligne EOI concurremment avec la transmission du dernier octet du message sorti. Si LF/EOI est sélectionné, l'instrument interprète le caractère LF comme fin du message entré si la ligne EOI est inhibée (ou tout octet de données reçu lorsque la ligne EOI est validée). Il transmet un retour chariot (CR) suivi d'un saut de ligne (LF avec la ligne EOI validée) pour mettre fin aux messages en sortie. Lire le chapitre Maintenance avant la sélection manuelle interne (personnel qualifié) de la fin de message. Les instruments de la série TM 5000 sont livrés avec la fin de message EOI ONLY sélectionnée.

Formattage d'un message

Pour être comprises, les commandes transmises aux instruments de la série
TM 5000 doivent avoir le format (ou syntaxe) approprié. Toutefois, ce format est très souple et peut subir de nombreuses variations. Une description de ce format et des variations admises est donnée ci-après.

Toutes les commandes doivent être en code ASCII. Toutefois, les minuscules et majuscules sont acceptées. Toute donnée sortie doit être en majuscules.

Comme expliqué précedemment, une commande consiste en un préfixe suivi, si nécessaire, par des arguments. Une commande suivie d'arguments doit posséder un délimiteur, le caractère SP (SPACE = espace), entre le préfixe et l'argument.

$\text{RQS}_{\text{SP}}\text{ON}$

Si les caractères formattés spéciaux, SP, CR, et LF (LF ne pouvant être utilisé si le mode LF/EOI est sélectionné) sont ajoutés entre le délimiteur de préfixe et l'argument, ils sont ignorés par le DM 5010. (SP) (CR) et (LF) sont indiqués en indices dans les exemples qui suivent :

Exemple 1 : $\text{RQS}_{\text{SP}}\text{ON;}$
Exemple 2 : $\text{RQS}_{\text{SP SP}}\text{ON;}$
Exemple 3 : $\text{RQS}_{\text{SP CR}}\text{LF}$
$_{\text{SP SP}}\text{ON}$

Dans la liste des commandes, certains préfixes et arguments sont présentés sous une forme complète et sous une forme abrégée. L'instrument accepte tout préfixe ou argument contenant au moins les caractères de la forme abrégée. Les caractères ajoutés à celle-ci doivent être ceux de la forme complète. Pour documenter ses programmes, l'utilisateur peut ajouter des caractères alphanumériques à un mot complet. Des caractères alphanumériques peuvent également être ajoutés à une interrogation, à condition d'être placés avant le point d'interrogation.

USER?
USERE?
USEREQ?
USEREQUEST?

De nombreux arguments sont séparés par une virgule ; toutefois, l'instrument acceptera comme délimiteur un (ou des) espace(s).

2,3
$2_{\text{SP}}3$
$2,_{\text{SP}}3$

NOTE

Dans le dernier exemple, l'espace est traîté comme un caractère formatté parce qu'il suit la virgule (délimiteur de l'argument).

Format des arguments numériques

L'instrument accepte les nombres suivants comme arguments numériques :

- Les nombres entiers avec ou sans signe (y compris +0 et -0). Les nombres entiers sans signe sont interprétés comme des nombres positifs. Exemples : +1, 2, -1, -10

- Les nombres décimaux avec ou sans signe. Les nombres décimaux sans signes sont interprétés comme des nombres positifs. Exemples : -3.2, +5.0, 1.2

- Les nombres à virgule flottante exprimés en notation scientifique. Exemples : +1.0E-2, 1.0E-2, 0.01E+0

L'argument le plus long autorisé est ±3.4028E+38.

Protocole des messages

Tout message reçu par le DM 5010 est stocké dans la Mémoire Tampon d'Entrée, traîté, puis exécuté. Le traitement d'un message consiste en le décodage des commandes, la détection des délimiteurs, et la vérification de la syntaxe. En ce qui concerne les commandes de réglage, l'instrument consigne les modifications indiquées dans la mémoire Réglages en Attente. Si une erreur est détectée en cours de traitement, l'instrument fait passer la ligne SRQ à l'état bas, ignore le reste du message, et réinitialise la mémoire Réglages en Attente. Ceci évite toute condition de fonctionnement incorrecte pouvant résulter de l'exécution partielle des commandes de réglage contenues dans un message.

L'exécution d'un message consiste en l'exécution des actions spécifiées par la (ou les) commande(s) qu'il contient. S'agissant des Commandes de Réglage, ceci signifie la remise à jour des réglages de l'instrument, et leur stockage dans la mémoire tampon Réglages Actuels. Les commandes de réglage sont exécutées par groupes - une série de commandes de réglage est traîtée et consignée dans la mémoire Réglages en Attente avant leur exécution. Ceci permet à l'utilisateur de spécifier de nouveaux réglages sans avoir à se préocupper de la validité d'une séquence particulière. Leur exécution survient lors du traîtement de la fin du message par l'instrument, d'une commande d'interrogation en sortie, ou d'une commande d'utilisation contenue dans un message.

Lors du traîtement d'une commande d'interrogation en sortie (contenue dans un message), l'instrument exécute toutes les commandes de réglage qui précèdent (remise à jour de ses conditions de fonctionnement). Il exécute alors la commande d'interrogation en extrayant la donnée appropriée et en la plaçant dans la Mémoire Tampon de Sortie. Puis il traîte et exécute le reste du message. Lorsque l'instrument est désigné comme Emetteur, cette donnée est transmise au contrôleur.

Lors du traîtement d'une commande d'utilisation (contenue dans un message), l'instrument exécute d'abord toutes les commandes de réglages précédentes avant de l'exécuter.

Messages multiples

La Mémoire Tampon d'Entrée a une capacité limitée et un message unique peut être assez long pour la remplir. Dans ce cas, une partie du message est traîtée avant que l'appareil accepte une entrée supplémentaire. Durant un traîtement de commande, il rejette toute autre donnée (en validant la ligne NRFD) jusqu'à ce que de l'espace soit disponible en mémoire tampon. L'instrument pourra alors accepter un second message avant que le premier ne soit traîté complètement, mais non un troisième (signal NRFD).

Après l'exécution d'une commande d'interrogation de sortie, l'instrument garde la réponse dans sa Mémoire Tampon de Sortie jusqu'à ce qu'il soit désigné comme Emetteur par le contrôleur. S'il reçoit un nouveau message avant la lecture de toute la sortie du précédent, il annule le contenu de la Mémoire Tampon de Sortie avant d'exécuter ce nouveau message. Ceci évite au contrôleur de recevoir des données indésirées issues d'anciens messages.

Autre situation pouvant annuler une sortie : l'exécution d'un long message peut remplir complètement les mémoires tampons d'entrée et de sortie. Dans ce cas, l'instrument ne peut finir l'exécution du message avant que le contrôleur ait lu les données transmises. Mais le contrôleur ne peut lire ces données avant d'avoir fini de transmettre son message. La Mémoire Tampon d'Entrée, étant pleine, rejette le reste du message du contrôleur (signal NRFD). Cette situation suspend l'activité du système, le contrôleur et l'instrument s'attendant réciproquement. Le DM 5010 génère alors un message d'erreur, fait passer la ligne SRQ à l'état bas, et annule le contenu de la Mémoire Tampon de Sortie. Cette action permet au contrôleur de transmettre le reste de son message, puis l'informe de l'exécution du message et de la disparition des autres données en sortie.

Un instrument de la série TM 5000 peut être désigné comme Emetteur sans avoir reçu de message lui spécifiant ce qu'il doit transmettre. Dans ce cas, les instruments d'acquisition (compteurs et multimètres numériques) renvoient une mesure (si elle est prête). Sinon, ils renvoient un message unique sur un octet dont tous les bits sont égaux à 1 (avec une Fin de Message) ; les autres instruments de la série TM 5000 ne renverront que ce message.

Réponse de l'instrument aux messages de l'interface IEEE-488

Les messages de l'interface et leurs effets sur les fonctions de l'interface de l'instrument sont définis dans les normes IEEE 488-1978. Ce paragraphe, qui en décrit les effets sur le fonctionnement de l'appareil, utilise des abréviations de ces normes.

UNL - Unlisten - N'est pas Récepteur (63 avec la ligne ATN)
UNT - Untalk - N'est pas Emetteur (95 avec la ligne ATN)

La commande UNL fait passer le Récepteur à l'état inactif (non adressé) ; l'instrument n'accepte pas de commande du GPIB.

La commande UNT fait passer l'Emetteur à l'état inactif ; l'instrument ne peut transmettre de données sur le GPIB.

Le voyant ADDRESSED est éteint lorsque ces deux fonctions sont à l'état inactif. Il est allumé si l'instrument est adressé soit en tant qu'Emetteur, soit en tant que Récepteur.

IFC - Interface Clear (Initialisation de l'Interface) (broche 9 du GPIB)

Ce message à ligne unique a le même effet que les messages UNT et UNL. Le voyant ADDRESSED (face avant) est éteint.

DCL - Device Clear (Initialisation de l'Instrument) (20 avec la ligne ATN)

Ce message réinitialise les communications entre l'instrument et le Contrôleur. En réponse à ce message, l'instrument annule tout message en entrée et en sortie et toute commande de réglage dans la mémoire tampon Réglages en Attente. Il en est de même pour toute erreur ou tout évènement non encore transmis, à l'exception de la Mise en Service. Si la ligne SRQ est à l'état bas (validée) pour une autre raison que la mise en service, elle passe à l'état haut à la réception du message DCL.

SDC - Selected Device Clear (Initialisation Particulière de l'Instrument) (4 avec la ligne ATN)

Ce message exécute la même fonction que DCL ; toutefois, seuls les instruments adressés comme Récepteurs répondent à ce message.

GET - Group Execute Trigger (Déclenchement Simultané de Tous les Instruments par le Contrôleur) (8 avec la ligne ATN)

L'instrument n'exécute cette commande que s'il est adressé comme Récepteur et si la fonction Device Trigger (Déclenchement de l'Instrument par le Contrôleur) a été validée par la commande Device Trigger (DT). Le message <GET> est ignoré et une Demande de Service est générée si la fonction DT est inhibée (DT OFF), si l'instrument est en mode Local, ou si un message est en cours de traitement à la réception de <GET8F.

SPE - Serial Poll Enable (validation de l'appel sélectif) (24 avec la ligne ATN)
SPD - Serial Poll Disable (inhibition de l'appel sélectif) (25 avec la ligne ATN)

Le message SPE valide la génération par l'instrument de mots d'état (en réponse à un appel sélectif en série) lorsqu'il est adressé comme Emetteur (Talk). Le message SPD ramène l'instrument en mode d'utilisation normal (transmission de données issues de la Mémoire Tampon de Sortie).

MLA - My Listen Address (Mon adresse en tant que Récepteur)
MTA - My Talk Address (Mon adresse en tant qu'Emetteur)

Les adresses primaires "Talk" et "Listen" sont déterminées par l'adresse des instruments sur le GPIB (sélectionnée à l'intérieur). L'adresse GPIB actuelle est affichée en face avant lorsque le bouton ID est enfoncé. Lorsque l'instrument est désigné comme Emetteur ou comme Récepteur, le voyant ADDRESSED en face avant s'allume.

LLO - Local Lockout (ne fonctionne plus en mode Local) (17 avec la ligne ATN)

En réponse à LLO, l'intrument passe à l'état "bloqué" - de LOCS à LWLS ou de REMS à RWLS.

REN - Remote Enable (Commande à Distance)

Si la ligne REN est à l'état bas (validée), l'instrument passe en mode Contrôle à distance (de LOCS à REMS ou de LWLS à RWLS) une fois reçue son adresse Récepteur. Si la ligne REN est à l'état haut (inhibée), l'instrument passe en mode Local (LOCS), et y reste tant que la ligne REN est à l'état haut.

Cette transition REN peut se produire après le début du traîtement d'un message. Dans ce cas, l'exécution de celui-ci n'est pas affectée par une transition.

GTL - Go To Local (Contrôle Local) (1 avec la ligne ATN)

Seuls les instruments adressés comme Récepteurs répondent à cette commande en passant en mode Local. Les transitions Contrôle à Distance-Contrôle Local provoquées par cette commande n'affectent pas l'exécution du message en cours de traitement (quand GTL est reçu).

Remote (Contrôle à Distance) - Local Operation (Contrôle Local)

Les lignes qui précèdent décrivent les transitions d'un état à l'autre provoquées par les messages GTL et REN. La plupart des commandes en face avant provoquent une transition entre REMS et LOCS en validant le message "Retour en mode Local" (rtl). Cette transition peut se produire durant l'exécution d'un message ; mais, par opposition aux transitions GTL et REN, elle en affecte l'exécution. Dans ce cas, l'instrument génère une erreur s'il subsiste des commandes de réglage ou d'utilisation non exécutées. Les commandes en face avant n'affectant que l'affichage (telle INST ID) n'ont pas d'incidence sur les états "A distance-Local" - seules les commandes agissant sur les réglages (à l'exception des commandes de déclenchement) génèrent le message rtl. Celui-ci est validé par l'entrée de plusieurs commandes au clavier, et est inhibé après le traîtement de ces commandes. Le message rtl prévenant toute transition dans l'état REMS, l'instrument inhibe le message rtl si une séquence de commandes n'a pas été exécutée dans un délai raisonnable (environ 5 à 10 secondes).

L'instrument conserve une copie de ses réglages dans la mémoire tampon Réglages Actuels ; ceux-ci sont remis à jour par tous nouveaux réglages issus de la face avant ou du Contrôleur. De plus, les fonctions de la face avant sont remises à jour pour refléter tout nouveau réglage. Ces réglages ne sont pas affectés par une transition de l'un des quatre états ("A distance - Local") précédemment définis à l'autre. L'indicateur REMOTE s'allume lorsque l'instrument est dans l'état REMS ou RWLS.

Local State (LOCS) - (Etat Local)

Les réglages de l'instrument sont contrôlés en face avant par l'opérateur. Seules les commandes du bus n'agissant pas sur les réglages sont exécutées (interrogations) ; toutes les autres commandes du bus (de réglage et d'utilisation) génèrent une erreur car leurs fonctions sont contrôlées en face avant.

Local With Lockout State (LWLS) - (Etat Local avec blocage de l'Etat Local)

L'instrument opère de la même façon qu'en mode LOCS, excepté que le message rtl n'inhibe pas le passage dans l'état RWLS.

Remote State (REMS) - (Etat Commande à Distance)

L'instrument exécute toutes ses commandes. Tout changement d'une commande en face avant (sauf d'une commande de déclenchement) génère un message rtl et provoque le retour en mode Local (LOCS).

Remote With Lockout State (RWLS) - (Contrôle à Distance avec blocage de l'Etat Local)

Identique à REMS excepté que le message rtl est ignoré.

INDICATIONS D'ETATS ET D'ERREURS

En utilisant la fonction Demande de Service (définie dans les normes IEEE-488), l'instrument peut adresser une demande de service au contrôleur. Cette demande de service permet également de signaler qu'un évènement (changement d'état ou erreur) est survenu. En réponse à une demande de service, le contrôleur effectue un Appel Sélectif en Série. Chaque instrument renvoie alors un mot d'état (STB) indiquant s'il est, ou non, à l'origine de la demande de service. Ce mot d'état peut également contenir une information (succincte) sur la tâche requise. Le format de cette information est indiqué tableau 3.2.

Lorsque le bit de donnée 8 est présent, le STB contient une information sur l'état de l'instrument qui est fournie par les bits 1 à 4. Le bit 4 indique si le DM 5010 attend un déclenchement. Le bit 3 indique qu'une mesure est disponible.

Parce que le STB convoie une information limitée concernant un évènement, les évènements sont divisés en deux types : le Mot d'Etat définit le type. Les types d'évènements se définissent de la façon suivante :

ERREUR DE COMMANDE — Indique que l'instrument a reçu une commande qu'il ne peut comprendre.

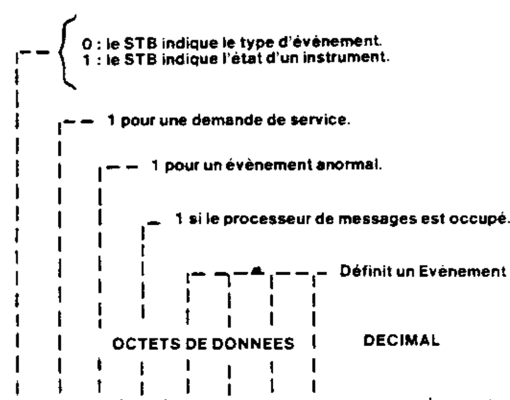
ERREUR D'EXECUTION — Indique que l'instrument a reçu une commande qu'il ne peut exécuter. Ceci peut provenir d'arguments erronés, ou de réglages contradictoires.

ERREUR INTERNE — Indique que l'instrument a détecté une condition (matérielle ou logicielle) empêchant une opération.

EVENEMENTS DU SYSTEME — Evènements communs à tous les éléments d'un système (Mise en Service, Requête Utilisateur, etc..).

AVERTISSEMENT INTERNE — Indique que l'instrument a détecté un problème. Il reste opérationnel, mais le problème doit être résolu (ex. : atténuation non étalonnée).

ETAT DE L'INSTRUMENT — Evènement relatif à un instrument particulier.



Mot d'état (exemple)	8	7	6	5	4	3	2	1		Pas occupé	occupé
Mise en service	0	1	0	X	0	0	0	1		65	81

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Tableau 3.2. Définition des octets du mot d'état

Par une Demande de Service, un instrument a la possibilité de fournir des informations supplémentaires sur de nombreux évènements, particulièrement les erreurs signalées dans le Mot d'Etat. Après avoir déterminé d'où est issue la Demande de Service (en examinant le STB), le contrôleur peut requérir ces informations en transmettant l'interrogation ERR?. En réponse, l'instrument renvoie un code définissant l'évènement (v. tableau 3.1).

Tableau 3.1.
INDICATIONS D'ERREURS ET D'ETATS

Evènements anormaux	Réponse à l'interro-gation	Appel sélectif[a] en série (décimal)
Erreurs de commande		
Préfixe erroné	101	97
Délimiteur de préfixe erroné	102	97
Argument erroné	103	97
Délimiteur d'argument erroné	104	97
Argument non numérique (nombre requis)	105	97
Argument manquant	106	97
Délimiteur de l'unité du message invalide	107	97
Erreurs d'exécution		
Commande non exécutable en mode Local	201	98
Réglages perdus du fait du retour en mode Local (rtl)	202	98
Mémoires d'E/S pleines, données de sortie "déchargées"	203	98
Argument hors-gamme	205	98
Déclenchement de groupe ignoré (GET)	206	98
L'instrument n'est pas en position étalonnée	231	98
Au delà des limites d'étalonnage ou de la capacité de la fonction NULL	232	98
Erreurs internes		
Erreur d'interruption	301	99
Erreur du système	302	99
Erreur dans le bloc mathématique	303	99
Temps de conversion erroné	311	99
Temps de réponse en face avant erroné	317	99
Constante d'étalonnage (en ohms) erronée	318	99
Checksum d'étalonnage erroné	351	99
Evènements normaux		
Evènements du système		
Mise en service	401	65
Opération Complète	402	66
Requête de l'utilisateur	403	67
Dépassement de gamme	601	102
Etat de l'instrument[b] :		
Mesure disponible	0	132
Attend un déclenchement	0	136
Mesure disponible et attend un déclenchement	0	140
< limites	701	193
> limites	703	195
Ni erreur ni évènement	0	128

[a]Si l'instrument est occupé, il renvoie le nombre indiqué auquel il ajoute 16.
[b]La commande POLL du contrôleur de la Série 4050 renvoie 0 en réponse aux Appels Sélectifs en Série entre 128 et 192 ; les réponses indiquées peuvent être obtenues à l'aide des instructions WBYTE et RBYTE.

Tableau 3.2
CODES D'ERREUR
VISUALISES EN FACE AVANT

Erreurs d'exécution :	
205	Argument hors-gamme
231	L'instrument n'est pas en position étalonnée
232	Au delà des limites d'étalonnage
Erreurs internes :	
303	Erreur dans le bloc mathématique
311	Temps de conversion erroné
317	Temps de réponse en face avant erroné
318	Constante d'étalonnage (en ohms) erronée
340	RAM erronée
341	RAM erronée
351	Checksum d'étalonnage erroné
372	ROM C000 mal positionnée
373	ROM D000 mal positionnée
374	ROM E000 mal positionnée
392	Checksum de la ROM C000 erroné
393	Checksum de la ROM D000 erroné
394	Checksum de la ROM E000 erroné
395	Checksum de la ROM F000 erroné
521	Le commutateur d'adresse GPIB (Analyse de signatures) est validé

Dans le cas de plusieurs évènements, l'instrument maintient la ligne SRQ à l'état bas jusqu'à ce que tous les évènements aient été signalés au contrôleur. Une fois que celui-ci en a pris connaissance (par un Appel Sélectif en Série), chaque évènement est annulé automatiquement. Le message de l'interface Device Clear (DCL) peut être utilisé pour annuler tous les évènements, sauf la Mise en Service.

Certaines commandes valident la transmission d'évènements individuels au Contrôleur et inhibent les Demandes de Service. Par exemple, la commande User Request (USER) permet à l'utilisateur de communiquer l'évènement "Requête de l'utilisateur" à partir de la face avant (bouton INST ID enfoncé). La commande RQS contrôle l'utilisation de demandes de service pour transmettre des évènements au Contrôleur.

RQS OFF inhibe toutes les demandes de service (sauf la Mise en Service). Dans ce mode, l'interrogation ERR? permet au Contrôleur de s'informer des évènements sans exécuter un Appel Sélectif en Série. Il peut émettre cette interrogation à tout instant ; l'instrument lui transmet alors tout évènement en attente d'être communiqué. Le Contrôleur peut annuler tous les évènements, soit en transmettant l'interrogation ERR? jusqu'à ce que le code zéro (0) soit renvoyé, soit par l'intermédiaire du message DCL de l'interface (Mise en Service exceptée).

En mode RQS OFF, le Contrôleur peut exécuter un Appel Sélectif en Série, mais le mot d'état obtenu ne contient que l'indication d'Etat propre à l'appareil. En mode RQS ON, le STB (mot d'état) contient le type de l'évènement. Une interrogation "Erreur" ultérieure renvoie une information supplémentaire sur cet évènement.

TRANSMISSION DE MESSAGES DE CONTROLE DE L'INTERFACE

Les commandes qui suivent sont utilisées par les contrôleurs de la série 4050 Tektronix et utilisables par les autres contrôleurs.

Les commandes ASCII sont transmises au DM 5010 à l'aide des instructions PRINT. La réception par le Contrôleur des réponses ASCII s'effectue par l'intermédiaire des instructions INPUT.

```
PRINT    16:"SET?"
INPUT    16:A$
```

16 étant l'adresse GPIB du DM 5010 (sélectionnée en usine).

Les messages de contrôle du Bus Interface sont transmis par l'intermédiaire des commandes WBYTE du Contrôleur. Dans les exemples suivants, A et B sont les adresses "Emettre" et "Recevoir". A = 32 plus l'adresse de l'instrument, et B = 64 plus l'adresse de l'instrument.

Listen (Recevoir)	WBYTE @, A:
Unlisten (Ne pas recevoir)	WBYTE @ 63:
Talk (Emettre)	WBYTE @ B:
Untalk (Ne pas émettre)	WBYTE @ 95:
Device clear (DCL) (initialisation de l'instrument)	WBYTE @ 20:
Selective device clear (SDC) (initialisation particulière de l'instrument)	WBYTE @ A,4:
Go to local (GTL) (retour en mode Local)	WBYTE @ A,1:
Remote with lockout (contrôle à distance avec blocage)	WBYTE @ A,17:
Local with lockout (blocage du contrôle local)	WBYTE @ 17:
Group Execute Trigger (GET) (déclenchement groupé)	WBYTE @ A,8:
Serial Poll Enable (Valmidation de l'appel sélectif en série (SPE)	WBYTE @ 24:
Serial Poll Disable Inhibition de l'appel sélectif en série (SPD)	WBYTE @ 25:

Des informations sur les Contrôleurs de la Série 4050 sont données dans le manuel d'utilisation correspondant.

REGLAGES EFFECTUES A LA MISE EN SERVICE

A la mise en service, le DM 5010 exécute un programme d'auto-test permettant de vérifier le bon fonctionnement des RAMs et des ROMs. Si aucune erreur n'est détectée, l'instrument passe à l'Etat Contrôle Local (LOCS), avec les réglages indiqués au tableau 3.3. La ligne SRQ du GPIB est également validée.

Ces réglages sont également restaurés lors de l'exécution de la commande INIT. La gamme de mesure de la fonction DCV n'est valable que pour le premier affichage, l'instrument se trouvant en mode Sélection de Gamme Automatique.

Tableau 3-3
REGLAGES EXISTANTS A LA MISE SOUS TENSION

Préfixe	Argument
AVE	2
CALC	OFF
DBR	1
DCV	-1.E+3
DIGIT	4.5
DT	OFF
LFR	OFF
LIMITS	0.0
MODE	RUN
MONITOR	OFF
NULL	0
OPC	OFF
OVER	OFF
RATIO	1.0
RQS	ON
SOURCE	FRONT
USER	OFF

TABLE DE CONVERSION ASCII ET IEEE 488 (GPIB)

BITS B7 B6 B5 →				Ø Ø Ø	Ø Ø 1	Ø 1 Ø	Ø 1 1	1 Ø Ø	1 Ø 1	1 1 Ø	1 1 1
				CONTROL		NUMBERS SYMBOLS		UPPER CASE		LOWER	
B4	B3	B2	B1								
Ø	Ø	Ø	Ø	0 NUL 0 (0)	20 DLE 10 (16)	40 SP 20 (32)	60 0 30 (48)	100 @ 40 (64)	120 P 50 (80)	140 ` 60 (96)	160 p 70 (112)
Ø	Ø	Ø	1	1 SOH GTL 1 (1)	21 DC1 LLO 11 (17)	41 ! 21 (33)	61 1 31 (49)	101 A 41 (65)	121 Q 51 (81)	141 a 61 (97)	161 q 71 (113)
Ø	Ø	1	Ø	2 STX 2 (2)	22 DC2 12 (18)	42 " 22 (34)	62 2 32 (50)	102 B 42 (66)	122 R 52 (82)	142 b 62 (98)	162 r 72 (114)
Ø	Ø	1	1	3 ETX 3 (3)	23 DC3 13 (19)	43 # 23 (35)	63 3 33 (51)	103 C 43 (67)	123 S 53 (83)	143 c 63 (99)	163 s 73 (115)
Ø	1	Ø	Ø	4 EOT SDC 4 (4)	24 DC4 DCL 14 (20)	44 $ 24 (36)	64 4 34 (52)	104 D 44 (68)	124 T 54 (84)	144 d 64 (100)	164 t 74 (116)
Ø	1	Ø	1	5 ENQ PPC 5 (5)	25 NAK PPU 15 (21)	45 % 25 (37)	65 5 35 (53)	105 E 45 (69)	125 U 55 (85)	145 e 65 (101)	165 u 75 (117)
Ø	1	1	Ø	6 ACK 6 (6)	26 SYN 16 (22)	46 & 26 (38)	66 6 36 (54)	106 F 46 (70)	126 V 56 (86)	146 f 66 (102)	166 v 76 (118)
Ø	1	1	1	7 BEL 7 (7)	27 ETB 17 (23)	47 ' 27 (39)	67 7 37 (55)	107 G 47 (71)	127 W 57 (87)	147 g 67 (103)	167 w 77 (119)
1	Ø	Ø	Ø	10 BS GET 8 (8)	30 CAN SPE 18 (24)	50 (28 (40)	70 8 38 (56)	110 H 48 (72)	130 X 58 (88)	150 h 68 (104)	170 x 78 (120)
1	Ø	Ø	1	11 HT TCT 9 (9)	31 EM SPD 19 (25)	51) 29 (41)	71 9 39 (57)	111 I 49 (73)	131 Y 59 (89)	151 i 69 (105)	171 y 79 (121)
1	Ø	1	Ø	12 LF A (10)	32 SUB 1A (26)	52 * 2A (42)	72 : 3A (58)	112 J 4A (74)	132 Z 5A (90)	152 j 6A (106)	172 z 7A (122)
1	Ø	1	1	13 VT B (11)	33 ESC 1B (27)	53 + 2B (43)	73 ; 3B (59)	113 K 4B (75)	133 [5B (91)	153 k 6B (107)	173 { 7B (123)
1	1	Ø	Ø	14 FF C (12)	34 FS 1C (28)	54 , 2C (44)	74 < 3C (60)	114 L 4C (76)	134 \ 5C (92)	154 l 6C (108)	174 | 7C (124)
1	1	Ø	1	15 CR D (13)	35 GS 1D (29)	55 − 2D (45)	75 = 3D (61)	115 M 4D (77)	135] 5D (93)	155 m 6D (109)	175 } 7D (125)
1	1	1	Ø	16 SO E (14)	36 RS 1E (30)	56 . 2E (46)	76 > 3E (62)	116 N 4E (78)	136 ^ 5E (94)	156 n 6E (110)	176 ~ 7E (126)
1	1	1	1	17 SI F (15)	37 US 1F (31)	57 / 2F (47)	77 ? UNL 3F (63)	117 O 4F (79)	137 _ UNT 5F (95)	157 o 6F (111)	177 RUBOUT (DEL) 7F (127)

Commandes adressées

Commandes universelles

Adresse "recevoir"

Adresse "transmettre"

Adresses secondaires ou commandes.

KEY TO CHART

octal — 25	PPU — GPIB code	
	NAK — ASCII character	
hex — 15	(21) — decimal	

3391-13

Fig. 3.3. Table de conversion ASCII et IEEE 488 (GPIB)

EXEMPLES DE PROGRAMMES

Programmes de Transmission et de Réception pour Contrôleurs Tektronix de la Série 4050.

```
100  REM PROGRAMME DE
     TRANSMISSION/RECEPTION DM 5010
110  REM L'ADRESSE PRIMAIRE DU DM 5010 EST 16
120  INIT
130  ON SRQ THEN 260
140  DIM A$ (200)
150  PRINT "ENTRER LE(S) MESSAGE(S): ";
160  INPUT C$
170  PRINT    16:C$
180  REM RECHERCHER LES INTERROGATIONS
190  IF POS(C$,"?",1)< > 0 THEN 220
200  REM RECHERCHER 'SEND'
210  IF POS(C$,"SEND",1)§0 THEN 150
220  REM ENTREE ISSUE DE L'INSTRUMENT
230  INPUT    16:A$
240  PRINT A$
250  GO TO 150
260  REM SOUS-PROGRAMME D'APPEL SELECTIF EN
     SERIE
270  POLL X,Y;16
280  PRINT "MOT D'ETAT: ";Y
290  RETURN
```

Programme de Transmission et de Réception pour Contrôleurs Tektronix de la Série 4040

```
 90  REM PROGRAMME DE
     TRANSMISSION/RECEPTION DM5010
 95  REM ADRESSE PRIMAIRE DU DM 5010 § 16
100  OPEN 1:"GPIB(PRI§16,EOM§< >):"
110  ON SRQ THEN GOSUB 240
115  ENABLE SRQ
120  DIM A$ TO (200)
130  PRINT "ENTRER LA (OU LES)
     COMMANDE(S)/INTERROGATION"
140  INPUT C$
145  IF C$§"EX" THEN GOTO 230
150  PRINT 1:C$
160  REM RECHERCHER LES INTERROGATIONS
170  IF POS(C$,"?",1)< > 0 THEN GOTO 200
180  IF POS(C$,"SEND",1)§0 THEN GOTO 130
190  REM ENTREE ISSUE DE L'INSTRUMENT
200  INPUT 1:A$
210  PRINT A$
220  GOTO 130
230  STOP
240  POLL SB,P,S;16
250  PRINT "SRQ VUE, MOT D'ETAT:",SB
260  RETURN
```

Ces exemples de programmes sont destinés à aider l'utilisateur à transmettre des commandes au DM 5010 pour la modification de ses réglages et le renvoi des données générées.

Une aide supplémentaire pour le développement de logiciel nécessaire à une application spécifique est fournie dans les manuels Tektronix suivants :

070-3985-00 - GPIB Programming Guide (Guide de Programmation du GPIB). Manuel décrivant les applications de cet instrument dans des systèmes compatibles IEEE-488. Ce manuel contient des instructions et conseils de programmation, ainsi que des exemples de programmes spécifiques.

070-2270-00 - 4051 GPIB Hardware Support Manual (Manuel d'utilisation du GPIB avec le contrôleur 4051). Manuel contenant une description détaillée du fonctionnement du Bus IEEE-488, des différentes opérations sur le Bus, et des circuits de l'Interface.

070-2058-01 - Programming in Basic (Programmation en Basic).

070-2059-01 - Graphic programming in Basic (Programmation graphique en Basic).

062-5971-01 - 4050-Series programming aids, T1 (Aide à la programmation des contrôleurs de la Série 4050 - logiciel inclus).

062-5972-01 - 4050-Series programming aids, T2 (Aide à la programmation des contrôleurs de la Série 4050 - logiciel inclus).

070-2380-01 - 4907 File manager operators manual (manuel d'utilisation du système de gestion de fichiers 4907).

070-2128-00 - 4924 Users manual (manuel d'utilisation du 4924).

070-1940-01 - 4050-Series graphic system operators manual (manuel d'utilisation des systèmes graphiques de la Série 4050).

070-2056-01 - 4050-Series graphic system reference manual (manuel de référence des systèmes graphiques de la Série 4050).

070-3918-00 - 4041 Operators manual (manuel d'utilisation du 4041).

061-2546-00 - 4041 Programming reference manual (manuel de référence pour la programmation du 4041).

AIDE A LA PROGRAMMATION DU DM 5010

Ces indications, illustrées d'exemples précis, sont destinées à aider l'utilisateur à développer ses propres programmes de contrôle du DM 5010. Les exemples de programmes ont été réalisés à l'aide d'un Contrôleur de la Série 4050 et du DM 5010. Certains exemples utilisent d'autres instruments de la Série TM 5000. Avant d'effectuer la programmation du DM 5010, sélectionner la Fin de Message, l'adresse GPIB, et le mode Emetteur Seulement, à l'aide des commutateurs correspondants. Pour afficher ces réglages en cours d'utilisation, appuyer sur le bouton INST ID. Le nombre affiché est l'adresse primaire GPIB. Le nombre décimal de droite (de l'affichage) s'allume si la Fin de Message sélectionnée est LF/EOI. Le signe "moins" s'allume si le mode Emetteur Seulement est sélectionné. Pour modifier ces réglages internes, s'adresser à un personnel de maintenance qualifié (v. chapitre Maintenance).

Dans les exemples de programmes, la variable D est affectée à l'adresse primaire GPIB du DM 5010 (16 à la livraison). L'utilisation d'une variable alphabétique élimine la nécessité de répéter le numéro d'adresse, et permet de changer aisément celle-ci.

Traitement des Demandes de Service

A la mise en service, le DM 5010 valide la ligne SRQ. La Demande de Service (SRQ) informe le contrôleur de l'interruption de la source d'alimentation durant le déroulement du programme, celle-ci pouvant nuire à sa bonne exécution.

Le DM 5010 peut également valider la ligne SRQ pour d'autres évènements (v. tableau 3.1, Indications d'erreurs et d'états). Certains contrôleurs ont la possibilité d'ignorer les Demandes de Service. D'autres doivent les exécuter toutes. Si des Demandes de Service doivent être exécutées dans le programme, penser à valider son interruption.

Programme de traitement des interruptions - programme exécutant les Demandes de Service survenant en cours d'exécution d'un programme. Il se compose essentiellement d'une instruction SRQ ON (en début de programme), et d'un sous-programme d'Appel Sélectif en Série (POLL) (en un point quelconque du programme). A l'occurence d'une Demande de Service, l'instruction ON SRQ transmet le contrôle du programme au sous-programme POLL. Cette instruction se trouve à la ligne 110 des exemples 1 et 3. Une interruption entraîne donc l'exécution par le contrôleur d'un Appel Sélectif en Série (POLL). Dans une instruction POLL, la première variable renvoie la position des instruments dans la liste des adresses GPIB. La seconde renvoie le Mot d'Etat. Voir l'exemple d'Appel Sélectif (par un seul appareil sur le Bus) à la ligne 1000 de l'Exemple 3 . La ligne 400 de l'exemple 4 "interroge" trois instruments sur le Bus en utilisant pour chaque adresse une variable alphabétique. Dans chaque exemple, l'Appel Sélectif renvoie le Mot d'état de l'instrument à l'origine de la Demande de Service. Les lignes 150, 160, et 170 du programme 9 comprennent un Appel Sélectif en Série utilisant les instructions WBYTE et RBYTE de la Série 4050.

Le sous-programme d'Appel Sélectif en Série peut être étendu au décodage des informations de l'évènement occasionnant la Demande de Service. Dans l'exemple 1, les lignes 510 et 520 annulent le bit "occupé" (busy) du Mot d'Etat. Les lignes 530 à 560 décodent le Mot d'Etat et les lignes 1000 à 7030 affichent sur l'écran du contrôleur le type de l'évènement.

L'exemple 7 utilise la Demande de Service du Moniteur pour détecter les mesures supérieures ou inférieures aux limites définies par la commande LIMITS, ou les dépassements de gamme. Les lignes 1020, 1040, et 1045 décodent le Mot d'Etat et initialisent l'affichage correspondant sur le contrôleur.

La ligne 130 de l'exemple 2 "interroge" (poll) l'instrument à l'adresse 16 pour annuler la Demande de Service de la mise sous tension. La ligne 160 annule toute demande de service ultérieure (RQS OFF). Après la génération de RQS OFF, l'interrogation ERR? peut être insérée dans le programme chaque fois qu'il s'avère nécessaire de déterminer l'état d'un évènement.

Blocage de la face avant

La face avant peut être inhibée de façon à ce que seul le Contrôleur puisse agir sur les réglages de l'instrument. Pour cela, valider la ligne REN (état Vrai) le temps nécessaire. Avec les contrôleurs de la Série 4050, l'instruction RUN valide automatiquement la ligne REN. L'instruction END inhibe la ligne REN. Puis transmettre le message de l'interface LLO (17 en décimal avec la ligne ATN). Avec un contrôleur de la Série 4050, ceci s'effectue à l'aide de l'état WBYTE. Finalement, adresser l'instrument en envoyant un réglage ou une interrogation, en utilisant l'état PRINT D ou envoyer seulement l'adresse "Recevoir" à l'aide de l'instruction WBYTE. Après ces trois étapes, la face avant est bloquée et le demeure jusqu'à ce que le signal REN passe à l'état Faux, ou qu'un message <GTL> (1 en décimal avec la ligne ATN) soit transmis. Voir les lignes 150 et 190 de l'exemple 4. Voir également les lignes 130 et 220 de l'exemple 5.

Utilisation de la commande INIT

Cette commande simplifie le programme du fait qu'elle diminue le nombre des commandes de réglage individuelles. A la ligne 150 de l'exemple 6, le DM 5010 reçoit la commande INIT suivie d'une série de commandes modifiant l'état des réglages initiaux (à la mise en service).

Invalidation d'une mesure en attente

Lorsque le signal entré est modifié par rapport à la mesure en attente, il peut être nécessaire d'invalider celle-ci, du fait qu'elle ne reflète plus les conditions actuelles. Ceci peut être réalisé en envoyant à l'instrument une commande de réglage, qui annulera le contenu de la Mémoire Tampon de sortie. Ou bien en transmettant une mesure au Contrôleur et en ignorant celle-ci.

Les mesures invalides peuvent être évitées en utilisant le mode Déclenché (MODE TRIG) pour contrôler l'occurence de chaque mesure.

Temps d'établissement

Un temps d'établissement peut être aménagé dans un programme, pour s'assurer de la validité de la mesure renvoyée au contrôleur. Se référer au chapitre Caractéristiques (Commande incrémentielle du Temps de Réponse).

Les lignes 230-250 de l'exemple 4 utilisent une boucle FOR...NEXT pour entrer cinq mesures dans la variable R. A la fin de la boucle, la variable R contient la cinquième mesure.

Les lignes 290-320 de l'exemple 5 effectuent la comparaison entre deux mesures du DM 5010. Si la différence est supérieure à 0,001, la comparaison s'effectue avec une autre mesure. Celle-ci se répète jusqu'à l'obtention de deux mesures pratiquement identiques.

Mesures par déclenchement

Pour déclencher une conversion simple, utiliser le mode Déclenché (MODE TRIG) et initialiser un déclenchement à l'aide de l'une des méthodes suivantes

1. Adresser l'instrument en tant qu'Emetteur. Voir la ligne 180 de l'exemple 2.

2. Transmettre une commande SEND.

3. Transmettre une commande DT TRIG. Puis déclencher le DM 5010 en lui envoyant le message de l'interface <GET> (8 en décimal avec la ligne ATN). Voir les lignes 120 et 5 de l'exemple 9.

4. Si le mode Déclenchement Externe (EXTRIG) est validé, maintenir la ligne P1031-16A de la carte d'isolation à l'état bas durant 10 μS (max.).

5. Aviser l'opérateur d'appuyer sur le bouton TRIGGERED en face avant.
   Pour un déclenchement répétitif (relaxé), utiliser la commande MODE RUN. Si le mode EXTRIG est validé, maintenir la ligne P1031-16A (carte d'isolation) à l'état bas.

Disponibilité d'une mesure

Il n'est pas nécessaire de déterminer si une mesure est disponible lorsque l'instrument est adressé en tant qu'Emetteur ou lors de l'utilisation de la commande SEND pour le renvoi de données. Pour ces deux méthodes, le DM 5010 déclenche une conversion si aucune mesure n'est en attente. Pour les autres méthodes, il existe plusieurs façons de déterminer si une mesure est disponible :

1. Transmettre la commande d'interrogation RDY?. La réponse "1" indique qu'une mesure est prête. Voir la ligne 140 de l'exemple 3.

2. Générer les commandes OPC ON et RQS ON. L'instrument valide la ligne SRQ lorsqu'une mesure est disponible. Voir la ligne 150 de l'exemple 8.

3. Répéter le programme d'Appel Sélectif en Série (POLL) en utilisant les instructions WBYTE, jusqu'à ce que le Mot d'Etat soit 132, 148, 140, ou 156. Voir les lignes 150 et 200 de l'exemple 9.

Utiliser les commandes RDY?, OPC ON, et le programme d'Appel Sélectif dans le cas de plusieurs tâches simultanées.

Transmission de mesures à un Récepteur

Avant le transfert d'une mesure du DM 5010 à un Récepteur sur le Bus GPIB, "adresser" cet instrument en tant que Récepteur. Puis adresser le DM 5010 comme Emetteur pour transmettre les mesures. Les données transmises à un Contrôleur peuvent être lues sous forme d'une chaîne de caractères ou d'une variable numérique. Voir la ligne 180 de l'exemple 2 et la ligne 150 de l'exemple 3.

PROGRAMMIERUNG

Einführung

Dieser Abschnitt des Handbuches informiert über die Programmierung des TEKTRONIX Programmierbaren Digital Multimeters DM 5010 über die IEEE-488 Digital-Schnittstelle. Die IEEE-488 Interface-Funktionszeichen für das DM 5010 sind in Abschnitt 1 aufgelistet. In diesem Handbuch wird die IEEE-488 Digital-Schnittstelle als General Purpose Interface Bus (GPIB) bezeichnet. Die nachstehenden Informationen setzen voraus, daß der Leser mit der GPIB-Kommunikation vertraut ist und einige Erfahrungen mit der Programmierung von Controllern hat. Mitteilungs-Protokolle über den GPIB sind in der Norm IEEE-488-1978, „Standard Digital Interface for Programmable Instrumentation"[1] beschrieben und spezifiziert. TM 5000 Geräte wurden für die Kommunikation mit allen GPIB-kompatiblen Controllern entwikkelt, die ASCII Mitteilungen (Befehle) über den GPIB senden und empfangen. Diese Befehle programmieren das Gerät oder fragen Informationen vom Gerät ab.

Die Befehle für programmierbare Geräte der Serie TM 5000 wurden für Kompatibiltät unter den Gerätetypen entwickelt. Der gleiche Befehl wird bei verschiedenen Geräten für die Steuerung ähnlicher Funktionen verwendet. Ferner sind die Befehle in Mnemoniken spezifiziert, die sich auf die jeweilige Funktion beziehen. Der Befehl INT z. B. stellt das Gerät auf seinen Einschalt-Zustand ein. Zur weiteren Erleichterung der Programmierung entsprechen die Befehls-Mnemoniken in den meisten Fällen denen auf der Frontplatte.

Die Geräte-Befehle werden in drei Formaten dargestellt:

- Eine Abbildung der Frontplatte – die die Beziehung der Befehle zu den Bedienungselementen auf der Frontplatte zeigt. Siehe Bild 3-1.
- Liste der funktionellen Befehle – eine Liste, die in Funktionsgruppen mit kurzen Beschreibungen aufgeteilt ist.
- Detaillierte Befehlsliste – eine alphabetische Auflistung der Befehle mit vollständiger Beschreibung.

[1] **Veröffentlicht durch das Institute of Electrical and Electronics Engineers, Inc., 345 East 47th Street, New York, N. Y. 10017.**

Programmierbare Geräte der Serie TM 5000 werden über eine Versorgungseinheit TM 5000 mit dem GPIB verbunden. Der Abschnitt Bedienungsanleitung in diesem Handbuch gibt Hinweise für den Einbau des Gerätes in die Versorgungseinheit. Dieser Abschnitt macht Sie auch mit den Vorsichtsmaßnahmen, den Bedienungselementen auf der Frontplatte und den intern wählbaren Gerätefunktionen vertraut.

Die GPIB Primäradresse für dieses Gerät kann intern durch qualifiziertes Servicepersonal verändert werden. Bei Versand ist das DM 5010 auf die Adresse mit dem Dezimaläquivalent 16 eingestellt. Auch das Endezeichen kann intern durch qualifiziertes Servicepersonal ausgewählt werden. Endezeichen werden in diesem Handbuch im Abschnitt „Mitteilungen und Kommunikationsprotokoll" beschrieben. Bei Versand von TM 5000 Geräten ist dieses Endezeichen auf EOI ONLY eingestellt. Hinweise für qualifiziertes Servicepersonal, wo und wie die Einstellung erfolgt, sind in diesem Handbuch im Abschnitt Wartung enthalten. Eindrücken der Taste INST ID veranlaßt das Gerät seine gewählte GPIB-Primäradresse darzustellen; der Dezimalpunkt ganz rechts leuchtet auf, wenn das gewählte Endezeichen LF/EOI ist. Das Minuszeichen leuchtet auf, wenn die Betriebsart Talk Only eingeschaltet ist.

Betriebsart Talk Only

In der Betriebsart Talk Only kann das DM 5010 über den GPIB unter lokaler Steuerung Daten an einen Hörer (Listener) senden. Für die Wahl dieser Betriebsart wird ein interner Schalter auf die Stellung Talk Only gesetzt. Hinweise dazu findet qualifiziertes Servicepersonal im Abschnitt Wartung.

In der Betriebsart Talk Only beginnt das DM 5010 mit dem Senden von Meßdaten wenn auf der Frontplatte die Taste INST ID gedrückt wird; es stoppt das Senden von Daten wenn auf der Frontplatte die Taste CLEAR gedrückt wird. Wird CLEAR während der Übertragung eines Meßergebnisses gedrückt, stoppt das Gerät erst nach dessen vollständiger Übertragung. Das Lämpchen ADDRESSED bleibt erleuchtet, bis die Übertragung der letzten Ablesung beendet ist.

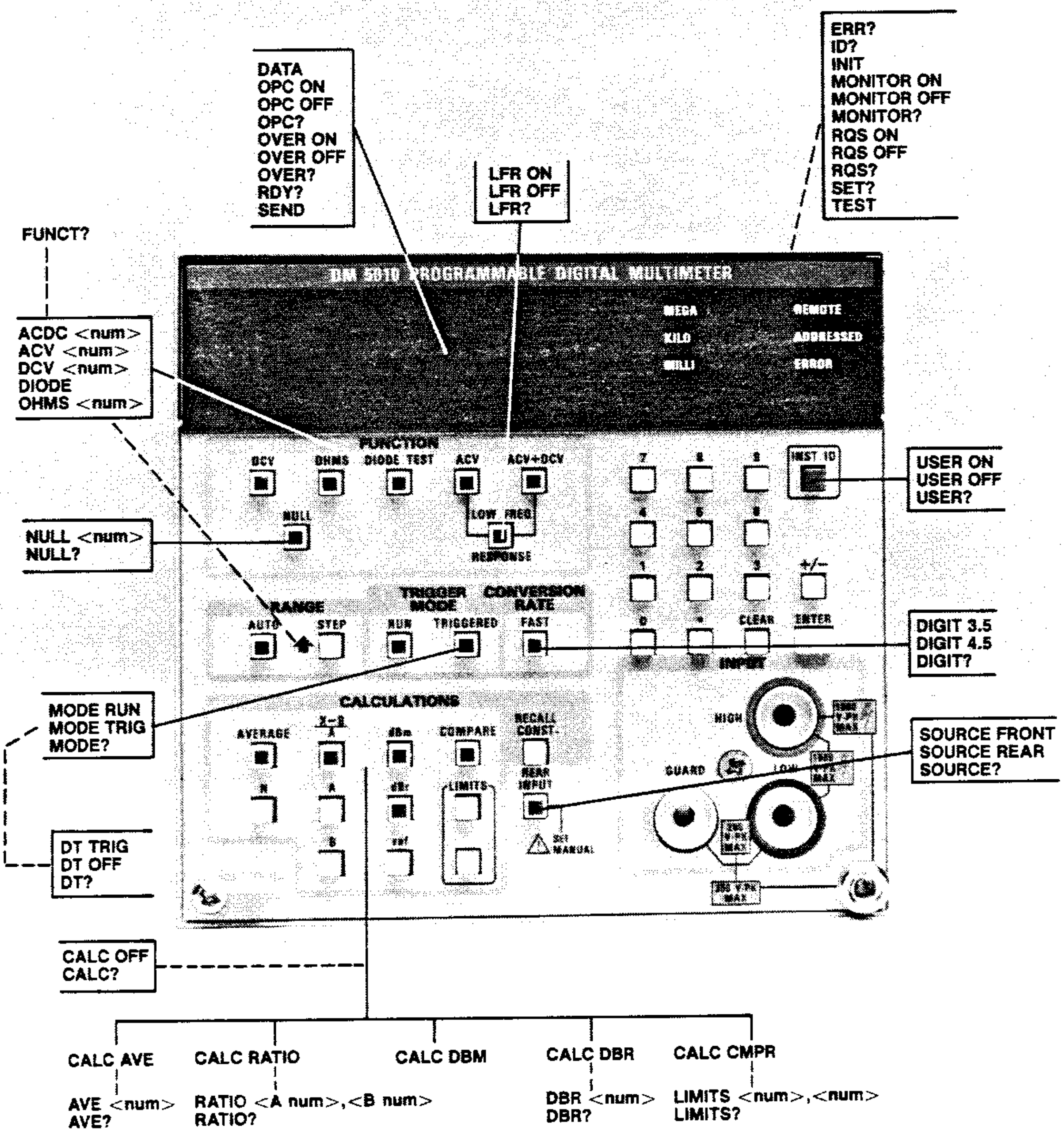

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Bild 3–1 Gerätebefehle und ihre Beziehung zu den Bedienungselementen auf der Frontplatte.

BEFEHLE

Das Gerät wird über die Bedienungselemente auf der Frontplatte oder über Befehle vom Controller gesteuert. Es gibt drei Befehlsarten:

Einstell-Befehle – steuern die Einstellung des Gerätes.

Abfrage-Befehle – fragen nach Daten.

Betriebs-Befehle – veranlassen eine bestimmte Tätigkeit.

VORSICHT

Vorsicht bei der Verwendung von weniger Zeichen als im abgekürzten Kopfteil oder Argument enthalten sind. Falsche Ergebnisse und Beschädigungen können auftreten wenn diese Daten an das falsche Gerät gesendet werden.

Ist das Gerät auf Fernbedienung eingestellt, werden alle Befehle beantwortet und ausgeführt. Bei Eigenbedienung, erzeugen „Einstellungs-" und „Betriebs-Befehle" Fehler, da die Gerätefunktionen über die Bedienungselemente auf der Frontplatte gesteuert werden; nur „Abfrage-Befehle" werden beantwortet.

Jeder Befehl beginnt mit einem Kopfteil – einem Wort das die jeweilige Funktion beschreibt. Viele Befehle müssen durch ein Argument nach dem Kopfteil ergänzt werden – einem Wort oder einer Zahl, die die gewünschte Funktion näher beschreibt.

VORSICHT

Wenn das Gerät in der Betriebsart AUTO arbeitet, soll die Eingangsspannung nicht wiederholt zwischen einem niedrigen Wert ($< 200\ mV_S$) und einem höheren Wert ($> 200\ V_S$) hin und her geschaltet werden. Für wiederholte Messungen, die zwischen den Spannungsextremen alternieren, verwenden Sie vor Erhöhung der Eingangsspannung zur Wahl eines entsprechenden höheren Bereichs die Betriebsart STEP, da sonst zeitweise Ungenauigkeiten bei Messungen im 200 mV Bereich auftreten können.

LISTE DER FUNKTIONELLEN BEFEHLE

GERÄTE BEFEHLE

Funktions-Befehle

ACDC <num> – Stellt ACV + DCV Funktion und Bereich ein.

ACV <num> – Stellt ACV Funktion und Bereich ein.

DCV <num> – Stellt DCV Funktion und Bereich ein.

DIODE – Stellt DIODE TEST Funktion ein.

FUNCT? – Abfrage nach Funktion und Bereich.

LFR ON – Gibt die Funktion LOW FREQ RESPONSE frei.

LFR OFF – Sperrt die Funktion LOW FREQ RESPONSE.

LFR? – Abfrage nach LFR ON oder LFR OFF.

NULL <num> – Gibt die Funktion NULL und den Offsetwert frei.

NULL? – Abfrage nach NULL Offsetwert.

OHMS <num> – Stellt OHMS Funktion und Bereich ein.

Trigger-Befehle

MODE RUN – Gibt die Triggerbetriebsart RUN frei.

MODE TRIG – Gibt die Triggerbetriebsart TRIGGERED frei.

MODE? – Abfrage nach MODE RUN oder MODE TRIG!

RDY? – Abfrage nach RDY 1, wenn eine Messung beendet ist; RDY 0, wenn eine Messung durchgeführt wird oder auf Triggerung wartet.

DIGIT 3,5 – Gibt die Übertragungsrate FAST frei.

DIGIT 4,5 – Gibt die normale Übertragungsrate frei.

DIGIT? – Abfrage nach DIGIT 3,5 oder DIGIT 4,5.

Berechnungs-Befehle

AVE <num> – Stellt den Wert der Konstanten N ein.

AVE? – Abfrage nach dem Wert der Konstanten N.

CALC AVE – Gibt die AVERAGE Berechnung frei.

CALC CMPR – Gibt die COMPARE Berechnung frei.

CALC DBM – Gibt die dBm Berechnung frei.

CALC DBR – Gibt die dBr Berechnung frei.

CALC RATIO - Gibt die X-B/A Berechnung frei.

CALC OFF - Sperrt alle Berechnungen.

CALC? - Abfrage nach CALC OFF oder der freigegebenen Berechnungsart.

DBR <num> - Stellt den Wert der Betriebskonstanten ein.

DBR? - Abfrage nach dem Wert der Bezugskonstanen.

LIMITS? <num>, <num> - Stellt die Werte der Konstanten LIMITS ein.

LIMITS? - Abfrage nach den Werten der Konstanten LIMITS.

MONITOR ON - Gibt SRQ frei wenn die Messung die LIMITS Konstanten übersteigt.

MONITOR OFF - Sperrt SRQ wenn die Messung die LIMITS Konstanten übersteigt.

MONITOR? - Abfrage nach MONITOR ON oder MONITOR OFF.

RATIO <num>, <num> - Stellt die Werte der Konstanten A und B ein.

RATIO? - Abfrage nach den Werten der Konstanten A und B.

EINGANG/AUSGANGS-BEFEHLE

DATA - Ausgangsdaten werden durch MONITOR SRQ gespeichert.

SEND - Ausgangsdaten im Ausgangspuffer; triggert falls erforderlich.

SOURCE REAR - Wählt den rückseitigen Interface-Eingangsanschluß.

SOURCE FRONT - Wählt den Eingangsanschluß auf der Frontplatte.

SOURCE? - Abfrage nach SOURCE FRONT oder SOURCE REAR.

SYSTEM-BEFEHLE

DT TRIG - Gibt die Geräte-Triggerfunktion frei. Das Gerät triggert nach der Interface-Mitteilung <GET>.

DT OFF - Sperrt die Geräte-Triggerfunktion.

DT? - Abfrage nach DT TRIG oder DT OFF.

ERR? - Abfrage nach dem Fehlercode.

ID? - Abfrage nach Geräte-Identifikation und Firmware Version.

INIT - Stellt auf die Einschalt-Bedingungen ein.

SET? - Abfrage nach den Geräte-Einstellungen.

TEST - Zeigt 0 bei richtiger, 351 bei unrichtiger Kalibrierungs-Prüfsumme an.

STATUS-BEFEHLE

OPC ON - Gibt die Bedienungsabfrage nach OPERATION COMPLETE frei.

OPC OFF - Sperrt die Bedienungsabfrage nach OPERATION COMPLETE.

OPC? - Abfrage nach OPC ON oder OPC OFF.

OVER ON - Gibt die Bedienungsabfrage nach Überschreiten des Bereichs frei.

OVER OFF - Sperrt die Bedienungsabfrage nach Überschreiten des Bereichs.

OVER? - Abfrage nach OVER ON oder OVER OFF.

RQS ON - Gibt die Bedienungsabfragen (SRQ) frei.

RQS OFF - Sperrt die Bedienungsabfragen (SRQ).

RQS? - Abfrage nach RQS ON oder RQS OFF.

USER ON - Gibt SRQ frei wenn die Taste ID gedrückt wird.

USER OFF - Sperrt SRQ wenn die Taste ID gedrückt wird.

USER? - Abfrage nach USER ON oder USER OFF.

DETAILLIERTE BEFEHLSLISTE

ACDC (AC und DC Spannungsfunktionen)

Art:

Einstellung

Einstellsyntax:

ACDC <number>
ACD <number>
ACDC

Beispiele:	Gewählter Bereich
ACDC 2	2 V
ACDC, 9	2 V
ACDC – 200	700 V, AUTO-Bereich
ACD	700 V, AUTO-Bereich
ACD 0	700 V, AUTO-Bereich

Beschreibung:

Das Kopfteil wählt ACD + DCV Funktion; das Argument wählt einen fixierten Bereich oder den AUTO-Bereich. Das Format für numerische Argumente wird im hinteren Teil dieses Abschnittes beschrieben. Das Argument kann jeder Wert $\leqq$ 700 sein; das Gerät rundet jedoch das Argument für den nächsten Bereich auf. Zum Beispiel für ein Argument 0,9 wählt das Gerät den Bereich 2 V.

Wenn das Argument weggelassen wird oder sein Wert weniger als 0 ist, geht das Gerät automatisch die Bereiche durch, beginnend mit dem höchsten Bereich.

Wenn das Argument über dem höchsten Bereich liegt, erzeugt das Gerät einen Befehlsfehler (und gibt bei RQS ON ein SRQ aus).

Bereiche
200 mV
2 V
20 V
200 V
700 V

ACV (AC Spannungsfunktion)

Art:

Einstellung

Einstellsyntax:

ACV <number>
ACV

Beispiele:	Gewählter Bereich:
ACV 18	20 V
ACV 2	2 V
ACV – 200	700 V, AUTO-Bereich
ACV	700 V, AUTO-Bereich

Beschreibung:

Das Kopfteil wählt die ACV Funktion; das Argument wählt einen fixierten Bereich oder den AUTO-Bereich. Das Format für numerische Argumente wird im hinteren Teil dieses Abschnittes beschrieben. Das Argument kann jeder Wert sein; das Gerät rundet jedoch das Argument für den nächsten Bereich auf. Zum Beispiel für das Argument 18 wählt das Gerät den 20 V Bereich.

Wenn das Argument weggelassen wird oder sein Wert weniger als 0 ist, geht das Gerät automatisch die Bereiche durch, beginnend mit dem höchsten Bereich.

Wenn das Argument über dem höchsten Bereich liegt, erzeugt das Gerät einen Befehlsfehler (und gibt bei RQS ON ein SRQ aus).

Bereiche:
200 mV
2 V
20 V
200 V
700 V

AVE (Mittelwert)

Art:

Einstellung oder Abfrage

Einstellsyntax:

AVE <number>
AVG <number>

Beispiel:

AVE 6
AVE 2
AVG 10

Abfragesyntax:

AVE?
AVG?

Abfrage-Antwort:

AVE <number>

Beschreibung:

Dieser Befehl spezifiziert die Anzahl der Messungen für die AVERAGE (Mittelwert) Berechnung. (Entspricht der Einstellung des Wertes für die Konstante N auf der Frontplatte). Siehe CALC AVE. Das Argument kann jede Zahl von 1 bis 19999 sein. Das Gerät rundet das Argument auf ganze Zahlen ab.

CALC (Berechnung)

Art:

Einstellung oder Abfrage

Einstellsyntax:

CALC <argument>
CALC <argument>, ... <argument>

Argumente:

AVE oder AVG
CMPR oder COMP
DBM
DBR
RATIO
OFF

Beispiele:

CALC OFF
CALC AVE
CALC AVE, DBM
CALC RATIO, AVE, DBR

Abfragesyntax:

CALC?

Abfrage-Antwort:

CALC OFF; oder Liste der freigegebenen Berechnung(en).

Beschreibung:

Wenn das Gerät einen CALC Befehl empfängt, schaltet es alle Berechnungen ab mit Ausnahme derjenigen, die hinter dem CALC Kopfteil stehen. Übersteigt das Ergebnis einer Berechnung die Fähigkeiten der Recheneinheit (±3,4028E+38), erzeugt das Gerät einen Recheneinheit-Fehler (303).

- CALC AVE oder CALC AVG gibt die AVERAGE Berechnung frei. Das Gerät berechnet den Mittelwert aus einer Reihe von Messungen. Die Anzahl der Messungen wird mit dem Befehl AVE <number> eingestellt.

  Eine Triggerung erzeugt genug Ablesungen für ein Mittelwertergebnis. Wird für eine Messung in einer Folge der Bereich überschritten, wird die AVE Berechnung unterbrochen.

  Wenn LFR auch freigegeben ist, wird die mit dem Befehl AVE <number> eingestellte Anzahl der Messungen mit 4 multipliziert.

- CALC CMPR oder CALC COMP gibt die COMPARE Berechnung frei. Das Gerät vergleicht den Eingang mit den durch den Befehl LIMITS eingestellten Werten. Der Text zu den nachstehenden Befehlen gibt an, welcher Ausgangsvergleich daraus resultiert:

  SEND – zeigt 1., 2., oder 3. für LO, PASS, oder HI an; bei Bereichsüberschreitung +1E+99; oder –1E+99.

  DATA – zeigt einen Meßwert außerhalb der Grenzbereiche an.

- CALC DBM gibt die dBm Berechnung frei und sperrt die dBr Berechnung. Das Gerät berechnet das Leistungsverhältnis der Eingangsspannung, bezogen auf 1 mW in 600 Ohm (0,7746 V).

  $$dBm = 20 \log_{10} \left| \frac{x}{\sqrt{.6}} \right|$$

- CACLC DBR gibt die DBR Berechnung frei und sperrt die dBm Berechnung. Das DM 5010 berechnet das logarithmische Verhältnis des Eingangs zu dem mit dem Befehl DBR <number> eingestellten Wert.

  $$dBr = 20 \log_{10} \left| \frac{x}{ref} \right|$$

- CALC RATIO gibt die X-B/A Berechnung frei, wobei X die Messung, B ein Offsetwert und A der Skalierungsfaktor ist. Die Werte von A und B werden mit dem Befehl RATIO eingestellt.

- CALC OFF sperrt alle Berechnungen.

DATA

Art:

Ausgabe

Syntax:

DATA

Antwort:

DATA <number>;
oder
DATA ± 1.E+99; (bei Bereichsüberschreitung)

Beschreibung:

Auf diesen Befehl erfolgt eine der nachstehend angegebenen Antworten. Er löst keine Übertragung aus und wartet nicht auf eine neue Messung, wie es der Befehl SEND tut.

1. Nach dem Einschalten wird 0 angezeigt, bis eine Messung zur Verfügung steht.

2. Wenn ein MONITOR SRQ ausgegeben wurde, zeigt DATA die Messung an, die das SRQ veranlaßt hat.

3. Wenn keine der vorstehenden Bedingungen gültig ist, zeigt DATA die letzte Messung an. DATA zeigt die gleiche Ablesung an, bis die nächste Übertragung ausgelöst wird und eine neue Ablesung zur Verfügung steht.

DATA kann für eine Messung eine höhere Auflösung angeben als sie auf der Frontplatte dargestellt oder durch den Befehl SEND angezeigt wird.

DBR

Art:

Einstellung oder Abfrage

Einstellsyntax:

DBR <number>

Beispiel:

DBR 1
DBR .707
DBR 2E-3

Abfragesyntax:

DBR?

Abfrage-Antwort:

DBR <number>;

Beschreibung:

Dieses Befehlsargument stellt den Wert der Konstanten ein, die für den Befehl CALC DBR verwendet wird. Er entspricht der Einstellung des Konstantenwertes auf der Frontplatte. Das Argument kann jede Zahl außer 0 sein.

DCV (DC Spannungsfunktion)

Art:

Einstellung

Einstellsyntax:

DCV <number>
DCV

Beispiele:	Gewählter Bereich
DCV 1.5	2 V
DCV	1000 V, AUTO-Bereich
DVV −1.E+3	1000 V, AUTO-Bereich

Beschreibung:

Das Kopfteil wählt die DCV Funktion; das Argument wählt einen fixierten Spannungsbereich. Das Format für numerische Argumente wird im hinteren Teil dieses Abschnittes beschrieben. Das Argument kann jeder Wert sein; das Gerät rundet jedoch das Argument auf den nächst höheren Bereich auf. Zum Beispiel für das Argument 1.5 wählt das Gerät den 2 V Bereich.

Wenn das Argument weggelassen wird oder sein Wert weniger als 0 ist, geht das Gerät automatisch die Bereiche durch, beginnend mit dem höchsten Bereich.

Wenn das Argument über dem höchsten Bereich liegt, erzeugt das Gerät einen Befehlsfehler (und gibt bei RQS ON ein SRQ aus).

Bereiche:
200 mV
2 V
20 V
200 V
1000 V

DIGIT (Digitale Auflösung)

Art:

Einstellung oder Abfrage

Einstellsyntax:

DIGIT 3.5
DIGIT 4.5
DIG 3.5
DIG 4.5

Abfragesyntax:

DIGIT?
DIG?

Abfrage-Antwort:

DIGIT 3.5;
DIGIT 4.5;

Beschreibung:

Dieser Befehl wählt die Übertragungsrate. Das Argument 3.5 stellt die FAST Übertragungsrate ein (3.5 Stellen Auflösung). Bei den Spannungsfunktionen benötigt eine Messung etwa 35 ms, bei der Ohm-Funktion etwa 130 ms.

Das Argument 4.5 stellt die normale Übertragungsrate ein (4.5 Stellen Ausflösung). Bei den Spannungsfunktionen benötigt eine Messung etwa 310 ms, bei der Ohm-Funktion etwa 600 ms.

DIODE (Diodentest)

Art:

Einstellung

Einstellsyntax:

DIODE
DIO

Beschreibung:

Dieser Befehl wählt die Funktion DIODE TEST. Ein Argument wird nicht akzeptiert.

DT (Gerätetrigger)

Art:

Einstellung oder Abfrage

Einstellsyntax:

DT TRIG
DT OFF

Abfragesyntax:

DT?

Abfrage-Antwort:

DT TRIG;
DT OFF;

Beschreibung:

Mit diesem Befehl wird die Geräte-Triggerfunktion gesperrt oder freigegeben. Wenn die Gerätetriggerung freigegeben ist, löst die IEEE 488 Interface-Mitteilung <GET> eine Triggerung aus.

Wenn <GET> empfangen wird während der Mitteilungs-Prozessor arbeitet oder wenn DT OFF ist erzeugt das Gerät einen Fehler der anzeigt, daß die Mitteilung <GET> ignoriert wurde.

ERR? (Fehler)

Art:

Abfrage

Abfragesyntax:

ERR?

Abfrage-Antwort:

$ERR_{sp\ sp}$ <number>

Beispiel:

$ERR_{sp\ sp}$ 401; (eingeschaltet)

Beschreibung:

Die Abfrage ERROR wird verwendet, um Informationen über den Status des Gerätes zu erhalten.

Auf die Abfrage ERROR wird ein Code dargestellt der anzeigt, welches Ereignis ein SRQ veranlaßt hat. Weitere Informationen finden Sie im Status- und Fehlerbericht.

FUNCT? (Funktion)

Art:

Abfrage

Abfragesyntax:

FUNCT?
FUNC?

Abfrage-Antwort Beispiele:

DCV 2.;
ACV20.;
DIODE;
ACDC 200.;
OHMS −2.E+6;

Beschreibung:

Auf diesen Befehl wird die derzeitige Meßfunktion angezeigt. Das Argument spezifiziert den jeweils verwendeten Bereich. Bei AUTO-Bereich wird ein negatives Argument angezeigt.

ID?

Art:

Abfrage

Abfragesyntax:

ID?

Abfrage-Antwort:

ID TEK/DM5010,V79.1Fxx;

Beschreibung:

Auf die Abfrage ID? wird die o. g. Antwort angezeigt.

TEK/DM5010 – Identifiziert das Gerät, Hersteller und Typ.

V79.1 – Identifiziert die Art der Tektronix Codes und Formate, denen das Gerät entspricht.

Fxx – Identifiziert die Firmenversion des Gerätes.

INIT

Art:

Betrieb

Syntax:

INIT

Beschreibung:

Dieser Befehl stellt die Gerätefunktionen auf Ihre Einschaltbedingungen zurück, wie sie in Tabelle 3-3 angegeben sind.

LFR

Art:

Einstellung oder Abfrage

Einstellsyntax:

LFR ON
LFR OFF

Abfragesyntax:

LFR?

Abfrage-Antwort:

LFR ON;
LFR OFF;

Beschreibung:

Mit diesem Befehl wird die Funktion LOW FREQ RESPONSE gesperrt oder freigegeben (wird mit den Funktionen ACV und ACV+DCV verwendet). Wenn freigegeben, berechnet das Gerät den Mittelwert aus vier Messungen.

Wenn CALC AVE auch freigegeben ist, wird die mit dem Befehl AVE <num> eingestellte Anzahl der Messungen mit 4 multipliziert.

LIMITS

Art:

Einstellung oder Abfrage

Einstellsyntax:

LIMITS <number>, <number>
LIM <number>, <number>

Beispiel:

LIMITS 3.2, −2
LIMITS −1, −6.5
LIM 6, 1

Abfragesyntax:

LIMITS?
LIM?

Abfrage-Antwort:

LIMITS <number>, <number>;

Beschreibung:

Die Argumente für diesen Befehl stellen die Grenzwerte ein, die für die COMPARE Berechnung und das MONITOR SRQ verwendet werden. Das erste Argument stellt den Grenzwert ein, welcher der oberen Taste LIMITS auf der Frontplatte entspricht; das zweite Argument stellt den Konstantenwert ein, welcher der unteren Taste LIMITS entspricht.

MODE

Art:

Einstellung oder Abfrage

Einstellsyntax:

MODE RUN
MODE TRIG
MOD RUN
MOD TRIG

Abfragesyntax:

MODE?
MOD?

Abfrage-Antwort:

MODE RUN;
MODE TRIG;

Beschreibung:

Dieser Befehl wählt die Trigger-Betriebsart. Das Argument RUN stellt die Trigger-Betriebsart RUN (freilaufend) ein.

Das Argument TRIG stellt die Betriebsart TRIGGERED ein. In dieser Betriebsart erfolgt nach Empfang einer der folgenden Mitteilungen eine Triggerung:

- Einem „SEND" Befehl.
- Einer Interface Mitteilung <GET> (nur wen DT freigegeben ist).
- My Talk Address (MTA) mit nicht spezifiziertem Ausgang (kein Abfrage-Befehl).
- EXTRIG rückseitige Interface-Triggerung (erfordert Einbau einer internen Überbrückung – siehe Abschnitt Wartung). Für eine einzelne Triggerung muß diese Leitung zwischen 0,5 und 10 µsec gehalten werden. Wird sie über einen längeren Zeitraum niedrig gehalten, löst das Gerät Mehrfachmessungen aus.

Wenn in der Betriebsart MODE TRIG und während das Gerät in AUTO-Bereich arbeitet ein Über- oder Unterschreiten des Bereichs vorkommt, ändert das Gerät den Bereich und führt eine weitere Messung aus.

MONITOR

Art:

Einstellung oder Abfrage

Einstellsyntax:

MONITOR ON
MONITOR OFF
MON ON
MON OFF

Abfragesyntax:

MONITOR?
MON?

Abfrage-Antwort:

MONITOR ON;
MONITOR OFF;

Beschreibung:

Mit diesem Befehl wird das MONITOR SRQ gesperrt oder freigegeben. Ist MONITOR SRQ freigegeben, speichert das Gerät die erste Messung außerhalb der Grenzwerte (die mit dem Befehl LIMITS eingestellt wurden) und generiert ein SRQ. Für nachfolgende Messungen (außerhalb der Grenzwerte) werden keine SRQ's erzeugt bis die Bedienungsabfrage erledigt ist und die Messung in Beantwortung des Befehls DATA an den Controller berichtet wurde.

Wenn das Gerät bei MON ON den Bereich überschreitet, gibt es eine Fehlermeldung aus, auch wenn OVER OFF ist.

NULL

Art:

Einstellung oder Abfrage

Einstellsyntax:

NULL <number>

Beispiele:

NULL.2
NULL 0

Abfragesyntax:

NULL?

Abfrage-Antwort:

NULL <number>

Beschreibung:

Dieser Befehl gibt die Funktion NULL frei; das Argument (in Volt oder Ohm) gibt den Wert des Offset an. Dieser Wert kann jede Zahl bis zu 100% des Bereichs sein.

Die Funktion NULL ist gesperrt, wenn die Meßfunktion geändert wird oder das Argument 0 ist. (Die Änderung der Meßfunktion stellt auch das Argument auf 0.)

WARNUNG

Wenn die NULL Funktion freigegeben ist, kann es vorkommen, daß die Messung nicht den an die Eingangsanschlüsse angelegten Spannungswert anzeigt.

OHMS

Art:

Einstellung

Einstellsyntax:

OHMS <number>
OHMS

Beispiele:	**Gewählter Bereich:**
OHMS	20 MΩ, AUTO-Bereich
OHMS 100	200 Ω
OHMS −2E+7	20 MΩ, AUTO-Bereich
OHMS 1E+4	20 kΩ

Beschreibung:

Das Kopfteil wählt die Funktion OHMS; das Argument wählt den Bereich. Das Format für numerische Argumente wird im hinteren Teil dieses Abschnittes beschrieben. Das Argument kann jeder Wert sein; das Gerät rundet jedoch das Argument auf den nächst höheren Bereich auf. Zum Beispiel für das Argument 100 wählt das Gerät den Bereich 200 Ω.

Wenn das Argument weggelassen wird oder sein Wert weniger als 0 ist, geht das Gerät automatisch die Bereiche durch, beginnend mit dem höchsten Bereich.

Wenn das Argument über dem höchsten Bereich liegt, erzeugt das Gerät einen Befehlsfehler (und gibt bei RQS ON ein SRQ aus).

Bereiche:
200 Ω
2 kΩ
20 kΩ
200 kΩ
2 MΩ
20 MΩ

OPC (Operation Complete)

Art:

Einstellung oder Abfrage

Einstellsyntax:

OPC ON
OPC OFF

Abfragesyntax:

OPC?

Abfrage-Antwort:

OPC ON;
OPC OFF;

Beschreibung:

Mit diesem Befehl wird die Bedienungsabfrage Operation Complete gesperrt oder freigegeben. Wenn freigegeben und RQS ist ON, gibt das Gerät ein SRQ aus, wenn eine neue Messung zur Verfügung steht.

OVER

Art:

Einstellung oder Abfrage

Einstellsyntax:

OVER ON
OVER OFF

Abfragesyntax:

OVER?

Abfrage-Antwort:

OVER ON;
OVER OFF;

Beschreibung:

Mit diesem Befehl wird die Bedienungsabfrage für Bereichsüberschreitung gesperrt oder freigegeben. Wenn freigegeben und RQS ist ON, gibt das Gerät ein SRQ aus, wenn es eine Messung außerhalb des Bereichs durchführt.

Bei OVER OFF gibt das Gerät zur Anzeige einer Bereichsüberschreitung ±1.E+99 aus (es gibt kein SRQ aus).

RATIO

Art:

Einstellung oder Abfrage

Einstellsyntax:

RATIO <number>, <number>

Beispiel:

RATIO 100, 15
RATIO 10, 2

Abfragesyntax:

RATIO?

Abfrage-Antwort:

RATIO <number>, <number>;

Beschreibung:

Die Argumente zu diesem Befehl stellen den Offsetwert und den Skalierungsfaktor für die X-B/A Berechnung ein. Siehe CALC RATIO. Das erste Argument stellt den Wert des Skalierungsfaktors ein (Taste A auf der Frontplatte); das zweite stellt den Offsetwert ein (Taste B auf der Frontplatte). Die Argumente können jede Zahl sein, nur der Skalierungsfaktor kann nicht 0 sein.

RDY?

Art:

Abfrage

Abfragesyntax:

RDY?

Abfrage-Antwort:

RDY$_{SP}$ $_{SP}$0;
RDY$_{SP}$ $_{SP}$1;

Beschreibung:

Wenn eine Messung durchgeführt wird oder das Gerät auf eine Triggerung wartet, wird auf diesen Befehl RDY 0 angezeigt. RDY 1 zeigt an, daß Daten zur Verfügung stehen.

RQS

Art:

Einstellung oder Abfrage

Einstellsyntax:

RQS ON
RQS OFF

Abfragesyntax:

RQS?

Abfrage-Antwort:

RQS ON;
RQS OFF;

Beschreibung

Dieser Befehl gibt das Gerät für die Ausgabe von Bedienungsabfragen frei. Das Argument OFF sperrt alle Bedienungsabfragen. Weitere Informationen finden Sie im Abschnitt Status- und Fehlerbericht.

SEND

Art:

Ausgang

Syntax:

SEND
SEN

Antwort:

<number>; (kein Kopfteil)

Beispiel:

±1.E+99; (Bereichsüberschreitung)
+3.2E+3;

Beschreibung:

Dieser Befehl veranlaßt das Gerät die letzte Messung auszugeben. Ist keine Messung verfügbar, löst das Gerät eine Messung aus und gibt sie dann aus.

Wenn die Berechnung COMPARE freigegeben ist, (CALC CMPR) zeigt das Gerät mit einer der nachstehenden Zahlen die Beziehung zwischen dem Eingang und den mit dem Befehl LIMITS eingestellten Grenzwerten an:

3.; Wenn der Eingang über beiden Grenzwerten liegt.

2.; Wenn der Eingang zwischen den Grenzwerten liegt oder gleich einem der Grenzwerte ist.

1.; Wenn der Eingang unter beiden Grenzwerten liegt.

+1.E+99; oder −1.E+99; bei Bereichsüberschreitung.

SET?

Art:

Abfrage

Abfragesyntax:

SET?

Abfrage-Antwortbeispiel (Einschalt-Einstellungen):

DCV −1.E+3;AVE 2; RATIO 1. 0.;DBR 1.;LIMITS 0., 0.;CALC OFF;NULL 0.;DIGIT 4.5;LFR OFF;MODE RUN;SOURCE FRONT;DT OFF;MONITOR OFF;OPC OFF; OVER OFF;USER OFF;RQS ON;

Beschreibung:

Auf diesen Befehl werden die derzeitigen Einstellungen aller Gerätefunktionen angezeigt. Die längste Anzeige besteht aus 225 Zeichen.

SOURCE

Art:

Einstellung oder Abfrage

Einstellsyntax:

SOURCE FRONT
SOURCE REAR
SOUR FRONT
SOUR REAR

Abfragesyntax:

SOURCE?
SOUR?

Abfrage-Antwort:

SOURCE FRONT;
SOURCE REAR;

Beschreibung:

SOURCE FRONT wählt für die Messung den Eingang auf der Frontplatte; SOURCE REAR wählt für die Messung die Interface-Anschlüsse an der Rückseite.

VORSICHT

Um Beschädigungen des Gerätes und Betriebsfehler zu vermeiden, darf nicht zwischen dem Eingang auf der Frontplatte und den Interface-Anschlüssen auf der Rückseite umgeschaltet werden, wenn mehr als 500 V_S an den Eingangsanschlüssen auf der Frontplatte anliegen.

TEST

Art:

Ausgang

Syntax:

TEST

Antwort:

TEST 0;
TEST 351;

Beschreibung:

Zeigt eine Zahl an, welche den Status der Kalibrierungs-Prüfsumme angibt. 0 wenn die Prüfsumme richtig ist; 351 wenn sie falsch ist.

USER

Art:

Einstellung oder Abfrage

Einstellsyntax:

USER ON
USER OFF

Abfragesyntax:

USER?

Abfrage-Antwort:

USER ON;
USER OFF;

Beschreibung:

Mit diesem Befehl wird die Service-Abfrage der Taste INST ID freigegeben oder gesperrt. Ist sie freigegeben, gibt das Gerät SRQ aus, wenn auf der Frontplatte die Taste INST ID gedrückt wird.

MITTEILUNGEN UND KOMMUNIKATIONS-PROTOKOLL

Befehls-Trennzeichen

Eine Mitteilung besteht aus einem, oder einer Reihe von Befehlen und einem Endezeichen. Bei Mitteilungen, die aus mehreren Befehlen bestehen, müssen die Befehle durch Strichpunkte getrennt sein. Ein Strichpunkt am Ende einer Mitteilung ist zusätzlich. So ist z. B., jede der nachstehenden Zeilen eine Mitteilung.

```
INIT
TEST;INIT;RQS ON;USER OFF;ID?;SET?
TEST;
```

Mitteilungs-Endezeichen

Mitteilungen können mit EOI oder dem ASCII-Zeichen LF beendet sein. Einige Controller machen EOI mit dem letzten Daten-Byte geltend; andere verwenden nur LF als Endezeichen. Das Gerät kann intern so eingestellt werden, daß es beide Endezeichen annimmt. Wird EOI ONLY als Endezeichen gewählt, interpretiert das Gerät den Empfang eines Daten-Bytes mit EOI als Ende der Eingangsmitteilung; es macht dann auch EOI mit dem letzten Byte der Ausgangsmitteilung geltend. Bei der LF/EOI Einstellung, interpretiert das Gerät das LF-Zeichen ohne EOI (oder irgendein Datenbyte mit EOI) als Ende einer Eingangsmitteilung; es überträgt CR (carriage return) gefolgt von „line feed" (LF mit EOI), um Ausgangsmitteilungen zu beenden. Servicepersonal findet Informationen über die Einstellung des Mitteilungs-Endezeichens im Abschnitt „Wartung". Beim Versand sind TM 5000 Geräte auf EOI ONLY eingestellt.

Formatierung einer Mitteilung

Um verstanden zu werden, müssen Befehle, die an TM 5000 Geräte gesendet werden, das richtige Format (Syntax) haben; dieses Format ist jedoch flexibel und es werden viele Variationen angenommen. Nachstehend wird dieses Format und die annehmbaren Variationen beschrieben.

Die Geräte erwarten, daß alle Befehle in ASCII kodiert sind; sie nehmen jedoch große und kleine ASCII-Zeichen an. Die Datenausgabe erfolgt in großen Zeichen.

Wie vorher besprochen, besteht ein Befehl aus einem Kopfteil dem, falls erforderlich, Argumente folgen. Ein Befehl mit Argumenten muß ein Kopfteil-Endezeichen haben, das aus dem Zwischenraumzeichen SP zwischen Kopfteil und Argument besteht.

RQS$_{\mathrm{SP}}$ON

Werden zusätzliche Formatierungszeichen SP, CR und LF (LF kann zur Formatierung nicht verwendet werden, wenn LF/EOI Endezeichen sind) zwischen Kopfteilendezeichen und Argument eingefügt, werden sie vom Gerät ignoriert.

Beispiel 1: RQS$_{\mathrm{SP}}$ON;

Beispiel 2: RQS$_{\mathrm{SP\ SP}}$ON;

Beispiel 3: RQS$_{\mathrm{SP\ CR\ LF\ SP\ SP}}$ON

Im allgemeinen werden diese Formatierungszeichen nach jedem Endezeichen und am Anfang und Ende einer Mitteilung ignoriert.

$_{\mathrm{SP}}$RQS$_{\mathrm{SP}}$ON;$_{\mathrm{CR\ LF}}$

$_{\mathrm{SP}}$USER$_{\mathrm{SP}}$OFF

In der Befehlsliste sind einige Kopfteile und Argumente in zwei Versionen aufgeführt, in der voll ausgeschriebenen Form und einer abgekürzten Form. Das Gerät nimmt alle Kopfteile und Argumente an, die zumindest die in der abgekürzten Form enthaltenen Zeichen besitzen; jedes weitere Zeichen muß dem in der voll ausgeschriebenen Form entsprechen. Zur Dokumentation von Programmen können der voll ausgeschriebenen Form Alphazeichen angehängt werden. Alphazeichen können auch einem Fragekopfteil angehängt werden, vorausgesetzt, am Ende steht ein Fragezeichen.

```
USER?
USERE?
USEREQ?
USEREQUEST?
```

Mehrfachargumente werden durch ein Komma getrennt; das Gerät nimmt jedoch auch einen Zwischenraum oder Zwischenräume als Trennzeichen an.

2,3
2$_{\mathrm{SP}}$3
2,$_{\mathrm{SP}}$3

ANMERKUNG

Im letzten Beispiel wird der Zwischenraum als Formatzeichen angesehen, da er hinter dem Komma steht (dem Argument-Trennzeichen).

Zahlen-Formate

Das Gerät akzeptiert die nachstehenden Zahlenarten für jedes numerische Argument.

- Ganze Zahlen mit und ohne Vorzeichen (einschl. + 0 und – 0). Ganze Zahlen ohne Vorzeichen werden als positiv angesehen. Bespiele: +1, 2, –1, –10.
- Dezimalzahlen mit und ohne Vorzeichen. Dezimalzahlen ohne Vorzeichen werden als positiv angesehen. Beispiele: –3.2, +5.0, 1.2.
- Gleitkommazahlen in wissenschaftlicher Schreibweise. Beispiele: +1.0E–2, 1.0E–2, 1.E–2, 0.01E+0.

Die höchste, als Argument akzeptierbare Zahl ist ±3.4028E+38.

Mitteilungs-Protokoll

Wenn das Gerät eine Mitteilung erhält, wird sie im Eingangs-Puffer gespeichert, bearbeitet und ausgeführt. Die Bearbeitung einer Mitteilung besteht aus der Dekodierung von Befehlen, dem Erkennen von Trennzeichen und dem Überprüfen der Syntax. Bei Einstellbefehlen speichert das Gerät die angezeigten Änderungen im Einstell-Puffer. Wird während der Bearbeitung ein Fehler entdeckt, gibt das Gerät eine Bedienungsabfrage (SRQ) aus, ignoriert den Rest der Mitteilung und stellt den Einstell-Puffer zurück. Durch Rückstellen des Einstell-Puffers werden unerwünschte Zustände vermieden, die dadurch entstehen können, daß einige Einstellbefehle der gleichen Mitteilung ausgeführt werden und andere nicht.

Die Ausführung einer Mitteilung besteht in der Durchführung der Tätigkeiten, die durch ihre Befehle spezifiziert sind. Bei Einstellbefehlen bedeutet das die Neu-Einstellung der Geräteeinstellungen und die Aufnahme dieser neuen Einstellungen in den Einstell-Puffer. Die Einstellbefehle werden in Gruppen ausgeführt – d.h., eine Reihe von Einstellbefehlen wird bearbeitet und in den Einstell-Puffer aufgenommen, bevor die Ausführung erfolgt. Das erlaubt dem Anwender einen neuen Status zu spezifizieren, ohne darauf zu achten, ob eine besondere Reihenfolge Gültigkeit hat. Die Durchführung der Einstellung erfolgt, wenn das Gerät das Mitteilungs-Endezeichen, einen Abfragebefehl oder einen Betriebsbefehl in einer Mitteilung bearbeitet.

Bearbeitet das Gerät einen Abfragebefehl in einer Mitteilung, dann werden zuerst alle vorhergehenden Einstellbefehle ausgeführt, um den Status des Gerätes auf den neuesten Stand zu bringen. Dann wird der Abfragebefehl ausgeführt, indem es die entsprechenden Daten abruft und sie in den Ausgangspuffer gibt. Danach wird die Bearbeitung und Ausführung des Rests der Mitteilung fortgesetzt. Wenn das Gerät zum Sprecher (talker) gemacht wird, werden die Daten an den Controller weitergegeben.

Wenn das Gerät in einer Mitteilung einen Betriebsbefehl bearbeitet, werden vor dem Betriebsbefehl alle vorhergehenden Einstellbefehle ausgeführt.

Mehrfach-Mitteilungen

Der Eingangs-Puffer hat eine begrenzte Kapazität und eine einzelne Mitteilung kann so lang sein, daß er damit ausgefüllt ist. In diesem Falle wird ein Teil der Mitteilung bearbeitet bevor das Gerät weitere Daten annimmt. Während der Befehlsausführung hält das Gerät zusätzliche Daten zurück (durch NRFD) bis im Puffer Platz zur Verfügung steht.

Wenn Platz vorhanden ist, kann das Gerät vor Ausführung der ersten eine zweite Mitteilung annehmen. Es hält jedoch zusätzliche Mitteilungen mit NRFD zurück, bis die erste Mitteilung vollständig durchgeführt ist.

Nachdem das Gerät in einer Mitteilung einen Abfragebefehl ausgeführt hat hält es die Antwort zurück, bis es vom Controller zum Sprecher (talker) gemacht wird. Empfängt das Gerät eine neue Mitteilung bevor der gesamte Ausgang der vorherigen Mitteilung ausgelesen ist, macht es vor der Ausführung der neuen Mitteilung den Ausgangs-Puffer frei. Dadurch wird verhindert, daß der Controller unerwünschte Daten aus alten Mitteilungen erhält.

Eine weitere Situation kann das Gerät veranlassen den Ausgang zu löschen. Die Ausführung einer langen Mitteilung kann dazu führen, daß Eingangs- und Ausgangs-Puffer voll werden. Wenn dies geschieht, kann das Gerät die Ausführung der Mitteilung nicht beenden weil es darauf wartet, daß der Controller die erzeugten Daten ausliest; der Controller kann die Daten aber nicht auslesen, weil er mit der Übertragung seiner Mitteilung noch nicht zu Ende ist. Da der Eingangs-Puffer voll ist und das Gerät den Rest der Mitteilung des Controllers mit NRFD zurückhält, hängt das System in der Schwebe weil Controller und Gerät aufeinander warten. Erkennt das Gerät diesen Zustand, erzeugt es eine Fehlermeldung, gibt ein SRQ aus und löscht die Daten im Ausgangs-Puffer. Das ermöglicht dem Controller den Rest der Mitteilung zu übertragen und der Controller wird informiert, daß die Mitteilung ausgeführt und der Ausgang gelöscht wurde.

Ein TM 5000 Gerät kann als Sprecher (talker) adressiert werden, ohne das es eine Mitteilung erhält, die angibt, was es ausgeben soll. In diesem Falle geben Erfassungsgeräte (Zähler und Multimeter) eine Messung aus wenn sie beendet ist. Ist keine Messung fertig, geben sie eine Byte-Mitteilung zurück bei der alle Bits gleich 1 sind (mit Endezeichen); andere TM 5000 Geräte geben nur diese Mitteilung zurück.

Gerätereaktionen auf IEEE 488 Interface Mitteilungen

Interface Mitteilungen und ihre Auswirkungen auf die Interface Funktionen des Gerätes sind im IEEE Standard 488-1978 defieniert. Abkürzungen dieser Norm werden in dieser Diskussion verwendet, in der die Auswirkungen der Interface Mitteilungen auf die Betriebsweise des Gerätes beschrieben werden.

UNL – Unlisten (63 mit ATN)
UNT – Untalk (95 mit ATN)

Wird der Befehl UNL empfangen, geht die Hörer (listener) Funktion des Gerätes in ihren Ruhezustand (nicht adressiert). Im Ruhezustand nimmt das Gerät keine Befehle vom GPIB an.

Die Sprecher (talker) Funktion geht in ihren Ruhezustand, wenn das Gerät den Befehl UNT empfängt. In diesem Zustand kann das Gerät über den GPIB keine Daten ausgeben. Wenn Talker und Listener Funktion im Ruhezustand sind, ist das Lämpchen „ADRESSED" aus. Ist das Gerät entweder Talk- oder Listen adressiert, ist das Lämpchen an.

IFC – Interface Clear (GPIB Stift 9)

Diese einzeilige Mitteilung hat die gleiche Auswirkung wie die UNL und UNT Mitteilungen. Das Lämpchen ADRESSED auf der Frontplatte ist aus.

DCL – Device Clear (20 mit ATN)

Die Mitteilung Device Clear stellt die Kommunikation zwischen Controller und Gerät wieder her. Als Antwort auf DCL löscht das Gerät alle Eingangs- und Ausgangsmitteilungen und jede nicht ausgeführte Einstellung im Einstellungs-Puffer. Ebenso werden alle auf Abruf wartenden Fehler und Ereignisse gelöscht, mit Ausnahme des Einschalt-Ereignisses. Wenn aus irgendeinem anderen Grund als dem Einschaltvorgang ein SRQ ausgegeben ist, wird beim Empfang von DCL das SRQ gelöscht.

SDC – Selected Device Clear (4 mit ATN)

Diese Mitteilung erfüllt die gleiche Funktion wie DCL; jedoch nur Geräte die als Listener adressiert sind antworten auf SDC.

GET – Group Exekute Trigger (8 mit ATN)

Das Gerät spricht auf <GET> nur an, wenn es als Listener adressiert ist und die Geräte-Triggerfunktion durch den Befehl Device Trigger (DT) freigegeben worden ist. Wenn die DT Funktion gesperrt ist (DT OFF), das Gerät auf Frontplattenbedienung eingestellt ist oder beim Empfang von <GET> eine Mitteilung ausführt, wird die Mitteilung <GET> ignoriert und ein SRQ erzeugt.

SPE – Serial Poll Enable (24 mit ATN)
SPD – Serial Poll Disable (25 mit ATN)

Die Mitteilung SPE gibt das Gerät für die Ausgabe des Serial Poll Status Byte frei, wenn es als Talker adressiert ist. Durch die Mitteilung SPD wird das Gerät auf seinen normalen Betrieb, die Sendung von Daten aus dem Ausgangs-Puffer, zurückgeschaltet.

MLA – My Listen Address
MTA – My Talk Address

Die primären Listen- und Talk Adressen werden durch die GPIB Adresse des Gerätes erstellt (intern eingestellt). Die jeweilige Einstellung der GPIB Adresse wird auf der Frontplatte dargestellt wenn der Knopf ID gedrückt wird. Wenn das Gerät Talk oder Listen adressiert ist, leuchtet das Lämpchen ADDRESSED auf der Frontplatte.

LLO – Local Lockout (17 mit ATN)

LLO wird von dem Gerät mit einem Umschaltvorgang beantwortet – von LOCS auf LWLS oder von REMS auf RWLS.

REN – Remote Enable

Wenn REN aktiviert ist und das Gerät hat seine Listen Adresse empfangen, schaltet es auf einen Fernbedienungsstatus um (von LOCS auf REMS oder von LWLS auf RWLS). Ist REN nicht aktiv, also falsch, wird aus jedem Status eine Umschaltung auf LOCS veranlaßt; das Gerät bleibt solange in LOCS wie REN falsch ist.

Eine REN-Umschaltung kann nach dem Beginn einer Mitteilungsbearbeitung vorkommen. In diesem Falle wird die Ausführung der in Bearbeitung befindlichen Mitteilung durch eine Umschaltung nicht beeinflußt.

GTL – Go To Local (1 mit ATN)

Nur Listen-adressierte Geräte antworten auf GTL durch Umschalten auf Eigenbedienung. Umschaltungen von Fern- auf Eigenbedienung durch GTL beeinflussen nicht die Ausführung von Mitteilungen, die beim Empfang von GTL bearbeitet werden.

Remote-Local Operation

Die vorstehende Diskussion der Interface-Mitteilungen beschreibt die Statusumschaltungen durch GTL und REN. Die meisten Bedienungselemente auf der Frontplatte verursachen eine Umschaltung von REMS auf LOCS durch eine Mitteilung, die return-to-local (rtl) genannt wird. Diese Umschaltung kann während der Mitteilungsausführung vorkommen; aber im Gegensatz zu GTL- und REN-Umschaltungen wird durch eine Umschaltung, die durch rtl veranlasst wurde, die Mitteilungsausführung beeinflußt. In diesem Fall erzeugt das Gerät einen Fehler, wenn es irgendwelche nicht ausgeführte Einstell- oder Betriebsbefehle gibt. Bedienungselemente auf der Frontplatte, die nur die Darstellung ändern (wie INST ID) beeinflussen die Fern- Eigenbedienungszustände nicht – nur Bedienungselemente, die Einstellungen ändern, können rtl geltend machen.

Rtl wird ungültig nach Änderung der Einstellungen auf der Frontplatte. Da rtl Umschaltungen auf REMS verhindert, gibt das Gerät kein rtl aus, wenn eine Folge von Tasteneingaben nicht in angemessener Zeit beendet wird (etwa 5 bis 10 Sekunden).

Das Gerät behält eine Auflistung seiner Einstellungen im Einstell-Puffer, die durch neue Einstellungen auf der Frontplatte oder vom Controller aktualisert werden. Ferner werden die Einstellungen auf der Frontplatte durch Befehle auf den neuesten Stand gebracht. Die Geräteeinstellungen werden durch Umschaltungen zwischen den vier remote-local Zuständen nicht beeinflußt. Bei REMS oder RWLS ist die Anzeige REMOTE erleuchtet.

Local State (LOCS)

In LOCS werden die Einstellungen des Gerätes durch die Bedienungsperson über die Bedienungselemente auf der Frontplatte gesteuert. In diesem Status werden nur Bus-Befehle ausgeführt, die die Einstellungen des Gerätes nicht verändern (Abfragebefehle); alle anderen Bus-Befehle (Einstellung und Betrieb) erzeugen einen Fehler, da ihre Funktionen über die Frontplatte gesteuert werden.

Local With Lockout State (LWLS)

Das Gerät arbeitet in gleicher Weise wie bei LOCS mit der Ausnahme, daß rtl keine Umschaltung auf Fernbedienung beinhaltet.

Remote State (REMS)

In diesem Status führt das Gerät alle Gerätebefehle aus. Bei Befehlen mit Anzeigen auf der Frontplatte, wird nach Ausführung dieser Befehle die Anzeige auf der Frontplatte aktualisiert.

Remote With Lockout State (RWLS)

Die Arbeitsweise des Gerätes entspricht der bei REMS mit der Ausnahme, daß die Mitteilung rtl ignoriert wird.

STATUS- UND FEHLERBERICHT

Über die Funktion Bedienungsabfrage (definiert in der IEEE-488 Norm) kann das Gerät den Controller darauf aufmerksam machen, daß es Bedienung benötigt. Dieser Bedienungsruf dient auch zur Anzeige, daß ein bestimmtes Ereignis (eine Stausänderung oder ein Fehler) aufgetreten ist. Um den Ruf zu bedienen, führt der Controller eine Serienabfrage durch; darauf antwortet das Gerät mit einem Statusbyte (STB) das anzeigt, ob es eine Bedienung verlangt hat oder nicht. Das STB kann auch eine begrenzte Menge an Information über den Bedienungsruf enthalten. Das Format der im STB kodierten Information wird in Bild 3-2 dargestellt.

Wenn das Datenbit 8 eingestellt ist, befördert das STB Statusinformation, die durch die Bits 1 bis 4 gekennzeichnet sind, Bit 4 wird eingestellt, wenn das DM 5010 auf eine Triggerung wartet; Bit 3 zeigt an, daß eine Messung zur Verfügung steht.

Da die vom STB beförderte Information über ein Ereignis begrenzt ist, sind die Ereignisse in Klassen aufgeteilt; die Klasse wird im Statusbyte angegeben. Die Ereignisklassen werden wie folgt definiert:

COMMAND ERROR Das Gerät hat einen Befehl empfangen, den es nicht verstehen kann.

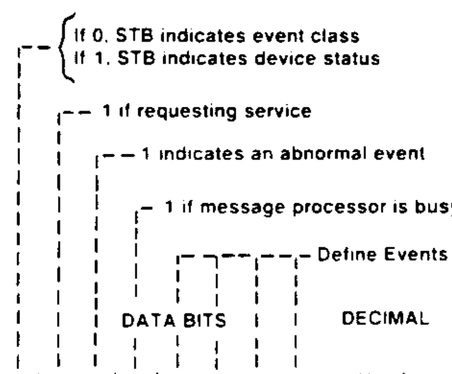
EXECUTION ERROR Das Gerät hat einen Befehl empfangen, den es nicht ausführen kann, verursacht durch Argumente außerhalb des Bereichs oder widersprüchliche Einstellungen.

INTERNAL ERROR Das Gerät hat ein Hardware- oder Firmware-Problem entdeckt, das den Betrieb verhindert.

SYSTEM EVENTS Ereignisse, die für alle Geräte in einem System gleich sind (z. B. Power on, User Request usw.).

INTERNAL WARNING Dadurch wird angezeigt, daß das Gerät ein Problem entdeckt hat. Das Gerät bleibt in Betrieb, aber das Problem sollte berichtigt werden (z. B. die Kalibrierung stimmt nicht).

DEVICE STATUS Vom Gerät abhängige Ereignisse.



Status Byte (Example)	8	7	6	5	4	3	2	1		Not busy	Busy
Power On	0	1	0	X	0	0	0	1		65	81

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Bild 3-2. Definition der STB Bits

Das Gerät kann zusätzliche Informationen über viele der Ereignisse liefern, besonders über die im Statusbyte berichteten Fehler. Nach der Feststellung, daß das Gerät nach Service gerufen hat (durch Prüfung des STB), kann der Controller mit einer Fehleranfrage „ERR?" weitere Informationen abfragen. Das Gerät antwortet mit einem Code, der das Ereignis definiert. Diese Codes werden in Tabelle 3-1 beschrieben.

Tabelle 3–1
FEHLERABFRAGE UND STATUSINFORMATION

Beschreibung	Antwort auf Fehlerabfrage	Antwort auf Serial Poll[a]
Befehls-Fehler:		
Ungültiges Befehls-Kopfteil	101	97
Fehler im Kopfteil-Trennzeichen	102	97
Fehler im Argument	103	97
Fehler im Argument-Trennzeichen	104	97
Argument fehlt	106	97
Ungültiges Mitteilungs-Endezeichen	107	97
Ausführungs-Fehler:		
Bei Eigenbedienung nicht ausführbar	201	98
Einstellungen durch rtl verloren	202	98
Ein- und Ausgangs-Puffer voll	203	98
Argument außerhalb des Bereichs	205	98
Gruppentriggerung ignoriert	206	98
Nicht kalibriert	231	98
Außerhalb der Kalibrier- oder Null-Fähigkeit	232	98
Interne Fehler:		
Unterbrechungs-Fehler	301	99
System-Fehler	302	99
Rechen-Fehler	303	99
Wandler-Ausfall	311	99
Frontplatten-Ausfall	317	99
Schlechte Ohm-Kalibrierungskonstante	318	99
Kalibrier-Prüfsummenfehler	351	99
Normale Ereignisse		
System-Ereignisse:		
Einschaltvorgang	401	65
Arbeit beendet	402	66
ID Anwenderabfrage	403	67
Interne Warnung:		
Bereichsüberschreitung	601	102
Gerätestatus[b]:		
Messung verfügbar	0	132
Warten auf Triggerung	0	136
Messung verfügbar und Warten auf Triggerung	0	140
Unterhalb der Grenzwerte	701	193
Oberhalb der Grenzwerte	703	195
Keine Fehler oder Ereignisse	0	128

[a] Wenn das Gerät arbeitet, antwortet es mit einer Zahl, die um 16 höher ist als die angegebene Zahl.

[b] Bei Controllern der Serie 4050 wird der Befehl POLL für Serial Poll-Antworten zwischen 128 und 192 mit 0 beantwortet; man erhält die aufgelisteten Antworten durch die Statements WBYTE und RBYTE.

Tabelle 3–2
FRONTPLATTEN UND FEHLERCODES

Darstellung	Beschreibung	
Ausführungs-Fehler		
205	Argument außerhalb des Bereichs	
231	Nicht kalibriert	
232	Außerhalb der Kalibrierfähigkeit	
Interne Fehler		
303	Rechen-Fehler	
311	Wandler-Ausfall	
317	Fronplatten-Ausfall	
318	Schlechte Ohm-Kalibrierkonstante	
340	RAM Fehler (positiv)	
341	RAM Fehler (negativ)	
351	Kalibrier-Prüfsummenfehler	
372	ROM Plazierungsfehler	C000
373	ROM Plazierungsfehler	D000
374	ROM Plazierungsfehler	E000
392	ROM Prüfsummenfehler	C000
393	ROM Prüfsummenfehler	D000
393	ROM Prüfsummenfehler	E000
395	ROM Prüfsummenfehler	F000
321	Zeigt an, daß der GPIB Adressenschalter (Signatur-Analyse) freigegeben ist	

Wenn mehr als ein Ereignis zu berichten ist, gibt das Gerät weiter SRQ aus bis alle Ereignisse berichtet sind. Nach dem Bericht über die Serienabfrage wird jedes Ereignis automatisch gelöscht. Die Interface-Mitteilung Device Clear (DCL) kann zur Löschung aller Ereignisse, mit Ausnahme von Power on, verwendet werden.

Zur Steuerung des Berichts einiger individueller Ereignisse und für das Sperren aller Bedienungsrufe stehen Befehle zur Verfügung. So bietet z. B. der Befehl User Request (USER) individuelle Steuerung über den Bericht der Anwenderabfrage, die nach Drücken der Taste INST ID auf der Frontplatte auftritt. Der Befehl Request for Service (RQS) steuert, ob das Gerät irgendein Ereignis mit SRQ berichtet.

RQS OFF hält alle SRQ's zurück (außer Power on), so daß die Abfrage ERR? in dieser Betriebsart dem Controller ermöglicht, Ereignisse herauszufinden, ohne zuerst eine Serienabfrage durchzuführen. Bei RQS OFF kann der Controller jederzeit die Abfrage ERR? stellen und das Gerät antwortet mit einem Ereignis, das darauf wartet berichtet zu werden. Der Controller kann durch Senden der Fehlerabfrage alle Ereignisse löschen, bis ein Nullcode (0) erscheint, oder alle Ereignisse, außer Power on, durch die Interface-Mitteilung DCL löschen.

Bei RQS OFF kann der Controller eine Serienabfrage durchführen, wobei das Statusbyte aber nur geräteabhängige Statusinformation enthält. Bei RQS ON enthält das STB die Klasse des Ereignisses und einen darauffolgenden im STB berichteten Fehler.

DAS SENDEN VON INTERFACE STEUER-MITTEILUNGEN

Die nachstehenden Controller-Befehle gelten für TEKTRONIX-Controller der Serie 4050 und repräsentativ für andere Controller.

Gerätebefehle werden an das DM 5010 in ASCII durch Anwendung der PRINT Statements übertragen. Als Antwort auf INPUT Statements vom Controller gibt das DM 5010 Daten aus. Zum Beispiel:

PRINT @ 16:„SET?"
INPUT @ 16:A$

wobei 16 die GPIB-Primäradresse des DM 5010 ist.

Interface-Steuermitteilungen können mit den Controller-Befehlen WBYTE an das DM 5010 gesendet werden. In den folgenden Beispielen sind A und B die Talk- und Listenadressen des DM 5010. Für A die Primäradresse plus 32; für B die Primäradresse plus 64.

Listen (MLA)	WBYTE @ A:
Unlisten (UNL)	WBYTE @ 63:
Talk (MTA)	WBYTE @ B:
Untalk (UNT)	WBYTE @ 95:
Device Clear (DCL)	WBYTE @ 20:
Selected Device Clear (SDC)	WBYTE @ A,4:
Go To Local (GTL)	WBYTE @ A,1:
Remote With Lockout (RWLS)	WBYTE @ A,17:
Local With Lockout (LWLS)	WBYTE @ 17:
Group Execute Trigger <GET>	WBYTE @ A,8:
Serial Poll Enable (SPE)	WBYTE @ 24:
Serial Poll Disable (SPD)	WBYTE @ 25:

Informationen über die Anwendung des RBYTE Statements enthält das Handbuch für Controller der Serie 4050.

EINSCHALT- (ANFANGS-) BEDINGUNGEN

Beim Einschalten führt der Microprozessor des DM 5010 eine Diagnoseroutine (Selbsttest) durch, um die Funktion des ROM und RAM zu prüfen. Wird kein Fehler entdeckt, schaltet das Gerät auf Eigenbedienung (LOCS) mit den in Tabelle 3-3 aufgelisteten Einstellungen um. Die SRQ Leitung am GPIB ist ebenfalls geltend gemacht.

Die in Tabelle 3-3 enthaltenen Einstellungen werden vom DM 5010 auch angenommen, wenn es den Befehl INIT ausführt. Die Bereichseinstellung für die Funktion DCV gilt nur für die erste Messung, da das Gerät im AUTO Bereich arbeitet.

Tabelle 3-3
DM 5010 EINSCHALT-EINSTELLUNGEN

Kopfteil	Argument
AVE	2
CALC	OFF
DBR	1
DCV	−1.E+3
DIGIT	4.5
DT	OFF
LFR	OFF
LIMITS	0,0
MODE	RUN
MONITOR	OFF
NULL	0
OPC	OFF
OVER	OFF
RATIO	1,0
RQS	ON
SOURCE	FRONT
USER	OFF

ASCII & IEEE 488 (GPIB) CODE CHART

B7 B6 B5 → / BITS B4 B3 B2 B1 ↓	Ø Ø Ø	Ø Ø 1	Ø 1 Ø	Ø 1 1	1 Ø Ø	1 Ø 1	1 1 Ø	1 1 1
	CONTROL		NUMBERS SYMBOLS		UPPER CASE		LOWER	
Ø Ø Ø Ø	0 NUL 0 (0)	20 DLE 10 (16)	40 SP 20 (32)	60 0 30 (48)	100 @ 40 (64)	120 P 50 (80)	140 ` 60 (96)	160 p 70 (112)
Ø Ø Ø 1	1 SOH GTL 1 (1)	21 DC1 LLO 11 (17)	41 ! 21 (33)	61 1 31 (49)	101 A 41 (65)	121 Q 51 (81)	141 a 61 (97)	161 q 71 (113)
Ø Ø 1 Ø	2 STX 2 (2)	22 DC2 12 (18)	42 " 22 (34)	62 2 32 (50)	102 B 42 (66)	122 R 52 (82)	142 b 62 (98)	162 r 72 (114)
Ø Ø 1 1	3 ETX 3 (3)	23 DC3 13 (19)	43 # 23 (35)	63 3 33 (51)	103 C 43 (67)	123 S 53 (83)	143 c 63 (99)	163 s 73 (115)
Ø 1 Ø Ø	4 EOT SDC 4 (4)	24 DC4 DCL 14 (20)	44 $ 24 (36)	64 4 34 (52)	104 D 44 (68)	124 T 54 (84)	144 d 64 (100)	164 t 74 (116)
Ø 1 Ø 1	5 ENQ PPC 5 (5)	25 NAK PPU 15 (21)	45 % 25 (37)	65 5 35 (53)	105 E 45 (69)	125 U 55 (85)	145 e 65 (101)	165 u 75 (117)
Ø 1 1 Ø	6 ACK 6 (6)	26 SYN 16 (22)	46 & 26 (38)	66 6 36 (54)	106 F 46 (70)	126 V 56 (86)	146 f 66 (102)	166 v 76 (118)
Ø 1 1 1	7 BEL 7 (7)	27 ETB 17 (23)	47 ' 27 (39)	67 7 37 (55)	107 G 47 (71)	127 W 57 (87)	147 g 67 (103)	167 w 77 (119)
1 Ø Ø Ø	10 BS GET 8 (8)	30 CAN SPE 18 (24)	50 (28 (40)	70 8 38 (56)	110 H 48 (72)	130 X 58 (88)	150 h 68 (104)	170 x 78 (120)
1 Ø Ø 1	11 HT TCT 9 (9)	31 EM SPD 19 (25)	51) 29 (41)	71 9 39 (57)	111 I 49 (73)	131 Y 59 (89)	151 i 69 (105)	171 y 79 (121)
1 Ø 1 Ø	12 LF A (10)	32 SUB 1A (26)	52 * 2A (42)	72 : 3A (58)	112 J 4A (74)	132 Z 5A (90)	152 j 6A (106)	172 z 7A (122)
1 Ø 1 1	13 VT B (11)	33 ESC 1B (27)	53 + 2B (43)	73 ; 3B (59)	113 K 4B (75)	133 [5B (91)	153 k 6B (107)	173 { 7B (123)
1 1 Ø Ø	14 FF C (12)	34 FS 1C (28)	54 , 2C (44)	74 < 3C (60)	114 L 4C (76)	134 \ 5C (92)	154 l 6C (108)	174 | 7C (124)
1 1 Ø 1	15 CR D (13)	35 GS 1D (29)	55 – 2D (45)	75 = 3D (61)	115 M 4D (77)	135] 5D (93)	155 m 6D (109)	175 } 7D (125)
1 1 1 Ø	16 SO E (14)	36 RS 1E (30)	56 . 2E (46)	76 > 3E (62)	116 N 4E (78)	136 ∧ 5E (94)	156 n 6E (110)	176 ~ 7E (126)
1 1 1 1	17 SI F (15)	37 US 1F (31)	57 / 2F (47)	77 ? UNL 3F (63)	117 O 4F (79)	137 _ UNT 5F (95)	157 o 6F (111)	177 RUBOUT (DEL) 7F (127)

ADDRESSED COMMANDS (column Ø Ø Ø) — UNIVERSAL COMMANDS (column Ø Ø 1) — LISTEN ADDRESSES (columns Ø 1 Ø, Ø 1 1) — TALK ADDRESSES (columns 1 Ø Ø, 1 Ø 1) — SECONDARY ADDRESSES OR COMMANDS (columns 1 1 Ø, 1 1 1)

KEY TO CHART

octal	25
GPIB code	PPU
ASCII character	NAK
hex	15
decimal	(21)

3391-13

Bild 3-3. ASCII und IEEE 488 (GPIB) Code.

Programm Beispiele

Sprecher/Hörer Programm für Controller der TEKTRONIX Serie 4050.

```
100 REM DM5010 Talker/Listener Program
110 REM DM5010 Primary Address = 16
120 INIT
130 ON SRQ THEN 260
140 DIM A$(200)
150 PRINT "Enter Message(s): ";
160 INPUT C$
170 PRINT @16:C$
180 REM Check for queries
190 IF POS(C$,"?",1)<>0 THEN 220
200 REM Check for 'SEND'
210 IF POS(C$,"SEND",1)=0 THEN 150
220 REM Input from device
230 INPUT @16:A$
240 PRINT A$
250 GO TO 150
260 REM Serial POLL Routine
270 POLL X,Y;16
280 PRINT "Status Byte: ";Y
290 RETURN
```

Sprecher/Hörer Programm für Controller der TEKTRONIX Serie 4040.

```
90 REM DM5010 TALKER/LISTENER PROGRAM
95 REM DM5010 PRIMARY ADDRESS = 16
100 OPEN #1:"GPIB(PRI=16,EOM=<>):"
110 ON SRQ THEN GOSUB 240
115 ENABLE SRQ
120 DIM A$ TO (200)
130 PRINT "ENTER COMMAND(S) / QUERY "
140 INPUT C$
145 IF C$="EX" THEN GOTO 230
150 PRINT #1:C$
160 REM CHECK FOR QUERIES
170 IF POS(C$,"?",1)<>0 THEN GOTO 200
180 IF POS(C$,"SEND",1)=0 THEN GOTO 130
190 REM INPUT FROM DEVICE
200 INPUT #1:A$
210 PRINT A$
220 GOTO 130
230 STOP
240 POLL SB,P,S;16
250 PRINT "SRQ SEEN, STATUS BYTE WAS:",SB
260 RETURN
```

Diese Programm-Beispiele ermöglichen einem Anwender Gerätebefehle an das DM 5010 zu senden, um Geräteeinstellungen zu ändern und die erzeugten Daten abzurufen.

Weitere Unterstützung bei der Entwicklung spezieller, anwendungsorientierter Software finden Sie in den nachstehenden TEKTRONIX Handbüchern.

070-3985-GPIB Programming Guide. Dieses Handbuch wurde speziell für die Anwendung dieses Gerätes in IEEE-488 Systemen geschrieben. Es enthält Programmierungsanleitungen, Tips und einige spezielle Programmbeispiele.

070-2270-00-4051 GPIB Hardware Support Manual. Dieses Handbuch bietet eine eingehende Diskussion des IEEE-488 Bus Betriebs, Erklärungen der Bus Timing Details und frühe Bus Interface-Schaltungen.

070-2058-01 – Programmieren in BASIC.

070-2059-01 – Graphisches Programmieren in BASIC.

062-5971-01 – Programmierungshilfen Serie 4050, T1 (incl. Software).

062-5972-01 – Programmierungshilfen Serie 4050, T2 (incl. Software).

070-2380-01 – 4907 File Manager Betriebsanleitung.

070-2128-00 – 4924 Anwender-Handbuch.

070-1940-01 – Graphisches System Serie 4050 Betriebsanleitung.

070-2056-01 – Graphisches System Serie 4050 Bezugshandbuch.

070-3918-00 – 4041 Betriebsanleitung.

061-2546-00 – 4041 Programmierungs-Handbuch.

PROGRAMMIERUNGSHILFEN

Diese Besprechung der Programmierungsvorschläge und die Programmbeispiele dienen als Hilfe bei der Entwicklung von Programmen zur Steuerung des DM 5010. Die Programmbeispiele wurden mit einem Controller der Serie 4050 und dem DM 5010 entwickelt; bei einigen Beispielen wurden auch andere TM 5000 Geräte verwendet.

Ein erster Programmierungsvorschlag betrifft die Einstellung der Betriebsartenschalter des DM 5010 für das Mitteilungs-Endezeichen, die GPIB Adresse und die Betriebsart Talk Only. Zur Bestimmung ihrer derzeitigen Einstellung drücken Sie die Taste INST ID. Die dargestellte Zahl ist die gewählte GPIB Primäradresse; das Dezimalzeichen ganz rechts leuchtet auf, wenn als Mitteilungs-Endezeichen LF/EOI gewählt ist; das Minuszeichen leuchtet auf, wenn die Betriebsart Talk Only gewählt ist. Hinweise zur Änderung der Schaltereinstellungen findet qualifiziertes Servicepersonal in diesem Handbuch im Abschnitt „Wartung".

In den Programmbeispielen ist die Variable D der GPIB Primäradresse des DM 5010 zugeordnet von der angenommen wird, daß sie auf das Dezimaläquivalent 16 eingestellt ist. Die Verwendung einer Variablen eliminiert die Wiederholung der Adressen-Dezimalzahl und ermöglicht die einfache Änderung der Adresse im Programm.

Behandlung von Service-Abfragen (SRQ)

Beim Einschalten macht das DM 5010 SRQ geltend. Das Einschalt SRQ ist eingesetzt, um den Controller zu informieren, wenn die Spannungsquelle während der Programmbearbeitung unterbrochen wird, da dies die richtige Programmausführung beeinflussen kann. Wenn RQS freigegeben ist, kann das DM 5010 auch für andere Ereignisse SRQ geltend machen (siehe Tabelle 3-1, Fehlerabfrage und Status-Information). Einige Controller können SRQ's ignorieren; andere Controller müssen alle SRQ's bedienen. Wenn SRQ's im Programm bedient werden müssen, stellen Sie sicher, daß seine Unterbrechung freigegeben wird.

Interrupt Handler

Eine Interrupt gesteuerte Routine zur Bedienung von SRQ's, die während der Programmbearbeitung auftreten. Ein Interrupt-Handler besteht im wesentlichen aus einem ON SRQ Statement am Anfang des Programms und einer Serial Poll-Routine irgendwo im Programm. Das ON SRQ Statement richtet die Programmsteuerung auf die Serienabfrage-Routine wenn ein SRQ auftritt. Siehe Programmbeispiel 1 oder 3, Zeile 110 für ON SRQ Statements. Wenn ein SRQ Interrupt auftritt, führt der Controller die Serienabfrage-Routine durch. In einem POLL Statement gibt die erste Variable die Geräteposition in der Liste der GPIB Adressen an; die zweite Variable gibt das Statusbyte an. Eine Serienabfrage eines Gerätes am Bus wird in Beispiel 3, Zeile 1000 illustriert. In Beispiel 4 fragt Zeile 400 drei Geräte auf dem Bus ab und verwendet die Variable für jede Geräteadresse. In jedem Beispiel zeigt POLL das Statusbyte des Gerätes an, das SRQ geltend gemacht hat. Programmbeispiel 9 Zeilen 150, 160 und 170 faßt eine Serienabfrage mit den Statements WBYTE und RBYTE der Serie 4050 zusammen.

Die Serienabfrage-Routine kann zur Dekodierung von Information über das SRQ auslösende Ereignis erweitert werden. Die Zeilen 510 und 520 in Beispiel 1 löschen das Arbeitsbit im Statusbyte; die Zeilen 530 bis 560 dekodieren das Statusbyte und die Zeilen 1000 bis 7030 drucken die Ereignisklasse aus.

Programmbeispiel 7 verwendet das MONITOR SRQ um Messungen herauszufinden, die oberhalb oder unterhalb der mit dem Befehl LIMITS eingestellten Grenzwerte liegen. Die Zeilen 1020, 1040, und 1045 dekodieren das Statusbyte und veranlassen den entsprechenden Ausdruck auf dem Controllerdisplay.

In Programmbeispiel 2, Zeile 130 fragt der Controller das Gerät an Adresse 16 ab, um das Einschalt-SRQ zu löschen. Zeile 116 schaltet RQS ab, um weitere SRQ's zu verhindern. Wenn RQS OFF ist, kann die Abfrage ERR? in das Programm eingefügt werden, um wenn es erforderlich ist, einen Ereignisstatus zu bestimmen.

Frontplatten-Abschaltung

Die Bedienung von der Frontplatte kann abgeschaltet werden, so daß nur der Controller Geräteeinstellungen ändern kann. Zur Abschaltung der Frontplatte machen Sie zuerst REN geltend. Solange Abschaltung der Frontplatte gewünscht wird, muß REN gültig bleiben. Bei Controllern der Serie 4050 macht das RUN Statement automatisch REN geltend; das Statement END hebt REN auf. Dann senden Sie die Interface-Mitteilung LLO (Dezimaläquivalent 17 mit ATN). Bei der Serie 4050 geschieht dies mit dem Statement WBYTE. Zuletzt adressieren Sie das Gerät, indem Sie einen Einstell- oder Abfragebefehl mit dem Statement PRINT @ D: oder nur die Listen-Adresse mit einem WBYTE Statement senden. Nach diesen drei Schritten ist die Frontpaltte abgeschaltet und bleibt so, bis REN falsch wird oder eine <GTL> Mitteilung (Dezimaläquivalent 1 mit ATN) gesendet wird. Siehe Programmbeispiel 4, Zeilen 150 und 190; und Beispiel 5, Zeilen 130 und 220.

Die Verwendung von INIT

Die Verwendung des Befehls INIT vereinfacht das Programm, da man gewöhnlich weniger Befehle zur Einstellung des Gerätestatus benötigt als für die individuelle Spezifizierung aller Einstellungen. Im Programmbeispiel 6, Zeile 150 empfängt das DM 5010 den Befehl INIT gefolgt von einer Serie von Befehlen, die den Gerätestatus von den INIT (Einschalt-) Einstellungen in den gewünschten Status ändern.

Löschen einer Darstellung

Nach einer Änderung des Eingangs kann es wünschenswert sein, die derzeitge Anzeige zu löschen, da sie nicht mehr der jetzigen Meßbedingung entspricht. Eine Möglichkeit ist es, dem Gerät einen Einstellbefehl zu senden - dies veranlaßt das Gerät die Daten im Ausgangs-Puffer zu löschen. Ein weiterer Weg ist dem Controller eine Messung einzugeben und sie zu ignorieren.

Durch Verwendung von MODE TRIG bei der Messung können ungültige Anzeigen vermieden werden.

Allowing Settling Time

Um sicherzustellen, daß die an den Controller übermittelte Messung gültig ist, kann in einem Programm Settling Time enthalten sein. Siehe Step Response Time im Abschnitt „Spezifikation".

In Programmbeispiel 4 verwenden die Zeilen 230–250 eine FOR...NEXT Schleife zur Eingabe von fünf Messungen in die Variable R. Am Ende der Schleife enthält die Variable R die fünfte Messung.

In Programmbeispiel 5 Zeilen 290–320 werden zwei DM 5010 Messungen verglichen; wenn die Differenz größer als 0,001 ist, wird eine weitere Messung zum Vergleich herangezogen. Die Vergleiche werden wiederholt bis die Differenz anzeigt, daß zwei Messungen nahezu gleich sind.

Getriggerte Messungen

Zur Auflösung einer einzelnen Umwandlung verwenden Sie MODE TRIG und initiieren eine Triggerung mit einem der nachstehenden Vorgänge:

1. Adressieren Sie das Gerät als Talker. Siehe Programmbeispiel 2, Zeile 180.

2. Befehl SEND.

3. Senden Sie DT TRIG. Dann triggern Sie das DM 5010 durch Übetragung einer Group Execute Trigger (GET) Interface Mitteilung (Dezimaläquivalent 8 mit ATN). Siehe Programmbeispiel 9, Zeilen 120 und 5.

4. Wenn die Betriebsart EXTRIG freigegeben ist, halten Sie für 10 µs oder weniger P1031-16A am Isolation Board auf Masse.

5. Veranlassen Sie, daß die Bedienungsperson die Taste TRIGGERED auf der Frontplatte drückt.

Für wiederholte (freilaufende) Triggerung verwenden Sie den Befehl MODE RUN. Ist die Betriebsart EXTRIG freigegeben, halten Sie P1031-16A am Isolation Board auf Masse.

Verfügbarkeit von Ablesungen

Wenn das Gerät als Talker adressiert ist oder wenn der Befehl SEND zum Abruf von Daten verwendet wird, ist es nicht erforderlich zu bestimmen, ob eine Ablesung verfügbar ist. Für jede dieser Abrufmethoden triggert das Gerät eine Übertragung wenn keine Ablesung ansteht.

Für andere Abrufmethoden gibt es mehrere Wege zu bestimmen, ob eine Ablesung verfügbar ist.

1. Senden Sie den Abrufbefehl RDY?. Ist die Antwort 1 ist eine Ablesung fertig. Siehe Programmbeispiel 3, Zeile 140.

2. Stellen Sie OPC ON und RQS ON. Das Gerät macht SRQ geltend, wenn eine Ablesung verfügbar ist. Siehe Beispiel 8, Zeile 150.

3. Wiederholen Sie eine Serienabfrage-Routine mit den Statements WBYTE bis das Statusbyte 132, 148, 140 oder 156 ist. Siehe Beispiel 9, Zeilen 150 und 200.

RDY?, OPC ON und die Serienabfrage-Routine sind nützlich, wenn mehrere Aufgaben gleichzeitig ablaufen.

Senden an einen Hörer (Listener)

Um eine DM 5010 Messung an einen GPIB Listener übertragen zu können, muß das empfangende Gerät als Listener adressiert sein. Dann adressieren Sie das DM 5010 als Talker für die Übertragung der Messungen. Erfolgt die Sendung an einen Controller, können die Daten in einen String oder nummerische Variable gelesen werden. Siehe Programmbeispiele 2, Zeile 180 und 3, Zeile 150.

WARNING

THE FOLLOWING SERVICING INSTRUCTIONS ARE FOR USE BY QUALIFIED PERSONNEL ONLY. TO AVOID PERSONAL INJURY, DO NOT PERFORM ANY SERVICING OTHER THAN THAT CONTAINED IN OPERATING INSTRUCTIONS UNLESS YOU ARE QUALIFIED TO DO SO. REFER TO OPERATORS SAFETY SUMMARY AND SERVICE SAFETY SUMMARY PRIOR TO PERFORMING ANY SERVICE.

PERFORMANCE CHECK

Introduction

This performance check verifies the Electrical Performance Requirements as listed in the Specification section in this manual. Perform the Adjustment Procedure if the instrument fails to meet these checks. For convenience, many steps in this procedure check the performance of this instrument at only one value in the specified performance range. Any value within the specified range, within appropriate limits, may be substituted. The performance check may be done at any ambient temperature between 0° and +50°C. Performance limits for two ambient temperature ranges are listed for some steps. Use the data listed for the temperature at which the instrument is operating. A summary sheet is provided at the back of this section for recording performance check results.

Test Equipment Required

The test equipment listed in Table 5-1, or equivalent, is recommended to perform the performance check. Specifications given for the test equipment are the minimum necessary for accurate performance verification. All test equipment is assumed to be correctly calibrated and operating within specification.

Table 5-1
TEST EQUIPMENT LIST

Description	Minimum Requirements	Performance Check Step	Recommended Equipment
TM 5000-Series Power Module		all	TEKTRONIX TM 5003, Opt. 02
Dc voltage calibrator	±200 mV: ±(0.0038% of rdng + 0.0025% of range) ±2 V-200 V: ±(0.0038% of rdng + 0.0013% of range) ±1000 V: ±(0.005% of rdng + 0.0025% of range)	1, 2, 3	Fluke 335D Dc Voltage Standard
Ac voltage calibrator	200 mV through 200 V: 10-20 Hz: ±(0.20% of rdng + 0.08% of range) 20-100 Hz: ±(0.20% of rdng +0.05% of range) 100 Hz-20 kHz: ±(0.05% of rdng + 0.05% of range) 20-100 kHz: ±(0.25% of rdng + 0.12% of range) 700 V: 10-20 Hz: ±(0.20% of rdng + 0.22% of range) 20-100 Hz: ±(0.20% of rdng + 0.15% of range) 100 Hz-15 kHz: ±(0.05% of rdng + 0.15% of range)	2, 3, 4	Fluke 5200A Ac Calibrator, and Fluke 5215A Power Amplifier

Table 5-1 (cont)

Description	Minimum Requirements	Performance Check Step	Recommended Equipment
Resistance standard[a]	200 Ω: ±(0.0038% of rdng + 0.0038% of range) 2 k-200 kΩ: ±(0.0038% of rdng + 0.0025% of range) 2 MΩ: ±(0.025% of rdng + 0.0025% of range) 20 MΩ: ±(0.038% of rdng + 0.0012% of range)	5	Electro Scientific Industries, Inc. DB 62 Dekabox and SR1 10 MΩ Standard Resistor
Counter	100 MHz ±0.0016%	4	TEKTRONIX DC 509 Universal Counter/Timer[b]
Resistor	100 kΩ, ±5%, 1/4 W	3	Tektronix Part No. 315-0104-00
Resistor	604 Ω, ±1%, 1/4 W	6	Tektronix Part No. 322-0172-00
Controller	GPIB compatible	9	TEKTRONIX 4050-Series Controller or TEKTRONIX 4041 Controller

[a]Resistance of Dekabox and interconnect cable must be known to the accuracy listed in Table 5-1 for each point checked in the Ohms Accuracy check.

[b]Requires a TM 500/5000-Series power module.

Preparation

Make certain the 50-60 Hz jumper is positioned to match the power module line frequency. To check the jumper position, turn the two plastic fasteners on the left side cover and remove the cover. Refer to Fig. 10-1 in the pullout pages for the jumper location and position. Replace the side cover.

Install the DM 5010 in the power module, and apply power. Allow 30 minutes warm-up time (60 minutes after storage in high-humidity environment) before beginning the performance check.

WARNING

Dangerous voltages may be encountered in the following steps. Caution must be exercised. Do not contact the output connectors of the voltage calibrator, the input terminals of the DM 5010, or the internal circuitry of the DM 5010. Set all voltage calibrators to a minimum output before making the necessary connections.

Preliminary Control Settings

DCV	on
NULL	off
LOW FREQ RESPONSE	off
RANGE	STEP (200 mV range)
TRIGGER MODE	RUN on
CONVERSION RATE	FAST off
CALCULATIONS	all off
REAR INPUT	off

1. Check Dc Voltage Accuracy

a. Set the DM 5010 front-panel controls to match the preliminary control settings listed above.

b. Connect the dc voltage calibrator to the DM 5010 HIGH and LOW input connectors through appropriate cables and adapters.

c. Set the calibrator output to the voltage listed in Table 5-2.

d. CHECK—that the DM 5010 display reads within the display limits listed in the table.

e. Set the CONVERSION RATE (FAST button) as listed in the next line of the table.

f. CHECK—that the DM 5010 display reads within the limits listed in the table.

g. Repeat parts c through f for the succeeding lines of the table.

h. Set the calibrator to a minimum output voltage.

i. Remove all connections to the DM 5010.

Table 5-2
DC VOLTAGE ACCURACY

DM 5010 Range	Dc Calibrator Voltage	DM 5010 FAST	Display Limits: Ambient Temp. Range +18 to +28°C	Display Limits: Ambient Temp. Range 0 to +18°C, +28 to +50°C
200 mV	0.0 V	off on	+0.02 to −0.02 +0.1 to −0.1	+0.07 to −0.07 +0.2 to −0.2
2 V	0.0 V	on off	+.001 to −.001 +.0001 to −.0001	+.002 to −.002 +.0006 to −.0006
20 V	0.0 V	off on	+0.001 to −0.001 +0.01 to −0.01	+0.006 to −0.006 +0.02 to −0.02
200 V	0.0 V	on off	+0.1 to −0.1 +0.01 to −0.01	+0.2 to −0.2 +0.06 to −0.06
1000 V	0.0 V	off on	+0.1 to −0.1 +1. to −1.	+0.4 to −0.4 +2. to −2.
200 mV	190 mV	off on	189.95 to 190.05 189.8 to 190.2	189.82 to 190.18 189.6 to 190.4
2 V	1.9 V	on off	1.898 to 1.902 1.8996 to 1.9004	1.896 to 1.904 1.8983 to 1.9017
20 V	19. V	off on	18.996 to 19.004 18.98 to 19.02	18.983 to 19.017 18.96 to 19.04
200 V	190. V	on off	189.8 to 190.2 189.96 to 190.04	189.6 to 190.4 189.83 to 190.17
1000 V	950. V	off on	949.7 to 950.3 948. to 952.	949.0 to 951.0 947. to 953.
Set the calibrator output to a minimum level.				
200 mV	−190 mV	off on	−189.95 to −190.05 −189.8 to −190.2	−189.82 to −190.18 −189.6 to −190.4
2 V	−1.9 V	on off	−1.898 to −1.902 −1.8996 to −1.9004	−1.896 to −1.904 −1.8983 to −1.9017
20 V	−19. V	off on	−18.996 to −19.004 −18.98 to −19.02	−18.983 to −19.017 −18.96 to −19.04
200 V	−190. V	on off	−189.8 to −190.2 −189.96 to −190.04	−189.6 to −190.4 −189.83 to −190.17
1000 V	−950. V	off on	−949.7 to −950.3 −948. to −952.	−949.0 to −951.0 −947. to −953.

2. Check Ac Voltage Accuracy

a. Set the DM 5010 front-panel controls to the preliminary control settings with the following exception:

ACV+DCV on

b. Connect the ac sinewave voltage calibrator to the DM 5010 HIGH and LOW input connectors.

c. Set the ac voltage calibrator output to the voltage and frequency listed in Table 5-3 or 5-4, depending on the ambient temperature.

NOTE

For the 10 and 20 Hz checks, press the LOW FREQ RESPONSE button to obtain a stable display. Release the button for the remaining frequency checks.

d. CHECK—that the DM 5010 display reads within the display limits for the frequencies and FUNCTIONS listed in the table (Dc input limits using ACV+DCV function are checked later in this step.)

e. Set the CONVERSION RATE (FAST button) as listed in the next line of the table.

f. CHECK—that the DM 5010 display reads within the limits for the frequencies and FUNCTIONS listed in the table.

g. Repeat parts c through f for each remaining line of the table. For the 200 and 700 V range checks, use the power amplifier.

h. Set the ac voltage calibrator to a minimum output and replace the ac calibrator with the dc voltage calibrator.

i. Set the DM 5010 range and the FAST button as listed in the first line of the table.

j. Set the dc calibrator output to the first voltage listed in the table.

k. Repeat parts d through f for each line of the table, checking only the display limits for dc input.

l. Set the dc voltage calibrator to a minimum output and remove all connections to the DM 5010.

Table 5-3
AC VOLTAGE ACCURACY
(Ambient Temp. Range +18 to +28°C)

DM 5010 Range	Calibrator Voltage	DM 5010 FAST	DM 5010 FUNCTION				
			ACV+DCV	ACV	ACV	ACV+DCV	ACV
			Calibrator Frequency				
			10 Hz*	20 Hz*	20 kHz	Dc	100 kHz
			Display Limits				
200 mV	190. mV	off	192.12 to 187.88	191.92 to 188.08	190.78 to 189.22	191.48 to 188.52	192.90 to 187.10
	100. mV		101.40 to 98.60	101.20 to 98.80	100.60 to 99.40	101.30 to 98.70	102.00 to 98.00
	10. mV		10.68 to 9.32	10.46 to 9.54	10.42 to 9.58	11.12 to 8.88	11.10 to 8.90
	190. mV	on	192.1 to 187.9	191.9 to 188.1	190.8 to 189.2	191.5 to 188.5	192.9 to 187.1
	100. mV		101.4 to 98.6	101.2 to 98.8	100.6 to 99.4	101.3 to 98.7	102.0 to 98.0
	10. mV		10.7 to 9.3	10.5 to 9.5	10.5 to 9.5	11.2 to 8.8	11.1 to 8.9

Table 5-3 (cont)

DM 5010 Range	Calibrator Voltage	DM 5010 FAST	DM 5010 FUNCTION: ACV+DCV	ACV	ACV	ACV+DCV	ACV
			Calibrator Frequency: 10 Hz*	20 Hz*	20 kHz	Dc	100 kHz
			Display Limits				
2 V	1.9 V	on	1.921 to 1.879	1.919 to 1.881	1.908 to 1.892		1.929 to 1.871
	1. V		1.014 to .986	1.012 to .988	1.006 to .994		1.020 to .980
	.1 V		.107 to .093	.105 to .095	.105 to .095		.111 to .089
	1.9 V	off	1.9212 to 1.8788	1.9192 to 1.8808	1.9078 to 1.8922		1.9290 to 1.8710
	1. V		1.0140 to .9860	1.0120 to .9880	1.0060 to .9940		1.0200 to .9800
	.1 V		.1068 to .0932	.1046 to .0954	.1042 to .0958		.1110 to .0890
20 V	19. V	off	19.212 to 18.788	19.192 to 18.808	19.078 to 18.922		19.290 to 18.710
	10. V		10.140 to 9.860	10.120 to 9.880	10.060 to 9.940		10.200 to 9.800
	1. V		1.068 to .932	1.046 to .954	1.042 to .958		1.110 to .890
	19. V	on	19.21 to 18.79	19.19 to 18.81	19.08 to 18.92		19.29 to 18.71
	10. V		10.14 to 9.86	10.12 to 9.88	10.06 to 9.94		10.20 to 9.80
	1. V		1.07 to .93	1.05 to .95	1.042 to .958		1.11 to .89
200 V	190. V	on	192.1 to 187.9	191.9 to 188.1	190.8 to 189.2	191.4 to 188.6	192.9 to 187.1
	100. V		101.4 to 98.6	101.2 to 98.8	100.6 to 99.4	101.2 to 98.8	102.0 to 98.0
	10. V		10.7 to 9.3	10.5 to 9.5	10.5 to 9.5	11.1 to 8.9	11.1 to 8.9
	190. V	off	192.12 to 187.88	191.92 to 188.08	190.78 to 189.22	191.38 to 188.62	192.90 to 187.10
	100. V		101.40 to 98.60	101.20 to 98.80	100.60 to 99.40	101.20 to 98.8	102.00 to 98.00
	10. V		10.68 to 9.32	10.46 to 9.54	10.42 to 9.58	11.02 to 9.98	11.10 to 8.90
					15 kHz	Dc	
700 V	665. V	off	676.6 to 653.4	674.5 to 655.5	670.5 to 659.5	669.5 to 660.5	
	350. V		359.1 to 340.9	357.0 to 343.0	354.9 to 345.1	354.2 to 345.8	
	100. V		107.1 to 92.9	105.0 to 95.0	104.4 to 95.6	103.7 to 96.3	
	665. V	on	677. to 653.	675. to 655.	671. to 659.	670. to 650.	
	350. V		359. to 341.	357. to 343.	355. to 345.	355. to 345.	
	100 V		107. to 93.	105. to 95.	105. to 95.	104. to 96.	

*Use LOW FREQ RESPONSE.

Table 5-4
AC VOLTAGE ACCURACY

(Ambient Temp. Range 0 to +18°C, +28 to +50°C)

DM 5010 Range	Calibrator Voltage	DM 5010 FAST	DM 5010 FUNCTION				
			ACV+DCV	ACV	ACV	ACV+DCV	ACV
			Calibrator Frequency				
			10 Hz*	20 Hz*	20 kHz	Dc	100 kHz
			Display Limits				
2 V	1.9 V	on	1.921 to 1.879	1.919 to 1.881	1.908 to 1.892		1.929 to 1.871
	1. V		1.014 to .986	1.012 to .988	1.006 to .994		1.020 to .980
	.1 V		.107 to .093	.105 to .095	.105 to .095		.111 to .089
	1.9 V	off	1.9212 to 1.8788	1.9192 to 1.8808	1.9078 to 1.8922		1.9290 to 1.8710
	1. V		1.0140 to .9860	1.0120 to .9880	1.0060 to .9940		1.0200 to .9800
	.1 V		.1068 to .0932	.1046 to .0954	.1042 to .0958		.1110 to .0890
20 V	19. V	off	19.212 to 18.788	19.192 to 18.808	19.078 to 18.922		19.290 to 18.710
	10. V		10.140 to 9.860	10.120 to 9.880	10.060 to 9.940		10.200 to 9.800
	1. V		1.068 to .932	1.046 to .954	1.042 to .958		1.110 to .890
	19. V	on	19.21 to 18.79	19.19 to 18.81	19.08 to 18.92		19.29 to 18.71
	10. V		10.14 to 9.86	10.12 to 9.88	10.06 to 9.94		10.20 to 9.80
	1. V		1.07 to .93	1.05 to .95	1.042 to .958		1.11 to .89
200 V	190. V	on	192.1 to 187.9	191.9 to 188.1	190.8 to 189.2	191.4 to 188.6	192.9 to 187.1
	100. V		101.4 to 98.6	101.2 to 98.8	100.6 to 99.4	101.2 to 98.8	102.0 to 98.0
	10. V		10.7 to 9.3	10.5 to 9.5	10.5 to 9.5	11.1 to 8.9	11.1 to 8.9
	190. V	off	192.12 to 187.88	191.92 to 188.08	190.78 to 189.22	191.38 to 188.62	192.90 to 187.10
	100. V		101.40 to 98.60	101.20 to 98.80	100.60 to 99.40	101.20 to 98.8	102.00 to 98.00
	10. V		10.68 to 9.32	10.46 to 9.54	10.42 to 9.58	11.02 to 9.98	11.10 to 8.90
					15 kHz	Dc	
700 V	665. V	off	676.6 to 653.4	674.5 to 655.5	670.5 to 659.5	669.5 to 660.5	
	350. V		359.1 to 340.9	357.0 to 343.0	354.9 to 345.1	354.2 to 345.8	
	100. V		107.1 to 92.9	105.0 to 95.0	104.4 to 95.6	103.7 to 96.3	
	665. V	on	677. to 653.	675. to 655.	671. to 659.	670. to 650.	
	350. V		359. to 341.	357. to 343.	355. to 345.	355. to 345.	
	100 V		107. to 93.	105. to 95.	105. to 95.	104. to 96.	

3. Check Dc Common Mode Rejection

a. Set the DM 5010 controls to the preliminary settings.

b. Connect the DM 5010 input connectors to the dc voltage calibrator as shown in Fig. 5-1A.

c. Set the dc voltage calibrator output to 100 V.

d. CHECK—that the DM 5010 display reads ≤3.16 mV.

e. Set the calibrator to a minimum output.

f. Add a connection from the DM 5010 GUARD connector as shown in Fig. 5-1B.

g. Set the dc voltage calibrator output to 100 V.

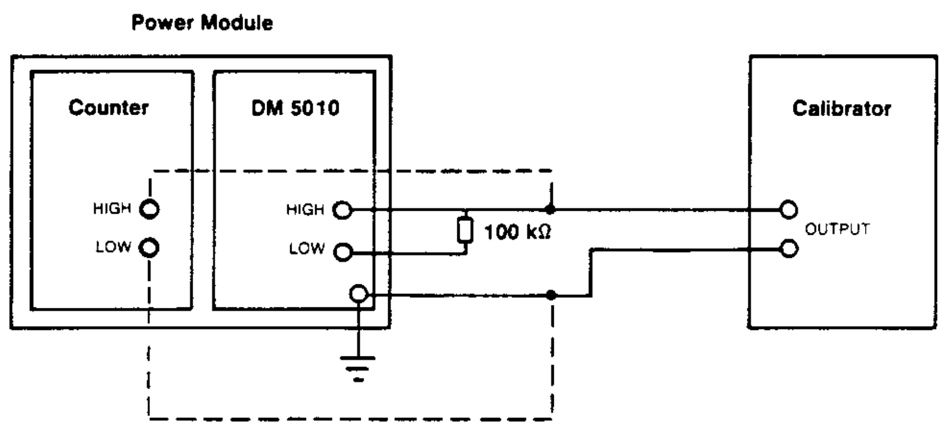
h. CHECK—that the DM 5010 display reads ≤1.00 mV.

i. Set the dc voltage calibrator to a minimum output and replace it with the ac voltage calibrator and counter.

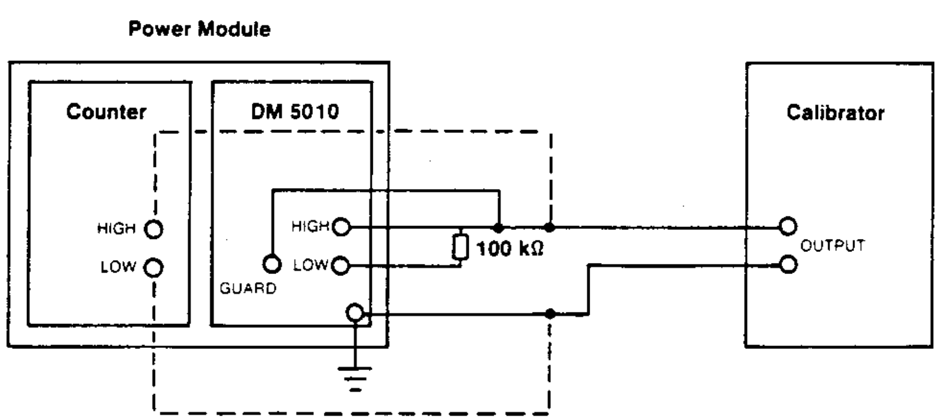
j. Set the ac voltage calibrator output to 15 V rms at 60.2, ±0.02 Hz. Use the counter to verify the calibrator frequency.

k. CHECK—that the absolute value of the DM 5010 display reads ≤0.21 mV.

l. Remove the connection to the DM 5010 GUARD connector.



A. Setup for unguarded common mode rejection ratio check.



B. Setup for guarded common mode rejection ratio check.

2994-27

Fig. 5-1. Common mode check setup.

m. CHECK—that the absolute value of the DM 5010 display reads ≤2.12 mV.

n. If desired, this step may be repeated with the calibrator, counter, and GUARD connected to the LOW side of the resistor instead of the HIGH side.

o. Set the voltage calibrator to a minimum output, and remove all connections to the DM 5010.

4. Check Dc Normal Mode Rejection

a. Make certain the DM 5010 50-60 Hz jumper is in the 60 Hz position.

b. Connect the counter, ac calibrator, and DM 5010 as shown in Fig. 5-2.

c. Set the DM 5010 controls to the preliminary settings with the following exception:

RANGE STEP (2 V range)

d. Store 0.0212 for one LIMITS constant.

e. Store −0.0212 for the other LIMITS constant.

f. Enable the COMPARE calculation.

g. Set the ac calibrator output to 1.5 V rms at the frequency listed in Table 5-5. Use the counter to verify the calibrator frequency.

h. CHECK—that the DM 5010 display reads PASS as shown in the table.

i. Repeat parts g and h for each remaining line of the table for the 60 Hz jumper position checks. Be sure to set the DM 5010 CONVERSION RATE (FAST button) as listed in the table.

j. Reposition the DM 5010 50-60 Hz jumper to the 50 Hz position.

k. CHECK—that the DM 5010 display reads PASS as shown in the table for the 50 Hz jumper position checks.

l. Remove all connections to the DM 5010.

m. Reposition the DM 5010 50-60 Hz jumper to the power module line frequency.

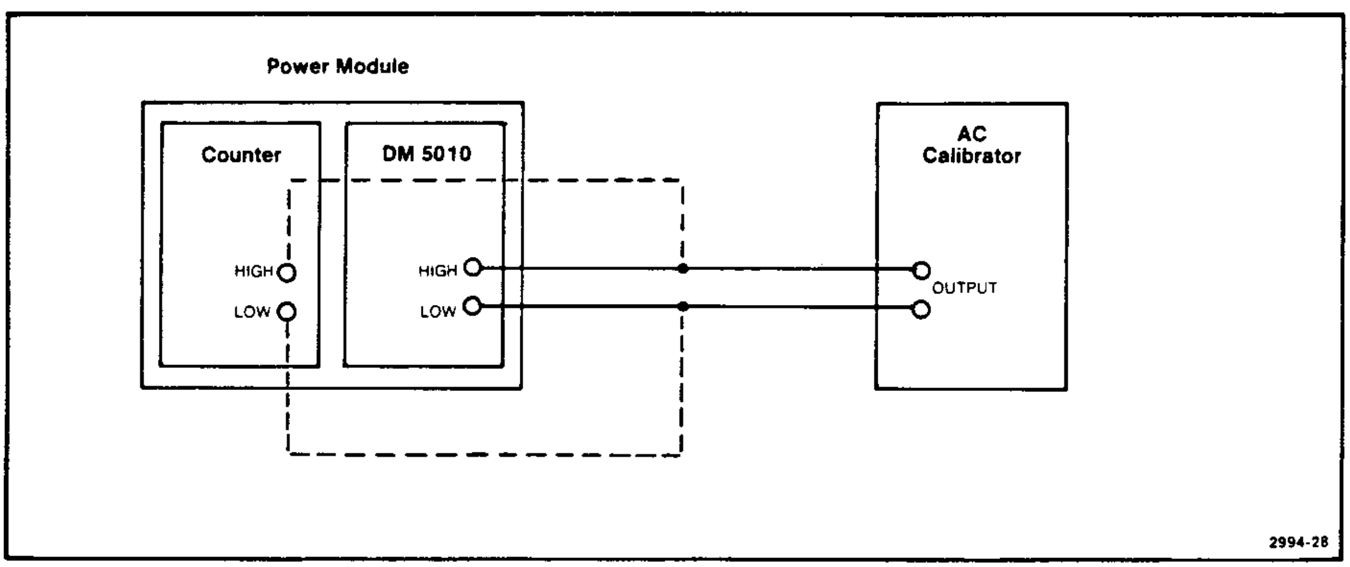


Fig. 5-2. Dc normal mode rejection setup.

Table 5-5
DC NORMAL MODE REJECTION

50-60 Hz Jumper Position	DM 5010 FAST	Calibrator Frequency (Hz)	Display Reading
	off	60.2, ±0.02	PASS
	on	60.2 ±0.02	PASS
60 Hz	on	59.8, ±0.02	PASS
	off	59.8, ±0.02	PASS
	off	50.2, ±0.02	PASS
	off	49.8, ±0.02	PASS
50 Hz	on	49.8, ±0.02	PASS
	on	50.2, ±0.02	PASS

5. Ohms Accuracy

a. Set the DM 5010 front-panel controls to the preliminary control settings with the following exception:

OHMS on

b. Connect a shorting plug between the DM 5010 HIGH and LOW input connectors.

c. CHECK—that the display reads within the limits listed in Table 5-6, at each conversion rate.

d. Set the DM 5010 front panel controls to the 200 Ω range and normal conversion rate. Press the NULL button. Remove the shorting plug and connect the decade resistance box to the DM 5010 input connectors using a coaxial cable with less than 0.3 Ω. See Fig. 5-3A.

e. Set the decade box resistance to the value listed in Table 5-7.

f. CHECK—that the display reads within the limits listed in the table.

g. Set the DM 5010 CONVERSION RATE as shown in the next line of the table.

h. CHECK—that the display reads within the limits listed in the table.

i. Set the DM 5010 range, CONVERSION RATE, and the decade box resistance as listed in the next line of the table.

j. Repeat parts f through i for the remaining lines of the table, except change the equipment setup as shown in Fig. 5-3B for the 20 MΩ range checks.

k. Remove all connections to the DM 5010.

Table 5-6
OHMS OFFSET ACCURACY

DM 5010 Range	DM 5010 FAST	Display Limits	
		Ambient Temp. Range +18 to +28°C	Ambient Temp. Range 0 to +18°C, +28 to +50°C
200 Ω	off	±0.03 Ω[a]	±0.12 Ω[a]
	on	±0.1 Ω[a]	±0.2 Ω[a]
2 kΩ	on	±.001 kΩ	±.002 kΩ
	off	±.0002 Ω[b]	±.0007 kΩ[b]
20 kΩ	off	±0.002 kΩ	±0.007 kΩ
	on	±0.01 kΩ	±0.02 kΩ
200 kΩ	on	±0.1 kΩ	±0.2 kΩ
	off	±0.02 kΩ	±0.07 kΩ
2 MΩ	off	±.0002 MΩ	±.0007 MΩ
	on	±.001 MΩ	±.002 MΩ
20 MΩ	on	±0.01 MΩ	±0.01 MΩ
	off	±0.001 MΩ	±0.002 MΩ

[a] With NULL, if NULL is not used add ±0.2 Ω.
[b] With NULL, if NULL is not used add ±0.0002 kΩ.

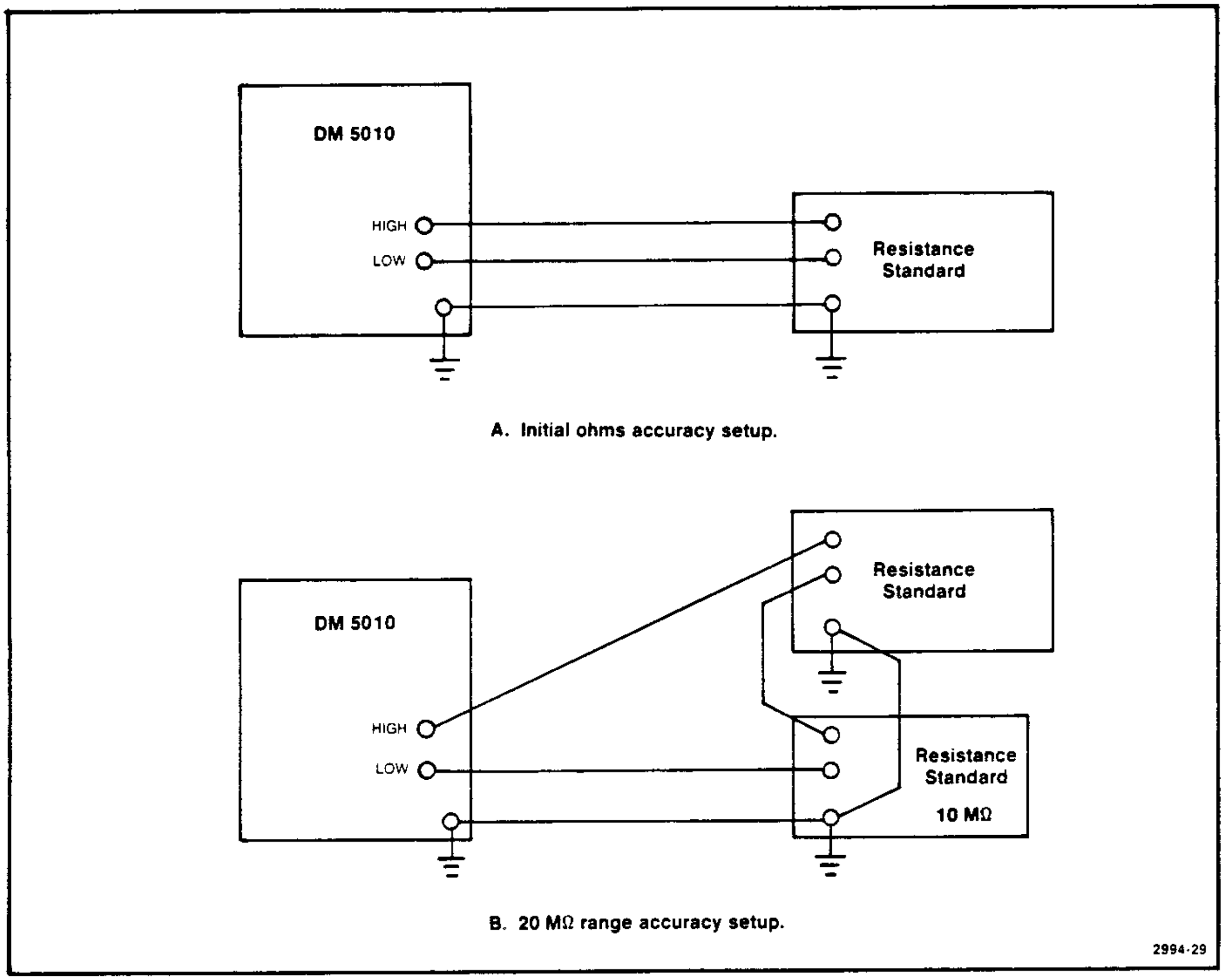


Fig. 5-3. Ohms accuracy setup.

Table 5-7
OHMS GAIN ACCURACY

DM 5010 Range	Resistance Standard	DM 5010 FAST	Display Limits	
			Ambient Temp. Range +18 to +28°C	Ambient Temp. Range 0 to +18°C, +28 to +50°C
200 Ω	0.00019 MΩ	off	R_{in} ±0.06 Ω	R_{in} ±0.24 Ω
		on	R_{in} ±0.2 Ω	R_{in} ±0.4 Ω
2 kΩ	0.00019 MΩ	on	R_{in} ±.001 kΩ	R_{in} ±.002 kΩ
		off	R_{in} ±.0002 kΩ	R_{in} ±.0008 kΩ
	0.00190 MΩ	off	R_{in} ±.0005 kΩ	R_{in} ±.0019 kΩ
		on	R_{in} ±.002 kΩ	R_{in} ±.004 kΩ
20 kΩ	0.00190 MΩ	on	R_{in} ±.01 kΩ	R_{in} ±0.02 kΩ
		off	R_{in} ±0.002 kΩ	R_{in} ±.008 kΩ
	0.01900 MΩ	off	R_{in} ±0.005 kΩ	R_{in} ±0.019 kΩ
		on	R_{in} ±0.02 kΩ	R_{in} ±.04 kΩ
200 kΩ	0.01900 MΩ	on	R_{in} ±.1 kΩ	R_{in} ±.2 kΩ
		off	R_{in} ±0.02 kΩ	R_{in} ±.08 kΩ
	0.19000 MΩ	off	R_{in} ±0.05 kΩ	R_{in} ±0.19 kΩ
		on	R_{in} ±0.2 kΩ	R_{in} ±.4 kΩ
2 MΩ	0.19000 MΩ	on	R_{in} ±.001 MΩ	R_{in} ±.003 MΩ
		off	R_{in} ±.0004 MΩ	R_{in} ±.0017 MΩ
	1.90000 MΩ	off	R_{in} ±.0021 MΩ	R_{in} ±.0110 MΩ
		on	R_{in} ±.003 MΩ	R_{in} ±.012 MΩ
20 MΩ	1.90000 MΩ	on	R_{in} ±.03 MΩ	R_{in} ±.04 MΩ
		off	R_{in} ±.004 MΩ	R_{in} ±.016 MΩ
	0.00000 MΩ[a]	off	R_{in} ±.016 MΩ	R_{in} ±.077 MΩ
		on	R_{in} ±.11 MΩ	R_{in} ±.017 MΩ
	9.00000 MΩ[a]	on	R_{in} ±.20 MΩ	R_{in} ±.31 MΩ
		off	R_{in} ±.030 MΩ	R_{in} ±.145 MΩ

[a]SR1 10 MΩ standard resistor in series with the DB62.

6. Diode Test Check

a. Set the DM 5010 controls to the preliminary settings.

b. Connect a 604 Ω resistor between the DM 5010 HIGH and LOW input connectors.

c. Press the DIODE TEST button (on).

d. CHECK—that the display reads between 0.5484 V and 0.6054 V.

e. Remove the resistor.

NOTE

The rear interface ohms offset and accuracy checks need not be made unless the instrument is used for measurements via the rear-interface connections.

7. Rear Interface Ohms Offset Check

For this check, short the power module connections to the DM 5010 rear-interface pins 28B (Hi) and 28A (Lo) on the ADC board (A17). Access to these pins is most easily made using a TM 5000-Series, Option 02 power module.

a. Set the DM 5010 controls to the preliminary control settings with the following exceptions:

OHMS	on
REAR INPUT	on

b. CHECK—that the DM 5010 display reads between −0 and −0.5 Ω.

c. Remove the short between the power module connections to the DM 5010 rear-interface input connector pins.

8. Rear Interface Accuracy Checks

To verify the accuracy of the DCV, ACV, ACV+DCV, and OHMS modes via the DM 5010 rear interface, follow the steps outlined in the performance check for the front-panel input connectors, but apply the voltages and resistances to the DM 5010 rear interface pins pins 28B (Hi) and 28A (Lo) on the ADC board (A17) via the power module connections.

NOTE

The output cable fixture from the calibrating sources to the rear interface pins may require modification to accommodate accuracy checks via the DM 5010 rear interface.

Press the DM 5010 REAR INPUT button to select rear interface input.

CAUTION

Do not exceed the maximum input voltages specified for rear interface input.

When rear-interface accuracy checks have been completed, remove all connections to the DM 5010.

9. GPIB Communication Check

a. Refer to the talker-listener programs in the Programming section of this manual. Using one of these programs, send commands to the DM 5010 and observe the front-panel changes. Send SET? and note the data returned to the controller.

b. CHECK—that the DM 5010 front panel correctly displays setting changes as sent and returns the correct setting information when queried.

c. Remove all connections.

This completes the performance check for the DM 5010.

PERFORMANCE CHECK SUMMARY SHEET

Date ____________________

Serial Number ______________________________ Tested by ______________________________

Step	Description	Minimum	Measured	Maximum

ADJUSTMENT PROCEDURE

Introduction

This procedure should be performed if the instrument fails to meet the performance requirements of the electrical characteristics listed in the Specification section of this manual. To ensure continued instrument accuracy, adjustment should be performed every 1000 hours of operation or every six months if used infrequently. Adjustment is also recommended following instrument repair or modification. Adjustments must be made at an ambient temperature between +21°C to +25°C. Allow thirty minutes warm-up time before beginning adjustments (sixty minutes after exposure to or storage in high humidity environment).

The recommended interval for battery replacement is approximately every two years. Performance of the Adjustment Procedure is necessary after battery replacement to restore the calibration factors to memory. See the Maintenance section of this manual for battery replacement information.

Services Available

Tektronix, Inc. provides complete instrument repair and adjustment at local field service centers and at the factory service center. Contact your local Tektronix Field Office or representative for further information.

Test Equipment Required

The test equipment listed in Table 6-1, or equivalent, is recommended for adjustment of the DM 5010. Specifications given for the test equipment are the minimum necessary for accurate instrument adjustment. All test equipment is assumed to be correctly calibrated and operating within specification.

Table 6-1
TEST EQUIPMENT LIST

Description	Minimum Requirements	Performance Check Step	Recommended Equipment
TM 5000-Series Power Module		all	TEKTRONIX TM 5003, Opt. 02
DC voltage calibrator	200 mV: ±(0.0038% of rdng + 0.0025% of range) 2 V-200 V: ±(0.0038% of rdng + 0.0013% of range) 1000 V: ±(0.005% of rdng + 0.0025% of range)	2	Fluke 335D Dc Voltage Standard
Ac voltage calibrator	200 mV through 200 V: 10-20 Hz: ±(0.20% of rdng + 0.08% of range) 20-100 Hz: ±(0.20% of rdng + 0.05% of range) 100 Hz-20 kHz: ±(0.05% of rdng + 0.05% of range) 20-100 kHz: ±(0.25% of rdng + 0.12% of range)	6, 7	Fluke 5200A Ac Calibrator, and Fluke 5215A Power Amplifier

Table 6-1 (cont)

Description	Minimum Requirements	Performance Check Step	Recommended Equipment
	700 V: 10-20 Hz: ±(0.20% of rdng + 0.22% of range) 20-100 Hz: ±(0.20% of rdng + 0.15% of range) 100 Hz-15 kHz: ±(0.05% of rdng + 0.15% of range)		
Resistance standard[a]	200 Ω: ±(0.0038% of rdng + 0.0038% of range) 2 k-200 kΩ: ±(0.0038% of rdng + 0.0025% of range) 2 MΩ: ±(0.025% of rdng + 0.0025% of range) 20 MΩ: ±(0.038% of rdng + 0.0012% of range)	4	Electro Scientific Industries, Inc. DB 62 Dekabox and SR1 10 MΩ Standard Resistor
Digital Voltmeter	Range: 0 to 1 kV. Accuracy: ±(0.05% of rdng +0.02% of full scale)	5	TEKTRONIX DM 501A Digital Multimeter[b]
Flexible Extender cable (2 ea)		5, 6, 7	Tektronix Part No. 067-0645-02

[a]Resistance of Dekabox and interconnect cable must be known to the accuracy listed in Table 6-1 for each point adjusted in Step 4.

[b]Requires a TM 500/5000-Series power module.

Preparation

Before adjustments can be performed, the internal CAL jumper must be repositioned. For access to the jumper, remove the instrument's left side cover by turning the two plastic fasteners. The jumper is located in the lower rear corner of the CPU board (A14). See Fig. 10-1 in the pullout pages of this manual. Reposition the CAL jumper, P1132, to the CAL position. Also, make certain the 50-60 Hz jumper is positioned to match the power module line frequency. This jumper is also located on the CPU board. Replace the side cover.

Since the DCV and OHMS adjustments are more sensitive to temperature variations, these adjustments are made with the instrument operating in the power module. Install the DM 5010 in the power module, turn on the power module and allow warm-up time before beginning adjustments.

WARNING

Dangerous voltages may be encountered in the following steps. Caution must be exercised. Do not contact the output connectors of the voltage calibrator, the input terminals of the DM 5010, or the internal circuitry of the DM 5010. Also, do not contact the internal adjustments, since they may be at the DM 5010 input potential; use only an insulated adjustment tool for adjustments.

Preliminary Control Settings

DCV	on
NULL	off
LOW FREQ RESPONSE	off
RANGE	STEP (200 mV range)
TRIGGER MODE	RUN on
CONVERSION RATE	FAST off
CALCULATIONS	all off
REAR INPUT	off

1. Adjust the DCV Offset Calibration Factors

a. Set the DM 5010 front-panel controls to the preliminary settings.

b. Connect the dual banana shorting plug between the DM 5010 HIGH and LOW INPUT connectors.

c. Press ENTER.

d. CHECK—that the display reads as shown in Table 6-2, ±1 in the least significant digit (LSD).

e. Set the range and FAST button as shown in the next line of the table.

f. Repeat parts c through e for each succeeding line in the table.

g. Remove the shorting plug.

Table 6-2
DCV OFFSET CALIBRATION FACTORS

DM 5010 Range	DM 5010 FAST	Press	Display Reading
200 mV	off	ENTER	0.00 mV
	on	ENTER	0.0 mV
2 V	on	ENTER	.000 V
	off	ENTER	.0000 V
20 V	off	ENTER	0.000 V
	on	ENTER	0.00 V
200 V	on	ENTER	0.0 V
	off	ENTER	0.00 V
1000 V	off	ENTER	0.0 V
	on	ENTER	0. V

2. Adjust the DCV Gain Calibration Factors

a. Set the DM 5010 controls to the preliminary control settings.

b. Connect the dc voltage calibrator through appropriate cables and connectors to the DM 5010 HIGH and LOW connectors.

c. Set the dc voltage calibrator output to 190 mV dc.

d. Press ENTER.

e. CHECK—that the display reads as shown in Table 6-3, ±1 in the LSD.

f. Set the FAST button as shown in the table.

g. Press ENTER.

h. CHECK—that the display reads as shown in the table, ±1 in the LSD.

Table 6-3
DCV GAIN CALIBRATION FACTORS

DM 5010 Range	Dc Calibrator Voltage	DM 5010 FAST	Press	Display Reading
200 mV	190 mV dc	off	ENTER	190.00 mV
		on	ENTER	190.0 mV
2 V	1.9 Vdc	on	ENTER	1.900 V
		off	ENTER	1.9000 V
20 V	19 Vdc	off	ENTER	19.000 V
		on	ENTER	19.00 V
200 V	190 Vdc	on	ENTER	190.0 V
		off	ENTER	190.00 V
1000 V	1000 Vdc	off	ENTER	1000.V
		on	ENTER	1000.0 V

i. Set the DM 5010 range as shown in the table.

j. Set the dc calibrator output to the next value in the table.

NOTE

Avoid over-ranging the DM 5010 while performing the adjustment procedure. Should over-range occur, allow several minutes for stabilization before proceeding with adjustments.

k. Repeat parts d through j for each succeeding line of the table.

l. Set the dc calibrator to 0 Vdc and remove the connections to the DM 5010.

3. Adjust the Ohms Offset Calibration Factors

a. Set the DM 5010 controls to the preliminary settings with the following exception:

OHMS on

b. Connect the dual banana shorting plug between the DM 5010 HIGH and LOW INPUT connectors.

c. Press ENTER.

d. CHECK—that the display reads as shown in Table 6-4, ±1 in the LSD.

e. Set the range and FAST button as listed in the next line of the table.

f. Repeat parts c through e for each succeeding line in the table.

g. Remove the shorting plug.

Table 6-4
OHMS OFFSET CALIBRATION FACTORS

DM 5010 Range	DM 5010 FAST	Press	Display Reading
200 Ω	off	ENTER	0.00
	on	ENTER	0.0
2 kΩ	on	ENTER	.000 kΩ
	off	ENTER	.0000 kΩ
20 kΩ	off	ENTER	0.000 kΩ
	on	ENTER	0.00 kΩ
200 kΩ	on	ENTER	0.0 kΩ
	off	ENTER	0.00 kΩ
2 MΩ	off	ENTER	.0000 MΩ
	on	ENTER	.000 MΩ
20 MΩ	on	ENTER	0.00 MΩ
	off	ENTER	0.000 MΩ

4. Adjust the Ohms Gain Calibration Factors

NOTE

The actual resistance of the precision resistance, including the interconnecting cable, must be known for each calibration point before this step can be performed. For convenience, write the actual resistance in the blank columns (Table 6-5), for each calibration point.

a. Set the DM 5010 controls to the preliminary settings with the following exception:

OHMS on

b. Connect the decade box to the DM 5010 input connectors as shown in Fig. 6-1A.

c. Set the decade box resistance to the value listed in Table 6-5.

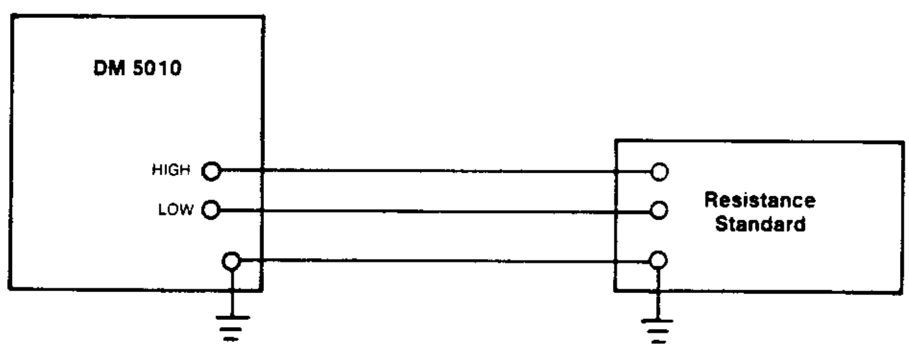
d. Press the keypad numeric and decimal point buttons listed in the table for the applied resistance value, beginning with the most significant digit. (For example; for 190 Ω press 1, 9, 0, and ENTER; for 190 kΩ press 1, 9, 0, 0, 0, 0, and ENTER).

e. Press ENTER.

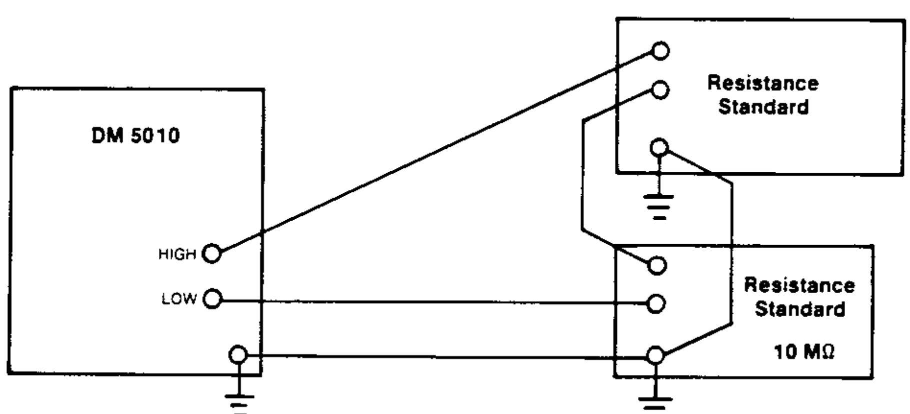
f. CHECK—that the display reads as shown in the table, ±1 in the LSD.

g. Repeat parts c through f for the remaining lines of Table 6-5 except change the equipment setup as shown in Fig. 6-1B for the 20 MΩ adjustments.

h. Remove all connections to the DM 5010.



A. Initial ohms gain adjustment setup.



B. 20 MΩ range adjustment setup.

2994-30

Fig. 6-1. Ohms adjustment setup.

Table 6-5
OHMS GAIN CALIBRATION FACTORS

DM 5010 Range	DM 5010 FAST	Resistance Standard	ENTER applied resistance	Display Reading (entered resistance)
200 Ω	off	0.00019 MΩ		
	on	0.00019 MΩ		
2 kΩ	on	0.00190 MΩ		
	off	0.00190 MΩ		
20 kΩ	off	0.01900 MΩ		
	on	0.01900 MΩ		
200 kΩ	on	0.19000 MΩ		
	off	0.19000 MΩ		
2 MΩ	off	1.90000 MΩ		
	on	1.90000 MΩ		±1 in LSD
20 MΩ[a]	on	9.00000 MΩ		±3 in LSD
	off	9.00000 MΩ		

[a]Connect SR1 10M standard in series with the DB 62. To minimize the effect of noise, make physical contact with the DM 5010 chassis ground terminal.

5. Adjust the ACV Offsets

a. Turn off the power module, remove the DM 5010, and connect the DM 5010 rear-interface connectors to the power module via the flexible extender cables. Turn on the power module.

b. Connect a shorting plug between the HIGH and LOW input connectors.

c. Set the DM 5010 controls to the preliminary settings with the following exceptions:

ACV+DCV on

d. Set the DM 501A to measure 200 mV dc.

e. Connect the DM 501A low connector to the DM 5010 Lo test point (TP1701) and the high connector to the DM 5010 Atten Out test point (TP1503). Refer to Fig. 10-1 for test point locations.

f. ADJUST—the Atten Offset (R1601), using an insulated adjustment tool, for a DM 501A reading of 0 ±0.05 mV.

g. Move the DM 501A high lead to the DM 5010 Amp Out test point (TP1201).

h. ADJUST—the Amp Offset (R1305) for a DM 501A reading of 0 ±0.50 mV.

i. Disconnect the DM 501A leads and remove the shorting plug.

6. Adjust ACV Gain Calibration Factors

a. Set the DM 5010 controls to the preliminary settings with the following exception:

ACV+DCV on

b. Connect the ac calibrator to the DM 5010 HIGH and LOW input connectors.

c. Set the 200 Hz ac calibrator output to the voltage listed in the table.

d. Press ENTER.

e. CHECK—that the display reads as listed in Table 6-6.

f. Set the DM 5010 range and FAST button as listed in the next line of the table.

g. Repeat parts c through f for each remaining line of the table. Use the power amplifier for the 200 V and 700 V range adjustments.

h. Set the calibrator output to a minimum level and remove all connections to the DM 5010.

7. Adjust the Ac Frequency Compensation

a. Set the DM 5010 controls to the preliminary settings with the following exceptions:

ACV+DCV	on
RANGE	STEP (200 V range)

b. Connect the ac calibrator to the DM 5010 HIGH and LOW input connectors.

c. Set the ac calibrator output to 190.00 V at 20 kHz, ±200 Hz.

Table 6-6
ACV GAIN CALIBRATION FACTORS

DM 5010 Range	Ac Calibrator (200 Hz)	DM 5010 FAST	Press	Display Reading
200 mV	19 mV	off	ENTER	19.00
		on	ENTER	19.0
	190 mV	on	ENTER	190.0
		off	ENTER	190.00
2 V	190 mV	off	ENTER	.1900
		on	ENTER	.190
	1.9 V	on	ENTER	1.900
		off	ENTER	1.9000
20 V	1.9 V	off	ENTER	1.900
		on	ENTER	1.90
	19 V	on	ENTER	19.00
		off	ENTER	19.000
200 V	19 V	off	ENTER	19.00
		on	ENTER	19.0
	190 V	on	ENTER	190.0
		off	ENTER	190.00
700 V	190 V	off	ENTER	190.0
		on	ENTER	190.
	700 V	on	ENTER	700.
		off	ENTER	700.0 ±3 in LSD

d. ADJUST—the 200 V H.F. Comp. (C1607) for a DM 5010 display reading of 190.00, ±0.02 V, using an insulated adjustment tool. Refer to Fig. 10-1. After adjustment, recheck the DM 5010 display reading and readjust, if necessary.

NOTE

If C1607 approaches the end of its adjustment range, turn off the power module, and remove the RMS board (A16). Adjust C1605 several complete turns in the same direction required for additional range by C1607. Reinstall the board, turn on the power module, and readjust C1607.

e. Set the ac calibrator output to 1.9000 V at 20 kHz, ±200 Hz.

f. Set the DM 5010 range to the 2 V range.

g. ADJUST—the 2 V/200 mV H.F. Comp. (C1503) for a display reading of 1.9000, ±0.0002 V.

h. Set the DM 5010 to the 20 V range.

i. Set the ac calibrator output to 19.000 V at 20 kHz, ±200 Hz.

j. ADJUST—the 20 V H.F. Comp. (C1403) for a display reading of 19.0000, ±0.005 V.

k. Set the DM 5010 to the 200 V range and repeat parts b through j to verify that the adjustments have not changed.

l. Set the ac calibrator output to a minimum level and remove connections to the DM 5010.

m. Turn off the power module and reposition the CAL jumper to the normal position. Replace the cover.

This completes the adjustment procedure.

MAINTENANCE

This section of the manual describes preparation for use (internal jumper and switch settings) and provides general maintenance and troubleshooting information.

CAUTION

To prevent damage to the DM 5010, turn off the power module before installing or removing the instrument. Do not use excessive force to install or remove.

PREPARATION FOR USE

Setting the GPIB Address Switches

For access to the GPIB address switches, remove the DM 5010 left side cover. Five of these switches (A5 through A1) set the decimal value of the primary GPIB address for the DM 5010. Refer to Fig. 7-1. Setting the primary address to 31 untalks and unlistens the DM 5010; the instrument does not respond to GPIB commands. Refer to Table 7-1 for switch settings.

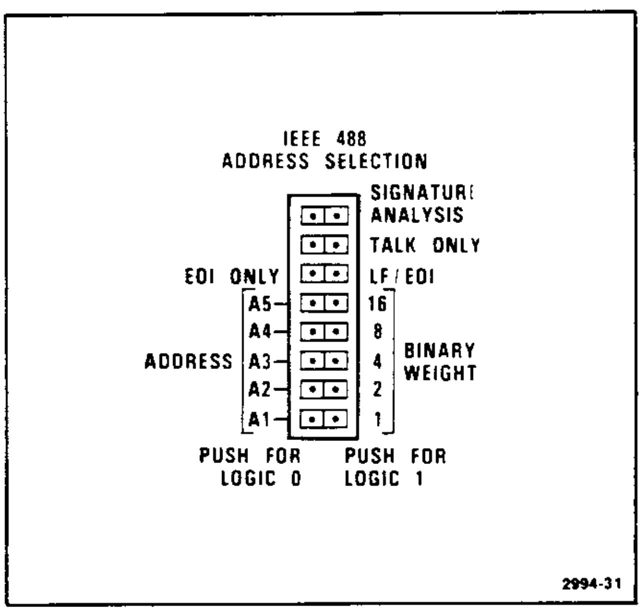


Fig. 7-1. GPIB address and message terminator switches.

Table 7-1
IEEE 488 (GPIB) PRIMARY ADDRESSES

A5	A4	A3	A2	A1	Primary Address
0	0	0	0	0	0
0	0	0	0	1	1
0	0	0	1	0	2
0	0	0	1	1	3
0	0	1	0	0	4
0	0	1	0	1	5
0	0	1	1	0	6
0	0	1	1	1	7
0	1	0	0	0	8
0	1	0	0	1	9
0	1	0	1	0	10
0	1	0	1	1	11
0	1	1	0	0	12
0	1	1	0	1	13
0	1	1	1	0	14
0	1	1	1	1	15
1	0	0	0	0	16
1	0	0	0	1	17
1	0	0	1	0	18
1	0	0	1	1	19
1	0	1	0	0	20
1	0	1	0	1	21
1	0	1	1	0	22
1	0	1	1	1	23
1	1	0	0	0	24
1	1	0	0	1	25
1	1	0	1	0	26
1	1	0	1	1	27
1	1	1	0	0	28
1	1	1	0	1	29
1	1	1	1	0	30
1	1	1	1	1	31

Message Terminator Switch Setting

The EOI ONLY switch selects the DM 5010 message terminator. For access to this switch, remove the instrument's left side cover. The switch is located on the CPU board (A14). Refer to Fig. 7-1. Operation of the DM 5010 with either switch position is described in Section 3 under Messages and Communication Protocol.

Talk Only Switch Setting

The Talk Only switch is one of the bank of eight switches located on the CPU board (A14). Remove the instrument's left side cover for access to this switch. Refer to Fig. 7-1. Setting the Talk Only switch to logic 1 selects the Talk Only mode.

Using the Rear Interface Connections

For rear interface connector pin assignments, see Tables 10-13, 10-14, and 10-15 in the pullout pages of this manual.

Rear-interface pins 28B (Hi) and 28A (Lo) on the ADC board (A17) are the input connections for measurements via the rear interface.

A negative-going TTL signal may be used to trigger instrument measurements via rear interface connections to the Isolation board (A15). Use of this function requires moving a jumper on the CPU board (A14). For access to the jumper, remove the instrument's left side cover. Connect pins 2 and 3 of J1733 using its $\overline{\text{EXTRIG}}$ jumper, P1733. Refer to Fig. 10-1. Apply the $\overline{\text{EXTRIG}}$ signal to the Isolation board rear interface pins 16A and 16B (Ground).

GENERAL MAINTENANCE

Rear Circuit Board Removal

To remove the CPU, Isolation, RMS, or ADC boards, turn off the power module and remove the plug-in. Turn the two plastic fasteners on each side cover and remove the covers. Next, remove the four screws on the instrument back plate and remove the plate. See Fig. 7-2. Then, remove the retainer bar. Carefully pull the selected board toward the rear of the instrument.

NOTE

Before removing the CPU board, unplug the ribbon cable connector from the Front Panel Driver board. Before removing the ADC board, remove the screw on the front panel between the input connectors.

A calibration fixture (Tektronix Part No. 067-1052-00) contains a board extractor for disengaging these boards. It also contains two extender boards designed for operating boards outside the instrument.

To reinstall boards, carefully align the board edges in the guides attached to the top and bottom instrument covers. Press the board firmly to seat it in the Main Interconnect board connectors. When inserting the ADC board, slide the board in until the input connectors contact the front panel. From the front of the instrument, insert a small screwdriver into the front panel connector holes and carefully align the input connectors with the holes while maintaining slight pressure on the back edge of the board. When properly aligned, press the board in firmly.

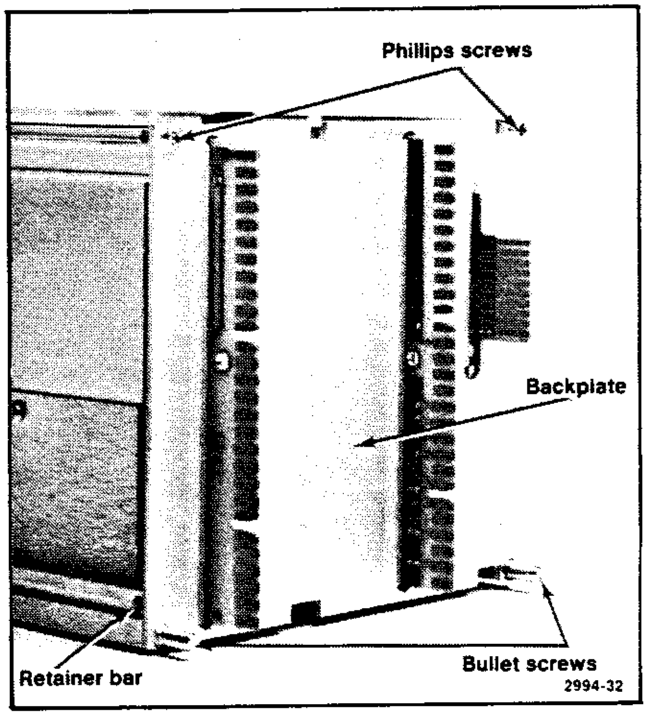


Fig. 7-2. Backplate and retainer bar removal.

Front-Panel Board Removal

To remove the Front Panel and Front Panel Driver board assembly, first remove the instrument side covers and back plate. Remove the front panel screw between the input connectors and remove the ADC board. Refer to Fig. 7-3. It is necessary to disengage the latch before removing the front panel boards. To disengage the latch, use a small screwdriver to push forward slightly on the rear latch (1) just in front of the spring. Press down on the latch knob to raise the latch knob extension at the point where the two latch pieces engage. While holding the latch knob down, push up on the front panel latch piece at the point of engagement (2) to disengage the two pieces. Then, pull the latch knob out.

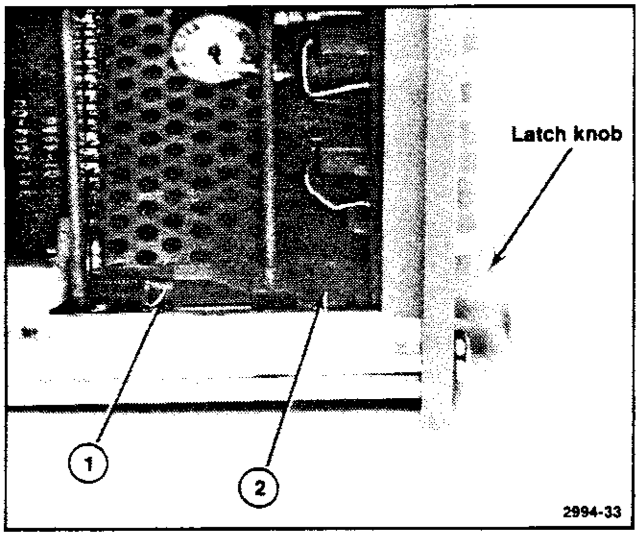


Fig. 7-3. Latch disassembly.

CAUTION

Do not install the plug-in in the power module while the latch is disassembled. Removal of the plug-in without use of the latch can be extremely difficult.

Next, remove the two screws near the front of the instrument top cover (see Fig. 7-4) and remove the cover. Then, remove the other front panel screw and the chassis ground terminal. Pull forward to remove the front panel assembly. Disconnect the ribbon cable from the Front Panel Driver board.

To remove the front panel from the board assembly, remove the five screws on the Front Panel board. To separate the two circuit boards, carefully pull the boards apart, maintaining nearly equal separation until the interconnecting pins disengage. Reassemble in the reverse order.

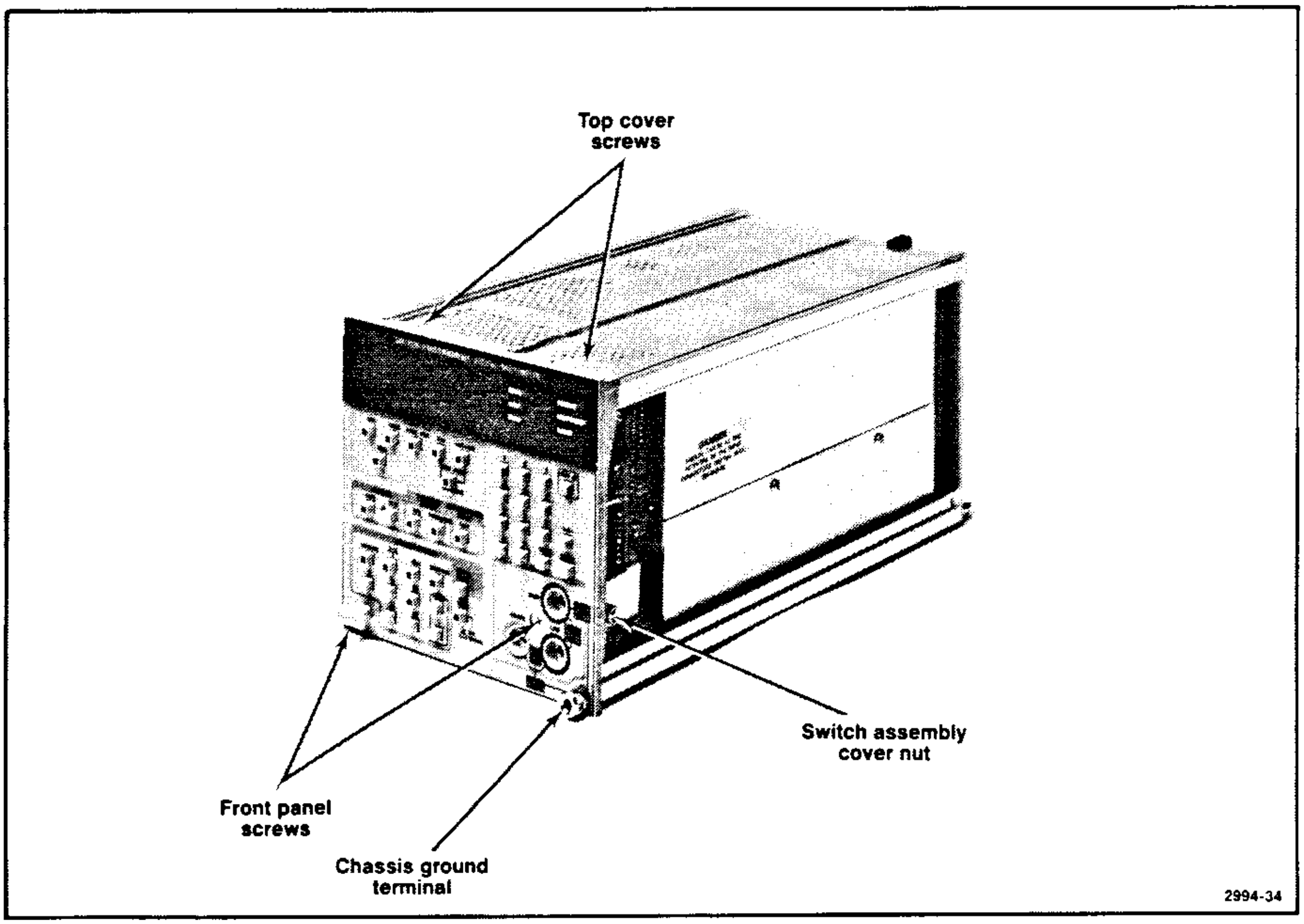


Fig. 7-4. Front panel removal.

Input Switch Assembly

For access to the input switch, remove the ADC board (A17) from the instrument. Then, remove the input connector assembly mounting nut and screw, and remove the guard shield. Refer to Fig. 7-4. Unsolder the wires to the switch. Next, remove the two screws in the back of the input connector assembly and remove the plate. The switch can now be removed. Be careful not to lose the actuator and spring located inside the input connector assembly. Reinstall the guard switch and input connector assembly in reverse order.

Adjusting C1301 and C1404

If the transformer is replaced, the adjustment of C1301 and C1404 should be checked. To accomplish this, place the Isolation board (A15) on an extender board and connect the plug-in to the power module via a flexible extender cable. The recommended equipment is listed below:

Oscilloscope	TEKTRONIX 7603
Dual Trace Amplifier	TEKTRONIX 7A18
Time Base	TEKTRONIX 7B50A

a. Connect the DM 5010 HIGH input connector to the LOW connector. Connect the oscilloscope as shown in Fig. 7-5. Apply power to the power module.

b. ADJUST—C1301 for minimum amplitude of the displayed square wave (≈33 μs period). Refer to Fig. 7-6.

c. Add a connection from the DM 5010 GUARD connector to the DM 5010 chassis ground.

d. ADJUST—C1404 for minimum amplitude of the displayed square wave.

e. Remove all connections to the DM 5010 and turn off the power module. Reinstall the Isolation board in the plug-in.

Battery Replacement

The recommended interval for battery replacement is approximately two years.

NOTE

Disconnecting the battery causes the loss of calibration factors stored in memory. Battery replacement must be followed by a 24-hour period of operation and then performance of the Adjustment Procedure.

For access to the battery, unplug the ribbon cable connector from the Front Panel Driver board and remove the CPU board (A14). The battery is located in the rear, bottom corner of the board. Unsolder the battery ears from the wires attached to the circuit board. Use diagonal pliers to cut the two plastic straps holding the battery in position. Place the new battery in the circuit board cutout with correct polarity. Fasten new plastic straps around the battery and through the circuit board holes. Solder the battery ears to the circuit board wires.

Power up the instrument for about 24 hours to properly charge the battery. Then, perform the Adjustment Procedure to restore calibration factors to instrument memory.

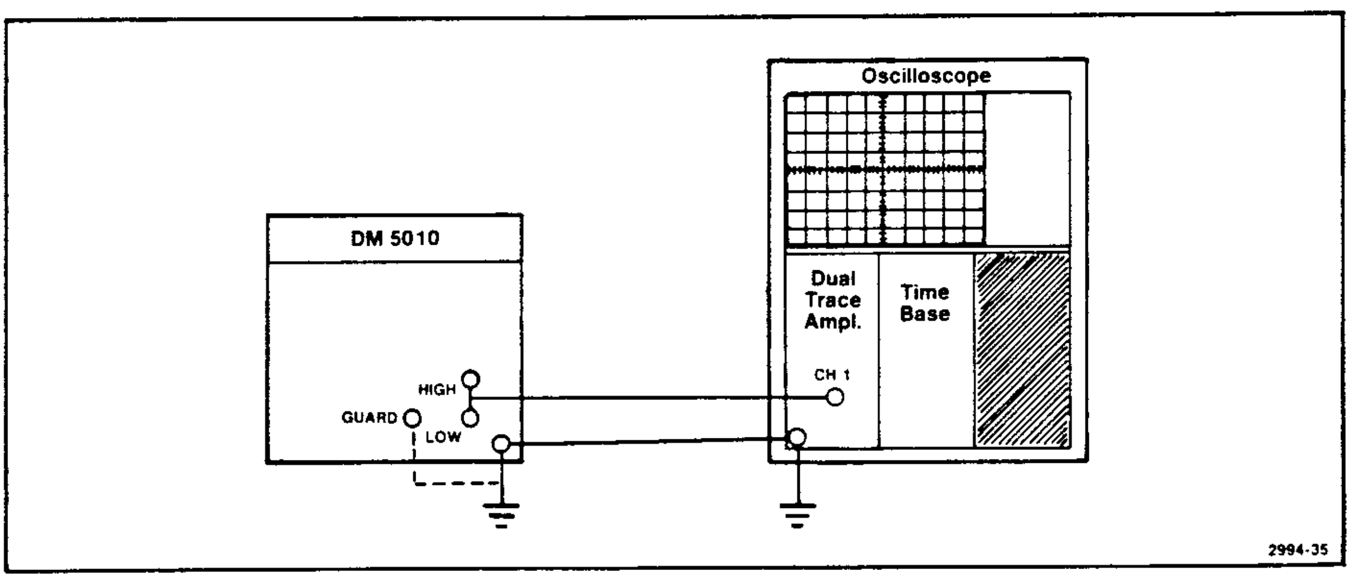


Fig. 7-5. Setup for C1301 and C1404 adjustment.

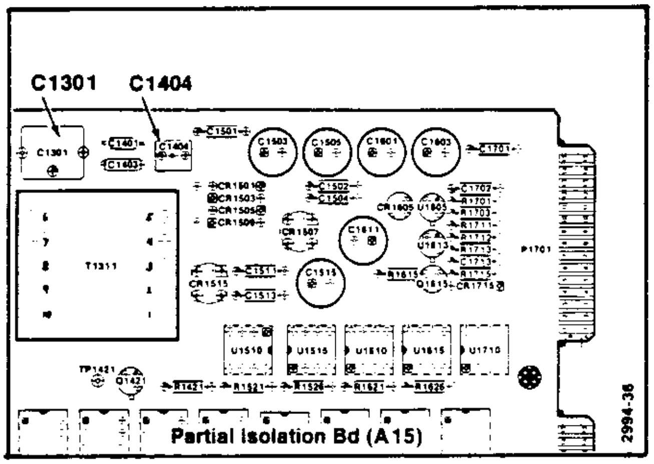


Fig. 7-6. Location of C1301 and C1404.

Troubleshooting Aids

Diagrams. Complete circuit diagrams are located in the foldout pages in the Diagrams and Circuit Board Illustrations section. The portions of the circuit mounted on circuit boards are enclosed by a solid line. The circuit number of each component in this instrument is shown on a diagram. See the first page of the Diagrams and Circuit Board Illustrations section for definitions of the symbols and reference designators used on the diagrams.

Circuit Board Illustrations. Circuit board illustrations are provided in conjunction with circuit diagrams. Each board-mounted component shown on a diagram is also identified on the circuit board illustration by circuit number. A table is provided with each diagram listing components by assembly and circuit number. The table also lists the component grid locations on both the diagram and circuit board illustrations.

Adjustment Locations. To aid in locating test points and adjustable components, the adjustment locations pullout page (normally used with the Adjustment Procedure) permits rapid location of adjustments and associated test points.

Calibration Fixture

Several calibration fixtures are available from Tektronix, Inc. that are helpful in troubleshooting the DM 5010.

067-1052-00—contains two extender boards and a board extractor.

067-0645-02—provides a flexible extender cable.

067-0996-00—contains a GPIB extender cable.

Contact your nearest Tektronix, Inc. Field Office or representative for ordering information.

Troubleshooting Equipment

Befor using any test equipment to make measurements on static-sensitive components or assemblies, be certain that any voltage or current supplied by the test equipment does not exceed the limits of the component to be tested.

Static-Sensitive Components

CAUTION

Static discharge can damage any semiconductor component in this instrument.

This instrument contains electrical components that are susceptible to damage from static discharge. See Table 7-2 for relative susceptibility of various classes of semiconductors. Static voltages of 1 kV to 30 kV are common in unprotected environments.

Observe the following precautions to avoid damage.

1. Minimize handling of static-sensitive components.

2. Transport and store static-sensitive components or assemblies in their original containers, on a metal rail, or on conductive foam. Label any package that contains static-sensitive assemblies or components.

3. Discharge the static voltage from your body by wearing a wrist strap while handling these components. Servicing static-sensitive assemblies or components should be performed only at a static-free work station by qualified service personnel.

4. Nothing capable of generating or holding a static charge should be allowed on the work station surface.

5. Keep the component leads shorted together whenever possible.

6. Pick up components by the body, never by the leads.

7. Do not slide the components over any surface.

8. Avoid handling components in areas that have a floor or work surface covering capable of generating a static charge.

9. Use a soldering iron that is connected to earth ground.

10. Use only special anti-static suction type or wick type desoldering tools.

Table 7-2
RELATIVE SUSCEPTIBILITY TO
TO STATIC DISCHARGE DAMAGE

Semiconductor Classes	Relative Susceptibility Levels[a]
MOS or CMOS microcircuits or discretes, or linear microcircuits with MOS inputs. (Most Sensitive)	1
ECL	2
Schottky signal diodes	3
Schottky TTL	4
High-frequency bipolar transistors	5
JFETs	6
Linear microcircuits	7
Low-power Schottky TTL	8
TTL (Least Sensitive)	9

[a]**Voltage equivalent for levels:**

1 = 100 to 500 V 4 = 500 V 7 = 400 to 1000 V(est.)
2 = 200 to 500 V 5 = 400 to 600 V 8 = 900 V
3 = 250 V 6 = 600 to 800 V 9 = 1200 V

(Voltage discharged from a 100 pF capacitor through a resistance of 100 Ω.)

Obtaining Replacement Parts

Electrical and mechanical parts can be obtained through your local Tektronix Field Office or representative. However, it may be possible to obtain many of the standard electronic components from a local commercial source. Before purchasing or ordering a part from a source other than Tektronix, Inc., check the Replaceable Electrical Parts list for the proper value, rating, tolerance, and description.

NOTE

When selecting replacement parts, remember that the physical size and shape of a component may affect its performance in the instrument.

Some parts are manufactured or selected by Tektronix, Inc., to satisfy particular requirements or are manufactured for Tektronix, Inc., to our specifications. Most of the mechanical parts used in this instrument have been manufactured by Tektronix, Inc. To determine the manufacturer, refer to the replaceable parts lists and the Cross Reference Index, Mfr. Code Number to Manufacturer.

When ordering replacement parts from Tektronix, Inc., include the following information:

1. Instrument type (include modification or option number);

2. instrument serial number;

3. a description of the part (if electrical, include complete circuit number); and

4. Tektronix part number.

Soldering Techniques

WARNING

To avoid electric-shock hazard, disconnect the instrument from the power source before soldering.

The reliability and accuracy of this instrument can be maintained only if proper soldering techniques are used when repairing or replacing parts. General soldering techniques, which apply to maintenance of any precision electronic equipment, should be used when working on this instrument. Use only 60/40 rosin-core, electronic grade solder. The choice of soldering iron is determined by the repair to be made.

CAUTION

The CPU, ADC, Front Panel Driver, Front Panel and Isolation boards are multilayer type boards with a conductive path laminated between the top and bottom board layers. All soldering on these boards should be done with extreme care to prevent breaking the connections to this conductive path.

Do not allow solder or solder flux to flow under printed circuit board switches. The printed circuit board is part of the switch contacts; intermittent switch operation can occur if the contacts are contaminated.

When soldering on circuit boards or small wiring, use only a 15 watt, pencil-type soldering iron. A higher wattage soldering iron can cause the etched circuit wiring to separate from the board base material and melt the insulation from small wiring. Always keep the soldering iron tip properly tinned to ensure the best heat transfer to the solder joint. Apply only enough heat to remove the component or to make a good solder joint. To protect heat-sensitive components, hold the component lead with a pair of long-nose pliers between the component body and the solder joint. Use a solder removing wick to remove excess solder from connections or to clean circuit board pads.

Semiconductors

To remove in-line integrated circuits mounted in sockets, use an extracting tool. This tool is available from Tektronix, Inc.; order Tektronix Part No. 003-0619-00. If an extracting tool is not available, use care to avoid damaging the pins. Pull slowly and evenly on both ends of the integrated circuit. Try to avoid disengaging one end before the other end.

Exterior Cleaning

Chassis. Accumulated dust on the instrument chassis can be removed with a soft cloth or small brush. Remove dirt that remains with a soft cloth dampened in a mild detergent and water solution; then remove the detergent with a soft cloth dampened in clean water. Do not use abrasive cleaners.

Front Panel. Use only a cotton swab or soft cloth, dampened in isopropyl alcohol or water.

CAUTION

To avoid damage, use only isopropyl alcohol or water. Do not use petroleum based cleaning agents. Before using a cleaner other than isopropyl alcohol, consult your Tektronix Service Center or representative.

Interior Cleaning

Clean circuit boards only when required for operation to specified performance. Cleaning and rinsing solutions can be used on all boards except the Front Panel board. The recommended cleaning and rinse solutions, plus specific cleaning precautions for each board are listed below by board name. Observe this board-specific information and the following general board cleaning information.

General Board Cleaning

1. For boards that can be cleaned with a detergent solution, use only a 20:1 solution of distilled water and Kelite Spray White[1].

2. Cleaning after minor repairs to circuit boards can be done by using a soft plastic tool to carefully chip away flux residue. Be careful not to damage circuit board paths and components.

3. Do not immerse boards in cleaning or rinsing solutions; use spray bottles to spray on the specified solutions.

CAUTION

Rinse the area extremely well to completely remove cleaning residue.

4. After cleaning, use dry, low-velocity air (approximately 5 lb/in^2) to blow-dry the board (except the Front Panel board).

5. To finish board drying, place in an oven at 40°C to 60°C for a minimum of twenty-four hours.

CAUTION

To prevent damage and to ensure proper operation, circuit boards and components must be dry before applying power.

Board Cleaning

Front-Panel Board (A11). Do not use any type of cleaning or rinsing solutions, water, or compressed air on this board, since cleaning may leave residue and contaminants inside the switch assemblies or on the circuit board contact areas; interfering with both mechanical and electrical operation. If the front-panel switches are intermittent, then replace the switches.

Front-Panel Drive Board (A12). Use the detergent solution specified under General Board Cleaning. Rinse with isopropyl alcohol or warm distilled water.

Main Interconnect Board (A13). Use isopropyl alcohol or the specified detergent solution for cleaning. Rinse very well with warm distilled water or clean isopropyl alcohol.

[1]Allied-Kelite Products Division of the Richardson Co.; Los Angeles, CA.

CPU Board (A14). Use the specified detergent solution or isopropyl alcohol for cleaning. Rinse well with clean isopropyl alcohol or warm distilled water.

CAUTION

To prevent instrument damage and performance degradation, do not allow cleaning or rinsing solutions on the GPIB switches (S1515), or on the battery or battery circuit. Board cleaning around the battery area may be done if the battery is removed first; however, this requires new battery straps for re-installation of the battery and performance of the adjustment procedure to restore calibration constants in memory. To help protect the GPIB switches, apply wide tape to the switch sides and top.

Isolation Board (A15). Use the specified detergent solution for cleaning; rinse well with distilled water.

CAUTION

Do not allow cleaning or rinsing solutions on the transformer. Isopropyl alcohol may be used for cleaning if the transformer is first removed from the board. Rinse very well with generous amounts of clean isopropyl alcohol.

RMS Board (A16). For cleaning, use the specified detergent solution. Rinse with distilled water.

CAUTION

Isopropyl alcohol may be used for cleaning this board if the board is very well rinsed with generous amounts of clean isopropyl alcohol.

ADC Board (A17) and Relay Board (A18). For cleaning, use the specified detergent solution; rinse very well with distilled water. Isopropyl alcohol may be used for cleaning provided the circuit board is very well rinsed with generous amounts of clean isopropyl alcohol.

CAUTION

Do not allow cleaning or rinsing solutions in or on the rear input relay (K1631 on the Relay board), or the guard input switch assembly (S1731).

CPU Board Coating

Some solder connections and board surface areas of the CPU board are coated with a clear, moisture-proof material called Humiseal. These areas are indicated by a gray shading in Fig. 10-6 in the pullout pages (see lower rear area of component side of board). After any soldering on these areas, the shaded solder connections and board surfaces must be recoated to ensure operation to specified performance in a high humidity environment. Clean the worked area by carefully scraping away the damaged portions of the coating. Remove any flux residue; then reapply Humiseal to the indicated surfaces and solder connections, on both sides of the board. Humiseal may be obtained by ordering Tektronix Part No. 006-1744-00.

TROUBLESHOOTING

Introduction

Troubleshooting information for the DM 5010 includes detailed instructions using traditional techniques and signature analysis for selected digital circuit troubleshooting. For troubleshooting purposes, the circuitry in the DM 5010 is broken into circuit sections. Table 7-3 lists typical problem symptoms for these sections. Use these symptoms to help select the malfunctioning circuit; then perform the verification in the table for the selected circuit. Any discrepancy found in verification confirms that the selected section is malfunctioning. If the instrument symptoms suggest malfunctions in several circuit sections, do the verification for the lower numbered section first. Then follow the detailed troubleshooting procedures listed by the circuit section and number following the table. Although the troubleshooting information cannot address every possible fault, it may help isolate the problem area. A review of the Theory of Operation section in this manual should also prove helpful. Refer to board illustrations adjacent to the diagrams in the pullout pages for component and test point locations.

If an error code is either displayed on the instrument front panel or returned to the controller in response to an ERR? query, refer to the error code definitions in the Programming section of this manual. The only error codes that indicate instrument malfunction are those classified as Internal Errors in the error code list. The displayed error code 521 indicates that the Signature Analysis switch is enabled. If CAL is displayed, the internal CAL jumper is set for instrument adjustment. Enabling the signature analysis or adjustment mode affects normal instrument operation.

For access to troubleshooting points on the four rear boards, use the DM 5010 extender boards listed under Troubleshooting Aids in this section of this manual. Also listed are flexible extender cables for operating the DM 5010 outside of the power module.

Signature Analysis

Signature analysis information for troubleshooting some DM 5010 digital circuitry is provided in the pulout pages in the back of this manual. It is probable that, over a period of time, product modifications and updates will become available, or necessary, or both. Due to the impact they have on instrument diagnostics and firmware, some modifications and updates must be installed in a serial manner; that is, all earlier modifications and updates may be a prerequisite to installation of the most recent one requested or suggested.

To determine the applicable signature version for your instrument, compare the board assembly (670-) and firmware (160-) numbers in the DM 5010 Signature Versions Table (in the back of this section) with those on the instrument boards. Use the signature analysis information in the pullout pages for the signature version indicated in the table for your instrument board and firmware configuration.

Signature Table 10A provides signature analysis information for checking the microprocessor, ROM, and address decoding on the CPU board. The DM 5010 setup information for these checks requires positioning the NOP jumper to disable bidirectional buffer U1435 and the buffered data bus. It also enables the NOP buffer, which sends NOP (no operation) instruction code to the microprocessor. This code causes the microprocessor to sequentially address each memory space in ROM. Signature analysis verifies that the data read from ROM is correct, thus ensuring that the microprocessor, data bus, and ROM are operational. After checking signatures, reset the NOP jumper to the normal operating position. The instrument must be powered down and then back up to reset the microprocessor to normal operation.

Signature Table 10B checks the range shift registers. These tests require setting the DM 5010 Signature Analysis switch to the SA mode. This causes the microprocessor to read and perform a special signature analysis routine. This routine uses a repeatable pattern to set the registers to known states.

WARNING

Dangerous voltages may be encountered in the following troubleshooting procedures. Caution must be exercised. Do not contact the output connectors of the voltage source, or the input connectors or internal circuitry of the DM 5010.

Table 7-3
TYPICAL TROUBLE SYMPTOMS

Typical Symptoms	Circuit Section—Verification
Extinguished or unchanging display.	CPU Board, Diagram 7
	1a. POWER SUPPLIES—Check for +5 V dc on P1731-1A or 1B and 2A or 2B (gnd).
	1b. CLOCK—Check for 1 MHz squarewave between TP1535 (CK) and TP1531 (gnd).
	1c. PON CIRCUIT—Check for TTL logic 1 at U1320-40 (PON).
Unchanging or flickering display, or internal error code.	CPU Board, Diagrams 7, 8
	2. MICROPROCESSOR—Place NOP jumper P1425 in the enable position. Check for a squarewave on the buffered address lines at U1235 and U1420A; each line should be one-half the frequency of the previous line, going from BA0 to BA11. Check the outputs of U1620 and U1520. Check that the ROM Enables (pin 18 of U1200, U1300, U1305, and U1400) are not locked high or low. With power off, reposition the NOP jumper to connect J1425, pins 1 and 2. Apply power and check that the data lines on both sides of U1435 are not locked high or low. Check that IRQ at U1320-4 is not locked low. Check that VMA and R/W (U1320-5 and 34) are toggling.

Table 7-3 (cont)

Typical Symptoms	Circuit Section—Verification
Dead, unchanging, or flickering display, or no response to pushbuttons.	CPU Board, Diagram 9 3. FRONT PANEL—Check that U1605-1 (RW3) is a logic 1. With the DIODE TEST button held in, check the same point for a 0.6 ms logic 0 pulse at ≈5 ms intervals.
Error code 311	Isolation Board, Diagram 4 4. ISOLATED SUPPLIES—Using an isolated ground reference, check the following supply voltages: P1701-7A +35.1 V dc, ±11% P1701-13B +36.9 V dc, ±11% P1701-13A −36.9 V dc, ±11% P1701-14A −17.6 V dc, ±11% P1701-14B +17.6 V dc, ±11% P1701-15B −17.6 V dc, ±11% P1701-15A −27 V dc, ±2%
No response to REAR INPUT button, wrong reading, hunts for range, displayed measurement drifts.	Isolation Board, Diagram 5 ADC Board, Diagram 2 RMS Board, Diagram 3 5. FUNCTION & RANGE REGISTERS—Repeatedly press the REAR INPUT button and check that the relay clicks with each button press.
Error code 311, wrong reading, hunts for range.	Isolation Board, Diagrams 4 and 5 ADC Board, Diagram 1 6. A/D CONVERTER—Connect U1120-3 on the ADC Board to analog ground. Display reads ≈zero in all DCV ranges.
One or more DCV readings is out of specification or 311 error code.	Dc Voltage Measuring Circuits, Diagram 1 7. Apply 0 V dc and 95% of the full scale dc voltage at the DM 5010 inputs for each DCV range. All readings are within specification.
One or more ACV or ACV+DCV readings is out of specification.	RMS Board, Diagram 3 8. RMS CONVERTER—For both ACV and ACV+DCV, apply a 200 Hz, 5% and 95% of full scale input at the DM 5010 inputs, for the 200 mV through 200 V ranges. Apply a 200 Hz, 14% and 95% of full scale input for the 700 V range. All readings are within specification.
One or more OHMS readings is out of specification.	RMS Board, Diagram 3 9. OHMS CONVERTER—Apply 0 Ω and 95% of the full scale input resistance, at the DM 5010 inputs, for each OHMS range. All readings are within specification.

Table 7-3 (cont)

Typical Symptoms	Circuit Section—Verification
Hangs up bus, or will not communicate over bus with controller.	10. GPIB—Connect a 4051 or 4052 to the DM 5010 power module. Turn all power on. If the message: NO SRQ ON UNIT-MESAGE NUMBER 43 is received, type: POLL X,Y;16 where 16 is the instrument address. Short the DM 5010 inputs. Type the following: PRI @16: "DCV 2" INP @16: A$ PRI A$ The last line on the controller display should be: 0.; or 0.0001; or −0.0001;. The instrument does not have to be within specification to verify bus operation.

Before beginning troubleshooting on the selected circuit section, visually inspect the circuit board for broken, damaged, or loose components, damaged or shorted circuit paths, etc.

1. POWER SUPPLY, CLOCK, PON CIRCUITS

a. POWER SUPPLY, Isolation Board, Diagram 4

If verification indicated a +5 V malfunction, remove the Isolation board from the DM 5010, but leave the board connected to the flexible extender cable. Check for +5 V at J1733-1A or 1B. If +5 V is present, then a load on either the Main Interconnect board or CPU board is pulling down the +5 V supply.

Check the 3 A fuse on the Isolation board.

Check for +5 V at U1000-2. If not present, check Q1105, Q1104, and PWR (P1031-6B) from the power module.

Check that VR1216 is not shorted.

Check U1000 and Q1101.

Reinstall the Isolation board.

b. CLOCK, CPU Board, Diagram 7

Check U1320-37 for a 1 MHz squarewave.

Check U1320-38 and 39 for a 4 MHz squarewave.

c. PON, CPU Board, Diagram 7

Check VR1232.

Check U1230 (all pins).

2. MICROPROCESSOR, CPU Board, Diagram 7

To troubleshoot this circuit, do the following steps or use a signature analyzer to check the signatures in Table 10A in the pullout pages.

a. On U1320, check that the address and data lines are toggling; $\overline{\text{IRQ}}$, RESET, NMI, and HALT are not stuck low; check for clock pulses on pins 37, 38, 39. Check power and ground to U1320.

b. Check power, ground, data, and address lines in the circuit area including U1235, U1420, U1510, U1520, U1620, U1720, U1730, U1435, U1430, U1425, U1200, U1300, U1305, U1400, U1600, U1505, U1220.

3. FRONT-PANEL, Front-Panel Drive board, Diagram 11

a. If all indicators and push buttons are inoperable, check J1820-12 for +5 V and J1820-20 for +8 V.

b. If one or more LEDs do not illuminate, check the associated anode driver and the circuit path from the anode driver to the front panel.

c. If the same segment in all LEDs stays off or on, check the associated cathode drivers and circuit paths.

d. If only one LED or segment is always off, check that LED and its circuit paths.

e. If one of the push buttons is inoperable, check the push button switch and its circuit board paths.

f. If several push buttons are inoperable, check the column drivers and row lines and their paths between the Front-Panel Drive and Front-Panel boards.

4. ISOLATED SUPPLIES, Isolation Board, Diagram 4

If any of these supplies are working, the problem with a malfunctioning supply is located in the isolated section. When troubleshooting a supply on the Isolation board, use an extender board only for the bottom Isolation board connector to the Main Interconnect board; leave the top connector unconnected.

a. Check the following no load supply voltages on the Isolation board:

Table 7-4
NO LOAD POWER SUPPLY VOLTAGES

+ lead	− lead	Voltage Limits (V dc)
P1701-15B	P1701-15A	+9.2 V to +11.6 V
-14B	-4A or 4B	+16.6 V to +20.8 V
-14A	-4A or 4B	−20.8 V to −16.6 V
-13B	-4A or 4B	+33.3 V to +41.7 V
-13A	-4A or 4B	−41.7 V to −33.3 V
-7A	-7B	+33.3 V to +41.7 V

If any of these voltages are outside the limits, check the associated rectifiers and filter capacitors.

b. Check for a 50 V peak-to-peak squarewave (18 μs up and 18 μs down) between the collectors (cases) of Q1201 or Q1202 and ground (TP1421). If the squarewave is not present, check the 1/2 A fuse.

c. Check for a 1 MHz TTL squarewave at J1733-11B (Bϕ2 on diagram 6). If not present, check the circuit back to U1230 on the CPU board.

d. Check for a 27.78 kHz TTL squarewave at U1325B-8 and 9 (on diagram 4). If present, check the transistors and associated components of the transformer drive circuit.

e. Check for a 250 kHz squarewave at U1535B-8 and 9 (diagram 6). If not present, check U1535.

f. Check for a 4 μs pulse every 72 μs at U1730-15. If not present, check the ÷18 circuit (U1635B, U1730, U1635C, U1530B, U1320B).

NOTE

A blown fuse may indicate an overload in another circuit. To troubleshoot an overload condition, it may be helpful to temporarily replace the fuse with a 75 to 200 Ω, 3 W resistor. After troubleshooting, be sure to reinstall the fuse.

5. FUNCTION & RANGE REGISTER

To troubleshoot this circuit, do the following steps or use a signature analyzer to check the signatures in Table 10B in the pullout pages. For the following steps, use an oscilloscope; connect the external trigger (− slope) to U1520-7 on the CPU board, diagram 7. Set the DM 5010 to the fast conversion rate. Set the oscilloscope to 5 V/cm and 2 ms/cm.

a. Check RC at J1731-10B. Look for a closely grouped set of 32 pulses; then check for a second group of 32 pulses, not as closely or as evenly spaced as the first group. Note the position of the last pulse. Then check RD at J1731-9B. It should have a fixed bit pattern only during the second pulse group checked previously. Change the DM 5010 range or function and check that the bit pattern changes. The RD line also has a short pulse just following the last RC pulse.. Also check RC and RD on the Main Interconnect board (diagram 10) and at the opto-isolators, U1515-3 and U1610-3 (diagram 5). Change the oscilloscope ground reference to PGND (P1701-4A or 4B, diagram 5), and position the trace near the top of the crt display. Check IRC and IRD at U1515-6 and U1610-6, and on diagram 10 at J1701-11A and 11B.

Next, check the STROBE signal on the ADC and RMS boards at shift registers U1500-1, diagram 2, and U1330-1, diagram 3, respectively. The strobe should appear only during the short pulse at the end of the RD pulse train. Check the input and output (pins 2 and 9) of each register.

If the shift registers are working and a range problem still exists, check the latches and the switches they drive for the malfunction. Refer to Figs. 10-2 and 10-5 in the pullout pages.

6. A/D CONVERTER, Isolation Board, Diagram 5

First determine whether the problem is in the isolated or grounded parts of the A/D Converter. To do this, place the Isolation board on one extender, leaving the top board connector unconnected. Jumper U1710-3 (U/$\overline{\text{D}}$) to U1510-6 (COMP) on the Isolation board. Check the display with U/$\overline{\text{D}}$ jumpered to COMP, an overrange negative voltage indicates the fault is in the isolated circuit; a displayed error code 311 suggests the fault is in the grounded circuit. Remove the jumper between U/$\overline{\text{D}}$ and COMP, and check the indicated circuit.

a. Isolated A/D Circuit: If the problem is in the isolated section, refer to the sections in the DC Voltage Measuring Circuit Troubleshooting section dealing with 311 errors and the Charge-Balancing Converter.

b. Grounded A/D Circuit: Check the path of the TRIG pulse through the control ICs at the following points:

U1530A-6 (In Progress)
U1435C-8
U1425A-5 (M/Z)
U1435A-3
U1330A-5 (Override)
U1230A-5
U1420C-8
U1425B-8

Check U1330B-8 (U/$\overline{\text{D}}$) and U1335B-10 (COMP). COMP should follow U/$\overline{\text{D}}$.

On diagram 6, check U1635A-12 (EOC) and U1520A-3 (EOAZ). Check Q1 through Q12 of U1525 for a squarewave signal; each signal should be one-half the frequency of the preceding signal.

To check the data generation, trigger the oscilloscope on TP1625, Stop, on diagram 7; then check that U1235-15 and U1320A-6 count out the 17 Advance pulses (diagram 6). Check U1030B-6 (DATA) for a serial representation of the 17 bit input to U1125 and U1030C-8. Check U1125-10 for a parallel representation of the counters inputs from U1020, U1120, U1220, and U1130. Trigger the oscilloscope on U1425A-5, M/$\overline{\text{Z}}$, diagram 5; then check that the UP and DOWN pulses beginning at U1020-5 and 4 propagate through the counter ICs and that their outputs toggle appropriately. Check that the counter is reset to 0 by the $\overline{\text{RS}}$ pulse, U1020-11.

7. DC VOLTAGE MEASURING CIRCUITS, ADC Board, Diagrams 1, 2

a. To check the supply voltages to this circuit, place the ADC board on an extender board and measure the voltages listed in Table 7-5.

Table 7-5
POWER SUPPLY AND REFERENCE VOLTAGES

Measurement Location	Diagram	Voltage Limits
U1230-16	1	+11.4 V to +12.6 V
U1230-6		−12.6 V to −11.4 V
VR1321-C		+6.28 V to +6.42 V
VR1223-C		+21.5 V to +22.5 V
VR1225-A		−22.5 V to −21.5 V
VR1001-C		+32.5 V to +41.7 V
VR1013-A		−41.7 V to −32.5 V
U1400-14	2	typically −22 V
U1400-7		−27.5 V to −26.5 V
VR1501-C		+4.8 V to +5.4 V

If the voltages are correct, continue troubleshooting at part 7b.

If these voltages are incorrect, remove the RMS board from the plug-in and remove the ADC board from the extender board. Measure the voltages in Table 7-6, on tne extender board connector. The measurement locations are the Main Interconnect board connector pin numbers.

Table 7-6
NO LOAD POWER SUPPLY VOLTAGES

Measurement Location (+ lead)	Measurement Location (− lead)	Voltage Limits
15B	15A	+9.2 V to +11.6 V
14B	6B	+16.6 V to +20.8 V
14A	6B	−20.8 V to −16.6 V
13B	6B	+33.3 V to +41.7 V
13A	6B	−41.7 V to −33.3 V

If these voltages are incorrect, refer to the Isolated Supplies troubleshooting information. If they are correct, check the regulation circuit U1601, U1603, U1605, VR1514, CR1611, R1611, and Q1613 on diagram 2 for the proper voltages.

Next, perform one of the troubleshooting parts, based on these symptoms: part b if the display indicates a 311 error code; part c if the displayed measurement is out of specification for the applied dc input voltage.

b. Set the DM 5010 to the power-on settings and check the waveforms in Fig. 7-7 at the locations given. If the waveforms are incorrect, check the components or troubleshooting procedure listed in Table 7-7 for the indicated system.

Table 7-7
ERROR CODE 311 FAULTS

Symptoms	Component
One or more power supplies is incorrect	See part a
I M/Z high, I U/D low	U1615 on diagram 5, A/D Converter troubleshooting procedure
I M/Z low I U/D high	U1230, C1139 on diagram 1 Q1514, C1514, R1514 on diagram 2

c. Check the FET gate waveforms shown in Fig. 7-8 for the indicated FETs with 0 V applied to the DM 5010 input. Set the DM 5010 settings to the power-on states.

If one or more gate waveforms are incorrect, the problem is associated with the FET, the DCV Signal Conditioner bootstrap buffer, or the FET gate drive circuits.

To check the bootstrap buffer, measure the voltage at the juction of the emitters of Q1017 and Q1021 (diagram 1). This voltage should be no more than a few millivolts. If not, troubleshoot the DCV Signal Conditioner, using the procedure provided below.

If the bootstrap buffer is operating correctly, trace the gate signal back through its driver and to the Function and Range Register or the Measurement Enable circuit. Refer to the Function and Range Register, if the problem is in that circuit. Tables 10-2 and 10-5 in the pullout pages show the register output states. If the problem is in the Measurement Enable circuit (no I M/$\overline{Z}$ at U1400-1, diagram 2), check Q1511, Q1512, and CR1511.

The remainder of this procedure provides troubleshooting information for each of the functional blocks in the isolated section.

Input Switch

Measure the voltage between the input end of R1637 and the isolated grounds (diagram 1).

If the voltage is not equal to the front panel input, check C1723, L1723, K1631, and the solder connections between K1631 and the ADC board.

If the voltage is not equal to the rear interface input, check K1631 and the solder connections between the relay and the ADC board.

If K1631 does not operate, check its drive circuit and the Function and Range Register (U1300-12) output (diagram 2).

Attenuator

Measure the voltage between the junction of R1521 and R1427, and the isolated ground (diagram 1). The junction will be loaded slightly by the test equipment used. Check the components listed in Table 7-8 for the symptoms indicated for the measured voltage. The Function and Range Register states are given in Tables 10-2 and 10-5 in the pullout pages.

Overvoltage Protection and Function Switching

Retain the measurement connections from the previous check, with the DM 5010 set to its power-on state. If the measured voltage is approximately −22 V or +22 V, check Q1327 or Q1323 (diagram 1).

Connect an oscilloscope between the input end of R1222 and the isolated ground. Use the I M/Z (U1230-3) trailing edge as the external trigger; set the oscilloscope for 50 mV/cm and 50 ms/cm. Apply 100 mV to the DM 5010 input. If the displayed waveform is not the same as the waveform in Fig. 7-9, check Q1319 and Q1317.

DCV Signal Conditioner

Connect the oscilloscope between the input end of R1121 and the isolated ground (diagram 1). Use the trailing edge of I M/Z (U1230-3) as the external trigger. Set the oscilloscope for 1 V/cm and 50 ms/cm. Set the DM 5010 to its power-on state. Apply 100 mV, 1 V, and 10 V to the DM 5010 input. For each input, check that the displayed

Table 7-8
ATTENUATOR FAULTS

Symptom	Diagram	Components
Voltage ≠ applied input (any range)	1	R1637
Voltage ≠ applied input in 200 mV through 20 V ranges. Checks good in 200 and 1000 V ranges	1,2	R1521, K1527, and its drive circuit, Function and Range Register (U1500-12) output
Voltage ≠ applied input in 200 or 1000 V ranges. Checks good in 200 mV-20 V ranges	1,2	R1429, K1525, and K1425, and their drive circuits. Function and Range Register (U1500-5, 7) outputs
Voltage ⩾ one-half the applied input in 200 mV through 20 V ranges	1,2	K1425 and its drive circuit, Function and Range Register (U1500-7) output
Voltage > applied input in 200 and 1000 V ranges	1,2	K1527 and its drive circuit, Function and Range Register, (U1500-12) output

waveform matches that shown in Fig. 7-10. If it does not, check U1210, R1101, R1102, Q1105, Q1106, Q1112, Q1114 (diagram 1), and their gate drive circuits (diagram 2); also check the output of the Function and Range Register (U1300-5, 4, 7, 6, on diagram 2). See Tables 10-2 and 10-5 in the pullout pages.

Connect the oscilloscope between U1110-2 and the isolated ground. Set the oscilloscope to 100 mV/cm and apply 100 mV to the DM 5010 input. Check that displayed waveform matches that shown in Fig. 7-10. If it does not, check the components listed in Table 7-9 for the indicated symptoms.

Table 7-9
DCV SIGNAL CONDITIONER FAULTS

Symptom	Components ⟨1⟩
U1110-2 at the + or − rail	U1110, U1210, Q1101, Q1111, Q1017, and Q1021
U1110-2 oscillating	C1017, C1019
DM 5010 display is correct but varies at least ±3 least significant digits	U1210

Charge-Balancing Converter

Connect the oscilloscope between the input end of R1229 and the isolated ground. Set the oscilloscope to 1 V/cm and 50 ms/cm and apply 100 mV to the DM 5010 input.

If the displayed waveform does not match that in Fig. 7-10, check R1121, CR1123, CR1125, VR1124, VR1126, and U1120.

Compare the DM 5010 display to the symptoms listed in Table 7-10 and check the indicated components on diagram 1.

Table 7-10
CHARGE-BALANCING CONVERTER FAULTS

Symptom	Components
Display indicates 311 error code when a 500 V or greater transient is applied to the DM 5010 input	CR1123, CR1125, VR1124, and VR1126
Display indicates 311 error code when the DM 5010 is in a fixed range and the applied input is more negative than the negative full scale value	CR1129, VR1129

8. RMS CONVERTER, RMS Board, Diagram 3

a. To check the first stage of the converter, apply a signal that reflects the problem to the DM 5010 input connectors. Be sure the DM 5010 is set to the ACV or ACV+DCV mode, and to the appropriate range (or autorange). Connect a digital multimeter to TP1701 (low) and TP1503 (high). Check that the nominal ac voltage measured is as listed below for the DM 5010 range:

DM 5010 Range	Nominal Ac Voltage
200 mV or 2 V	same as applied input
20 V	0.1 times the applied input
200 or 700 V	0.001 times applied input

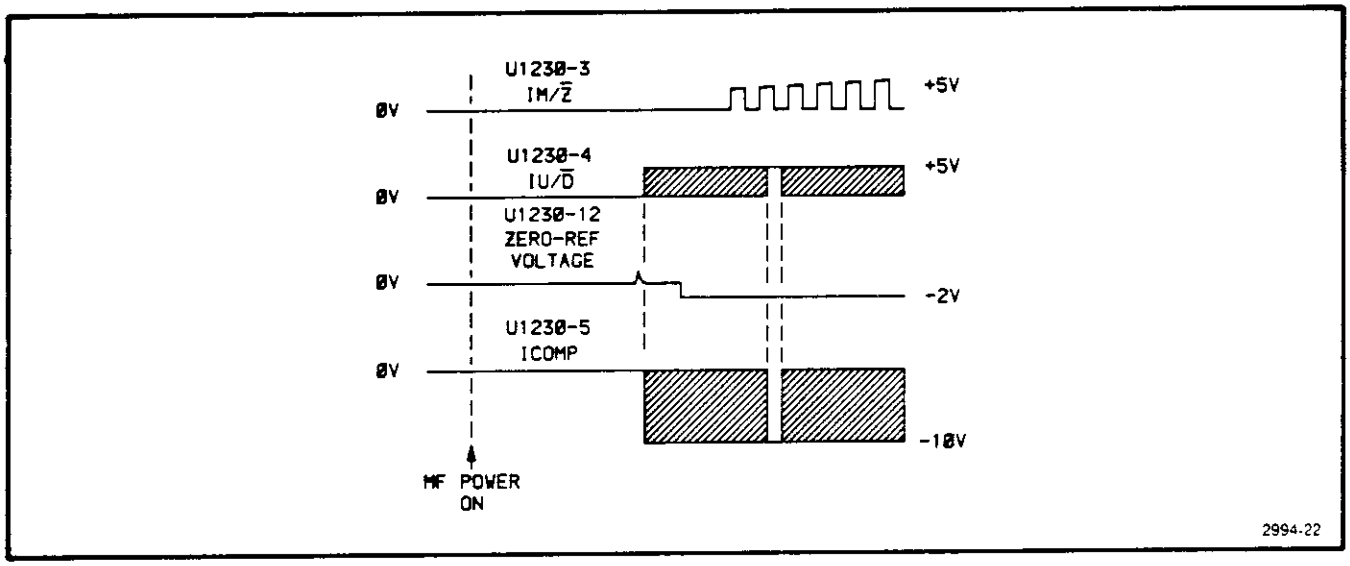


Fig. 7-7. I M/Z, I U/D, ICOMP and the zero-reference voltage waveforms after power on.

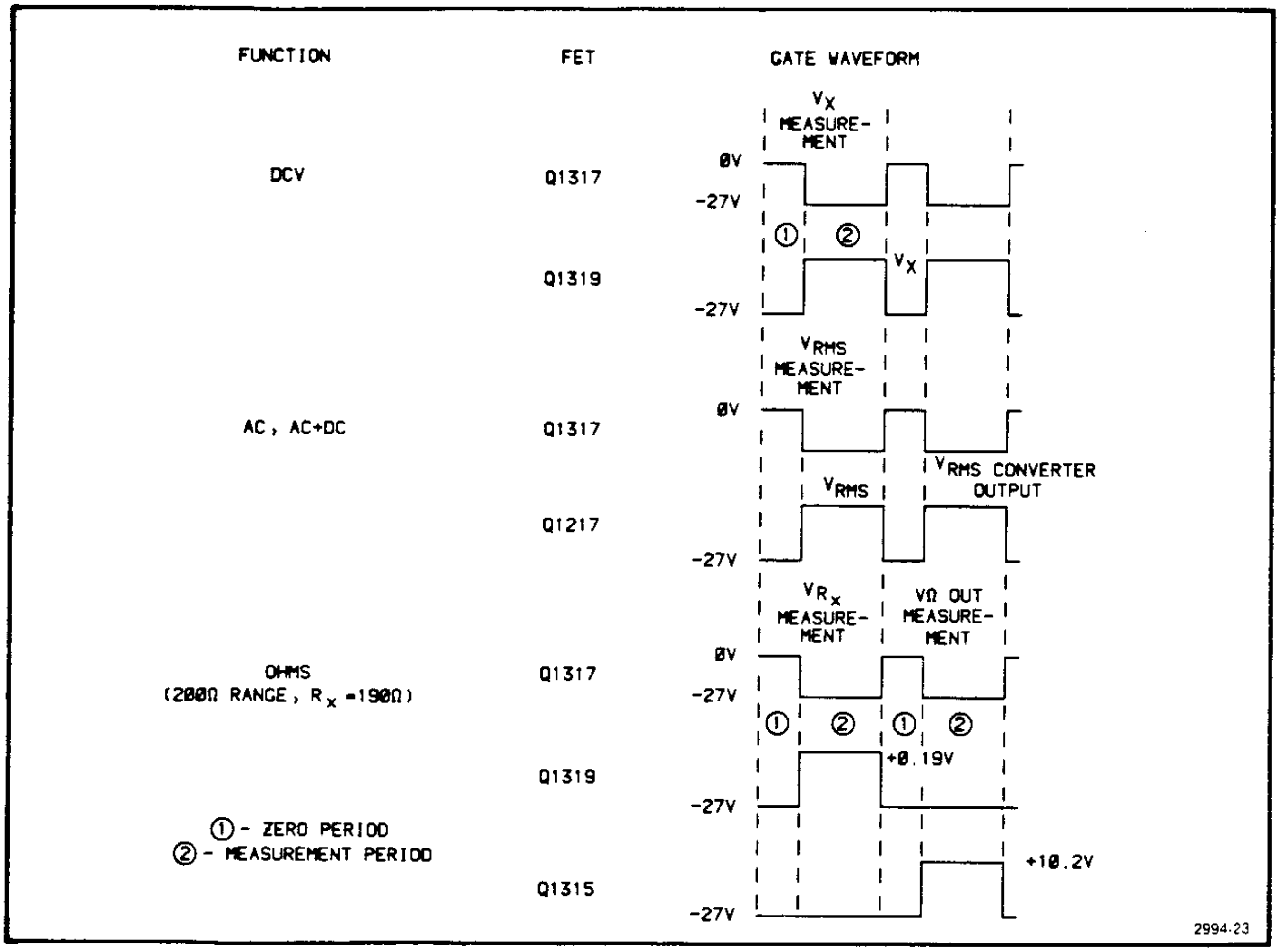


Fig. 7-8. FET Gate timing diagram.

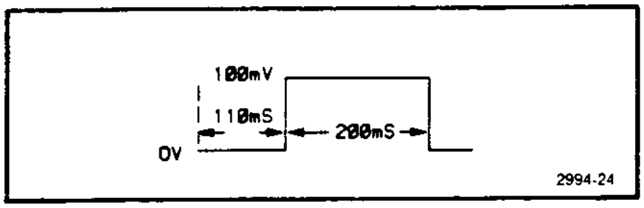


Fig. 7-9. Over-voltage protection and function switching waveform.

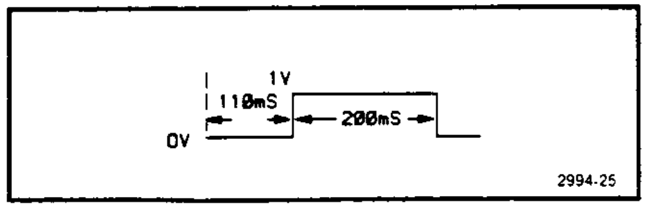


Fig. 7-10. DCV Signal Conditioner and Charge-Balancing Converter waveform.

If the measured voltage is correct, troubleshoot the next stage, according to part 7b. If incorrect, check the components listed in Table 7-11 for the indicated symptoms.

Table 7-11
RMS CONVERTER FAULTS

Symptom	Component
Error occurs in ACV mode but not in ACV+DCV mode	C1621
Error occurs in ACV+DCV mode with a dc or low frequency ac input	K1621, R1621
Error occurs in all ranges	R1603, R1501, K1621, U1500, C1605, C1607, C1609, C1503, C1505, + and −12 V supplies
Error occurs in 200 mV, 2 V ranges	R1501, C1505, C1503
Error occurs in 20 V range	R1403, R1401, C1403, C1504
Error occurs in 200, 700 V ranges	R1309, C1311

b. To check the second stage of the RMS Converter, move the digital multimeter high lead to TP1201 (low lead remains at TP1701). Set the applied input voltage to a full scale value for the DM 5010 range being checked. Check that the nominal ac voltage measured is as listed below for the DM 5010 range.

DM 5010 Range	Nominal Ac Voltage
200 mV—200 V	2 V
700 V	0.7 V

If no error is found, check the final stage of the converter in part 7c. If an error is detected, check the components listed in Table 7-12 for the DM 5010 symptoms.

Table 7-12
RMS CONVERTER FAULTS

Symptom	Component
Error occurs in all ranges	R1307, R1201, U1200, + and −12 V supplies
Error occurs in 200 mV, 200 V ranges	R1201
Error occurs in 2 V, 20 V, 700 V ranges	R1211, K1201

c. To check the final converter stage, move the digital multimeter high lead to U1100-8 (low lead remains at TP1701). Check that the measured dc voltage is equal to the rms value of the applied input, scaled to a maximum of 2 V for a full scale input. If an error is detected, check U1100, C1101, C1103, C1001, and R1101. If no error is found, check Q1217 on the ADC board (diagram 1). If Q1217 is good, make sure the A/D Converter is functioning properly by measuring a dc input in the DCV mode. If not, refer to the A/D Converter and Dc Voltage Measuring Circuits troubleshooting information.

9. OHMS CONVERTER, RMS Board, Diagram 3

To troubleshoot the Ohms Converter, place the RMS board on an extender board and set the DM 5010 to the OHMS mode, with the range (in STEP mode) and input condition as listed in Table 7-13. Measure the voltage between the component listed in the table and ohms ground. If the voltage is outside the limits listed, check the designated component.

If the output of U1417-2 is correct, disconnect the RMS board from the extender board and remove the ADC board. On the extender board, measure the voltage between pins 7B and 8B. If the voltage is not between 33.3 and 41.7 V, refer to the Isolated Supplies troubleshooting information. Continue with the measurements in the table.

After making the voltage measurements in Table 7-13, check the components listed below for the indicated symptoms.

Table 7-13
POWER SUPPLY AND REFERENCE VOLTAGES

Conditions	Measurement Location	Limits	Components
200 Ω range, 0 Ω input	U1417-2	22.8 to 25.2	See text
	U1120-4	−2.3 to −3.1	VR1415
	VR1123-C	8.82 to 9.18	R1221, VR1123, C1111
	U1120-3	0.638 to 0.671	R1123, R1121, CR1021, CR1121, U1120
	P1711-8A	9.50 to 10.76	U1120, CR1227, RT1227, CR1225, R1229, R1321, R1225, R1223, K1313 and its drive circuit, U1330-11
	VR1013-C	1.8 to 2.6	R1013, VR1013
200 Ω range, open input	P1711-4A or 4B	3.5 to 4.7	Q1021, CR1011,RT1011, R1331, K1131 and K1231 and their drive circuits, U1300-12, and 14
2 kΩ range, 0 Ω input	P1711-8A	1.12 to 1.27	K1313 and its drive circuit, U1330-11
20 kΩ range, 0 Ω input	P1711-8A	9.50 to 10.76	U1330-11
200 kΩ range, 0 Ω input	P1711-8A	1.12 to 1.27	U1330-11
2 MΩ range, 0 Ω input	P1711-8A	1.12 to 1.27	U1330-11
20 MΩ range, 0 Ω input	P1711-8A	1.12 to 1.27	U1330-11

Table 7-14
OHMS CONVERTER FAULTS

Symptom	Component
Display is incorrect in all ranges	Q1315 and its drive circuits (diagram 1) and the output of the Function and Range Register, U1400-11, U1500-6 (diagram 2). For each OHMS range, check the output of the Function and Range Register U1330-11, 12, 13, and 14 (diagram 3).
Display indicates 191.90 Ω with a 190.00 Ω input	K1031 and its drive circuit, and the output of the Function and Range Register U1330-13 (diagram 13)

Nonlinearity in the 20 MΩ range is caused by a lowering of the insulation resistance between High and Low, High and Ω Out, and Low, and chassis ground. Check the components between these signal lines to find the fault.

Signal	ADC Board 1	RMS Board 3
High	P1713-4A	P1711-4A
Low	P1713-2A	P1711-2A
Ω Out	P1713-8B	P1711-8A

10. GPIB, CPU Board, Diagram 9

GPIB circuit faults may appear in four places:

GPIB IC U1105
Data buffer U1100
Control buffer U1110
Circuit board

Visually inspect the circuit board paths and solder connections in the GPIB circuit for damage and poor connections. Place the CPU board on an extender board plugged into the DM 5010 and apply power via a flexible extender cable to the power module.

a. Check that the data on both sides of data buffer U1100 are the same.

b. Check that the control lines are the same on both sides of control buffer U1110. Check that the lines are in a valid state.

c. To check U1100, remove U1105, using proper static handling procedures; then force U1100-1 (TE) high or low. Force the data buffer inputs (U1100-12 to 19) high and low, checking its outputs (pins 2 to 9). A similar procedure can be used on U1110.

d. If U1100 and U1110 are not faulty, change U1105.

Table 7-15 Signature Versions

Assembly ROM	1.0	
A14, CPU	670-6815-00	
U1200	160-1329-00	
U1300	160-1328-00	
U1305	160-1327-00	
U1400	160-1326-00	
A15, Isolation	670-6814-00	
A16, RMS	670-6816-00	
A17, ADC	670-6817-00	

OPTIONS

No options are available.

REPLACEABLE ELECTRICAL PARTS

PARTS ORDERING INFORMATION

Replacement parts are available from or through your local Tektronix, Inc. Field Office or representative.

Changes to Tektronix instruments are sometimes made to accommodate improved components as they become available, and to give you the benefit of the latest circuit improvements developed in our engineering department. It is therefore important, when ordering parts, to include the following information in your order: Part number, instrument type or number, serial number, and modification number if applicable.

If a part you have ordered has been replaced with a new or improved part, your local Tektronix, Inc. Field Office or representative will contact you concerning any change in part number.

Change information, if any, is located at the rear of this manual.

LIST OF ASSEMBLIES

A list of assemblies can be found at the beginning of the Electrical Parts List. The assemblies are listed in numerical order. When the complete component number of a part is known, this list will identify the assembly in which the part is located.

CROSS INDEX-MFR. CODE NUMBER TO MANUFACTURER

The Mfr. Code Number to Manufacturer index for the Electrical Parts List is located immediately after this page. The Cross Index provides codes, names and addresses of manufacturers of components listed in the Electrical Parts List.

ABBREVIATIONS

Abbreviations conform to American National Standard Y1.1.

COMPONENT NUMBER (column one of the Electrical Parts List)

A numbering method has been used to identify assemblies, subassemblies and parts. Examples of this numbering method and typical expansions are illustrated by the following:

Example a.

component number

A23R1234 — A23 R1234

Assembly number — Circuit number

Read: Resistor 1234 of Assembly 23

Example b.

component number

A23A2R1234 — A23 A2 R1234

Assembly number — Subassembly number — Circuit number

Read: Resistor 1234 of Subassembly 2 of Assembly 23

Only the circuit number will appear on the diagrams and circuit board illustrations. Each diagram and circuit board illustration is clearly marked with the assembly number. Assembly numbers are also marked on the mechanical exploded views located in the Mechanical Parts List. The component number is obtained by adding the assembly number prefix to the circuit number.

The Electrical Parts List is divided and arranged by assemblies in numerical sequence (e.g., assembly A1 with its subassemblies and parts, precedes assembly A2 with its subassemblies and parts).

Chassis-mounted parts have no assembly number prefix and are located at the end of the Electrical Parts List.

TEKTRONIX PART NO. (column two of the Electrical Parts List)

Indicates part number to be used when ordering replacement part from Tektronix.

SERIAL/MODEL NO. (columns three and four of the Electrical Parts List)

Column three (3) indicates the serial number at which the part was first used. Column four (4) indicates the serial number at which the part was removed. No serial number entered indicates part is good for all serial numbers.

NAME & DESCRIPTION (column five of the Electrical Parts List)

In the Parts List, an Item Name is separated from the description by a colon (:). Because of space limitations, an Item Name may sometimes appear as incomplete. For further Item Name identification, the U.S. Federal Cataloging Handbook H6-1 can be utilized where possible.

MFR. CODE (column six of the Electrical Parts List)

Indicates the code number of the actual manufacturer of the part. (Code to name and address cross reference can be found immediately after this page.)

MFR. PART NUMBER (column seven of the Electrical Parts List)

Indicates actual manufacturers part number.

CROSS INDEX - MFR. CODE NUMBER TO MANUFACTURER

Mfr. Code	Manufacturer	Address	City, State, Zip Code
00779	AMP INC	P O BOX 3608	HARRISBURG PA 17105
00853	SANGAMO WESTON INC SANGAMO CAPACITOR DIV	SANGAMO RD P O BOX 128	PICKENS SC 29671
01002	GENERAL ELECTRIC CO CAPACITOR PRODUCTS DEPT	JOHN ST	HUDSON FALLS NY 12839
01121	ALLEN-BRADLEY CO	1201 SOUTH 2ND ST	MILWAUKEE WI 53204
01295	TEXAS INSTRUMENTS INC SEMICONDUCTOR GROUP	13500 N CENTRAL EXPRESSWAY P O BOX 225012 M/S 49	DALLAS TX 75265
01963	CHERRY ELECTRICAL PRODUCTS CORP	3600 SUNSET AVE	WAUKEGAN IL 60085
02735	RCA CORP SOLID STATE DIVISION	ROUTE 202	SOMERVILLE NJ 08876
03508	GENERAL ELECTRIC CO SEMI-CONDUCTOR PRODUCTS DEPT	W GENESEE ST	AUBURN NY 13021
03888	KDI PYROFILM CORP	60 S JEFFERSON RD	WHIPPANY NJ 07981
04222	AVX CERAMICS DIV OF AVX CORP	19TH AVE SOUTH P O BOX 867	MYRTLE BEACH SC 29577
04713	MOTOROLA INC SEMICONDUCTOR GROUP	5005 E MCDOWELL RD	PHOENIX AZ 85008
05397	UNION CARBIDE CORP MATERIALS SYSTEMS DIV	11901 MADISON AVE	CLEVELAND OH 44101
05574	VIKING CONNECTORS INC	21001 NORDHOFF ST	CHATSWORTH CA 91311
05828	GENERAL INSTRUMENT CORP GOVERNMENT SYSTEMS DIV	600 W JOHN ST	HICKSVILLE NY 11802
07263	FAIRCHILD CAMERA AND INSTRUMENT CORP SEMICONDUCTOR DIV	464 ELLIS ST	MOUNTAIN VIEW CA 94042
07716	TRW INC TRW ELECTRONICS COMPONENTS TRW IRC FIXED RESISTORS/BURLINGTON	2850 MT PLEASANT AVE	BURLINGTON IA 52601
12969	UNITRODE CORP	580 PLEASANT ST	WATERTOWN MA 02172
14433	ITT SEMICONDUCTORS DIV		WEST PALM BEACH FL
14552	MICRO/SEMICONDUCTOR CORP	2830 S FAIRVIEW ST	SANTA ANA CA 92704
14752	ELECTRO CUBE INC	1710 S DEL MAR AVE	SAN GABRIEL CA 91776
15636	ELEC-TROL INC	26477 N GOLDEN VALLEY RD	SAUGUS CA 91350
17856	SILICONIX INC	2201 LAURELWOOD RD	SANTA CLARA CA 95054
18324	SIGNETICS CORP	811 E ARQUES	SUNNYVALE CA 94086
19209	GENERAL ELECTRIC CO BATTERY BUSINESS DEPT	441 HWY N P O BOX 861	GAINESVILLE FL 32602
19647	CADDOCK ELECTRONICS INC	3127 CHICAGO AVE	RIVERSIDE CA 92507
19701	MEPCO/ELECTRA INC A NORTH AMERICAN PHILIPS CO	P O BOX 760	MINERAL WELLS TX 76067
22526	DU PONT E I DE NEMOURS AND CO INC DU PONT CONNECTOR SYSTEMS	30 HUNTER LANE	CAMP HILL PA 17011
24355	ANALOG DEVICES INC	RT 1 INDUSTRIAL PK P O BOX 280	NORWOOD MA 02062
24546	CORNING GLASS WORKS	550 HIGH ST	BRADFORD PA 16701
27014	NATIONAL SEMICONDUCTOR CORP	2900 SEMICONDUCTOR DR	SANTA CLARA CA 95051
31433	UNION CARBIDE CORP ELECTRONICS DIV	PO BOX 5928	GREENVILLE SC 29606
32997	BOURNS INC TRIMPOT DIV	1200 COLUMBIA AVE	RIVERSIDE CA 92507
33096	COLORADO CRYSTAL CORP	2303 W 8TH ST	LOVELAND CO 80537
34335	ADVANCED MICRO DEVICES	901 THOMPSON PL	SUNNYVALE CA 94086
34371	HARRIS SEMICONDUCTOR DIV OF HARRIS CORP	P O BOX 883	MELBOURNE FL 32901
50157	MIDWEST COMPONENTS INC	1981 PORT CITY BLVD P O BOX 787	MUSKEGON MI 49443
50434	HEWLETT-PACKARD CO OPTOELECTRONICS DIV	640 PAGE MILL RD	PALO ALTO CA 94304
52763	STETTNER ELECTRONICS INC	6135 AIRWAYS BLVD PO BOX 21947	CHATTANOOGA TN 37421
52769	SPRAGUE-GOODMAN ELECTRONICS INC	134 FULTON AVE	GARDEN CITY PARK NY 11040
54473	MATSUSHITA ELECTRIC CORP OF AMERICA	ONE PANASONIC WAY	SECAUCUS NJ 07094
55680	NICHICON /AMERICA/ CORP	927 E STATE PKY	SCHAUMBURG IL 60195
56289	SPRAGUE ELECTRIC CO	87 MARSHALL ST	NORTH ADAMS MA 01247
57668	ROHM CORP	16931 MILLIKEN AVE	IRVINE CA 92713
58361	GENERAL INSTRUMENT CORP OPTOELECTRONICS DIV	3400 HILLVIEW AVE	PALO ALTO CA 94304

CROSS INDEX - MFR. CODE NUMBER TO MANUFACTURER

Mfr. Code	Manufacturer	Address	City, State, Zip Code
59660	TUSONIX INC	2155 N FORBES BLVD	TUCSON, ARIZONA 85705
71400	MCGRAW-EDISON CO BUSSMANN MFG DIV	502 EARTH CITY PLAZA P O BOX 14460	ST LOUIS MO 63178
74970	JOHNSON E F CO	299 10TH AVE S W	WASECA MN 56093
75042	TRW INC TRW ELECTRONIC COMPONENTS IRC FIXED RESISTORS PHILADELPHIA DIV	401 N BROAD ST	PHILADELPHIA PA 19108
75915	LITTELFUSE INC	800 E NORTHWEST HWY	DES PLAINES IL 60016
80009	TEKTRONIX INC	4900 S W GRIFFITH DR P O BOX 500	BEAVERTON OR 97077
81073	GRAYHILL INC	561 HILLGROVE AVE P O BOX 373	LA GRANGE IL 60525
91637	DALE ELECTRONICS INC	P O BOX 609	COLUMBUS NE 68601
TK1727	PHILIPS NEDERLAND BV AFD ELONCO	POSTBUS 90050	5600 PB EINDHOVEN THE NETHERLANDS

Component No.	Tektronix Part No.	Serial/Assembly No. Effective	Dscont	Name & Description	Mfr. Code	Mfr. Part No.
A11	670-6812-00			CIRCUIT BD ASSY:FRONT PANEL	80009	670-6812-00
A11DS1000	150-1066-00			LAMP,LED RDOUT:ORANGE,6 SEG,+/-1.	58361	Q3384/MAN4605A
A11DS1005	150-1053-00			LAMP,LED RDOUT:ORANGE,	58361	MAN4610A/Q3411
A11DS1010	150-1043-00			LT EMITTING DIO:ORANGE,635NM,35MA MAX	58361	MV5774C
A11DS1015	150-1043-00			LT EMITTING DIO:ORANGE,635NM,35MA MAX	58361	MV5774C
A11DS1020	150-1043-00			LT EMITTING DIO:ORANGE,635NM,35MA MAX	58361	MV5774C
A11DS1030	150-1043-00			LT EMITTING DIO:ORANGE,635NM,35MA MAX	58361	MV5774C
A11DS1032	150-1043-00			LT EMITTING DIO:ORANGE,635NM,35MA MAX	58361	MV5774C
A11DS1100	150-1053-00			LAMP,LED RDOUT:ORANGE,	58361	MAN4610A/Q3411
A11DS1105	150-1053-00			LAMP,LED RDOUT:ORANGE,	58361	MAN4610A/Q3411
A11DS1110	150-1043-00			LT EMITTING DIO:ORANGE,635NM,35MA MAX	58361	MV5774C
A11DS1115	150-1043-00			LT EMITTING DIO:ORANGE,635NM,35MA MAX	58361	MV5774C
A11DS1120	150-1043-00			LT EMITTING DIO:ORANGE,635NM,35MA MAX	58361	MV5774C
A11DS1130	150-1043-00			LT EMITTING DIO:ORANGE,635NM,35MA MAX	58361	MV5774C
A11DS1135	150-1043-00			LT EMITTING DIO:ORANGE,635NM,35MA MAX	58361	MV5774C
A11DS1200	150-1053-00			LAMP,LED RDOUT:ORANGE,	58361	MAN4610A/Q3411
A11DS1210	150-1043-00			LT EMITTING DIO:ORANGE,635NM,35MA MAX	58361	MV5774C
A11DS1215	150-1043-00			LT EMITTING DIO:ORANGE,635NM,35MA MAX	58361	MV5774C
A11DS1217	150-1043-00			LT EMITTING DIO:ORANGE,635NM,35MA MAX	58361	MV5774C
A11DS1220	150-1043-00			LT EMITTING DIO:ORANGE,635NM,35MA MAX	58361	MV5774C
A11DS1225	150-1043-00			LT EMITTING DIO:ORANGE,635NM,35MA MAX	58361	MV5774C
A11DS1230	150-1043-00			LT EMITTING DIO:ORANGE,635NM,35MA MAX	58361	MV5774C
A11DS1237	150-1043-00			LT EMITTING DIO:ORANGE,635NM,35MA MAX	58361	MV5774C
A11DS1302	150-1043-00			LT EMITTING DIO:ORANGE,635NM,35MA MAX	58361	MV5774C
A11DS1304	150-1043-00			LT EMITTING DIO:ORANGE,635NM,35MA MAX	58361	MV5774C
A11DS1306	150-1043-00			LT EMITTING DIO:ORANGE,635NM,35MA MAX	58361	MV5774C
A11DS1502	150-1043-00			LT EMITTING DIO:ORANGE,635NM,35MA MAX	58361	MV5774C
A11DS1504	150-1043-00			LT EMITTING DIO:ORANGE,635NM,35MA MAX	58361	MV5774C
A11DS1506	150-1043-00			LT EMITTING DIO:ORANGE,635NM,35MA MAX	58361	MV5774C
A11J1120	136-0263-04			SOCKET,PIN TERM:U/W 0.025 SQ PIN	22526	75377-001
A11J1300	136-0263-04			SOCKET,PIN TERM:U/W 0.025 SQ PIN	22526	75377-001
A11J1320	136-0263-04			SOCKET,PIN TERM:U/W 0.025 SQ PIN	22526	75377-001
A11J1400	136-0263-04			SOCKET,PIN TERM:U/W 0.025 SQ PIN	22526	75377-001
A11S1010	263-0019-35			SWITCH PB ASSY:MOMENTARY	80009	263-0019-35
A11S1015	263-0019-35			SWITCH PB ASSY:MOMENTARY	80009	263-0019-35
A11S1020	263-0019-35			SWITCH PB ASSY:MOMENTARY	80009	263-0019-35
A11S1025	263-0019-38			SWITCH PB ASSY:MOMENTARY	80009	263-0019-38
A11S1030	263-0019-35			SWITCH PB ASSY:MOMENTARY	80009	263-0019-35
A11S1032	263-0019-35			SWITCH PB ASSY:MOMENTARY	80009	263-0019-35
A11S1035	263-0019-38			SWITCH PB ASSY:MOMENTARY	80009	263-0019-38
A11S1037	263-0019-38			SWITCH PB ASSY:MOMENTARY	80009	263-0019-38
A11S1039	263-0019-38			SWITCH PB ASSY:MOMENTARY	80009	263-0019-38
A11S1110	263-0019-35			SWITCH PB ASSY:MOMENTARY	80009	263-0019-35
A11S1115	263-0019-35			SWITCH PB ASSY:MOMENTARY	80009	263-0019-35
A11S1120	263-0019-35			SWITCH PB ASSY:MOMENTARY	80009	263-0019-35
A11S1130	263-0019-35			SWITCH PB ASSY:MOMENTARY	80009	263-0019-35
A11S1135	263-0019-35			SWITCH PB ASSY:MOMENTARY	80009	263-0019-35
A11S1139	263-0019-38			SWITCH PB ASSY:MOMENTARY	80009	263-0019-38
A11S1210	263-0019-35			SWITCH PB ASSY:MOMENTARY	80009	263-0019-35
A11S1215	263-0019-35			SWITCH PB ASSY:MOMENTARY	80009	263-0019-35
A11S1217	263-0019-35			SWITCH PB ASSY:MOMENTARY	80009	263-0019-35
A11S1220	263-0019-35			SWITCH PB ASSY:MOMENTARY	80009	263-0019-35
A11S1225	263-0019-35			SWITCH PB ASSY:MOMENTARY	80009	263-0019-35
A11S1230	263-0019-35			SWITCH PB ASSY:MOMENTARY	80009	263-0019-35
A11S1232	263-0019-38			SWITCH PB ASSY:MOMENTARY	80009	263-0019-38
A11S1235	263-0019-38			SWITCH PB ASSY:MOMENTARY	80009	263-0019-38
A11S1237	263-0019-35			SWITCH PB ASSY:MOMENTARY	80009	263-0019-35
A11S1239	263-0019-38			SWITCH PB ASSY:MOMENTARY	80009	263-0019-38
A11S1310	263-0019-38			SWITCH PB ASSY:MOMENTARY	80009	263-0019-38

Component No.	Tektronix Part No.	Serial/Assembly No. Effective	Dscont	Name & Description	Mfr. Code	Mfr. Part No.
A11S1315	263-0019-38			SWITCH PB ASSY:MOMENTARY	80009	263-0019-38
A11S1320	263-0019-38			SWITCH PB ASSY:MOMENTARY	80009	263-0019-38
A11S1325	263-0019-38			SWITCH PB ASSY:MOMENTARY	80009	263-0019-38
A11S1410	263-0019-38			SWITCH PB ASSY:MOMENTARY	80009	263-0019-38
A11S1412	263-0019-38			SWITCH PB ASSY:MOMENTARY	80009	263-0019-38
A11S1415	263-0019-38			SWITCH PB ASSY:MOMENTARY	80009	263-0019-38
A11S1417	263-0019-38			SWITCH PB ASSY:MOMENTARY	80009	263-0019-38
A11S1420	263-0019-38			SWITCH PB ASSY:MOMENTARY	80009	263-0019-38
A11S1422	263-0019-38			SWITCH PB ASSY:MOMENTARY	80009	263-0019-38
A11S1425	263-0019-38			SWITCH PB ASSY:MOMENTARY	80009	263-0019-38
A11S1427	263-0019-38			SWITCH PB ASSY:MOMENTARY	80009	263-0019-38
A11S1510	263-0019-36			SWITCH PB ASSY:MOMENTARY	80009	263-0019-36
A11S1520	263-0019-38			SWITCH PB ASSY:MOMENTARY	80009	263-0019-38
A11S1525	263-0019-37			SWITCH PB ASSY:MOMENTARY	80009	263-0019-37
A12	670-6813-00			CIRCUIT BD ASSY:FP DRIVE	80009	670-6813-00
A12C1315	281-0775-00			CAP,FXD,CER DI:0.1UF,20%,50V	04222	MA205E104MAA
A12C1431	281-0775-00			CAP,FXD,CER DI:0.1UF,20%,50V	04222	MA205E104MAA
A12C1531	281-0775-00			CAP,FXD,CER DI:0.1UF,20%,50V	04222	MA205E104MAA
A12C1533	281-0775-00			CAP,FXD,CER DI:0.1UF,20%,50V	04222	MA205E104MAA
A12C1741	290-0727-00			CAP,FXD,ELCTLT:300UF,+75-10%,25V	56289	500D307G025EH7
A12C1821	281-0775-00			CAP,FXD,CER DI:0.1UF,20%,50V	04222	MA205E104MAA
A12C1823	281-0775-00			CAP,FXD,CER DI:0.1UF,20%,50V	04222	MA205E104MAA
A12J1820	131-2514-00			CONN,RCPT,ELEC:CKT BD,2 X 10,MALE	00779	86479-1
A12L1731	108-0336-00			COIL,RF:FIXED,100UH	80009	108-0336-00
A12P1120	131-0590-00			TERMINAL,PIN:0.71 L X 0.025 SQ PH BRZ	80009	131-0590-00
A12P1300	131-0590-00			TERMINAL,PIN:0.71 L X 0.025 SQ PH BRZ	80009	131-0590-00
A12P1320	131-0590-00			TERMINAL,PIN:0.71 L X 0.025 SQ PH BRZ	80009	131-0590-00
A12P1400	131-0590-00			TERMINAL,PIN:0.71 L X 0.025 SQ PH BRZ	80009	131-0590-00
A12Q1001	151-0391-00			TRANSISTOR:PNP,SI,X-81	04713	SPS6867K
A12Q1005	151-0391-00			TRANSISTOR:PNP,SI,X-81	04713	SPS6867K
A12Q1101	151-0391-00			TRANSISTOR:PNP,SI,X-81	04713	SPS6867K
A12Q1105	151-0391-00			TRANSISTOR:PNP,SI,X-81	04713	SPS6867K
A12Q1201	151-0391-00			TRANSISTOR:PNP,SI,X-81	04713	SPS6867K
A12Q1205	151-0391-00			TRANSISTOR:PNP,SI,X-81	04713	SPS6867K
A12Q1301	151-0391-00			TRANSISTOR:PNP,SI,X-81	04713	SPS6867K
A12Q1305	151-0391-00			TRANSISTOR:PNP,SI,X-81	04713	SPS6867K
A12R1121	315-0912-00			RES,FXD,FILM:9.1K OHM,5%,0.25W	57668	NTR25J-E09K1
A12R1123	315-0563-00			RES,FXD,FILM:56K OHM,5%,0.25W	19701	5043CX56K00J
A12R1125	315-0912-00			RES,FXD,FILM:9.1K OHM,5%,0.25W	57668	NTR25J-E09K1
A12R1127	315-0563-00			RES,FXD,FILM:56K OHM,5%,0.25W	19701	5043CX56K00J
A12R1129	315-0912-00			RES,FXD,FILM:9.1K OHM,5%,0.25W	57668	NTR25J-E09K1
A12R1221	315-0563-00			RES,FXD,FILM:56K OHM,5%,0.25W	19701	5043CX56K00J
A12R1223	315-0912-00			RES,FXD,FILM:9.1K OHM,5%,0.25W	57668	NTR25J-E09K1
A12R1225	315-0563-00			RES,FXD,FILM:56K OHM,5%,0.25W	19701	5043CX56K00J
A12R1227	315-0912-00			RES,FXD,FILM:9.1K OHM,5%,0.25W	57668	NTR25J-E09K1
A12R1229	315-0563-00			RES,FXD,FILM:56K OHM,5%,0.25W	19701	5043CX56K00J
A12R1311	315-0563-00			RES,FXD,FILM:56K OHM,5%,0.25W	19701	5043CX56K00J
A12R1313	315-0563-00			RES,FXD,FILM:56K OHM,5%,0.25W	19701	5043CX56K00J
A12R1315	315-0563-00			RES,FXD,FILM:56K OHM,5%,0.25W	19701	5043CX56K00J
A12R1321	315-0912-00			RES,FXD,FILM:9.1K OHM,5%,0.25W	57668	NTR25J-E09K1
A12R1323	315-0912-00			RES,FXD,FILM:9.1K OHM,5%,0.25W	57668	NTR25J-E09K1
A12R1325	315-0912-00			RES,FXD,FILM:9.1K OHM,5%,0.25W	57668	NTR25J-E09K1
A12R1511	315-0151-00			RES,FXD,FILM:150 OHM,5%,0.25W	57668	NTR25J-E150E
A12R1513	315-0151-00			RES,FXD,FILM:150 OHM,5%,0.25W	57668	NTR25J-E150E
A12R1515	315-0151-00			RES,FXD,FILM:150 OHM,5%,0.25W	57668	NTR25J-E150E
A12R1517	315-0151-00			RES,FXD,FILM:150 OHM,5%,0.25W	57668	NTR25J-E150E
A12R1519	315-0151-00			RES,FXD,FILM:150 OHM,5%,0.25W	57668	NTR25J-E150E
A12R1611	315-0151-00			RES,FXD,FILM:150 OHM,5%,0.25W	57668	NTR25J-E150E
A12R1613	315-0151-00			RES,FXD,FILM:150 OHM,5%,0.25W	57668	NTR25J-E150E

Component No.	Tektronix Part No.	Serial/Assembly No. Effective	Dscont	Name & Description	Mfr. Code	Mfr. Part No.
A12R1615	315-0151-00			RES,FXD,FILM:150 OHM,5%,0.25W	57668	NTR25J-E150E
A12R1821	307-0107-00			RES,FXD,CMPSN:5.6 OHM,5%,0.25W	01121	CB56G5
A12U1040	156-0469-02			MICROCKT,DGTL:3/8 LINE DCDR	01295	SN74LS138NP3
A12U1130	156-0140-02			MICROCKT,DGTL:HEX BUFFERS W/OC HV OUT,	18324	N7417(NB OR FB)
A12U1230	156-0140-02			MICROCKT,DGTL:HEX BUFFERS W/OC HV OUT,	18324	N7417(NB OR FB)
A12U1330	156-0140-02			MICROCKT,DGTL:HEX BUFFERS W/OC HV OUT,	18324	N7417(NB OR FB)
A12U1420	156-1528-00			MICROCKT,DGTL:BIPOLAR,QUARD 2-INP NAND PWR DRVR	56289	UHP-408
A12U1520	156-1528-00			MICROCKT,DGTL:BIPOLAR,QUARD 2-INP NAND PWR DRVR	56289	UHP-408
A12U1720	156-0277-00			MICROCKT,LINEAR:VOLTAGE REGULATOR	04713	LM340T-5.0
A13	670-6818-00			CIRCUIT BD ASSY:MAIN INTERCONNECT	80009	670-6818-00
A13J1701	131-1362-01			CONN,RCPT,ELEC:CKT BD,15/30 CONTACT	80009	131-1362-01
A13J1711	131-1362-01			CONN,RCPT,ELEC:CKT BD,15/30 CONTACT	80009	131-1362-01
A13J1713	131-1362-01			CONN,RCPT,ELEC:CKT BD,15/30 CONTACT	80009	131-1362-01
A13J1731	131-2063-00			CONN,RCPT,ELEC:CIRCUIT BOARD,15/30 FEMALE	05574	000-201-4986
A13J1733	131-2063-00			CONN,RCPT,ELEC:CIRCUIT BOARD,15/30 FEMALE	05574	000-201-4986
A14	670-6815-00	B010100	B010989	CIRCUIT BD ASSY:CPU	80009	670-6815-00
A14	670-6815-01	B010990		CIRCUIT BD ASSY:CPU	80009	670-6815-01
A14BT1121	146-0037-00			BATTERY,STORAGE:2.4V,0.15AH @ 14MA,(2)1/3 A CELLS,NICAD	19209	41B021AC00101
A14C1101	281-0775-00			CAP,FXD,CER DI:0.1UF,20%,50V	04222	MA205E104MAA
A14C1102	281-0775-00			CAP,FXD,CER DI:0.1UF,20%,50V	04222	MA205E104MAA
A14C1133	281-0775-00			CAP,FXD,CER DI:0.1UF,20%,50V	04222	MA205E104MAA
A14C1201	281-0775-00			CAP,FXD,CER DI:0.1UF,20%,50V	04222	MA205E104MAA
A14C1213	283-0643-00			CAP,FXD,MICA DI:22PF,0.5%,500V	00853	D105E22000
A14C1215	283-0643-00			CAP,FXD,MICA DI:22PF,0.5%,500V	00853	D105E22000
A14C1223	290-0524-00	B010100	B010989	CAP,FXD,ELCTLT:4.7UF,20%,10V	05397	T368A475M010AZ
A14C1223	290-0527-00	B010990		CAP,FXD,ELCTLT:15UF,20%,20V	05397	T368B156M020AS
A14C1233	281-0775-00			CAP,FXD,CER DI:0.1UF,20%,50V	04222	MA205E104MAA
A14C1235	281-0775-00			CAP,FXD,CER DI:0.1UF,20%,50V	04222	MA205E104MAA
A14C1301	281-0775-00			CAP,FXD,CER DI:0.1UF,20%,50V	04222	MA205E104MAA
A14C1302	281-0775-00			CAP,FXD,CER DI:0.1UF,20%,50V	04222	MA205E104MAA
A14C1321	281-0775-00			CAP,FXD,CER DI:0.1UF,20%,50V	04222	MA205E104MAA
A14C1401	281-0775-00			CAP,FXD,CER DI:0.1UF,20%,50V	04222	MA205E104MAA
A14C1421	281-0775-00			CAP,FXD,CER DI:0.1UF,20%,50V	04222	MA205E104MAA
A14C1426	281-0775-00			CAP,FXD,CER DI:0.1UF,20%,50V	04222	MA205E104MAA
A14C1431	281-0775-00			CAP,FXD,CER DI:0.1UF,20%,50V	04222	MA205E104MAA
A14C1435	281-0775-00			CAP,FXD,CER DI:0.1UF,20%,50V	04222	MA205E104MAA
A14C1501	281-0775-00			CAP,FXD,CER DI:0.1UF,20%,50V	04222	MA205E104MAA
A14C1521	281-0775-00			CAP,FXD,CER DI:0.1UF,20%,50V	04222	MA205E104MAA
A14C1523	281-0775-00			CAP,FXD,CER DI:0.1UF,20%,50V	04222	MA205E104MAA
A14C1601	281-0775-00			CAP,FXD,CER DI:0.1UF,20%,50V	04222	MA205E104MAA
A14C1602	281-0775-00			CAP,FXD,CER DI:0.1UF,20%,50V	04222	MA205E104MAA
A14C1621	281-0775-00			CAP,FXD,CER DI:0.1UF,20%,50V	04222	MA205E104MAA
A14C1631	281-0775-00			CAP,FXD,CER DI:0.1UF,20%,50V	04222	MA205E104MAA
A14C1721	281-0775-00			CAP,FXD,CER DI:0.1UF,20%,50V	04222	MA205E104MAA
A14C1723	283-0108-00	B010990		CAP,FXD,CER DI:220PF,10%,200V	31433	C320C221K2G5CA
A14C1731	283-0177-00			CAP,FXD,CER DI:1UF,+80-20%,25V	04222	SR302E105ZAATR
A14CR1133	152-0245-00			SEMICOND DVC,DI:SW,SI,40V,DO-7	03508	DA2740
A14CR1235	152-0245-00			SEMICOND DVC,DI:SW,SI,40V,DO-7	03508	DA2740
A14J1132	131-0608-00			TERMINAL,PIN:0.365 L X 0.025 BRZ GLD PL (QTY 3)	22526	48283-036
A14J1425	131-0608-00			TERMINAL,PIN:0.365 L X 0.025 BRZ GLD PL (QTY 3)	22526	48283-036
A14J1721	131-0608-00			TERMINAL,PIN:0.365 L X 0.025 BRZ GLD PL (QTY 3)	22526	48283-036
A14J1723	131-0608-00			TERMINAL,PIN:0.365 L X 0.025 BRZ GLD PL (QTY 3)	22526	48283-036

Component No.	Tektronix Part No.	Serial/Assembly No. Effective	Dscont	Name & Description	Mfr. Code	Mfr. Part No.
A14Q1121	151-0190-00			TRANSISTOR:NPN,SI,TO-92	80009	151-0190-00
A14Q1123	151-1103-00			TRANSISTOR:FE,N CHANNEL,SI,TO-72	17856	DM1001
A14R1101	315-0472-00			RES,FXD,FILM:4.7K OHM,5%,0.25W	57668	NTR25J-E04K7
A14R1121	315-0103-00	B010100	B010989	RES,FXD,FILM:10K OHM,5%,0.25W	19701	5043CX10K00J
A14R1123	315-0103-00			RES,FXD,FILM:10K OHM,5%,0.25W	19701	5043CX10K00J
A14R1129	315-0103-00			RES,FXD,FILM:10K OHM,5%,0.25W	19701	5043CX10K00J
A14R1131	315-0101-00			RES,FXD,FILM:100 OHM,5%,0.25W	57668	NTR25J-E 100E
A14R1132	315-0103-00			RES,FXD,FILM:10K OHM,5%,0.25W	19701	5043CX10K00J
A14R1133	315-0223-00			RES,FXD,FILM:22K OHM,5%,0.25W	19701	5043CX22K00J92U
A14R1134	315-0223-00			RES,FXD,FILM:22K OHM,5%,0.25W	19701	5043CX22K00J92U
A14R1135	315-0101-00			RES,FXD,FILM:100 OHM,5%,0.25W	57668	NTR25J-E 100E
A14R1221	315-0222-00			RES,FXD,FILM:2.2K OHM,5%,0.25W	57668	NTR25J-E02K2
A14R1223	315-0104-00			RES,FXD,FILM:100K OHM,5%,0.25W	57668	NTR25J-E100K
A14R1225	315-0103-00			RES,FXD,FILM:10K OHM,5%,0.25W	19701	5043CX10K00J
A14R1227	315-0103-00	B010100	B010989	RES,FXD,FILM:10K OHM,5%,0.25W	19701	5043CX10K00J
A14R1227	315-0133-00	B010990		RES,FXD,FILM:13K OHM,5%,0.25W	19701	5043CX13K00J
A14R1231	321-0216-00			RES,FXD,FILM:1.74K OHM,1%,0.125W,TC=T0	07716	CEAD17400F
A14R1232	321-0666-00			RES,FXD,FILM:3.04K OHM,0.5%,0.125W,TC=T2	07716	CEAC304000
A14R1233	315-0102-00			RES,FXD,FILM:1K OHM,5%,0.25W	57668	NTR25JE01K0
A14R1311	315-0393-00			RES,FXD,FILM:39K OHM,5%,0.25W	57668	NTR25J-E39K0
A14R1313	315-0472-00			RES,FXD,FILM:4.7K OHM,5%,0.25W	57668	NTR25J-E04K7
A14R1321	315-0472-00			RES,FXD,FILM:4.7K OHM,5%,0.25W	57668	NTR25J-E04K7
A14R1611	307-0445-00			RES NTWK,FXD,FI:4.7K OHM,20%,(9)RES	32997	4310R-101-472
A14R1621	307-0445-00			RES NTWK,FXD,FI:4.7K OHM,20%,(9)RES	32997	4310R-101-472
A14R1623	315-0271-00	B010990		RES,FXD,FILM:270 OHM,5%,0.25W	57668	NTR25J-E270E
A14S1515	260-1721-00			SWITCH,ROCKER:8,SPST,125MA,30VDC	81073	76SB08S
A14TP1531	214-0579-00			TERM,TEST POINT:BRS CD PL	80009	214-0579-00
A14TP1533	214-0579-00			TERM,TEST POINT:BRS CD PL	80009	214-0579-00
A14TP1535	214-0579-00			TERM,TEST POINT:BRS CD PL	80009	214-0579-00
A14TP1621	214-0579-00			TERM,TEST POINT:BRS CD PL	80009	214-0579-00
A14TP1625	214-0579-00			TERM,TEST POINT:BRS CD PL	80009	214-0579-00
A14U1100	156-1414-00			MICROCKT,DGTL:TTL,OCTAL GPIB XCVR DATA BUS	01295	SN75160 (N OR J)
A14U1105	156-1444-00	B010100	B101819	MICROCKT,DGTL:GPIB ADAPTER	01295	TMS9914NL
A14U1105	156-1441-01	B010820		MICROCKT,LINEAR:10 BIT VIDEO SPEED D/A CONV	80009	156-1441-01
A14U1110	156-1415-00			MICROCKT,DGTL:TTL,OCTAL GPIB XCVR MGT BUS	01295	SN75161A N
A14U1200	160-1329-00			MICROCKT,DGTL:4096 X 8 EPROM,PROGRAMMED	80009	160-1329-00
A14U1220	156-0887-00			MICROCKT,DGTL:CMOS,256 X 4 RAM	34371	HM1-6562-9
A14U1230	156-1225-00			MICROCKT,LINEAR:DUAL COMPARATOR	01295	LM393P
A14U1235	156-0956-02			MICROCKT,DGTL:OCTAL BFR W/3 STATE OUT	01295	SN74LS244NP3
A14U1300	160-1328-00			MICROCKT,DGTL:4096 X 8 EPROM,PROGRAMMED	80009	160-1328-00
A14U1305	160-1327-00			MICROCKT,DGTL:4096 X 8 EPROM,PROGRAMMED	80009	160-1327-00
A14U1320	156-1342-00			MICROCKT,DGTL:NMOS,8 BIT W/CLOCK & RAM	04713	MC6802P
A14U1400	160-1326-00			MICROCKT,DGTL:4096 X 8 EPROM,PROGRAMMED	80009	160-1326-00
A14U1420	156-0956-02			MICROCKT,DGTL:OCTAL BFR W/3 STATE OUT	01295	SN74LS244NP3
A14U1425	156-0385-02			MICROCKT,DGTL:HEX INVERTER	07263	74LS04PCQR
A14U1430	156-0914-02			MICROCKT,DGTL:OCT ST BFR W/3 STATE OUT	01295	SN74LS240NP3
A14U1435	156-1111-02			MICROCKT,DGTL:OCTAL BUS TRANSCEIVERS	01295	SN74LS245N3
A14U1505	156-1127-01			MICROCKT,DGTL:1024 X 4 STATIC RAM	80009	156-1127-01
A14U1510	156-0541-02			MICROCKT,DGTL:DUAL 2-TO 4-LINE DCDR/DEMUX	04713	SN74LS139NDS
A14U1520	156-0469-02			MICROCKT,DGTL:3/8 LINE DCDR	01295	SN74LS138NP3
A14U1600	156-1127-01			MICROCKT,DGTL:1024 X 4 STATIC RAM	80009	156-1127-01
A14U1605	156-1535-00			MICROCKT,DGTL:NMOS,PROGRAMMABLE KYBD/DLY IN TERFACE,	34335	AM8279-5(N OR J)
A14U1610	156-0914-02			MICROCKT,DGTL:OCT ST BFR W/3 STATE OUT	01295	SN74LS240NP3
A14U1620	156-0469-02			MICROCKT,DGTL:3/8 LINE DCDR	01295	SN74LS138NP3
A14U1630	156-0386-02			MICROCKT,DGTL:TRIPLE 3-INP NAND GATE	07263	74LS10PCQR
A14U1720	156-0804-02			MICROCKT,DGTL:QUADRUPLE S-R LATCH	01295	SN74LS279NP3/JP4
A14U1730	156-0724-02			MICROCKT,DGTL:HEX INV W/OC OUT,SCRN,	01295	SN74LS05NP3
A14VR1232	152-0667-00			SEMICOND DVC,DI:ZEN,SI,3.0 V ± 2% AT 2MA	04713	SZG30025RL

Component No.	Tektronix Part No.	Serial/Assembly No. Effective	Dscont	Name & Description	Mfr. Code	Mfr. Part No.
A14Y1221	158-0251-00			XTAL UNIT,QTZ:4.0MHZ,0.001%,ANTIRESONANT	33096	PB 1370
A15	670-6814-00	B010100	B021245	CIRCUIT BD ASSY:ISOLATION	80009	670-6814-00
A15	670-6814-01	B021245	B021349	CIRCUIT BD ASSY:ISOLATION	80009	670-6814-01
A15	670-6814-02	B021350		CIRCUIT BD ASSY:ISOLATION	80009	670-6814-02
A15C1001	281-0775-00			CAP,FXD,CER DI:0.1UF,20%,50V	04222	MA205E104MAA
A15C1005	283-0198-00			CAP,FXD,CER DI:0.22UF,20%,50V	05397	C330C224M5U1CA
A15C1021	281-0775-00			CAP,FXD,CER DI:0.1UF,20%,50V	04222	MA205E104MAA
A15C1101	281-0775-00			CAP,FXD,CER DI:0.1UF,20%,50V	04222	MA205E104MAA
A15C1107	281-0775-00			CAP,FXD,CER DI:0.1UF,20%,50V	04222	MA205E104MAA
A15C1111	283-0212-00			CAP,FXD,CER DI:2UF,20%,50V	04222	SR405E205MAA
A15C1113	290-0755-00			CAP,FXD,ELCTLT:100UF,+50%-10%,10V	54473	ECE-A10V100L
A15C1121	281-0775-00			CAP,FXD,CER DI:0.1UF,20%,50V	04222	MA205E104MAA
A15C1131	281-0775-00			CAP,FXD,CER DI:0.1UF,20%,50V	04222	MA205E104MAA
A15C1201	283-0100-00			CAP,FXD,CER DI:0.0047UF,10%,200V	04222	SR306A472KAA
A15C1203	283-0212-00			CAP,FXD,CER DI:2UF,20%,50V	04222	SR405E205MAA
A15C1215	281-0775-00	B010100	B010369	CAP,FXD,CER DI:0.1UF,20%,50V	04222	MA205E104MAA
A15C1215	281-0813-00	B010370		CAP,FXD,CER DI:0.047UF,20%,50V	05397	C412C473M5V2CA
A15C1216	281-0775-00	B010100	B010369	CAP,FXD,CER DI:0.1UF,20%,50V	04222	MA205E104MAA
A15C1216	281-0813-00	B010370		CAP,FXD,CER DI:0.047UF,20%,50V	05397	C412C473M5V2CA
A15C1221	290-0114-00			CAP,FXD,ELCTLT:47UF,20%,6V	05397	T110B476M006AS
A15C1223	281-0775-00			CAP,FXD,CER DI:0.1UF,20%,50V	04222	MA205E104MAA
A15C1301	281-0116-00			CAP,VAR,AIR DI:1.5-9.1PF,530V	74970	189-0754-075
A15C1321	281-0775-00			CAP,FXD,CER DI:0.1UF,20%,50V	04222	MA205E104MAA
A15C1326	281-0775-00			CAP,FXD,CER DI:0.1UF,20%,50V	04222	MA205E104MAA
A15C1331	281-0775-00			CAP,FXD,CER DI:0.1UF,20%,50V	04222	MA205E104MAA
A15C1401	283-0434-00	B010100	B010499	CAP,FXD,CER DI:26.5PF,2%,1000V	59660	808000C0G02659F
A15C1401	283-0109-00	B010500		CAP,FXD,CER DI:27PF,5%,1000V	59660	858-534C0G0270J
A15C1403	283-0199-00			CAP,FXD,CER DI:25PF,10%,4000V	59660	0818617C0G0250K
A15C1404	281-0184-00			CAP,VAR,PLASTIC:2-18PF,500VDC	TK1727	2222-809-05003
A15C1421	281-0775-00			CAP,FXD,CER DI:0.1UF,20%,50V	04222	MA205E104MAA
A15C1426	281-0775-00			CAP,FXD,CER DI:0.1UF,20%,50V	04222	MA205E104MAA
A15C1501	281-0775-00			CAP,FXD,CER DI:0.1UF,20%,50V	04222	MA205E104MAA
A15C1502	281-0775-00			CAP,FXD,CER DI:0.1UF,20%,50V	04222	MA205E104MAA
A15C1503	290-0768-00			CAP,FXD,ELCTLT:10UF,+50-10%,100VDC	54473	ECE-A100V10L
A15C1504	281-0775-00			CAP,FXD,CER DI:0.1UF,20%,50V	04222	MA205E104MAA
A15C1505	290-0950-00			CAP,FXD,ELCTLT:100UF,+50-10%,50V	55680	ULB1H101TJAANA
A15C1511	281-0775-00			CAP,FXD,CER DI:0.1UF,20%,50V	04222	MA205E104MAA
A15C1513	281-0775-00			CAP,FXD,CER DI:0.1UF,20%,50V	04222	MA205E104MAA
A15C1515	290-0768-00			CAP,FXD,ELCTLT:10UF,+50-10%,100VDC	54473	ECE-A100V10L
A15C1521	281-0775-00			CAP,FXD,CER DI:0.1UF,20%,50V	04222	MA205E104MAA
A15C1526	281-0775-00			CAP,FXD,CER DI:0.1UF,20%,50V	04222	MA205E104MAA
A15C1601	290-0950-00			CAP,FXD,ELCTLT:100UF,+50-10%,50V	55680	ULB1H101TJAANA
A15C1603	290-0745-00			CAP,FXD,ELCTLT:22UF,+50-10%,25V	54473	ECE-A25V22L
A15C1611	290-0768-00			CAP,FXD,ELCTLT:10UF,+50-10%,100VDC	54473	ECE-A100V10L
A15C1621	281-0775-00			CAP,FXD,CER DI:0.1UF,20%,50V	04222	MA205E104MAA
A15C1626	281-0775-00			CAP,FXD,CER DI:0.1UF,20%,50V	04222	MA205E104MAA
A15C1701	281-0775-00			CAP,FXD,CER DI:0.1UF,20%,50V	04222	MA205E104MAA
A15C1702	281-0775-00			CAP,FXD,CER DI:0.1UF,20%,50V	04222	MA205E104MAA
A15C1713	281-0775-00			CAP,FXD,CER DI:0.1UF,20%,50V	04222	MA205E104MAA
A15C1721	281-0775-00			CAP,FXD,CER DI:0.1UF,20%,50V	04222	MA205E104MAA
A15C1731	283-0177-00			CAP,FXD,CER DI:1UF,+80-20%,25V	04222	SR302E105ZAATR
A15CR1201	152-0574-00			SEMICOND DVC,DI:SW,SI,120V,0.15A,DO-35	12969	NDP566
A15CR1203	152-0574-00			SEMICOND DVC,DI:SW,SI,120V,0.15A,DO-35	12969	NDP566
A15CR1211	152-0574-00			SEMICOND DVC,DI:SW,SI,120V,0.15A,DO-35	12969	NDP566
A15CR1212	152-0574-00			SEMICOND DVC,DI:SW,SI,120V,0.15A,DO-35	12969	NDP566
A15CR1501	152-0574-00			SEMICOND DVC,DI:SW,SI,120V,0.15A,DO-35	12969	NDP566
A15CR1503	152-0574-00			SEMICOND DVC,DI:SW,SI,120V,0.15A,DO-35	12969	NDP566
A15CR1505	152-0574-00			SEMICOND DVC,DI:SW,SI,120V,0.15A,DO-35	12969	NDP566
A15CR1507	152-0779-00			SEMICOND DVC,DI:RECT,SI,200V,0.75A	05828	RM02M

Component No.	Tektronix Part No.	Serial/Assembly No. Effective	Dscont	Name & Description	Mfr. Code	Mfr. Part No.
A15CR1509	152-0574-00			SEMICOND DVC,DI:SW,SI,120V,0.15A,DO-35	12969	NDP566
A15CR1515	152-0779-00			SEMICOND DVC,DI:RECT,SI,200V,0.75A	05828	RM02M
A15CR1605	152-0307-00			SEMICOND DVC,DI:SW,SI,100V,0.13A,DO-92	04713	SS01150
A15CR1715	152-0141-02			SEMICOND DVC,DI:SW,SI,30V,150MA,30V	03508	DA2527 (1N4152)
A15F1111	159-0015-00			FUSE,CARTRIDGE:3AG,3A,250V,0.65SEC	75915	312 003
A15F1113	159-0025-00			FUSE,CARTRIDGE:3AG,0.5A,250V,0.25SEC	71400	AGC-CW-1/2
A15L1201	108-0200-00			COIL,RF:FIXED,52UH	80009	108-0200-00
A15L1203	108-0200-00			COIL,RF:FIXED,52UH	80009	108-0200-00
A15Q1101	151-0301-00			TRANSISTOR:PNP,SI,TO-18	04713	ST898
A15Q1104	151-0188-00			TRANSISTOR:PNP,SI,TO-92	80009	151-0188-00
A15Q1105	151-0190-00			TRANSISTOR:NPN,SI,TO-92	80009	151-0190-00
A15Q1201	151-0200-00			TRANSISTOR:NPN,SI,TO-5	04713	2N3499
A15Q1202	151-0200-00			TRANSISTOR:NPN,SI,TO-5	04713	2N3499
A15Q1211	151-0190-00			TRANSISTOR:NPN,SI,TO-92	80009	151-0190-00
A15Q1212	151-0190-00			TRANSISTOR:NPN,SI,TO-92	80009	151-0190-00
A15Q1213	151-0188-00			TRANSISTOR:PNP,SI,TO-92	80009	151-0188-00
A15Q1214	151-0188-00			TRANSISTOR:PNP,SI,TO-92	80009	151-0188-00
A15Q1421	151-0190-00			TRANSISTOR:NPN,SI,TO-92	80009	151-0190-00
A15Q1615	151-0301-00			TRANSISTOR:PNP,SI,TO-18	04713	ST898
A15R1001	315-0431-00			RES,FXD,FILM:430 OHM,5%,0.25W	19701	5043CX430R0J
A15R1003	315-0333-00			RES,FXD,FILM:33K OHM,5%,0.25W	57668	NTR25J-E33K0
A15R1005	315-0102-00			RES,FXD,FILM:1K OHM,5%,0.25W	57668	NTR25JE01K0
A15R1101	315-0201-00			RES,FXD,FILM:200 OHM,5%,0.25W	57668	NTR25J-E200E
A15R1102	315-0821-00			RES,FXD,FILM:820 OHM,5%,0.25W	19701	5043CX820R0J
A15R1103	315-0123-00			RES,FXD,FILM:12K OHM,5%,0.25W	57668	NTR25J-E12K0
A15R1104	315-0562-00			RES,FXD,FILM:5.6K OHM,5%,0.25W	57668	NTR25J-E05K6
A15R1105	315-0333-00			RES,FXD,FILM:33K OHM,5%,0.25W	57668	NTR25J-E33K0
A15R1106	317-0047-00			RES,FXD,CMPSN:4.7 OHM,5%,0.125W	01121	BB47G5
A15R1107	315-0391-00			RES,FXD,FILM:390 OHM,5%,0.25W	57668	NTR25J-E390E
A15R1108	315-0123-00			RES,FXD,FILM:12K OHM,5%,0.25W	57668	NTR25J-E12K0
A15R1109	315-0123-00			RES,FXD,FILM:12K OHM,5%,0.25W	57668	NTR25J-E12K0
A15R1201	315-0910-00			RES,FXD,FILM:91 OHM,5%,0.25W	19701	5043CX91R00J
A15R1211	315-0102-00			RES,FXD,FILM:1K OHM,5%,0.25W	57668	NTR25JE01K0
A15R1212	315-0102-00			RES,FXD,FILM:1K OHM,5%,0.25W	57668	NTR25JE01K0
A15R1213	315-0751-00			RES,FXD,FILM:750 OHM,5%,0.25W	57668	NTR25J-E750E
A15R1214	315-0751-00			RES,FXD,FILM:750 OHM,5%,0.25W	57668	NTR25J-E750E
A15R1215	315-0271-00			RES,FXD,FILM:270 OHM,5%,0.25W	57668	NTR25J-E270E
A15R1216	315-0271-00			RES,FXD,FILM:270 OHM,5%,0.25W	57668	NTR25J-E270E
A15R1217	315-0122-00			RES,FXD,FILM:1.2K OHM,5%,0.25W	57668	NTR25J-E01K2
A15R1421	315-0122-00			RES,FXD,FILM:1.2K OHM,5%,0.25W	57668	NTR25J-E01K2
A15R1521	315-0271-00			RES,FXD,FILM:270 OHM,5%,0.25W	57668	NTR25J-E270E
A15R1526	315-0271-00			RES,FXD,FILM:270 OHM,5%,0.25W	57668	NTR25J-E270E
A15R1531	315-0102-00			RES,FXD,FILM:1K OHM,5%,0.25W	57668	NTR25JE01K0
A15R1615	315-0242-00			RES,FXD,FILM:2.4K OHM,5%,0.25W	57668	NTR25J-E02K4
A15R1621	315-0271-00			RES,FXD,FILM:270 OHM,5%,0.25W	57668	NTR25J-E270E
A15R1626	315-0271-00			RES,FXD,FILM:270 OHM,5%,0.25W	57668	NTR25J-E270E
A15R1701	315-0102-00			RES,FXD,FILM:1K OHM,5%,0.25W	57668	NTR25JE01K0
A15R1703	315-0562-00			RES,FXD,FILM:5.6K OHM,5%,0.25W	57668	NTR25J-E05K6
A15R1711	315-0562-00			RES,FXD,FILM:5.6K OHM,5%,0.25W	57668	NTR25J-E05K6
A15R1712	315-0750-00			RES,FXD,FILM:75 OHM,5%,0.25W	57668	NTR25J-E75E0
A15R1713	315-0102-00			RES,FXD,FILM:1K OHM,5%,0.25W	57668	NTR25JE01K0
A15R1715	315-0303-00			RES,FXD,FILM:30K OHM,5%,0.25W	19701	5043CX30K00J
A15R1721	315-0750-00			RES,FXD,FILM:75 OHM,5%,0.25W	57668	NTR25J-E75E0
A15T1311	120-1349-00			TRANSFORMER,RF:ISOLATION	80009	120-1349-00
A15TP1421	214-0579-00			TERM,TEST POINT:BRS CD PL	80009	214-0579-00
A15U1000	156-0067-00			MICROCKT,LINEAR:OPNL AMPL,SEL	04713	MC1741CP1
A15U1020	156-0412-02			MICROCKT,DGTL:SYN 4 BIT UP/DOWN CNTR	27014	DM74LS193NA+
A15U1030	156-0382-02			MICROCKT,DGTL:QUAD 2 INP NAND GATE BURN	18324	N74LS00NB
A15U1120	156-0412-02			MICROCKT,DGTL:SYN 4 BIT UP/DOWN CNTR	27014	DM74LS193NA+

Component No.	Tektronix Part No.	Serial/Assembly No. Effective	Dscont	Name & Description	Mfr. Code	Mfr. Part No.
A15U1125	156-0299-02			MICROCKT,DGTL:TTL,16-BIT DATA SELECTOR	18324	N74150(NB OR FB)
A15U1130	156-0412-02			MICROCKT,DGTL:SYN 4 BIT UP/DOWN CNTR	27014	DM74LS193NA+
A15U1135	156-0386-02			MICROCKT,DGTL:TRIPLE 3-INP NAND GATE	07263	74LS10PCQR
A15U1220	156-0412-02			MICROCKT,DGTL:SYN 4 BIT UP/DOWN CNTR	27014	DM74LS193NA+
A15U1230	156-0567-02			MICROCKT,DGTL:DUAL J-K NEG EDGE TRIG FF	27014	DM74LS113NA+
A15U1235	156-0844-02			MICROCKT,DGTL:SYN 4 BIT CNTR	01295	SN74LS161A(NP3)
A15U1320	156-0567-02			MICROCKT,DGTL:DUAL J-K NEG EDGE TRIG FF	27014	DM74LS113NA+
A15U1325	156-0567-02			MICROCKT,DGTL:DUAL J-K NEG EDGE TRIG FF	27014	DM74LS113NA+
A15U1330	156-0567-02			MICROCKT,DGTL:DUAL J-K NEG EDGE TRIG FF	27014	DM74LS113NA+
A15U1335	156-0464-02			MICROCKT,DGTL:DUAL 4-INP NAND GATE	01295	SN74LS20NP3
A15U1420	156-0382-02			MICROCKT,DGTL:QUAD 2 INP NAND GATE BURN	18324	N74LS00NB
A15U1425	156-0567-02			MICROCKT,DGTL:DUAL J-K NEG EDGE TRIG FF	27014	DM74LS113NA+
A15U1430	156-0382-02			MICROCKT,DGTL:QUAD 2 INP NAND GATE BURN	18324	N74LS00NB
A15U1435	156-0480-02			MICROCKT,DGTL:QUAD 2-INP & GATE	01295	SN74LS08NP3
A15U1510	156-1522-00			CPLR,OPTOELECTR:LED & PHOTOTRANSISTOR	50434	HCPL-2601
A15U1515	156-1522-00			CPLR,OPTOELECTR:LED & PHOTOTRANSISTOR	50434	HCPL-2601
A15U1520	156-0382-02			MICROCKT,DGTL:QUAD 2 INP NAND GATE BURN	18324	N74LS00NB
A15U1525	156-0545-01			MICROCKT,DGTL:12 BIT BINARY CNTR	02735	CD4040BFX
A15U1530	156-0382-02			MICROCKT,DGTL:QUAD 2 INP NAND GATE BURN	18324	N74LS00NB
A15U1535	156-0041-05	B010100	B021349	MICROCKT,DGTL:DUAL D FLIP FLOP SCRN	01295	SN7474NP3
A15U1535	156-0331-03	B021350		MICROCKT,DGTL:DUAL D TYPE POSITIVE EDGE	01295	SN74S74NP3
A15U1605	156-0991-00			MICROCKT,LINEAR:VOLTAGE REGULATOR	04713	MC78L05ACP
A15U1610	156-1522-00			CPLR,OPTOELECTR:LED & PHOTOTRANSISTOR	50434	HCPL-2601
A15U1613	156-0991-00			MICROCKT,LINEAR:VOLTAGE REGULATOR	04713	MC78L05ACP
A15U1615	156-1522-00			CPLR,OPTOELECTR:LED & PHOTOTRANSISTOR	50434	HCPL-2601
A15U1620	156-0465-01			MICROCKT,DGTL:8-INP NAND GATE,CHK	80009	156-0465-01
A15U1625	156-0465-01			MICROCKT,DGTL:8-INP NAND GATE,CHK	80009	156-0465-01
A15U1630	156-0388-03			MICROCKT,DGTL:DUAL D FLIP-FLOP	01295	SN74LS74ANP3
A15U1635	156-0386-02			MICROCKT,DGTL:TRIPLE 3-INP NAND GATE	07263	74LS10PCQR
A15U1710	156-1522-00			CPLR,OPTOELECTR:LED & PHOTOTRANSISTOR	50434	HCPL-2601
A15U1720	156-0465-01			MICROCKT,DGTL:8-INP NAND GATE,CHK	80009	156-0465-01
A15U1730	156-0784-02			MICROCKT,DGTL:SYNCHRONOUS 4-BIT BINARY CNTR	01295	SN74LS163AN P3
A15VR1001	152-0662-00			SEMICOND DVC,DI:ZEN,SI,5V,1%,400MW,DO-7	04713	SZG195RL
A15VR1216	152-0279-00			SEMICOND DVC,DI:ZEN,SI,5.1V,5%,0.4W,DO-7	14552	TD3810989
A16	670-6816-00			CIRCUIT BD ASSY:RMS	80009	670-6816-00
A16C1001	285-0809-00			CAP,FXD,PLASTIC:1UF,10%,50V	56289	LP66A1A105K
A16C1013	290-0768-00			CAP,FXD,ELCTLT:10UF,+50-10%,100VDC	54473	ECE-A100V10L
A16C1101	290-0121-00			CAP,FXD,ELCTLT:2UF,+75-10%,25V	01002	76F92KC2R0
A16C1103	290-0488-00			CAP,FXD,ELCTLT:2.2UF,10%,20V	05397	T322B225K020AS
A16C1105	281-0775-00			CAP,FXD,CER DI:0.1UF,20%,50V	04222	MA205E104MAA
A16C1107	281-0775-00			CAP,FXD,CER DI:0.1UF,20%,50V	04222	MA205E104MAA
A16C1111	281-0775-00			CAP,FXD,CER DI:0.1UF,20%,50V	04222	MA205E104MAA
A16C1113	281-0775-00			CAP,FXD,CER DI:0.1UF,20%,50V	04222	MA205E104MAA
A16C1301	281-0775-00			CAP,FXD,CER DI:0.1UF,20%,50V	04222	MA205E104MAA
A16C1303	281-0775-00			CAP,FXD,CER DI:0.1UF,20%,50V	04222	MA205E104MAA
A16C1311	283-0593-00			CAP,FXD,MICA DI:0.01UF,1%,100V	00853	D301F103F0
A16C1403	281-0248-00			CAP,VAR,AIR DI:1.8-10.16PF,75MVDC	74970	186-0613-105
A16C1405	283-0676-00			CAP,FXD,MICA DI:82PF,1%,500V	00853	D105E820F0
A16C1415	281-0775-00			CAP,FXD,CER DI:0.1UF,20%,50V	04222	MA205E104MAA
A16C1417	283-0203-00			CAP,FXD,CER DI:0.47UF,20%,50V	04222	SR305SC474MAA
A16C1503	281-0064-00			CAP,VAR,PLASTIC:0.25-1.5PF,600V	52769	ER-530-013
A16C1505	281-0658-00	B010100	B010199	CAP,FXD,CER DI:6.2PF,+/-0.25PF,500	52763	2RDPLZ007 6P20CC
A16C1505	281-0645-00	B010200		CAP,FXD,CER DI:8.2PF,+/-0.25PF,500V	52763	2RDPLZ007 8P20CC
A16C1513	281-0775-00			CAP,FXD,CER DI:0.1UF,20%,50V	04222	MA205E104MAA
A16C1515	283-0203-00			CAP,FXD,CER DI:0.47UF,20%,50V	04222	SR305SC474MAA
A16C1525	283-0203-00			CAP,FXD,CER DI:0.47UF,20%,50V	04222	SR305SC474MAA
A16C1526	281-0775-00			CAP,FXD,CER DI:0.1UF,20%,50V	04222	MA205E104MAA
A16C1527	283-0203-00			CAP,FXD,CER DI:0.47UF,20%,50V	04222	SR305SC474MAA
A16C1528	281-0775-00			CAP,FXD,CER DI:0.1UF,20%,50V	04222	MA205E104MAA

Component No.	Tektronix Part No.	Serial/Assembly No. Effective	Dscont	Name & Description	Mfr. Code	Mfr. Part No.
A16C1601	281-0775-00			CAP,FXD,CER DI:0.1UF,20%,50V	04222	MA205E104MAA
A16C1603	281-0775-00			CAP,FXD,CER DI:0.1UF,20%,50V	04222	MA205E104MAA
A16C1605	281-0064-00			CAP,VAR,PLASTIC:0.25-1.5PF,600V	52769	ER-530-013
A16C1607	281-0064-00			CAP,VAR,PLASTIC:0.25-1.5PF,600V	52769	ER-530-013
A16C1609	283-0342-00			CAP,FXD,CER DI:6.5PF,0.5%,2000V	59660	838564C0H0659D
A16C1621	285-1077-00			CAP,FXD,PLASTIC:0.1UF,20%,600V	14752	23081F104M
A16CR1011	152-0704-00			SEMICOND DVC,DI:RECT,SI,1A,1KV,DO-41	05828	1N4007G
A16CR1021	152-0141-02			SEMICOND DVC,DI:SW,SI,30V,150MA,30V	03508	DA2527 (1N4152)
A16CR1023	152-0141-02			SEMICOND DVC,DI:SW,SI,30V,150MA,30V	03508	DA2527 (1N4152)
A16CR1121	152-0141-02			SEMICOND DVC,DI:SW,SI,30V,150MA,30V	03508	DA2527 (1N4152)
A16CR1225	152-0704-00			SEMICOND DVC,DI:RECT,SI,1A,1KV,DO-41	05828	1N4007G
A16CR1227	152-0141-02			SEMICOND DVC,DI:SW,SI,30V,150MA,30V	03508	DA2527 (1N4152)
A16CR1231	152-0141-02			SEMICOND DVC,DI:SW,SI,30V,150MA,30V	03508	DA2527 (1N4152)
A16CR1233	152-0141-02			SEMICOND DVC,DI:SW,SI,30V,150MA,30V	03508	DA2527 (1N4152)
A16CR1415	152-0141-02			SEMICOND DVC,DI:SW,SI,30V,150MA,30V	03508	DA2527 (1N4152)
A16CR1511	152-0141-02			SEMICOND DVC,DI:SW,SI,30V,150MA,30V	03508	DA2527 (1N4152)
A16CR1513	152-0141-02			SEMICOND DVC,DI:SW,SI,30V,150MA,30V	03508	DA2527 (1N4152)
A16CR1527	152-0141-02			SEMICOND DVC,DI:SW,SI,30V,150MA,30V	03508	DA2527 (1N4152)
A16CR1529	152-0141-02			SEMICOND DVC,DI:SW,SI,30V,150MA,30V	03508	DA2527 (1N4152)
A16CR1613	152-0323-00			SEMICOND DVC,DI:SW,SI,35V,0.1A,DO-7	14433	MG1518
A16CR1615	152-0323-00			SEMICOND DVC,DI:SW,SI,35V,0.1A,DO-7	14433	MG1518
A16K1031	148-0141-00			RELAY,REED:1 FORM A,0.5A,100VDC,COIL 15VDC, 2.2K OHM	15636	R7620-2
A16K1131	148-0141-00			RELAY,REED:1 FORM A,0.5A,100VDC,COIL 15VDC, 2.2K OHM	15636	R7620-2
A16K1201	148-0126-00			RELAY,REED:FORM A,00MA,250VDC,COIL 5VDC	15636	R6895-1
A16K1231	148-0141-00			RELAY,REED:1 FORM A,0.5A,100VDC,COIL 15VDC, 2.2K OHM	15636	R7620-2
A16K1313	148-0126-00			RELAY,REED:FORM A,00MA,250VDC,COIL 5VDC	15636	R6895-1
A16K1405	148-0126-00			RELAY,REED:FORM A,00MA,250VDC,COIL 5VDC	15636	R6895-1
A16K1503	148-0126-00			RELAY,REED:FORM A,00MA,250VDC,COIL 5VDC	15636	R6895-1
A16K1621	148-0141-00			RELAY,REED:1 FORM A,0.5A,100VDC,COIL 15VDC, 2.2K OHM	15636	R7620-2
A16K1633	148-0141-00			RELAY,REED:1 FORM A,0.5A,100VDC,COIL 15VDC, 2.2K OHM	15636	R7620-2
A16Q1021	151-1131-00			TRANSISTOR:FE,N-CHANNEL,SI,TO-72C	17856	FN4582
A16Q1320	156-1527-00			MICROCKT,LINEAR:5 XSTR ARRAY	02735	CA3183AE-98
A16Q1420	156-1527-00			MICROCKT,LINEAR:5 XSTR ARRAY	02735	CA3183AE-98
A16R1001	311-1337-00			RES,VAR,NONWW:TRMR,25K OHM,0.5W	32997	3006P-M84-253
A16R1003	315-0103-00			RES,FXD,FILM:10K OHM,5%,0.25W	19701	5043CX10K00J
A16R1013	315-0103-00			RES,FXD,FILM:10K OHM,5%,0.25W	19701	5043CX10K00J
A16R1021	315-0101-00			RES,FXD,FILM:100 OHM,5%,0.25W	57668	NTR25J-E 100E
A16R1031	325-0355-00			RES,FXD,FILM:1M OHM,0.1%,0.25W	91637	PTF65T16100038
A16R1032	315-0162-00			RES,FXD,FILM:1.6K OHM,5%,0.25W	19701	5043CX1K600J
A16R1033	321-1389-07			RES,FXD,FILM:111K OHM,0.1%,0.125W,TC=T9	19701	5033RE1113BB298F
A16R1101	321-0959-03			RES,FXD,FILM:24.01K OHM,0.25%,0.125W,T2	24546	NC55C24.01KC
A16R1121	321-0908-02			RES,FXD,FILM:1.31K OHM,0.5%,0.125W,TC=T2	24546	NC55C1311D
A16R1123	321-1310-03			RES,FXD,FILM:16.7K OHM,0.25%,0.125W,TC=T2	19701	5033RC16K72C
A16R1201	321-0318-07			RES,FXD,FILM:20.0K OHM,0.1%,0.125W,TC=T9	19701	5033RE20K00BCM
A16R1211	321-0703-00			RES,FXD,FILM:2.19K OHM,0.25%,0.125W,T0=T9	19701	5033RE2K190C
A16R1221	321-0289-00			RES,FXD,FILM:10.0K OHM,1%,0.125W,TC=T0	19701	5033ED10K0F
A16R1223	321-0364-03			RES,FXD,FILM:60.4K OHM,0.25%,0.125W,T=T2	19701	5033RC60K40C
A16R1225	321-0481-01			RES,FXD,FILM:1M OHM,0.5%,0.125W,TC=T0	07716	CEAD100030
A16R1229	323-0443-01			RES,FXD,FILM:402K OHM,0.5%,0.5W,TC=T0	24546	NA65D 40230
A16R1231	315-0162-00			RES,FXD,FILM:1.6K OHM,5%,0.25W	19701	5043CX1K600J
A16R1233	315-0162-00			RES,FXD,FILM:1.6K OHM,5%,0.25W	19701	5043CX1K600J
A16R1303	315-0184-00			RES,FXD,FILM:180K OHM,5%,0.25W	19701	5043CX180K0J
A16R1305	311-1337-00			RES,VAR,NONWW:TRMR,25K OHM,0.5W	32997	3006P-M84-253
A16R1307	321-0222-07			RES,FXD,FILM:2.0K OHM,0.1%,0.125W,TC=T9	19701	5033RE2K000B

Component No.	Tektronix Part No.	Serial/Assembly No. Effective	Dscont	Name & Description	Mfr. Code	Mfr. Part No.
A16R1309	321-0222-07			RES,FXD,FILM:2.0K OHM,0.1%,0.125W,TC=T9	19701	5033RE2K000B
A16R1321	323-0445-01			RES,FXD,FILM:422K,OHM,0.5%,0.5W,TC=T0	24546	NA60D 42230
A16R1323	322-0254-02			RES,FXD,FILM:4.32K OHM,0.5%,0.25W,TC=T2	24546	NC60C4321C
A16R1325	315-0562-00			RES,FXD,FILM:5.6K OHM,5%,0.25W	57668	NTR25J-E05K6
A16R1327	315-0562-00			RES,FXD,FILM:5.6K OHM,5%,0.25W	57668	NTR25J-E05K6
A16R1331	325-0354-00			RES,FXD,FILM:10K OHM,0.1%,0.25W	19701	5033ZA10K00B
A16R1333	325-0349-00			RES,FXD,FILM:10M OHM,0.25%,0.5W,TC=T9	03888	PME70 10MOHM.25%
A16R1401	321-1610-03			RES,FXD,FILM:22.22K OHM,0.25%,0.125W,TC=T2	19701	5033RC22K22D
A16R1403	321-0414-07			RES,FXD,FILM:200K OHM,0.1%,0.125W,TC=T9	24546	NE55E2003B
A16R1415	321-1133-02			RES,FXD,FILM:240 OHM,0.5%,0.125W,TC=T2	24546	NC60024000
A16R1421	315-0562-00			RES,FXD,FILM:5.6K OHM,5%,0.25W	57668	NTR25J-E05K6
A16R1423	315-0562-00			RES,FXD,FILM:5.6K OHM,5%,0.25W	57668	NTR25J-E05K6
A16R1425	315-0562-00			RES,FXD,FILM:5.6K OHM,5%,0.25W	57668	NTR25J-E05K6
A16R1426	315-0562-00			RES,FXD,FILM:5.6K OHM,5%,0.25W	57668	NTR25J-E05K6
A16R1427	315-0562-00			RES,FXD,FILM:5.6K OHM,5%,0.25W	57668	NTR25J-E05K6
A16R1429	315-0562-00			RES,FXD,FILM:5.6K OHM,5%,0.25W	57668	NTR25J-E05K6
A16R1501	321-0510-07			RES,FXD,FILM:2.00 MEG OHM,0.1%,0.125W,TC=T0	19701	5033RE2M00B
A16R1521	315-0562-00			RES,FXD,FILM:5.6K OHM,5%,0.25W	57668	NTR25J-E05K6
A16R1523	315-0122-00			RES,FXD,FILM:1.2K OHM,5%,0.25W	57668	NTR25J-E01K2
A16R1525	315-0122-00			RES,FXD,FILM:1.2K OHM,5%,0.25W	57668	NTR25J-E01K2
A16R1601	311-1337-00			RES,VAR,NONWW:TRMR,25K OHM,0.5W	32997	3006P-W84-253
A16R1603	323-0510-07	B010100	B010709	RES,FXD,FILM:2.0MEG OHM,0.1%,0.5W,TC=T9	91637	CMF65116-C20003B
A16R1603	325-0385-00	B010710		RES,FXD,FILM:2M OHM,0.1%,0.5W,TC=T9	03888	PME70 2MOHM .1%
A16R1609	321-0306-00			RES,FXD,FILM:15.0K OHM,1%,0.125W,TC=T0	19701	5033ED15J00F
A16R1621	315-0201-02			RES,FXD,CMPSN:200 OHM,5%,0.25W	01121	CB2015
A16R1633	315-0102-00			RES,FXD,FILM:1K OHM,5%,0.25W	57668	NTR25JE01K0
A16RT1011	307-0662-00			RES,THERMAL:1K OHM,40%	50157	180Q10216
A16RT1227	307-0767-00			RES,THERMAL:5K OHM,+40%-20%	50157	180Q50203
A16TP1201	214-0579-00			TERM,TEST POINT:BRS CD PL	80009	214-0579-00
A16TP1503	214-0579-00			TERM,TEST POINT:BRS CD PL	80009	214-0579-00
A16TP1701	214-0579-00			TERM,TEST POINT:BRS CD PL	80009	214-0579-00
A16TP1703	214-0579-00			TERM,TEST POINT:BRS CD PL	80009	214-0579-00
A16U1100	156-1457-01			MICROCKT,LINEAR:TRUE RMS TO DC CONVERTER,	24355	AD41134
A16U1120	156-1149-01			MICROCKT,LINEAR:OPERATION AMP JFET INPUT	27014	AL160307
A16U1200	156-0742-01			MICROCKT,LINEAR:OPNL AMPL,FUNCTIONAL TEST	80009	156-0742-01
A16U1330	156-0796-00			MICROCKT,DGTL:8 STG SHF & STORE BUS RGTR	02735	CD4094BF
A16U1417	156-1529-00			MICROCKT,LINEAR:3-TERM ADJ OUT POS V RGLTR	04713	LM317LZ
A16U1430	156-0796-00			MICROCKT,DGTL:8 STG SHF & STORE BUS RGTR	02735	CD4094BF
A16U1500	156-1156-00			MICROCKT,LINEAR:OPERATIONAL AMPLIFIER	27014	LF356N
A16U1515	156-0991-00			MICROCKT,LINEAR:VOLTAGE REGULATOR	04713	MC78L05ACP
A16U1525	156-1207-00			MICROCKT,LINEAR:VOLTAGE REGULATOR,-12 V	04713	MC79L12ACG
A16U1527	156-1160-00			MICROCKT,LINEAR:VOLTAGE REGULATOR	04713	MC78L12ACG
A16U1530	156-0480-02			MICROCKT,DGTL:QUAD 2-INP & GATE	01295	SN74LS08NP3
A16VR1013	152-0278-00			SEMICOND DVC,DI:ZEN,SI,3V,5%,0.4W,DO-7	04713	SZG35009K20
A16VR1123	152-0611-00			SEMICOND DVC,DI:ZEN,SI,9V,2%,0.4W,DO-7	04713	SZ14347
A16VR1415	152-0278-00			SEMICOND DVC,DI:ZEN,SI,3V,5%,0.4W,DO-7	04713	SZG35009K20
A16W1105	131-0566-00			BUS,COND:DUMMY RES,0.094 OD X 0.225L	24546	OMA 07
A17	672-1015-00	B010100	B020979	CIRCUIT BD ASSY:RELAY	80009	672-1015-00
A17	672-1015-01	B020980	B021903	CIRCUIT BD ASSY:RELAY	80009	672-1015-01
A17	672-1015-03	B021904		CIRCUIT BD ASSY:RELAY	80009	672-1015-03
A17C1001	281-0775-00			CAP,FXD,CER DI:0.1UF,20%,50V	04222	MA205E104MAA
A17C1013	281-0775-00			CAP,FXD,CER DI:0.1UF,20%,50V	04222	MA205E104MAA
A17C1017	281-0770-00			CAP,FXD,CER DI:1000PF,20%,100V	04222	MA101C102MAA
A17C1019	281-0770-00			CAP,FXD,CER DI:1000PF,20%,100V	04222	MA101C102MAA
A17C1021	290-0770-00	B010100	B010369	CAP,FXD,ELCTLT:100UF,+50-10%,25VDC	54473	ECE-A25V100L
A17C1031	290-0770-00	B010100	B010369	CAP,FXD,ELCTLT:100UF,+50-10%,25VDC	54473	ECE-A25V100L
A17C1123	281-0775-00			CAP,FXD,CER DI:0.1UF,20%,50V	04222	MA205E104MAA
A17C1126	281-0811-00			CAP,FXD,CER DI:10PF,10%,100V	04222	MA101A100KAA
A17C1128	281-0775-00			CAP,FXD,CER DI:0.1UF,20%,50V	04222	MA205E104MAA

Component No.	Tektronix Part No.	Serial/Assembly No. Effective	Dscont	Name & Description	Mfr. Code	Mfr. Part No.
A17C1131	281-0775-00			CAP,FXD,CER DI:0.1UF,20%,50V	04222	MA205E104MAA
A17C1133	290-0770-00	B010100	B010369	CAP,FXD,ELCTLT:100UF,+50-10%,25VDC	54473	ECE-A25V100L
A17C1135	290-0770-00	B010100	B010369	CAP,FXD,ELCTLT:100UF,+50-10%,25VDC	54473	ECE-A25V100L
A17C1137	281-0775-00			CAP,FXD,CER DI:0.1UF,20%,50V	04222	MA205E104MAA
A17C1139	285-0809-00			CAP,FXD,PLASTIC:1UF,10%,50V	56289	LP66A1A105K
A17C1202	281-0786-00			CAP,FXD,CER DI:150PF,10%,100V	04222	MA101A151KAA
A17C1204	281-0786-00			CAP,FXD,CER DI:150PF,10%,100V	04222	MA101A151KAA
A17C1206	281-0786-00			CAP,FXD,CER DI:150PF,10%,100V	04222	MA101A151KAA
A17C1211	281-0786-00			CAP,FXD,CER DI:150PF,10%,100V	04222	MA101A151KAA
A17C1221	283-0601-00			CAP,FXD,MICA DI:22PF,10%,300V	00853	D155E220K0
A17C1225	285-1220-00			CAP,FXD,PLASTIC:1200PF,10%,200V	14752	A1509
A17C1311	281-0786-00			CAP,FXD,CER DI:150PF,10%,100V	04222	MA101A151KAA
A17C1312	281-0786-00			CAP,FXD,CER DI:150PF,10%,100V	04222	MA101A151KAA
A17C1323	281-0775-00			CAP,FXD,CER DI:0.1UF,20%,50V	04222	MA205E104MAA
A17C1331	290-0770-00			CAP,FXD,ELCTLT:100UF,+50-10%,25VDC	54473	ECE-A25V100L
A17C1411	281-0786-00			CAP,FXD,CER DI:150PF,10%,100V	04222	MA101A151KAA
A17C1412	281-0786-00			CAP,FXD,CER DI:150PF,10%,100V	04222	MA101A151KAA
A17C1513	281-0775-00			CAP,FXD,CER DI:0.1UF,20%,50V	04222	MA205E104MAA
A17C1514	290-0177-00			CAP,FXD,ELCTLT:1UF,20%,50V	05397	T320A105M050AS
A17C1601	281-0775-00			CAP,FXD,CER DI:0.1UF,20%,50V	04222	MA205E104MAA
A17C1602	283-0203-00			CAP,FXD,CER DI:0.47UF,20%,50V	04222	SR305SC474MAA
A17C1603	281-0775-00			CAP,FXD,CER DI:0.1UF,20%,50V	04222	MA205E104MAA
A17C1604	283-0203-00			CAP,FXD,CER DI:0.47UF,20%,50V	04222	SR305SC474MAA
A17C1605	281-0775-00			CAP,FXD,CER DI:0.1UF,20%,50V	04222	MA205E104MAA
A17C1606	283-0203-00			CAP,FXD,CER DI:0.47UF,20%,50V	04222	SR305SC474MAA
A17C1611	281-0775-00			CAP,FXD,CER DI:0.1UF,20%,50V	04222	MA205E104MAA
A17C1612	290-0177-00			CAP,FXD,ELCTLT:1UF,20%,50V	05397	T320A105M050AS
A17C1613	283-0212-00			CAP,FXD,CER DI:2UF,20%,50V	04222	SR405E205MAA
A17C1723	283-0109-00			CAP,FXD,CER DI:27PF,5%,1000V	59660	858-534C0G0270J
A17CR1111	152-0141-02			SEMICOND DVC,DI:SW,SI,30V,150MA,30V	03508	DA2527 (1N4152)
A17CR1113	152-0141-02			SEMICOND DVC,DI:SW,SI,30V,150MA,30V	03508	DA2527 (1N4152)
A17CR1121	153-0057-00	B010100	B021469	SEMICOND DVC,DI:SELECTED	80009	153-0057-00
A17CR1121	152-0323-00	B021470		SEMICOND DVC,DI:SW,SI,35V,0.1A,DO-7	14433	MG1518
A17CR1122	153-0057-00	B010100	B021469	SEMICOND DVC,DI:SELECTED	80009	153-0057-00
A17CR1122	152-0323-00	B021470		SEMICOND DVC,DI:SW,SI,35V,0.1A,DO-7	14433	MG1518
A17CR1123	153-0057-00	B010100	B021469	SEMICOND DVC,DI:SELECTED	80009	153-0057-00
A17CR1123	152-0323-00	B021470		SEMICOND DVC,DI:SW,SI,35V,0.1A,DO-7	14433	MG1518
A17CR1125	153-0057-00	B010100	B021469	SEMICOND DVC,DI:SELECTED	80009	153-0057-00
A17CR1125	152-0323-00	B021470		SEMICOND DVC,DI:SW,SI,35V,0.1A,DO-7	14433	MG1518
A17CR1129	152-0141-02			SEMICOND DVC,DI:SW,SI,30V,150MA,30V	03508	DA2527 (1N4152)
A17CR1221	153-0057-00	B010100	B021469	SEMICOND DVC,DI:SELECTED	80009	153-0057-00
A17CR1221	152-0323-00	B021470		SEMICOND DVC,DI:SW,SI,35V,0.1A,DO-7	14433	MG1518
A17CR1223	153-0057-00	B010100	B021469	SEMICOND DVC,DI:SELECTED	80009	153-0057-00
A17CR1223	152-0323-00	B021470		SEMICOND DVC,DI:SW,SI,35V,0.1A,DO-7	14433	MG1518
A17CR1419	152-0141-02			SEMICOND DVC,DI:SW,SI,30V,150MA,30V	03508	DA2527 (1N4152)
A17CR1511	152-0141-02			SEMICOND DVC,DI:SW,SI,30V,150MA,30V	03508	DA2527 (1N4152)
A17CR1517	152-0141-02			SEMICOND DVC,DI:SW,SI,30V,150MA,30V	03508	DA2527 (1N4152)
A17CR1519	152-0141-02			SEMICOND DVC,DI:SW,SI,30V,150MA,30V	03508	DA2527 (1N4152)
A17CR1611	152-0141-02			SEMICOND DVC,DI:SW,SI,30V,150MA,30V	03508	DA2527 (1N4152)
A17CR1612	152-0141-02			SEMICOND DVC,DI:SW,SI,30V,150MA,30V	03508	DA2527 (1N4152)
A17CR1621	152-0141-02			SEMICOND DVC,DI:SW,SI,30V,150MA,30V	03508	DA2527 (1N4152)
A17CR1623	152-0141-02			SEMICOND DVC,DI:SW,SI,30V,150MA,30V	03508	DA2527 (1N4152)
A17K1425	148-0141-00			RELAY,REED:1 FORM A,0.5A,100VDC,COIL 15VDC, 2.2K OHM	15636	R7620-2
A17K1525	148-0141-00			RELAY,REED:1 FORM A,0.5A,100VDC,COIL 15VDC, 2.2K OHM	15636	R7620-2
A17K1527	148-0141-00			RELAY,REED:1 FORM A,0.5A,100VDC,COIL 15VDC, 2.2K OHM	15636	R7620-2
A17K1631	----- -----			(RELAY,ARMATURE:4 FORM C,6V,2A)		

Component No.	Tektronix Part No.	Serial/Assembly No. Effective	Dscont	Name & Description	Mfr. Code	Mfr. Part No.
				(PART OF A17A1 ONLY)		
A17L1723	108-1134-00			COIL,RF:FIXED,5.3UH	80009	108-1134-00
A17Q1001	151-0350-00			TRANSISTOR:PNP,SI,TO-92	04713	SPS6700
A17Q1015	151-0347-00			TRANSISTOR:NPN,SI,TO-92	04713	SPS7951
A17Q1017	151-0347-00			TRANSISTOR:NPN,SI,TO-92	04713	SPS7951
A17Q1021	151-0350-00			TRANSISTOR:PNP,SI,TO-92	04713	SPS6700
A17Q1101	151-0407-00			TRANSISTOR:NPN,SI,TO-39	04713	SS2456
A17Q1105	151-1133-00			TRANSISTOR:FE,N-CHANNEL,SI,TO-18C	17856	FN4579
A17Q1106	151-1133-00			TRANSISTOR:FE,N-CHANNEL,SI,TO-18C	17856	FN4579
A17Q1111	151-0406-00			TRANSISTOR:PNP,SI,TO-39	04713	ST1264
A17Q1112	151-1133-00			TRANSISTOR:FE,N-CHANNEL,SI,TO-18C	17856	FN4579
A17Q1114	151-1133-00			TRANSISTOR:FE,N-CHANNEL,SI,TO-18C	17856	FN4579
A17Q1201	151-0347-00			TRANSISTOR:NPN,SI,TO-92	04713	SPS7951
A17Q1202	151-0347-00			TRANSISTOR:NPN,SI,TO-92	04713	SPS7951
A17Q1211	151-0347-00			TRANSISTOR:NPN,SI,TO-92	04713	SPS7951
A17Q1212	151-0347-00			TRANSISTOR:NPN,SI,TO-92	04713	SPS7951
A17Q1215	151-0347-00			TRANSISTOR:NPN,SI,TO-92	04713	SPS7951
A17Q1217	151-1134-00			TRANSISTOR:FE,N-CHANNEL,SI,TO-72	17856	FN4594
A17Q1222	151-1131-00			TRANSISTOR:FE,N-CHANNEL,SI,TO-72C	17856	FN4582
A17Q1311	151-0347-00			TRANSISTOR:NPN,SI,TO-92	04713	SPS7951
A17Q1313	151-0347-00			TRANSISTOR:NPN,SI,TO-92	04713	SPS7951
A17Q1315	151-1134-00			TRANSISTOR:FE,N-CHANNEL,SI,TO-72	17856	FN4594
A17Q1317	151-1134-00			TRANSISTOR:FE,N-CHANNEL,SI,TO-72	17856	FN4594
A17Q1319	151-1134-00			TRANSISTOR:FE,N-CHANNEL,SI,TO-72	17856	FN4594
A17Q1321	151-1131-00			TRANSISTOR:FE,N-CHANNEL,SI,TO-72C	17856	FN4582
A17Q1323	151-1131-00			TRANSISTOR:FE,N-CHANNEL,SI,TO-72C	17856	FN4582
A17Q1327	151-1131-00			TRANSISTOR:FE,N-CHANNEL,SI,TO-72C	17856	FN4582
A17Q1411	151-0347-00			TRANSISTOR:NPN,SI,TO-92	04713	SPS7951
A17Q1413	151-0347-00			TRANSISTOR:NPN,SI,TO-92	04713	SPS7951
A17Q1511	151-0301-00			TRANSISTOR:PNP,SI,TO-18	04713	ST898
A17Q1512	151-0190-00			TRANSISTOR:NPN,SI,TO-92	80009	151-0190-00
A17Q1513	151-0347-00			TRANSISTOR:NPN,SI,TO-92	04713	SPS7951
A17Q1514	151-1066-00			TRANSISTOR:FET,P-CHAN,SI,TO-92	04713	SPF3038
A17Q1515	151-0347-00			TRANSISTOR:NPN,SI,TO-92	04713	SPS7951
A17Q1611	151-0254-00			TRANSISTOR:DARLINGTON,NPN,SI	03508	X38L3118
A17Q1613	151-0134-00			TRANSISTOR:PNP,SI,TO-39	04713	SM3195
A17R1001	321-0178-00			RES,FXD,FILM:698 OHM,1%,0.125W,TC=T0	07716	CEAD698R0F
A17R1011	315-0513-00			RES,FXD,FILM:51K OHM,5%,0.25W	57668	NTR25J-E51K0
A17R1013	321-0178-00			RES,FXD,FILM:698 OHM,1%,0.125W,TC=T0	07716	CEAD698R0F
A17R1033	315-0432-00			RES,FXD,FILM:4.3K OHM,5%,0.25W	57668	NTR25J-E04K3
A17R1101	325-0350-00			RES,FXD,FILM:5.9K OHM,0.1%,0.125W	19701	5033ZA5K900B
A17R1102	325-0351-00			RES,FXD,FILM:53K OHM,0.1%,0.125W	19701	5033ZA53K00B
A17R1103	315-0513-00			RES,FXD,FILM:51K OHM,5%,0.25W	57668	NTR25J-E51K0
A17R1104	315-0105-00			RES,FXD,FILM:1M OHM,5%,0.25W	19701	5043CX1M000J
A17R1115	315-0562-00			RES,FXD,FILM:5.6K OHM,5%,0.25W	57668	NTR25J-E05K6
A17R1116	315-0104-00			RES,FXD,FILM:100K OHM,5%,0.25W	57668	NTR25J-E100K
A17R1117	315-0510-00			RES,FXD,FILM:51 OHM,5%,0.25W	19701	5043CX51R00J
A17R1120	321-0983-00	B010370		RES,FXD,FILM:4.5 MEG OHM,1%,0.125W,TC=T0	91637	CMF55116-G45003F
A17R1121	315-0303-00			RES,FXD,FILM:30K OHM,5%,0.25W	19701	5043CX30K00J
A17R1122	315-0510-00			RES,FXD,FILM:51 OHM,5%,0.25W	19701	5043CX51R00J
A17R1124	315-0243-00			RES,FXD,FILM:24K OHM,5%,0.25W	57668	NTR25J-E24K0
A17R1125	315-0432-00			RES,FXD,FILM:4.3K OHM,5%,0.25W	57668	NTR25J-E04K3
A17R1126	315-0432-00			RES,FXD,FILM:4.3K OHM,5%,0.25W	57668	NTR25J-E04K3
A17R1129	315-0362-00			RES,FXD,FILM:3.6K OHM,5%,0.25W	19701	5043CX3K600J
A17R1139	315-0472-00			RES,FXD,FILM:4.7K OHM,5%,0.25W	57668	NTR25J-E04K7
A17R1201	315-0363-00			RES,FXD,FILM:36K OHM,5%,0.25W	57668	NTR25J-E36K0
A17R1203	315-0363-00			RES,FXD,FILM:36K OHM,5%,0.25W	57668	NTR25J-E36K0
A17R1205	315-0363-00			RES,FXD,FILM:36K OHM,5%,0.25W	57668	NTR25J-E36K0
A17R1207	315-0363-00			RES,FXD,FILM:36K OHM,5%,0.25W	57668	NTR25J-E36K0

Component No.	Tektronix Part No.	Serial/Assembly No. Effective	Dscont	Name & Description	Mfr. Code	Mfr. Part No.
A17R1212	315-0105-00			RES,FXD,FILM:1M OHM,5%,0.25W	19701	5043CX1M000J
A17R1213	321-0685-00			RES,FXD,FILM:30K OHM,0.5%,0.125W,TC=T2	19701	5033RC30K00D
A17R1214	321-1427-02			RES,FXD,FILM:277K OHM,0.5%,0.125W,TC=T2	19701	5033RC277K0D
A17R1215	321-0646-00			RES,FXD,FILM:200K OHM,0.5%,0.125W,TC=T2	07716	CEAC20002D
A17R1222	315-0243-00			RES,FXD,FILM:24K OHM,5%,0.25W	57668	NTR25J-E24K0
A17R1223	315-0752-00			RES,FXD,FILM:7.5K OHM,5%,0.25W	57668	NTR25J-E07K5
A17R1225	315-0752-00			RES,FXD,FILM:7.5K OHM,5%,0.25W	57668	NTR25J-E07K5
A17R1227	315-0473-00			RES,FXD,FILM:47K OHM,5%,0.25W	57668	NTR25J-E47K0
A17R1228	321-0510-00	B010100	B010769	RES,FXD,FILM:2.00M OHM,1%,0.125W,TC=T0	03888	PME55020003F
A17R1229	325-0352-00	B010100	B010769	RES,FXD,FILM:71.5K OHM,0.1%,0.125W	19701	5033ZA71K50B
A17R1229	325-0353-00	B010770		RES,FXD,FILM:90K OHM,0.1%,0.125W	19701	5033ZA90K00B
A17R1231	325-0353-00	B010100	B010769	RES,FXD,FILM:90K OHM,0.1%,0.125W	19701	5033ZA90K00B
A17R1231	325-0384-00	B010770		RES,FXD,FILM:117K OHM,0.1%,0.125W,TC=T16	19701	5023ZA117K0B
A17R1233	321-0361-00			RES,FXD,FILM:56.2K OHM,1%,0.125W,TC=T0	07716	CEAD56201F
A17R1301	307-0839-00			RES,FXD,FILM:200K OHM,1%,3W,TC=250PPM/DEG C	07716	GS3 200K OHM+-1%
A17R1313	315-0363-00			RES,FXD,FILM:36K OHM,5%,0.25W	57668	NTR25J-E36K0
A17R1314	315-0363-00			RES,FXD,FILM:36K OHM,5%,0.25W	57668	NTR25J-E36K0
A17R1315	315-0203-00			RES,FXD,FILM:20K OHM,5%,0.25W	57668	NTR25J-E 20K
A17R1316	315-0203-00			RES,FXD,FILM:20K OHM,5%,0.25W	57668	NTR25J-E 20K
A17R1321	321-0182-00			RES,FXD,FILM:768 OHM,1%,0.125W,TC=T0	07716	CEAD768R0F
A17R1323	315-0271-00			RES,FXD,FILM:270 OHM,5%,0.25W	57668	NTR25J-E270E
A17R1331	315-0123-00			RES,FXD,FILM:12K OHM,5%,0.25W	57668	NTR25J-E12K0
A17R1413	315-0363-00			RES,FXD,FILM:36K OHM,5%,0.25W	57668	NTR25J-E36K0
A17R1414	315-0363-00			RES,FXD,FILM:36K OHM,5%,0.25W	57668	NTR25J-E36K0
A17R1415	315-0104-00			RES,FXD,FILM:100K OHM,5%,0.25W	57668	NTR25J-E100K
A17R1416	315-0203-00			RES,FXD,FILM:20K OHM,5%,0.25W	57668	NTR25J-E 20K
A17R1417	315-0562-00			RES,FXD,FILM:5.6K OHM,5%,0.25W	57668	NTR25J-E05K6
A17R1418	321-0646-00			RES,FXD,FILM:200K OHM,0.5%,0.125W,TC=T2	07716	CEAC20002D
A17R1419	315-0162-00			RES,FXD,FILM:1.6K OHM,5%,0.25W	19701	5043CX1K600J
A17R1427	321-0645-00			RES,FXD,FILM:100K OHM,0.5%,0.125W,TC=T2	19701	5033RC10030
A17R1429	307-0769-00			RES NTWK,FXD,FI:1,9.9M OHM,90K OHM,10K OHM, 0.25W,1200VDC	19647	1776-9
A17R1501	315-0272-00			RES,FXD,FILM:2.7K OHM,5%,0.25W	57668	NTR25J-E02K7
A17R1511	315-0473-00			RES,FXD,FILM:47K OHM,5%,0.25W	57668	NTR25J-E47K0
A17R1512	315-0242-00			RES,FXD,FILM:2.4K OHM,5%,0.25W	57668	NTR25J-E02K4
A17R1513	315-0102-00			RES,FXD,FILM:1K OHM,5%,0.25W	57668	NTR25JE01K0
A17R1514	315-0364-00			RES,FXD,FILM:360K OHM,5%,0.25W	57668	NTR25J-E360K
A17R1515	315-0132-00			RES,FXD,FILM:1.3K OHM,5%,0.25W	57668	NTR25J-E01K3
A17R1516	315-0562-00			RES,FXD,FILM:5.6K OHM,5%,0.25W	57668	NTR25J-E05K6
A17R1517	315-0162-00			RES,FXD,FILM:1.6K OHM,5%,0.25W	19701	5043CX1K600J
A17R1518	315-0562-00			RES,FXD,FILM:5.6K OHM,5%,0.25W	57668	NTR25J-E05K6
A17R1519	315-0162-00			RES,FXD,FILM:1.6K OHM,5%,0.25W	19701	5043CX1K600J
A17R1521	307-0839-00			RES,FXD,FILM:200K OHM,1%,3W,TC=250PPM/DEG C	07716	GS3 200K OHM+-1%
A17R1611	315-0202-00			RES,FXD,FILM:2K OHM,5%,0.25W	57668	NTR25J-E 2K
A17R1615	308-0642-00			RES,FXD,WW:40.0 OHM,0.5%,0.5W	91637	RS12B40R000
A17R1621	315-0103-00			RES,FXD,FILM:10K OHM,5%,0.25W	19701	5043CX10K00J
A17R1626	315-0105-00			RES,FXD,FILM:1M OHM,5%,0.25W	19701	5043CX1M000J
A17R1637	308-0788-00			RES,FXD,WW:20 OHM,5%,1W	75042	BW-20F-20R00J
A17S1731	260-1518-00			SWITCH,SENS:DPDT,5A,125VAC,MOMENTARY	01963	E61-00A
A17U1110	156-1149-01			MICROCKT,LINEAR:OPERATION AMP JFET INPUT	27014	AL160307
A17U1120	156-1156-00			MICROCKT,LINEAR:OPERATIONAL AMPLIFIER	27014	LF356N
A17U1210	156-1492-01			MICROCKT,LINEAR:OPERATIONAL AMPLIFIER,SCRN (EARLY INSTRUMENTS MAY USE SELECTED 156-0921-01.PARTS ARE INTERCHANGEABLE.)	24355	AD040764
A17U1230	156-1306-00			MICROCKT,LINEAR:TTL,4.5 DIGIT A/D CONVERTER	17856	SLD2004
A17U1300	156-0796-01			MICROCKT,DGTL:8 STG SHF & STORE BUS RGTR	02735	CD4094BFX
A17U1400	156-0350-01	B010100	B021903	MICROCKT,DGTL:CMOS,QUAD 2-INPUT NAND GATE	80009	156-0350-01
A17U1400	156-0350-05	B021904		MICROCKT,DGTL:QUAD 2 INPUT NAND GATE	02735	CD4011BFX
A17U1500	156-0796-01			MICROCKT,DGTL:8 STG SHF & STORE BUS RGTR	02735	CD4094BFX

Component No.	Tektronix Part No.	Serial/Assembly No. Effective	Dscont	Name & Description	Mfr. Code	Mfr. Part No.
A17U1601	156-1160-00			MICROCKT,LINEAR:VOLTAGE REGULATOR	04713	MC78L12ACG
A17U1603	156-0991-00			MICROCKT,LINEAR:VOLTAGE REGULATOR	04713	MC78L05ACP
A17U1605	156-1207-00			MICROCKT,LINEAR:VOLTAGE REGULATOR,-12 V	04713	MC79L12ACG
A17VR1001	152-0278-00			SEMICOND DVC,DI:ZEN,SI,3V,5%,0.4W,DO-7	04713	SZG35009K20
A17VR1011	152-0227-00			SEMICOND DVC,DI:ZEN,SI,6.2V,5%,0.4W,DO-7	04713	SZ13903
A17VR1013	152-0278-00			SEMICOND DVC,DI:ZEN,SI,3V,5%,0.4W,DO-7	04713	SZG35009K20
A17VR1015	152-0227-00			SEMICOND DVC,DI:ZEN,SI,6.2V,5%,0.4W,DO-7	04713	SZ13903
A17VR1124	152-0278-00			SEMICOND DVC,DI:ZEN,SI,3V,5%,0.4W,DO-7	04713	SZG35009K20
A17VR1126	152-0278-00			SEMICOND DVC,DI:ZEN,SI,3V,5%,0.4W,DO-7	04713	SZG35009K20
A17VR1129	152-0217-00			SEMICOND DVC,DI:ZEN,SI,8.2V,5%,0.4W,DO-7	04713	SZG20
A17VR1223	152-0778-00			SEMICOND DVC,DI:ZEN,SI,22V,2%,0.4W,DO-35	04713	SZG30337RL
A17VR1225	152-0778-00			SEMICOND DVC,DI:ZEN,SI,22V,2%,0.4W,DO-35	04713	SZG30337RL
A17VR1321	152-0526-00			SEMICOND DVC,DI:ZEN,SI,6.35V,1%,0.4W,DO-7	14552	DT840615A
A17VR1501	152-0195-00			SEMICOND DVC,DI:ZEN,SI,5.1V,5%,0.4W,DO-7	04713	SZ11755RL
A17VR1514	152-0777-00			SEMICOND DVC,DI:ZEN,SI,27V,2%,0.4W,DO-35	04713	SZG30343RL
A17W1613	131-0566-00			BUS,COND:DUMMY RES,0.094 OD X 0.225L	24546	OMA 07
A17A1	670-6945-00	B010100	B021903	CIRCUIT BD ASSY:RELAY	80009	670-6945-00
A17A1	670-6945-01	B021904		CIRCUIT BD ASSY:RELAY (NO ELECTRICAL PARTS)	80009	670-6945-01

DIAGRAMS AND CIRCUIT BOARD ILLUSTRATIONS

Symbols

Graphic symbols and class designation letters are based on ANSI Standard Y32.2-1975.

Logic symbology is based on ANSI Y32.14-1973 in terms of positive logic. Logic symbols depict the logic function performed and may differ from the manufacturer's data.

The overline on a signal name indicates that the signal performs its intended function when it is in the low state.

Abbreviations are based on ANSI Y1.1-1972.

Other ANSI standards that are used in the preparation of diagrams by Tektronix, Inc. are:

Y14.15, 1966	Drafting Practices.
Y14.2, 1973	Line Conventions and Lettering.
Y10.5, 1968	Letter Symbols for Quantities Used in Electrical Science and Electrical Engineering.

American National Standard Institute
1430 Broadway
New York, New York 10018

Component Values

Electrical components shown on the diagrams are in the following units unless noted otherwise:

Capacitors = Values one or greater are in picofarads (pF). Values less than one are in microfarads (μF).

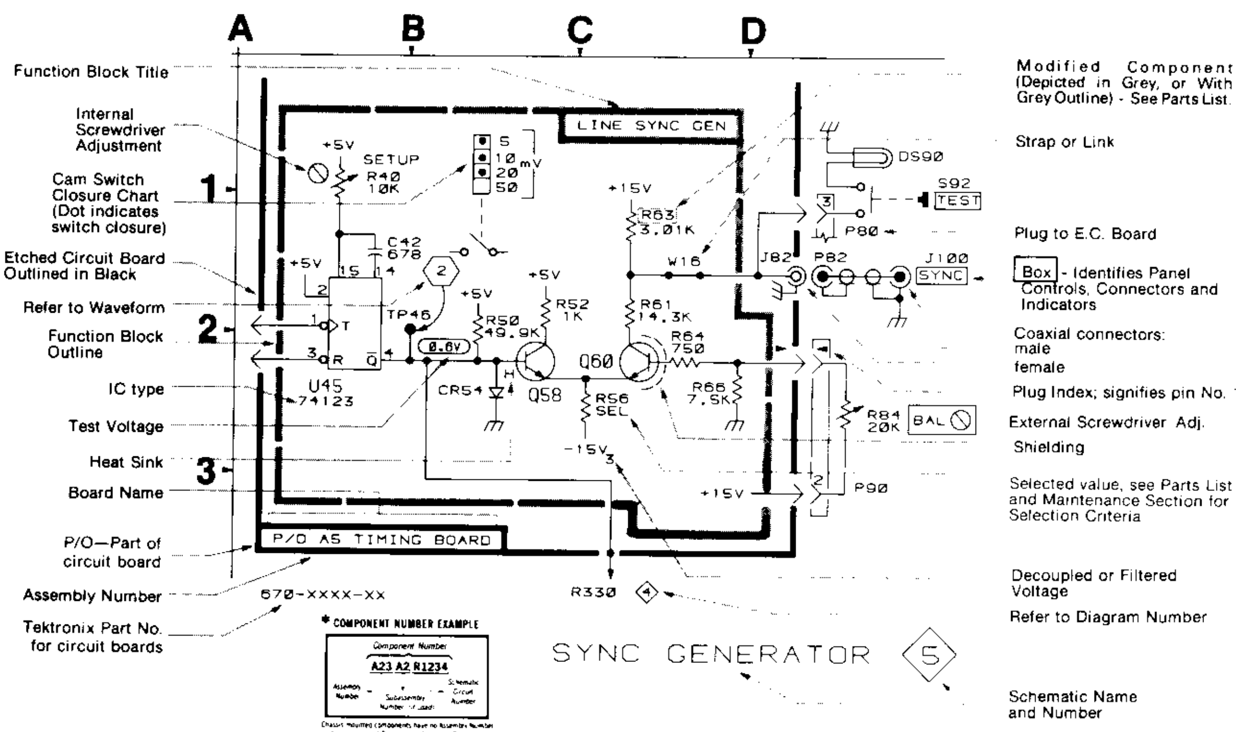
Resistors = Ohms (Ω).

The information and special symbols below may appear in this manual.

Assembly Numbers and Grid Coordinates

Each assembly in the instrument is assigned an assembly number (e.g., A20). The assembly number appears on the circuit board outline on the diagram, in the title for the circuit board component location illustration, and in the lookup table for the schematic diagram and corresponding component locator illustration. The Replaceable Electrical Parts list is arranged by assemblies in numerical sequence; the components are listed by component number *(see following illustration for constructing a component number).

The schematic diagram and circuit board component location illustration have grids. A lookup table with the grid coordinates is provided for ease of locating the component. Only the components illustrated on the facing diagram are listed in the lookup table. When more than one schematic diagram is used to illustrate the circuitry on a circuit board, the circuit board illustration may only appear opposite the first diagram on which it was illustrated; the lookup table will list the diagram number of other diagrams that the circuitry of the circuit board appears on.



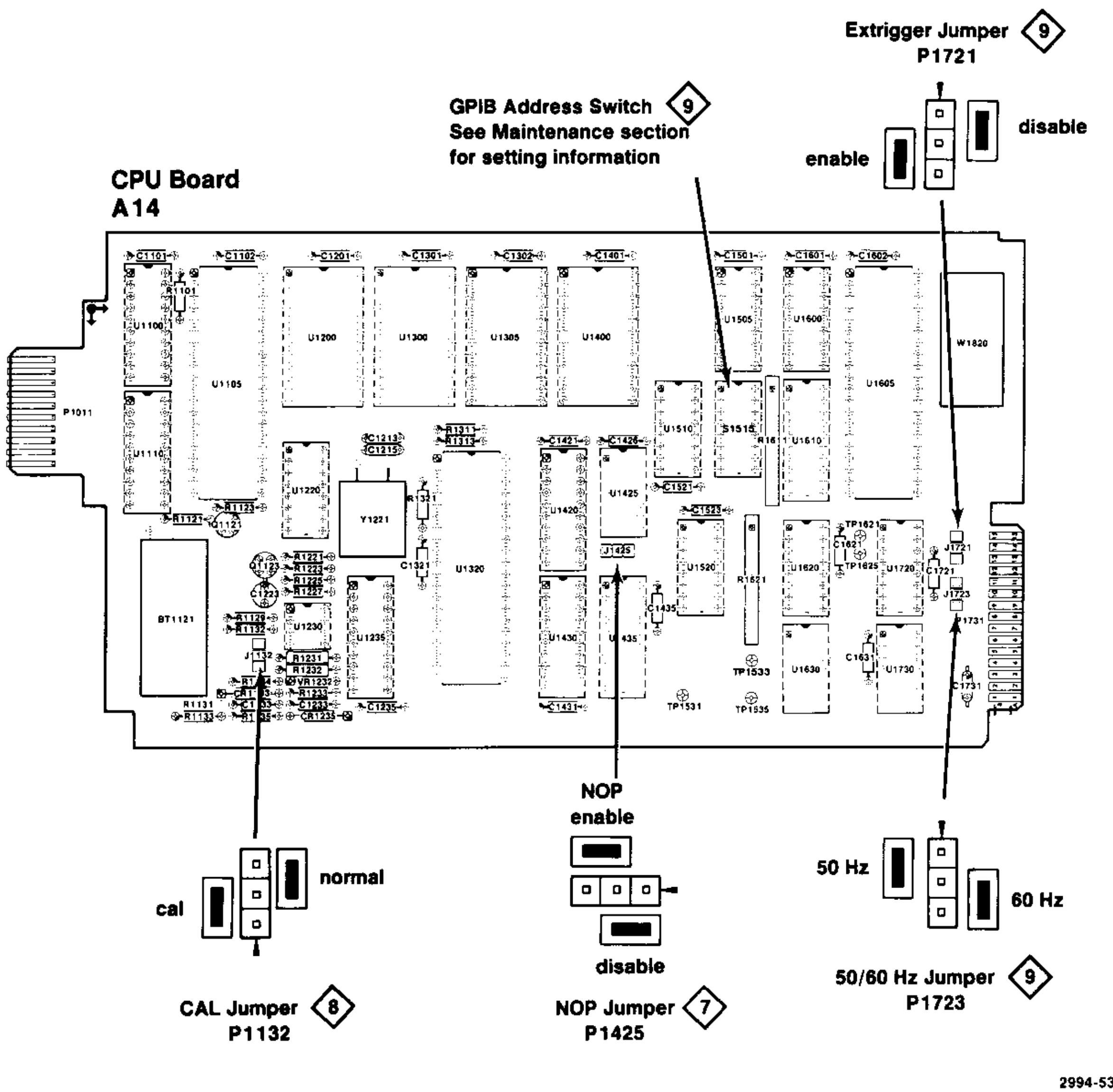
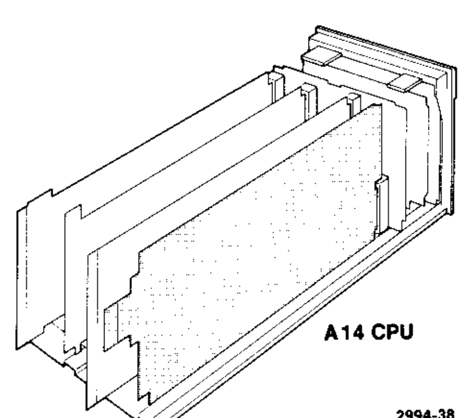


Fig. 10-1 Jumper and GPIB address switch locations.



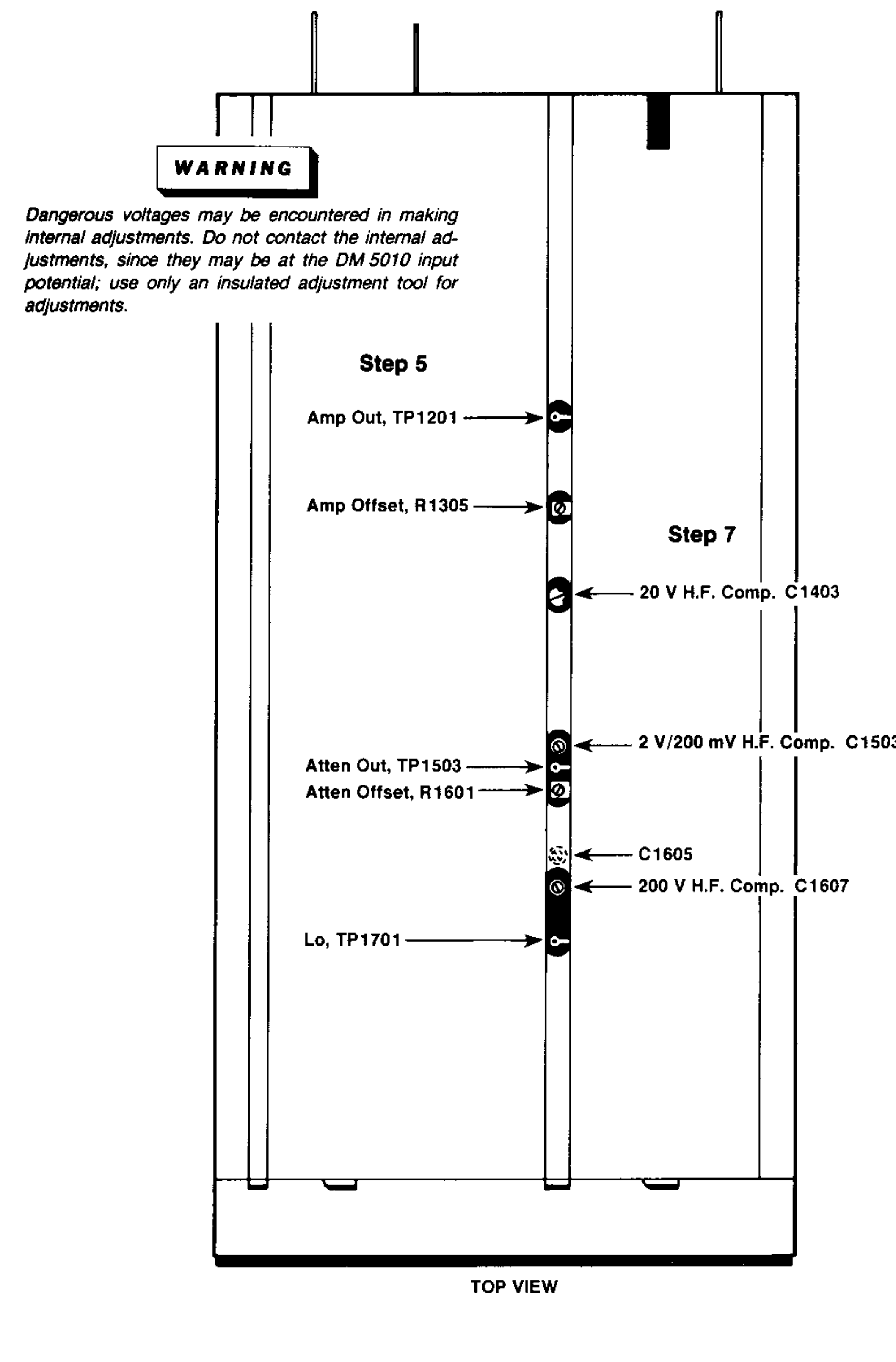
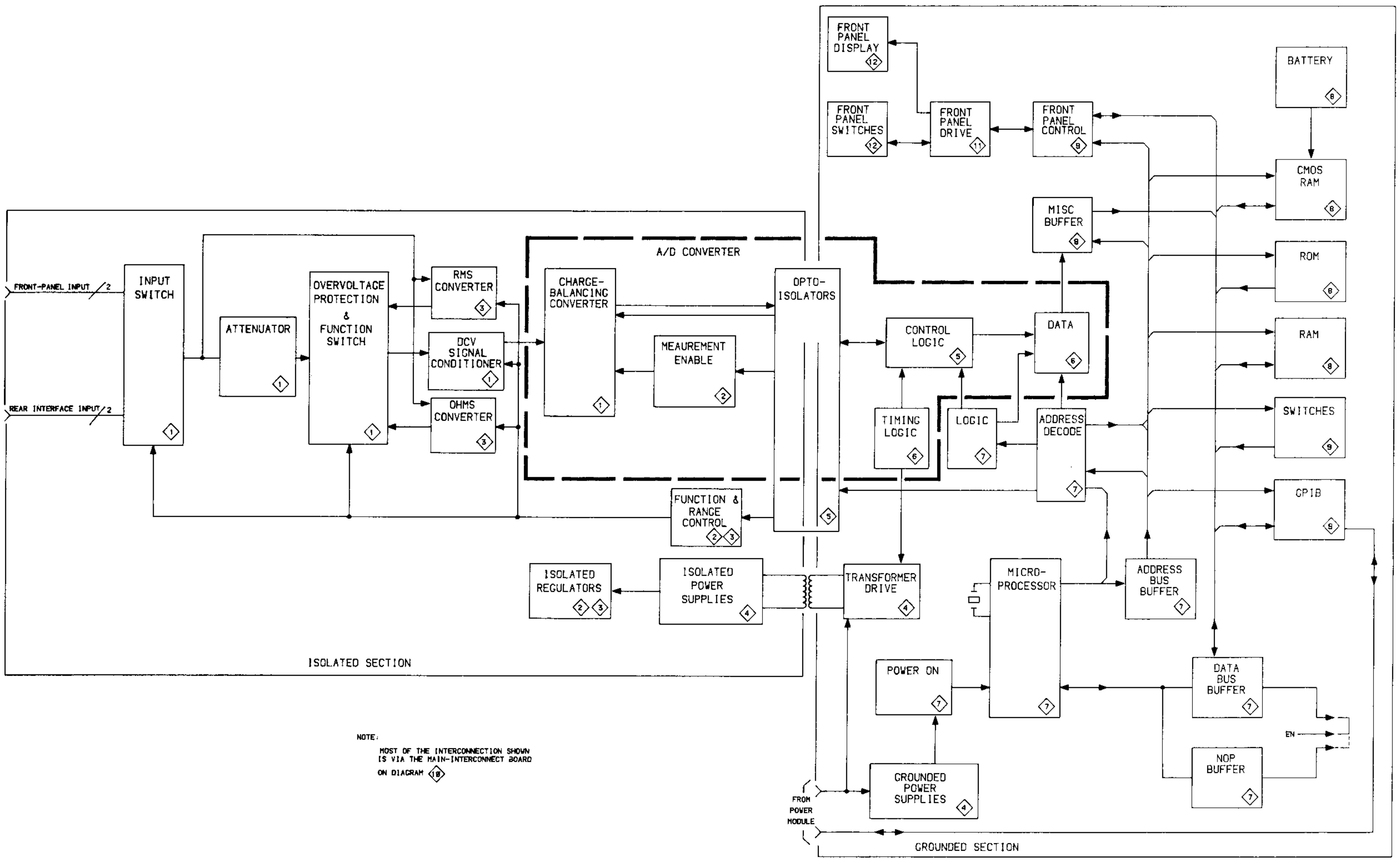


Fig. 10-2. Location of DM 5010 adjustments and test points. 3



2984-112

DM 5010 BLOCK DIAGRAM

Table 10-1
COMPONENT REFERENCE CHART

P/O A17 ASSY — ADC BOARD (1)

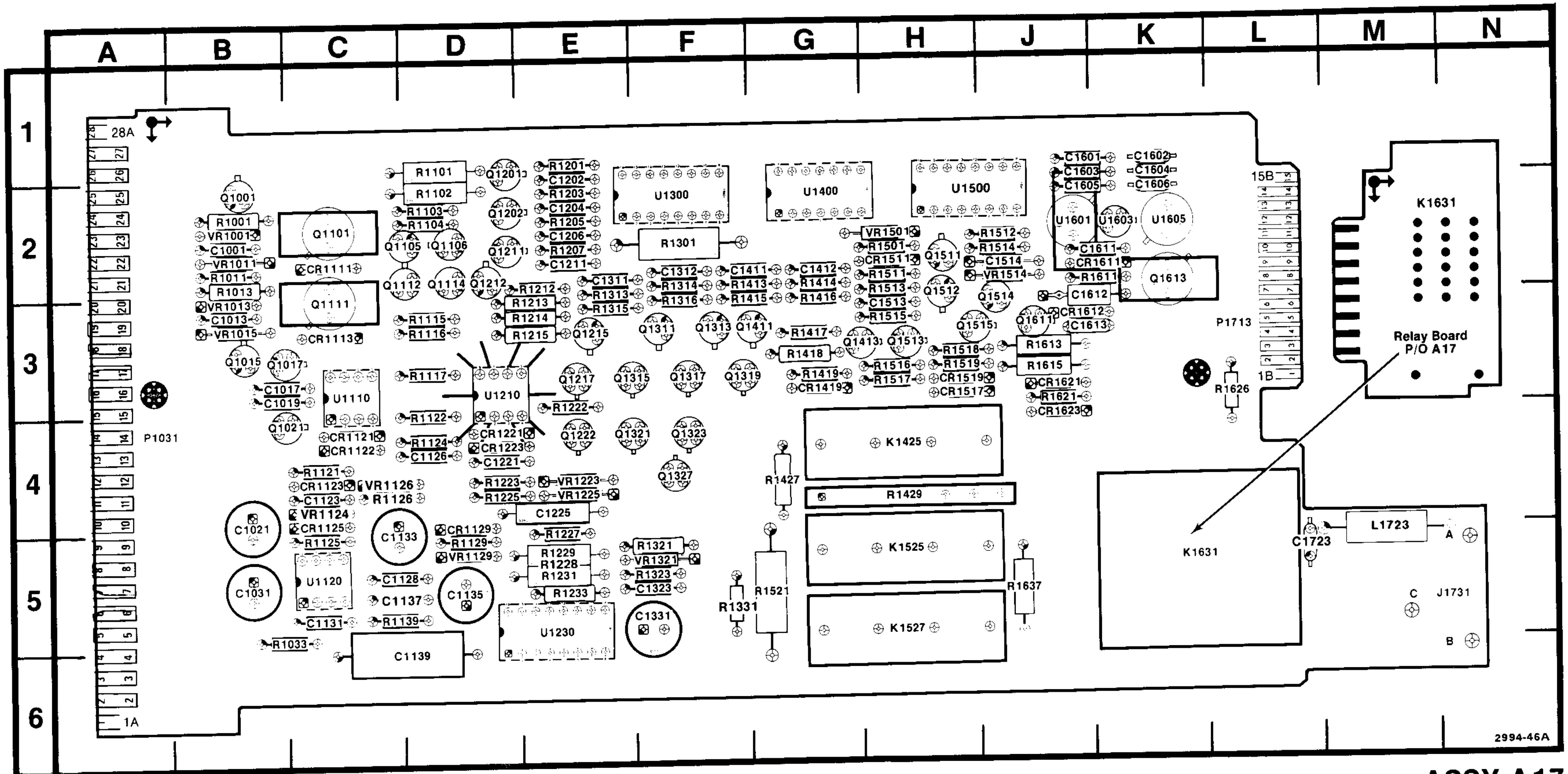
CIRCUIT NUMBER	SCHEMATIC LOCATION	BOARD LOCATION
C1001	B6	B2
C1013	C9	B3
C1017	D7	B3
C1019	D8	B3
C1021*	J6	B4
C1031*	J7	B5
C1123	J6	C4
C1126	C6	D4
C1128	J9	C5
C1131	J7	C5
C1133*	J9	C5
C1135*	I9	D5
C1137	J9	C5
C1139	J7	D6
C1221	C6	D4
C1225	K6	E4
C1323	K8	F5
C1331	J8	F5
C1723	C3	L5
CR1111	D7	C2
CR1113	D9	C3
CR1121*	D8	C4
CR1122*	C8	C4
CR1123*	H6	C4
CR1125*	H7	C4
CR1129	L6	D4
CR1221*	D5	D4
CR1223*	C5	D4
CR1419	G5	G3
CR1517	F5	H3
CR1519	F2	H3
CR1621	C2	J3
CR1623	D1	J4
J1731	B2	N5
K1425	G4	H4
K1525	F4	H5
K1527	F2	H5
K1631	D1	K5
L1723	C2	M5
P1713	H9	K3
Q1001	C7	B2
Q1015	C8	B3
Q1017	E7	B3
Q1021	E8	C4
Q1101	D6	C2
Q1105	F7	D2
Q1106	H7	D2
Q1111	D9	C3
Q1112	F6	D2
Q1114	G6	D2
Q1217	K3	E3
Q1222	I5	E4
Q1315	K5	F3
Q1317	K4	F3
Q1319	J3	F3
Q1321	H4	F4
Q1323	I3	F4
Q1327	H3	F4

CIRCUIT NUMBER	SCHEMATIC LOCATION	BOARD LOCATION
R1001	C7	B2
R1011	B8	B2
R1013	C9	B2
R1033	I9	C5
R1101	G7	D1
R1102	G7	D2
R1103	G6	D2
R1104	G6	D2
R1115	E5	D2
R1116	F8	D2
R1117	D7	D2
R1120*	H6	
R1121	H7	C4
R1122	D9	D4
R1124	D6	D4
R1125	I7	C5
R1126	I6	C4
R1129	L6	D5
R1139	J7	C5
R1212	H8	E2
R1213	H8	E3
R1214	H8	E3
R1215	L3	E3
R1222	C5	E3
R1223	I3	D4
R1225	J4	D4
R1227	K6	E5
R1228	J7	E5
R1229	J6	E5
R1231	K6	E5
R1233	J7	E5
R1301	L5	F2
R1315	K3	E3
R1316	K5	F3
R1321	J7	F5
R1323	J7	F5
R1331	L7	F5
R1415	J4	G3
R1416	J4	G3
R1418	K5	G3
R1419	G5	G3
R1427	G3	G4
R1429	G4	H4
R1517	E4	H3
R1519	F2	H3
R1521	G3	G5
R1615	C1	J3
R1626	E3	L3
R1637	E2	J5
S1731	B3	N5
U1110	D8	C3
U1120	J7	C5
U1210	D5	D2
U1230	L7	E5
VR1001	B7	B2
VR1011	C8	B2
VR1013	B9	B3
VR1015	C8	B3
VR1124	I7	C4
VR1126	I6	C4
VR1129	L6	D5
VR1223	I4	E4
VR1225	J3	E4
VR1321	J8	F5
W1613	C1	J3

*See Parts List for serial number ranges.

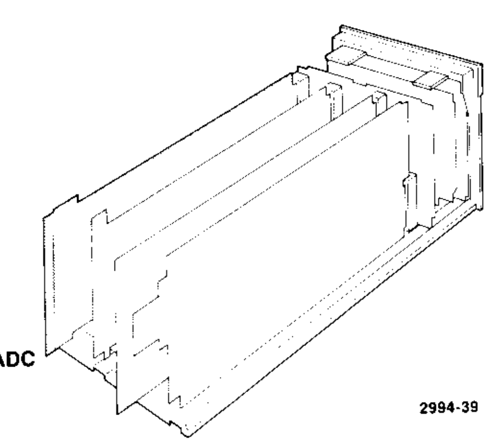
P/O A17 ASSY also shown on (2)

PARTS LOCATION GRID



ASSY A17

Fig. 10-3. ADC Board (A17)



Static Sensitive Devices
See Maintenance Section

COMPONENT NUMBER EXAMPLE

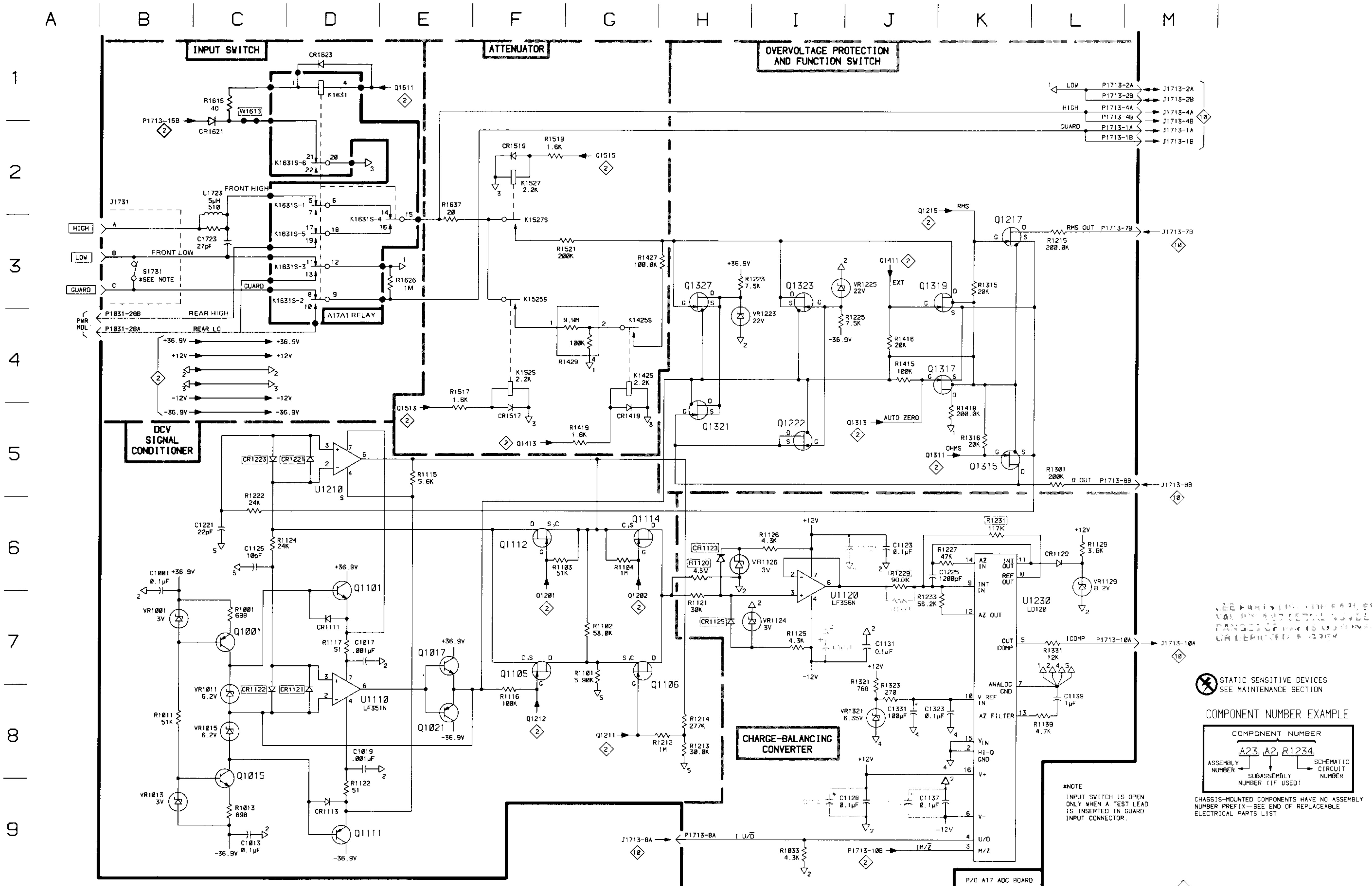
Component Number
A23 A2 R1234
Assembly Number — Subassembly Number (if used) — Schematic Circuit Number

Chassis-mounted components have no Assembly Number prefix—see end of Replaceable Electrical Parts List

REV JULY 1986

Table 10-2
INPUT & ATTENUATION SWITCHING

Switches, Transistors Actuated	REAR INPUT	INPUT X1	INPUT ÷ 10	RMS TERMINATION	AUTO ZERO	DCV 1 KV	DCV 200 V	DCV 20 V	DCV 2 V	DCV 200 mV	ACV 700 V	ACV 200 V	ACV 20 V	ACV 2 V	ACV 200 mV	ACV + DCV 700 V	ACV + DCV 200 V	ACV + DCV 20 V	ACV + DCV 2 V	ACV + DCV 200 mV	OHMS EXT 20 MΩ	OHMS EXT 2 MΩ	OHMS EXT 200 KΩ	OHMS EXT 20 KΩ	OHMS EXT 2KΩ	OHMS EXT 200 Ω	OHMS TOTAL 20 MΩ	OHMS TOTAL 2 MΩ	OHMS TOTAL 200 KΩ	OHMS TOTAL 20 KΩ	OHMS TOTAL 2 KΩ	OHMS TOTAL 200 Ω	COMMENTS			
Rear Input Switch																																				
K1631	X																																Selects front or rear inputs			
Input Attenuation Switches																																				
K1527		X																															Provides input attenuation of 1			
K1525			X																														Used only with K1425 to provide ÷ 10			
K1425			X	X																													Provides RMS termination when used alone			
Function Switches																																				
Q1317					X																												On when zeroing A/D converter			
Q1217																																	On when using RMS converter			
Q1315																											X	X	X	X	X	X	On when measuring Ohms total			
Q1319						X	X	X	X	X											X	X	X	X	X	X							On when measuring an external voltage			
DCV Gain Switches																																	Gain of the DCV Converter	10	1	0.1
Q1105										X												X	X	X	X	X								X		
Q1106						X		X																						X		X				X
Q1112						X	X	X	X		X	X	X	X	X	X	X	X	X	X	X						X	X	X	X	X	X			X	X
Q1114							X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X			X	X	



DM 5010

2994-100
REV JULY 1986

INPUT SIG CONDITIONING

INPUT & ATTEN SWITCHING

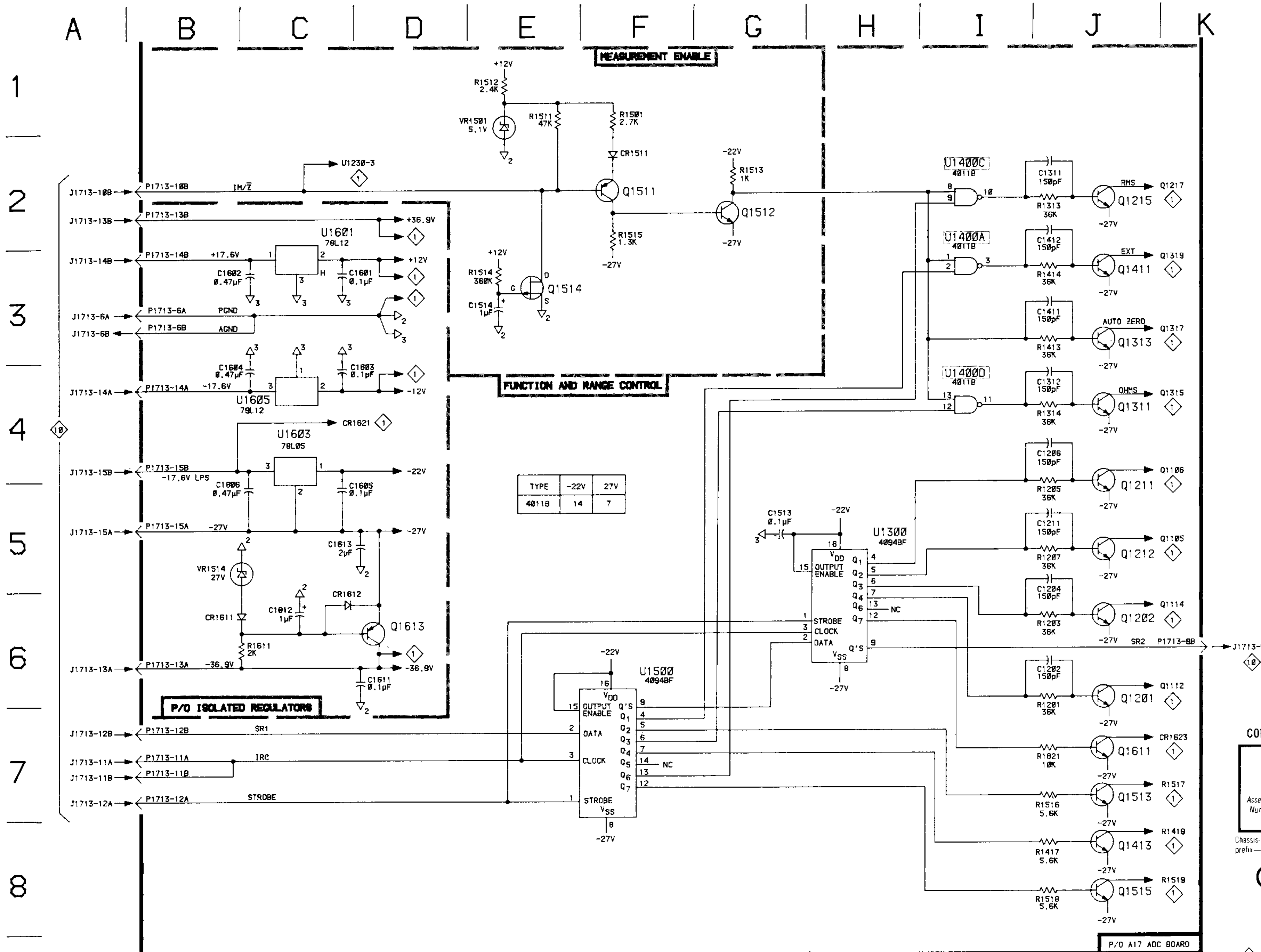
Table 10-3
COMPONENT REFERENCE CHART
(See Fig. 10-3)

P/O A17 ASSY — ADC BOARD ⟨2⟩

CIRCUIT NUMBER	SCHEMATIC LOCATION	BOARD LOCATION	CIRCUIT NUMBER	SCHEMATIC LOCATION	BOARD LOCATION
C1202	J6	E1	Q1513	J7	H3
C1204	J5	E2	Q1514	E3	J3
C1206	J4	E2	Q1515	J8	J3
C1211	J5	E2	Q1611	J7	J3
C1311	J2	E2	Q1613	D6	K2
C1312	J4	F2			
C1411	J3	G2	R1201	J7	E1
C1412	J2	G2	R1203	J6	E2
C1513	G5	H3	R1205	J5	E2
C1514	E3	J2	R1207	J5	E2
C1601	D3	J1	R1313	J2	E2
C1602	B3	K1	R1314	J4	F2
C1603	D4	J1	R1413	J3	G2
C1604	B4	K1	R1414	J3	G2
C1605	D5	J2	R1417	J8	G3
C1606	B5	K2	R1501	F1	H2
C1611	D6	K2	R1511	E1	H2
C1612	C6	J3	R1512	E1	J2
C1613	C5	J3	R1513	G2	H2
			R1514	E3	J2
CR1511	F2	H2	R1515	F2	H3
CR1611	B6	K2	R1516	J7	H3
CR1612	C6	J3	R1518	J8	H3
			R1611	C6	K2
Q1201	J6	D1	R1621	J7	J3
Q1202	J6	D2			
Q1211	J5	D2	U1300	H5	F2
Q1212	J5	D2	U1400*	I2	G2
Q1215	J2	E3	U1500	F6	H2
Q1311	J4	F3	U1601	C2	J2
Q1313	J3	F3	U1603	C4	K2
Q1411	J3	G3	U1605	C4	K2
Q1413	J8	H3			
Q1511	F2	H2	VR1501	E1	H2
Q1512	G2	H2	VR1514	B5	J2

P/O A17 ASSY also shown on ⟨1⟩

*See Parts List for serial number ranges.



TYPE	-22V	27V
4011B	14	7

COMPONENT NUMBER EXAMPLE

Component Number

A23 A2 R1234

Assembly Number — Subassembly Number (if used) — Schematic Circuit Number

Chassis-mounted components have no Assembly Number prefix—see end of Replaceable Electrical Parts List.

Static Sensitive Devices
See Maintenance Section

Table 10-4
COMPONENT REFERENCE CHART

A16 ASSY — RMS BOARD ⟨3⟩

CIRCUIT NUMBER	SCHEMATIC LOCATION	BOARD LOCATION
C1001	I9	B2
C1013	I2	B3
C1101	J7	B2
C1103	I6	C2
C1105	J6	C2
C1107	J8	D2
C1111	G3	C3
C1113	I2	C3
C1301	F8	E2
C1303	F9	E2
C1311	G9	F3
C1403	G8	F2
C1405	G8	F2
C1415	E1	G3
C1417	C1	G3
C1503	F7	H2
C1505	F7	H2
C1513	D3	H3
C1515	C3	H3
C1525	C3	H4
C1526	D3	H4
C1527	C2	H4
C1528	D2	H4
C1601	E8	J2
C1603	E9	J2
C1605	D9	J2
C1607	D8	K2
C1609	D8	K2
C1621	C7	J5
CR1011	J3	B3
CR1021	H2	B3
CR1023	L5	B4
CR1121*	H2	C3
CR1201	L8	D2
CR1225	J2	D3
CR1227	I2	D3
CR1231	L4	E4
CR1233	L6	E4
CR1415	L5	G3
CR1511	L7	G3
CR1513	L7	H3
CR1527	L9	H4
CR1529	L8	H4
CR1613	D7	J3
CR1615	D7	K3
K1031	L6	B5
K1031	K3	B5
K1131	L3	C5
K1131	L6	C5
K1201	H8	D2
K1201	L8	D2
K1231	J4	D5
K1231	L5	D5
K1313	G1	F3
K1313	L5	F3
K1405	L8	G2
K1503	F7	H2
K1503	L7	H2
K1621	L9	K4
K1621	C8	K4
K1633	L9	K5
K1633	C7	K5
P1711	B7	L3
Q1021	I3	B4
Q1320	L4	F4
Q1420	L7	G4

CIRCUIT NUMBER	SCHEMATIC LOCATION	BOARD LOCATION
R1003	K7	B2
R1013	I3	B3
R1021	H1	B3
R1031	K3	B5
R1032	L6	B5
R1033	K3	B5
R1101	I9	C2
R1121	H3	C3
R1123	G2	C3
R1201	H7	D2
R1211	H8	D2
R1221	G2	D3
R1223	G1	D3
R1225	H1	D3
R1229	I1	E3
R1231	L5	E5
R1233	L6	E5
R1303	H7	E2
R1305	H7	F2
R1307	G7	F2
R1309	G9	F2
R1321	I1	E3
R1323	D2	E3
R1325	K5	F4
R1327	K6	F4
R1331	K3	E5
R1333	J2	E5
R1401	G7	F2
R1403	G7	F2
R1415	D1	G3
R1421	K6	F4
R1423	K5	F4
R1425	K8	G4
R1426	K8	G4
R1427	K7	G4
R1429	K9	G4
R1501	E7	G2
R1521	K9	G4
R1523	L9	H4
R1525	L9	H4
R1601	E7	J2
R1603	D7	J2
R1609	C8	K2
R1621	C7	K4
R1633	B7	K6
RT1011	J3	A3
RT1227	I2	D3
TP1201	I7	E2
TP1503	F7	H2
TP1701	D7	K1
U1100	J7	C2
U1120	H2	C4
U1200	H7	E2
U1200	E9	E2
U1330	I4	F5
U1417	D1	G3
U1430	G4	G5
U1500	D9	H2
U1500	E7	H2
U1515	C3	H3
U1525	D3	H4
U1527	D2	H4
U1530	E8	H5
U1530	F5	H5
VR1013	I3	B3
VR1123	G3	D3
VR1415	G4	G3

*See Parts List for serial number ranges.

PARTS LOCATION GRID

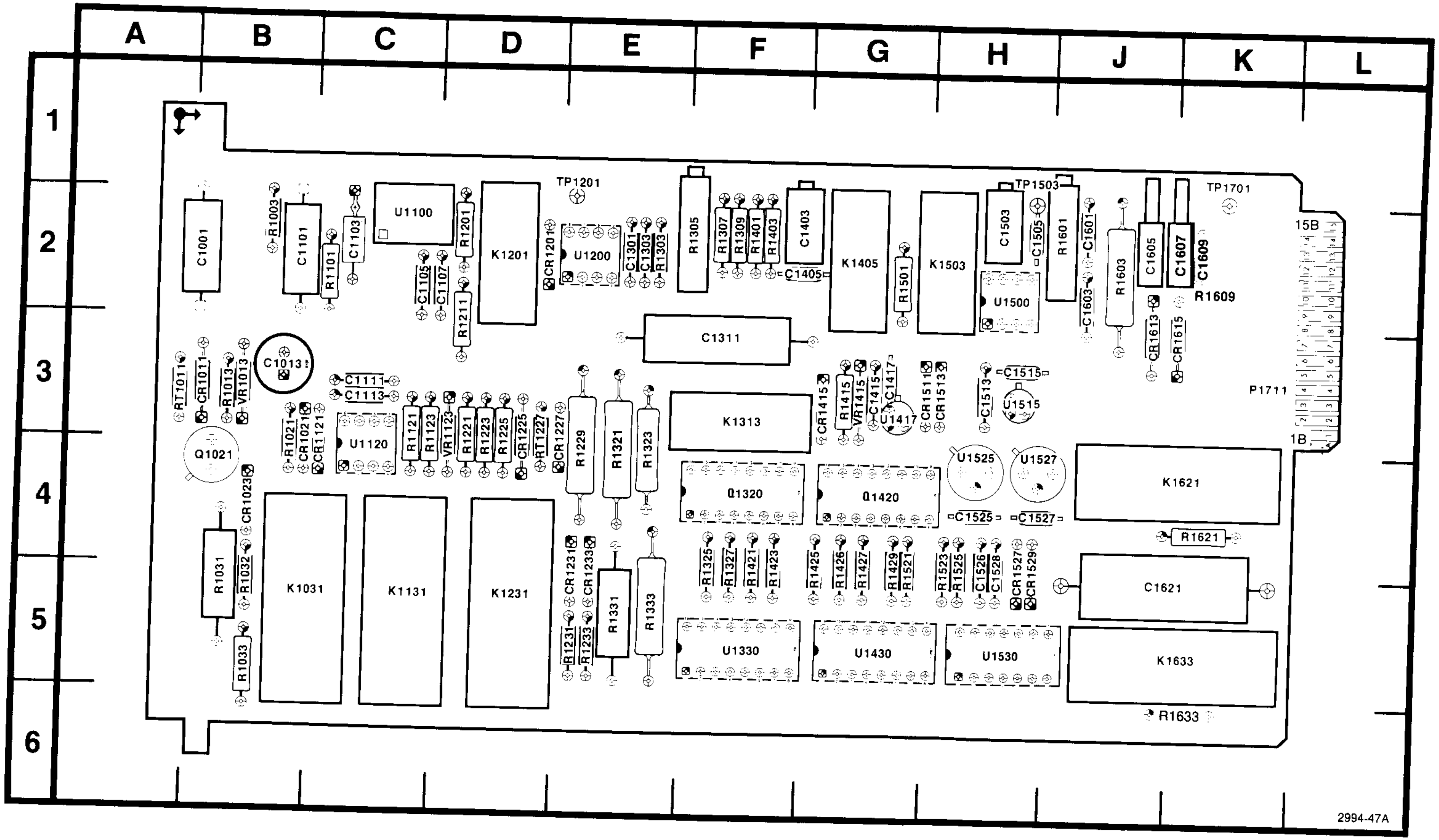


Fig. 10-4. RMS Board (A16).

ASSY A16

Static Sensitive Devices
See Maintenance Section

COMPONENT NUMBER EXAMPLE

Component Number
A23 A2 R1234
Assembly Number — Subassembly Number (if used) — Schematic Circuit Number

Chassis mounted components have no Assembly Number prefix—see end of Replaceable Electrical Parts List.

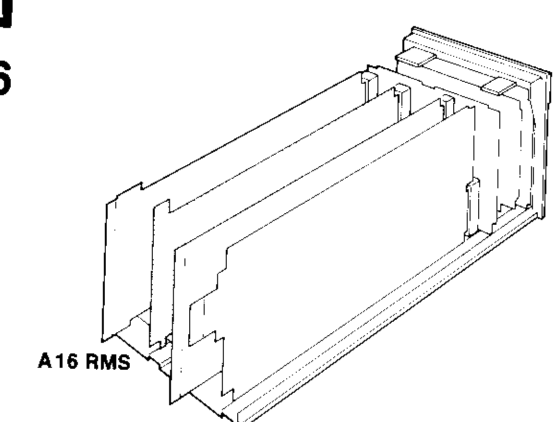
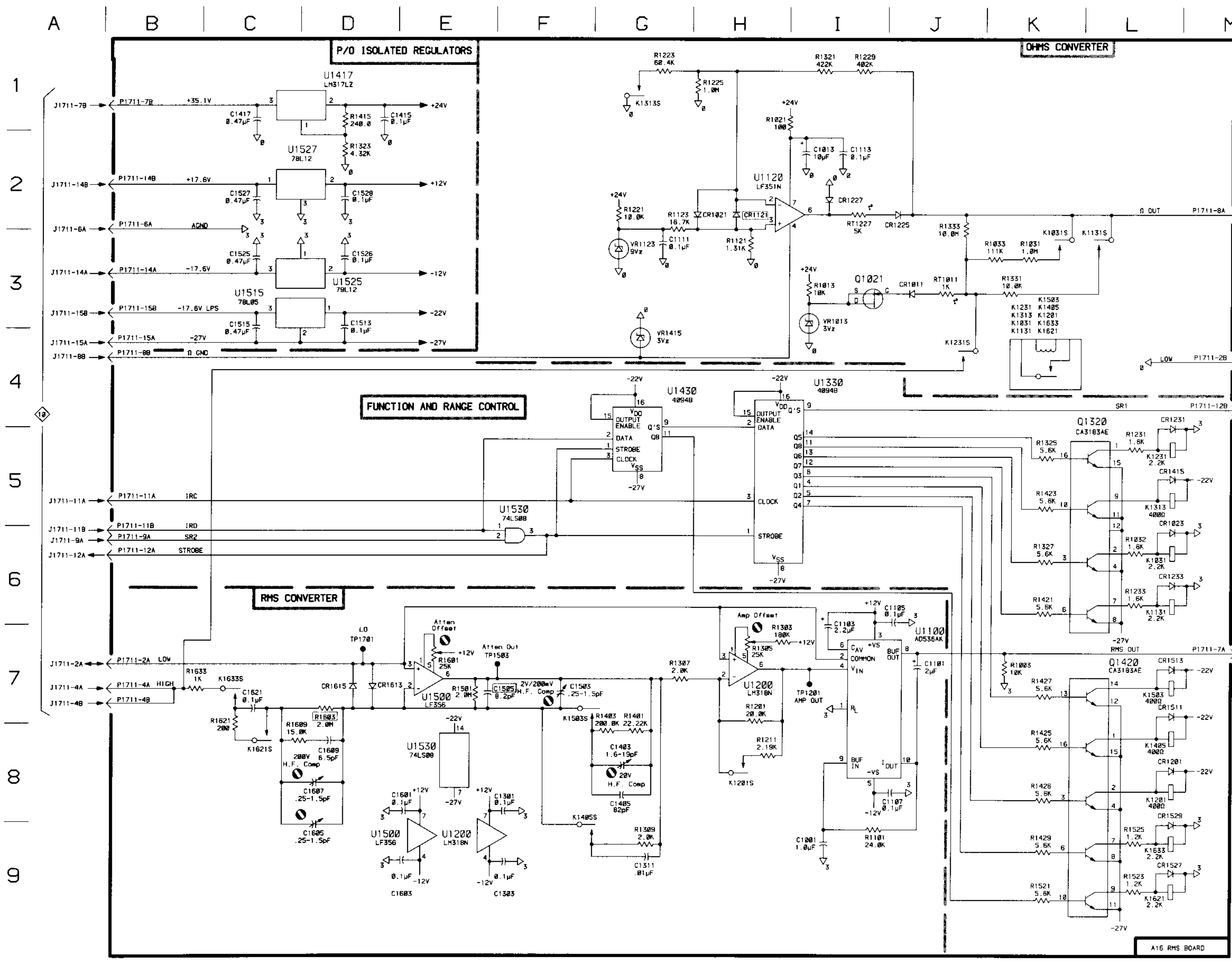


Table 10-5
INPUT & ATTENUATION SWITCHING

Switches, Transistors Actuated	MODE AND RANGE					DCV					ACV					ACV + DCV					OHMS EXT						OHMS TOTAL						COMMENTS					
	REAR INPUT	INPUT X1	INPUT ÷ 10	RMS TERMINATION	AUTO ZERO	1 kV	200 V	20 V	2 V	200 mV	700 V	200 V	20 V	2 V	200 mV	700 V	200 V	20 V	2 V	200 mV	20 MΩ	2 MΩ	200 KΩ	20 KΩ	2KΩ	200 Ω	20 MΩ	2 MΩ	200 KΩ	20 KΩ	2KΩ	200Ω						
Ohms Voltage Switching																																						
K1313																								X		X				X		X	Changes Ohms source voltage					
K1131																									X	X					X	X	R_{ref} = 10 kΩ					
K1031																							X	X					X	X			R_{ref} = 1MΩ					
K1231																					X	X	X	X	X	X	X	X	X	X	X	X	Connects R_{ref} in series with R_{ext}					
RMS Converter Switching																																						
K1633											X	X	X	X	X	X	X	X	X	X													External input to RMS Converter					
K1621																X	X	X	X	X													Bypasses AC input for ACV + DCV					
RMS Gain Switches																																	Gain of the RMS Converter	10	1	0.1	0.01	0.001
K1201											X		X	X		X		X	X																X	X		X
K1405											X	X				X	X																				X	X
K1503													X					X																		X		



SEE PARTS LIST FOR EARLIER VALUES AND SERIAL NUMBER RANGES OF PARTS OUTLINED OR DEPICTED IN GREY

STATIC SENSITIVE DEVICES SEE MAINTENANCE SECTION

COMPONENT NUMBER EXAMPLE

COMPONENT NUMBER

A23 A2 R1234

ASSEMBLY NUMBER — SUBASSEMBLY NUMBER (IF USED) — SCHEMATIC CIRCUIT NUMBER

CHASSIS-MOUNTED COMPONENTS HAVE NO ASSEMBLY NUMBER PREFIX—SEE END OF REPLACEABLE ELECTRICAL PARTS LIST

Table 10-6
COMPONENT REFERENCE CHART

P/O A15 ASSY — ISOLATION BOARD ⟨4⟩

CIRCUIT NUMBER	SCHEMATIC LOCATION	BOARD LOCATION	CIRCUIT NUMBER	SCHEMATIC LOCATION	BOARD LOCATION
C1001	D2	B2	CR1509	H5	H2
C1005	F3	B2	CR1515	H6	G3
C1021	J3	B5	CR1605	H8	J2
C1101	E2	C1			
C1107	F1	C2	F1111	B1	C3
C1111	G1	C2	F1113	C7	C3
C1113	H1	C2			
C1121	J3	C5	L1201	F8	D2
C1131	J3	C6	L1203	F5	D2
C1201	F6	D2			
C1203	E7	E2	P1031	B1	A6
C1215	D8	D3			
C1216	D7	E3	Q1101	F2	C1
C1221	I3	E4	Q1104	D2	C2
C1223	J3	E5	Q1105	C2	C2
C1301	H9	F1	Q1201	F8	D1
C1321	J3	E5	Q1202	F6	D2
C1326	J3	F5	Q1211	E8	D3
C1331	J3	E6	Q1212	E6	E3
C1401	I9	G2	Q1213	D9	D3
C1403	H9	G2	Q1214	D7	E3
C1404	I9	G1			
C1421	J3	F5	R1001	D2	B2
C1426	K3	G5	R1003	D3	B2
C1501	J6	H1	R1005	F3	B2
C1502	J7	J2	R1101	E1	C1
C1503	J6	H1	R1102	E2	C1
C1504	J7	J2	R1103	D2	C2
C1505	I7	J1	R1104	C2	C2
C1511	J6	H2	R1105	F3	D1
C1513	J6	H3	R1106	F2	D1
C1515	I6	J2	R1107	E1	C1
C1521	K3	H5	R1108	B2	C2
C1526	K3	H5	R1109	B2	C2
C1601	I7	J1	R1201	F6	E2
C1603	J8	K1	R1211	E8	D3
C1611	I6	J2	R1212	E6	E3
C1621	K3	J5	R1213	D8	D3
C1626	K3	J5	R1214	D6	E3
C1701	J8	K1	R1215	D8	D3
C1721	K3	K5	R1216	D6	E3
C1731	I3	L6	R1217	E4	D3
CR1201	F7	D2	T1311	G6	F2
CR1203	F5	D2	TP1421	B4	F3
CR1211	E8	D2			
CR1212	E5	E2	U1000	E2	B1
CR1501	I5	H2	U1325	C7	F4
CR1503	H5	H2			
CR1505	I5	H2	VR1001	D3	B2
CR1507	H7	H2	VR1216	E4	E3

P/O A15 ASSY also shown on ⟨5⟩ ⟨6⟩

PARTS LOCATION GRID

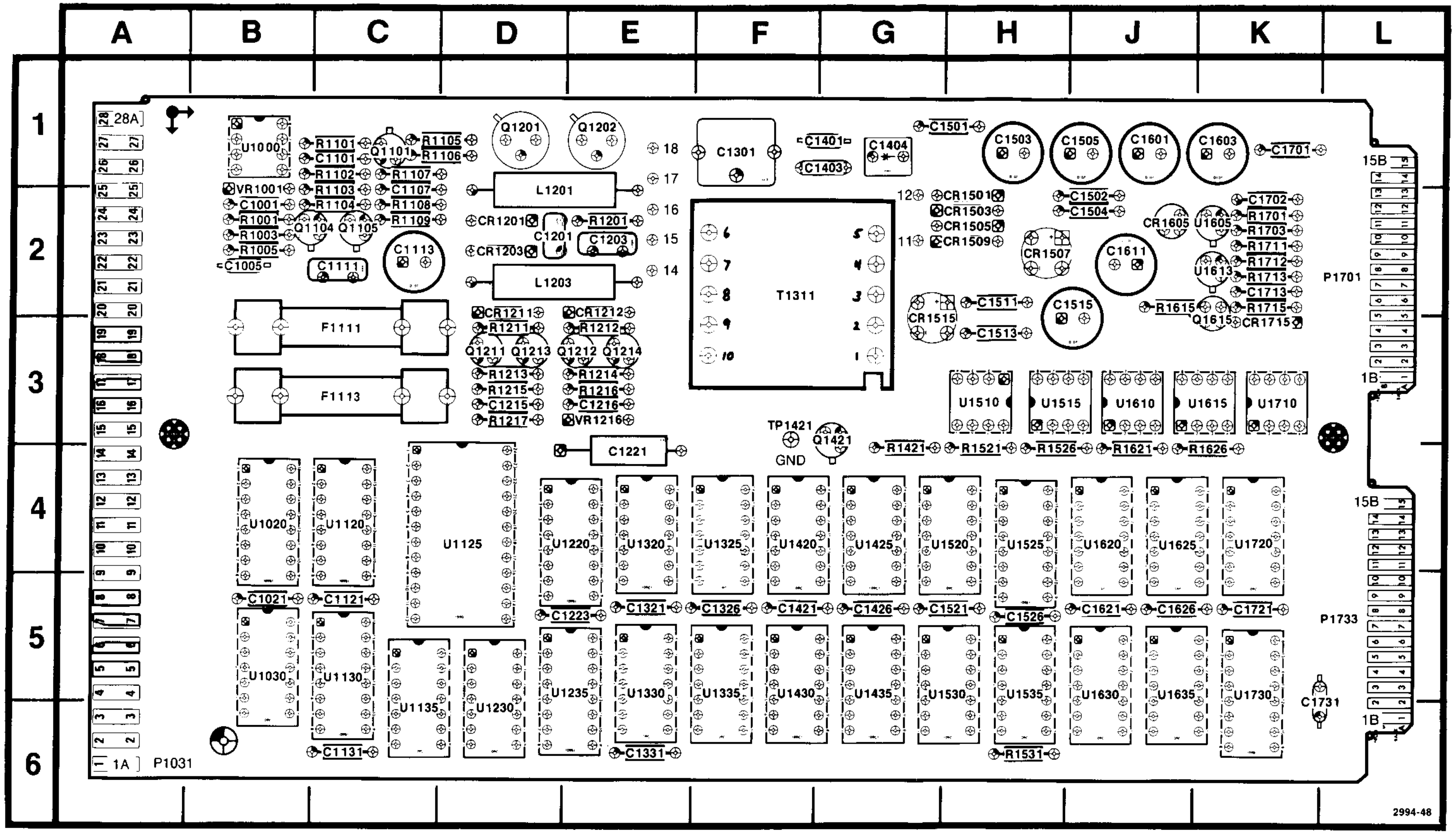
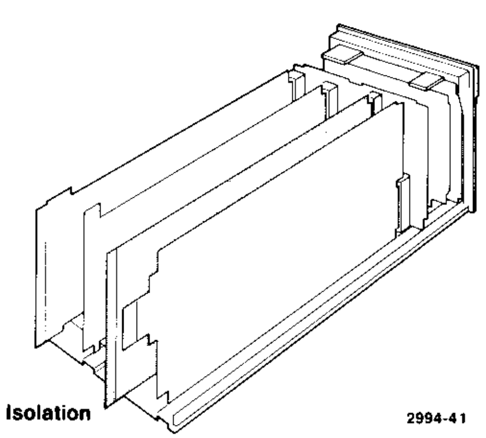


Fig. 10-5. Isolation Board (A15).

ASSY A15

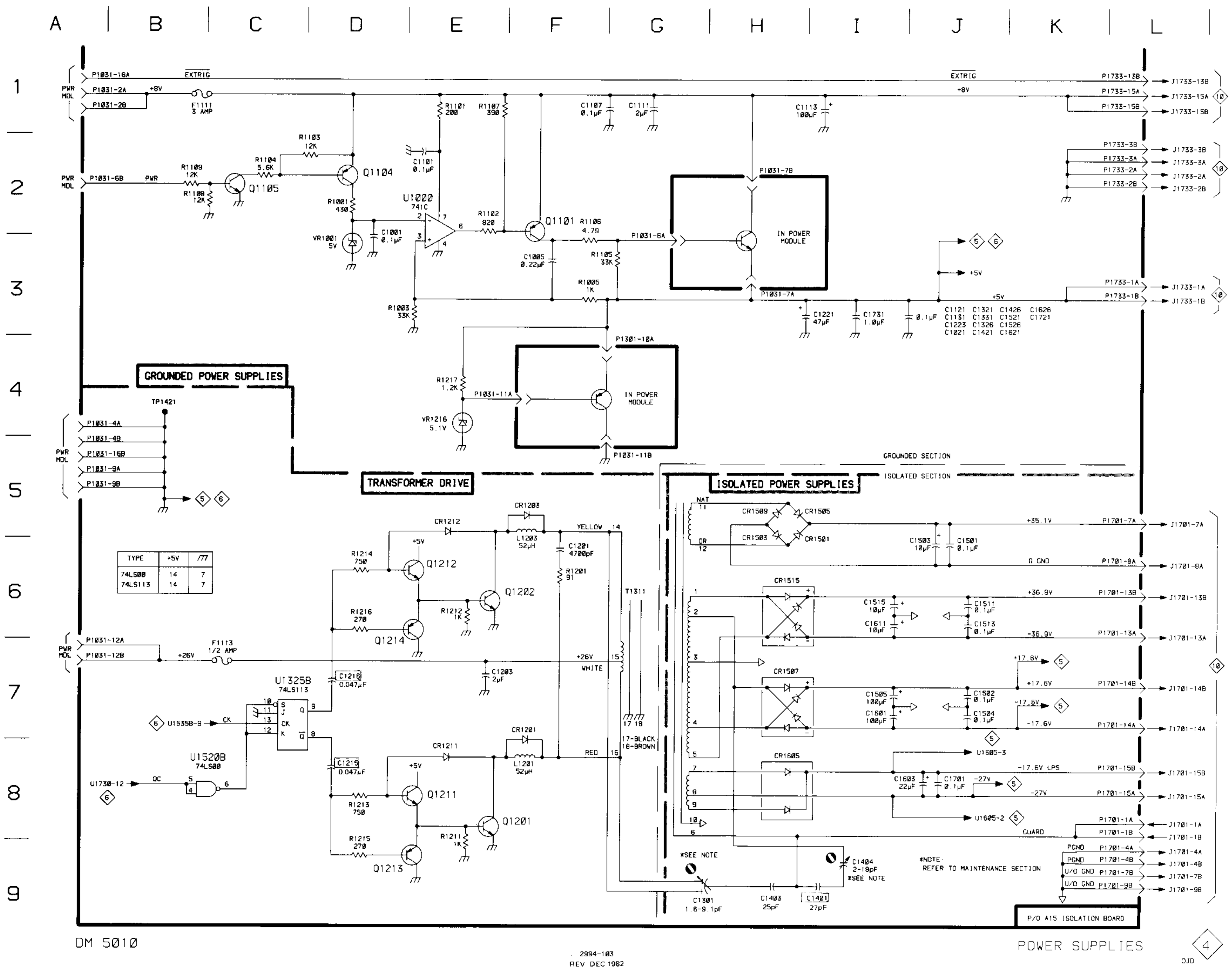


Static Sensitive Devices
See Maintenance Section

COMPONENT NUMBER EXAMPLE

Component Number
A23 A2 R1234
Assembly Number
Subassembly Number (if used)
Schematic Circuit Number

Chassis-mounted components have no Assembly Number prefix—see end of Replaceable Electrical Parts List



SEE PARTS LIST FOR EARLIER VALUES AND SERIAL NUMBER RANGES OF PARTS OUTLINED OR DEPICTED IN GREY.

STATIC SENSITIVE DEVICES
SEE MAINTENANCE SECTION

COMPONENT NUMBER EXAMPLE

COMPONENT NUMBER
A23 A2 R1234
ASSEMBLY NUMBER — SUBASSEMBLY NUMBER (IF USED) — SCHEMATIC CIRCUIT NUMBER

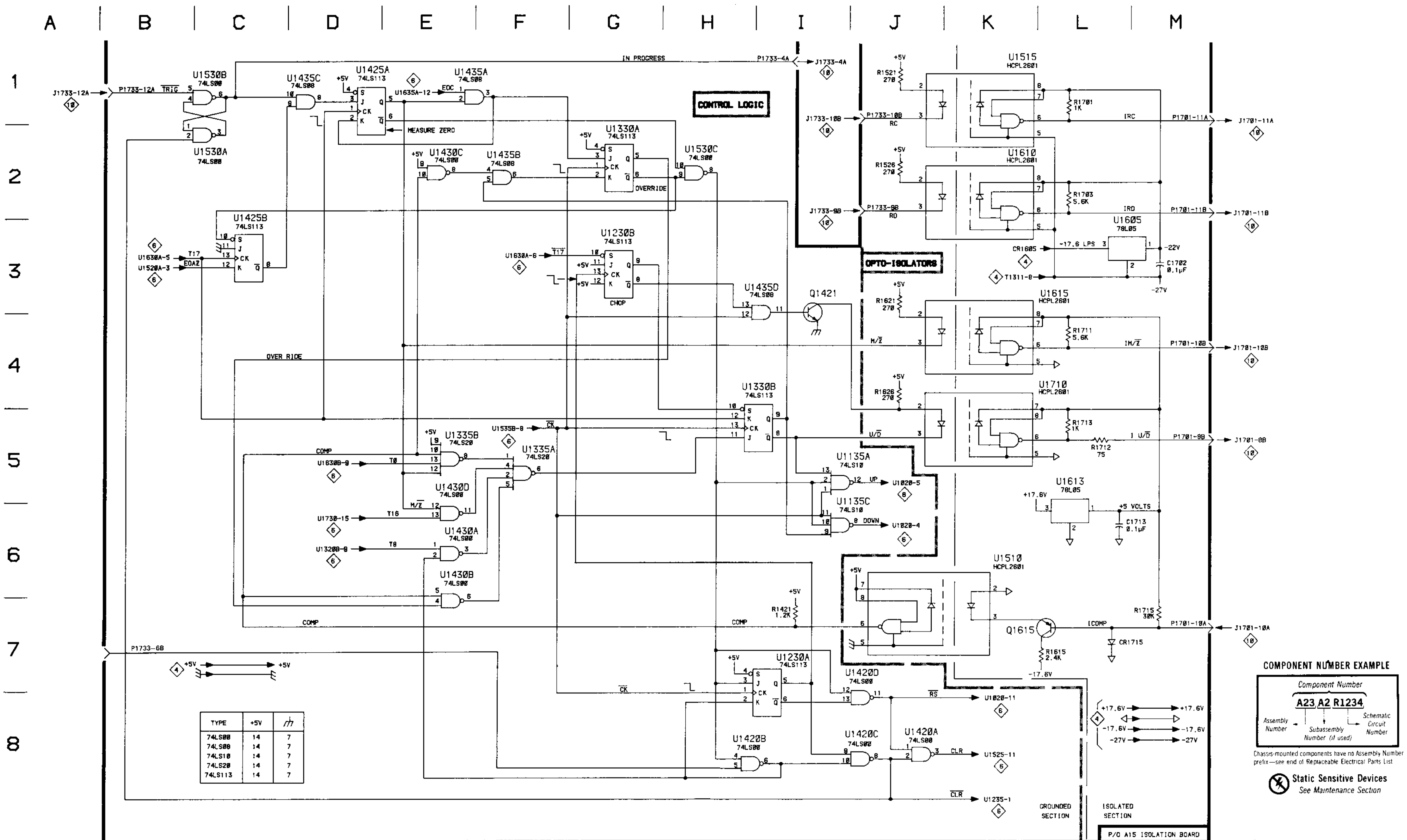
CHASSIS-MOUNTED COMPONENTS HAVE NO ASSEMBLY NUMBER PREFIX—SEE END OF REPLACEABLE ELECTRICAL PARTS LIST

Table 10-7
COMPONENT REFERENCE CHART
(See Fig. 10-5)

P/O A15 ASSY — ISOLATION BOARD ◇5

CIRCUIT NUMBER	SCHEMATIC LOCATION	BOARD LOCATION	CIRCUIT NUMBER	SCHEMATIC LOCATION	BOARD LOCATION
C1702	M3	K2	R1713	L5	K2
C1713	M6	K2	R1715	M7	K2
CR1715	M7	K3			
			U1135	J5	C6
P1701	M7	L2	U1230	I7	D6
			U1330	G2	E5
Q1421	I3	G3	U1335	F5	F5
Q1615	K7	K3	U1420	J8	F4
			U1425	D1	G4
R1421	I7	G4	U1430	E6	F5
R1521	J1	H4	U1435	E1	G5
R1526	J2	H4	U1510	K6	H3
R1615	L7	J2	U1515	K1	H3
R1621	J3	J4	U1530	C1	H5
R1626	J4	K4	U1605	L2	K2
R1701	L1	K2	U1610	K2	J3
R1703	L2	K2	U1613	L5	K2
R1711	L4	K2	U1615	L3	K3
R1712	L5	K2	U1710	L4	K3

P/O A15 ASSY also shown on ◇4 ◇6



TYPE	+5V	⏚
74LS00	14	7
74LS00	14	7
74LS10	14	7
74LS20	14	7
74LS113	14	7

COMPONENT NUMBER EXAMPLE

Component Number
A23 A2 R1234
Assembly Number — Subassembly Number (if used) — Schematic Circuit Number

Chassis-mounted components have no Assembly Number prefix—see end of Replaceable Electrical Parts List

Static Sensitive Devices
See Maintenance Section

COMPONENT REFERENCE CHART

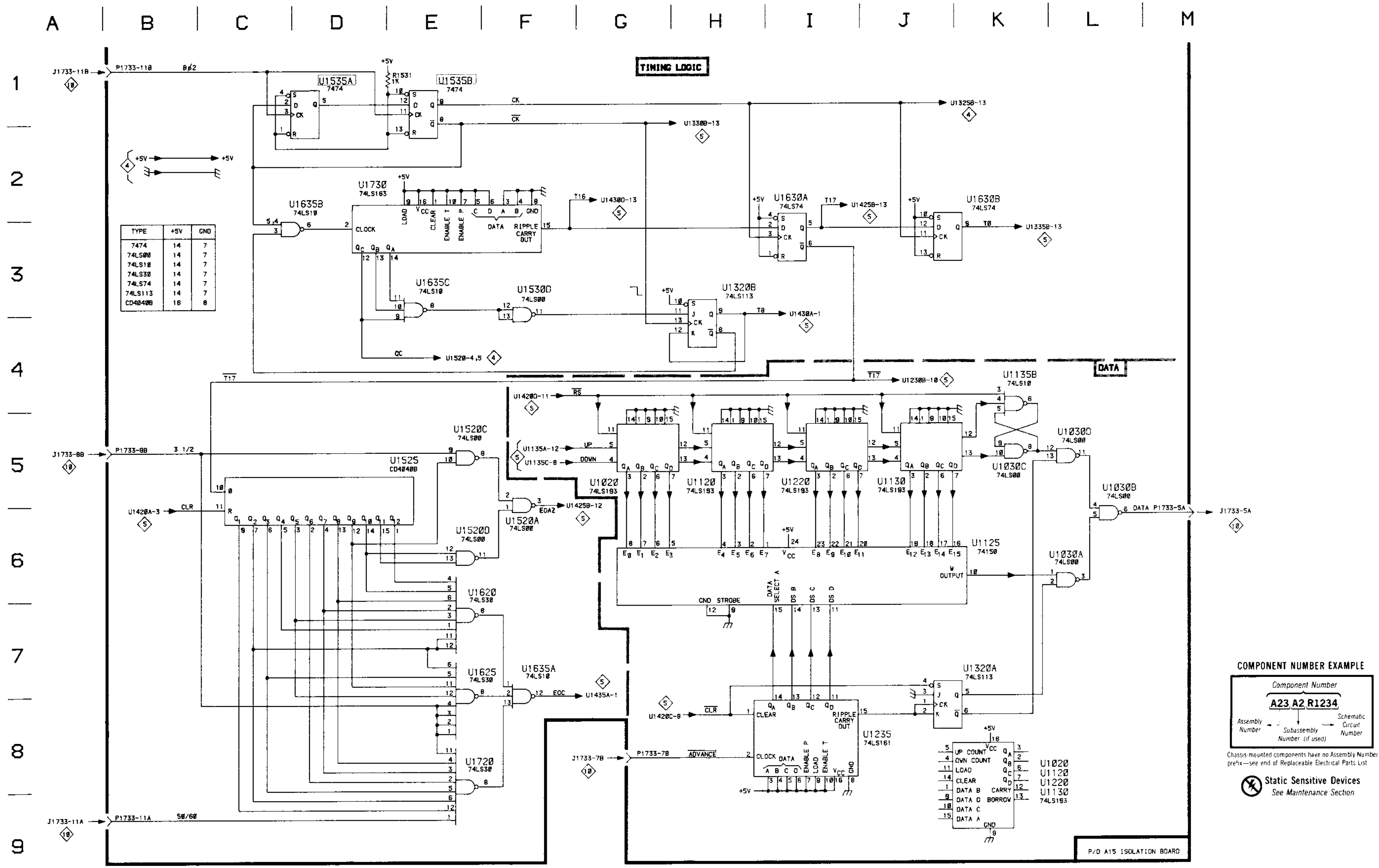
Table 10-8
COMPONENT REFERENCE CHART
(See Fig. 10-5)

P/O A15 ASSY — ISOLATION BOARD 6

CIRCUIT NUMBER	SCHEMATIC LOCATION	BOARD LOCATION	CIRCUIT NUMBER	SCHEMATIC LOCATION	BOARD LOCATION
P1733	M6	L5	U1220	I5	E4
			U1235	J6	E5
R1531	E1	H6	U1320	K7	E4
			U1520	F6	H4
U1020	L8	B4	U1525	E5	H4
U1020	G5	B4	U1535*	D1	H5
U1030	L6	B5	U1620	F6	J4
U1120	L8	C4	U1625	F7	J4
U1120	H5	C4	U1630	I2	J5
U1125	K6	D4	U1635	F7	J5
U1130	L9	C5	U1720	F8	K4
U1130	J5	C5	U1730	D2	K5
U1220	L8	E4			

P/O A15 ASSY also shown on 4 5

*See Parts List for serial number ranges.



TYPE	+5V	GND
7474	14	7
74LS00	14	7
74LS10	14	7
74LS30	14	7
74LS74	14	7
74LS113	14	7
CD4040B	16	8

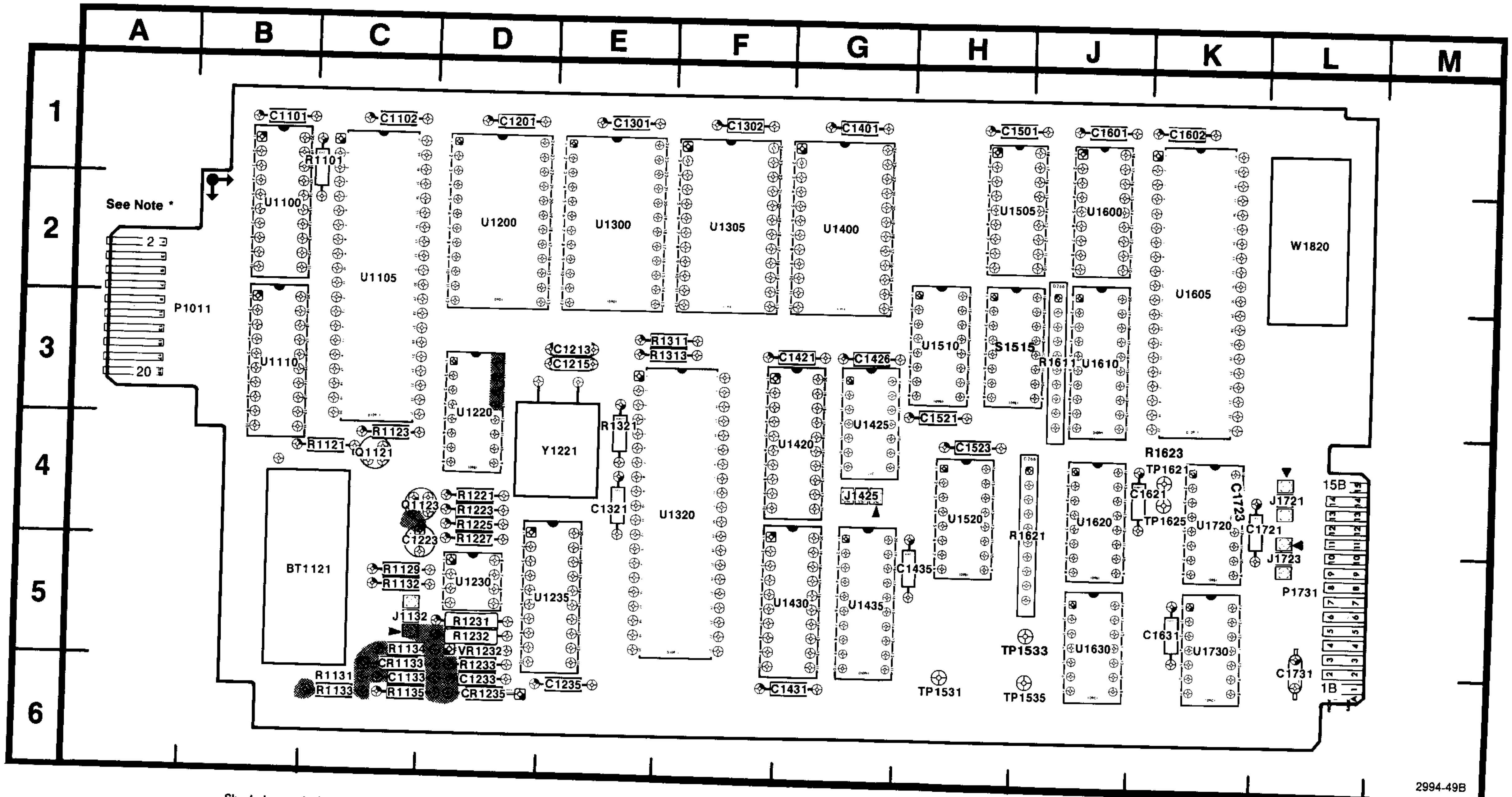
Table 10-9
COMPONENT REFERENCE CHART

P/O A14 ASSY — CPU BOARD ⟨7⟩

CIRCUIT NUMBER	SCHEMATIC LOCATION	BOARD LOCATION	CIRCUIT NUMBER	SCHEMATIC LOCATION	BOARD LOCATION
C1101	E4	B1	R1223	E3	D4
C1102	E4	C1	R1225	D2	D4
C1201	E4	D1	R1227	C2	D4
C1213	E3	E3	R1231	C3	D5
C1215	F3	E3	R1232	C2	D5
C1223	D3	C5	R1233	B3	D6
C1233	E4	D6	R1311	F3	F3
C1235	E5	E6	R1313	F2	F3
C1301	E5	E1	R1321	F2	E4
C1302	E5	F1	R1621	H3	J4
C1321	E4	E4			
C1401	E4	G1	TP1531	B5	H6
C1421	E4	G3	TP1533	H3	J5
C1426	E4	G3	TP1535	K5	J6
C1431	E5	G6	TP1621	L6	K4
C1435	E5	H5	TP1625	K5	K4
C1501	E5	H1			
C1521	E4	H3	U1230	E2	D5
C1523	E4	H4	U1235	E6	E5
C1601	E4	J1	U1320	G1	F4
C1602	E4	K1	U1420	E7	G4
C1621	E5	K4	U1425	H4	G3
C1631	E5	K5	U1430	K3	G5
C1721	E5	K4	U1435	K1	G5
C1731	D4	L5	U1510	I6	H3
			U1520	K8	H4
J1425	I3	G4	U1620	K5	J4
			U1720	L7	K4
P1425	I3	G4	U1730	L9	K5
P1731	B4	L5			
			VR1232	B2	D5
R1129	D2	C5			
R1132	D3	C5	Y1221	E3	E4
R1221	E2	D4			

P/O A14 ASSY also shown on ⟨8⟩ ⟨9⟩

PARTS LOCATION GRID



Shaded areas indicate coated areas of circuit board (both sides).
See CPU Board Coating in Maintenance section.

Fig. 10-6. CPU Board (A14).

ASSY A14

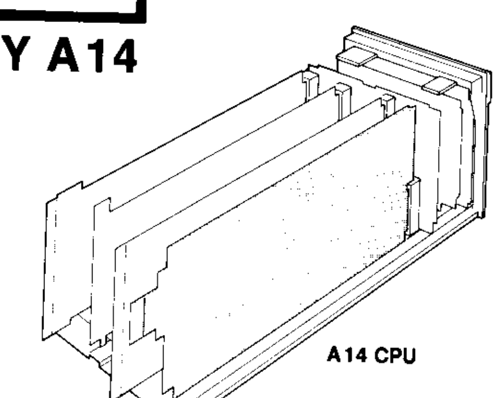
Static Sensitive Devices
See Maintenance Section

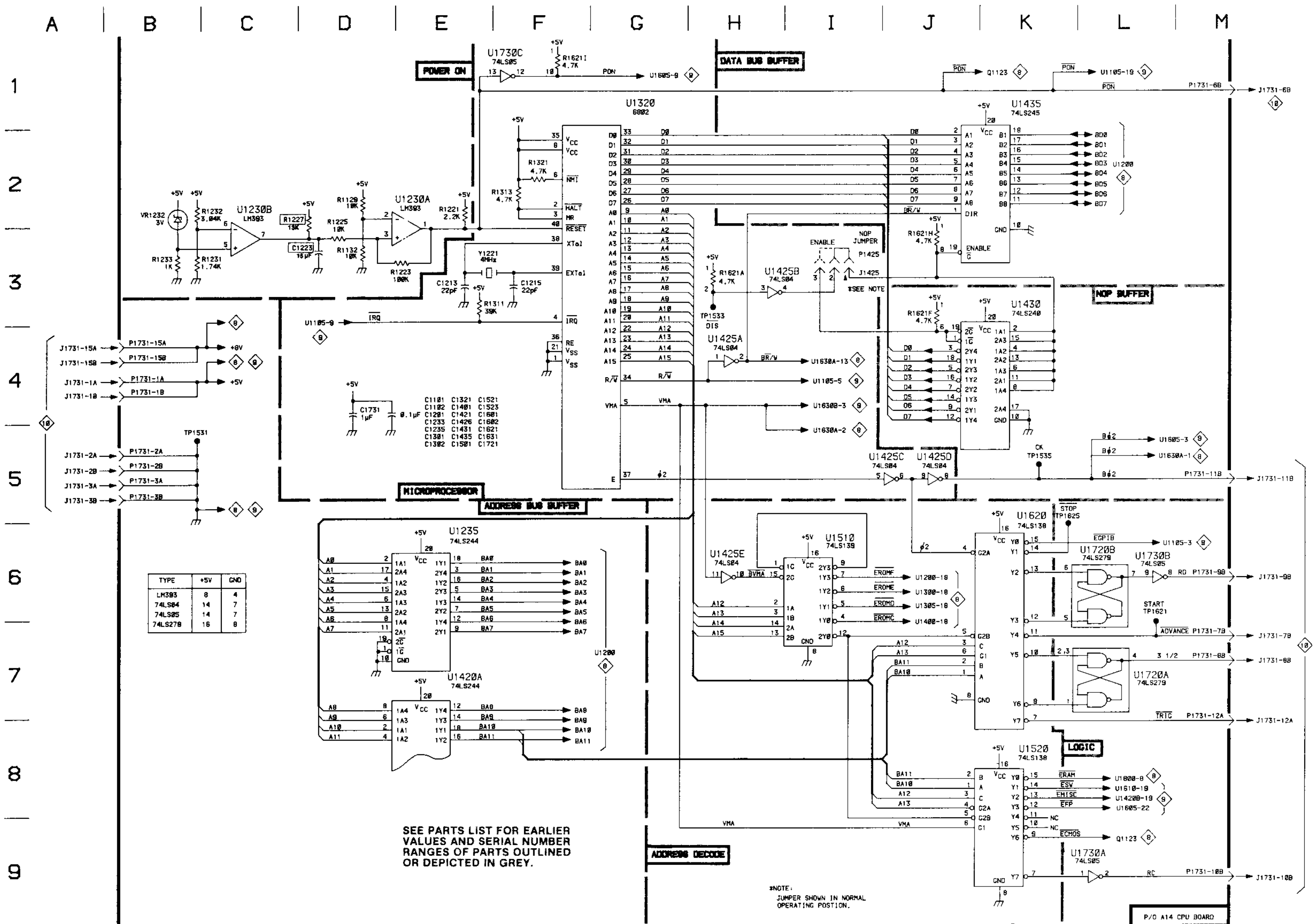
Note: Even numbered connections on side shown.
Odd numbered connections on back side of connector.

COMPONENT NUMBER EXAMPLE

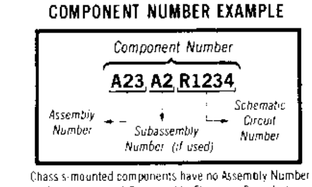
Component Number
A23 A2 R1234
Assembly Number — *Subassembly Number (if used)* — *Schematic Circuit Number*

Chassis mounted components have no Assembly Number prefix—see end of Replaceable Electrical Parts List.

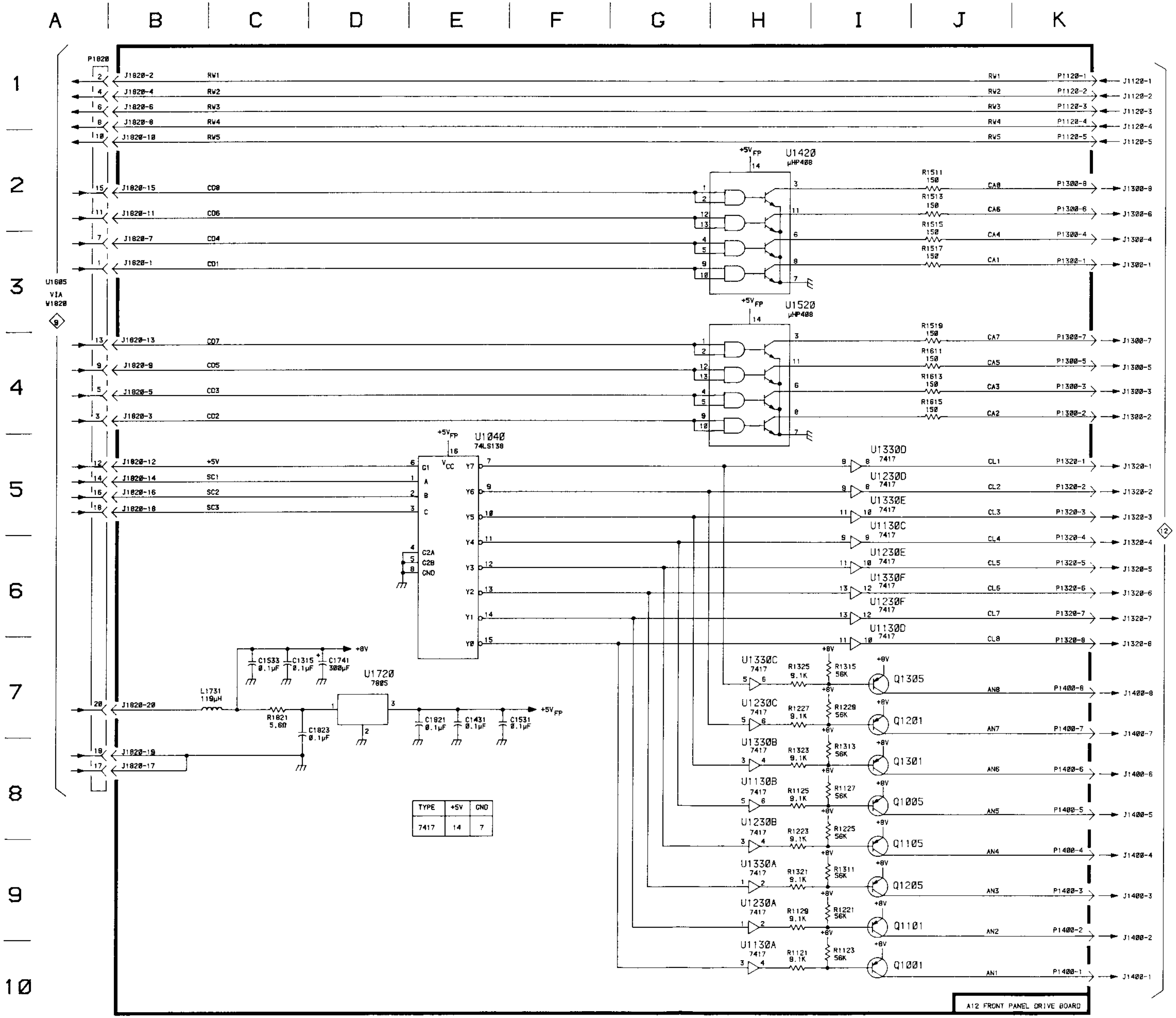




TYPE	+5V	GND
LM393	8	4
74LS04	14	7
74LS05	14	7
74LS279	16	8



Static Sensitive Devices
See Maintenance Section



TYPE	+5V	GND
7417	14	7

COMPONENT NUMBER EXAMPLE

Component Number

A23 A2 R1234

Assembly Number — Subassembly Number (if used) — Schematic Circuit Number

Chassis-mounted components have no Assembly Number prefix—see end of Replaceable Electrical Parts List.

Static Sensitive Devices
See Maintenance Section

Table 10-10
COMPONENT REFERENCE CHART
(See Fig. 10-6)

P/O A14 ASSY — CPU BOARD ⟨8⟩

CIRCUIT NUMBER	SCHEMATIC LOCATION	BOARD LOCATION	CIRCUIT NUMBER	SCHEMATIC LOCATION	BOARD LOCATION
BT1121	I9	C5	R1131	I8	C6
C1133	J8	C6	R1133	J8	C6
CR1133	I8	C6	R1134	I8	C5
CR1235	H8	D6	R1135	H8	C6
J1132	I7	C5	U1200	D2	D2
J1505	H5	H2	U1220	K6	D3
P1132	I7	C5	U1300	F2	E2
Q1123	I8	C4	U1305	H2	F2
			U1400	K2	G2
			U1505	H5	H2
			U1600	F5	J2

P/O A14 ASSY also shown on ⟨7⟩ ⟨9⟩

PARTS LOCATION GRID

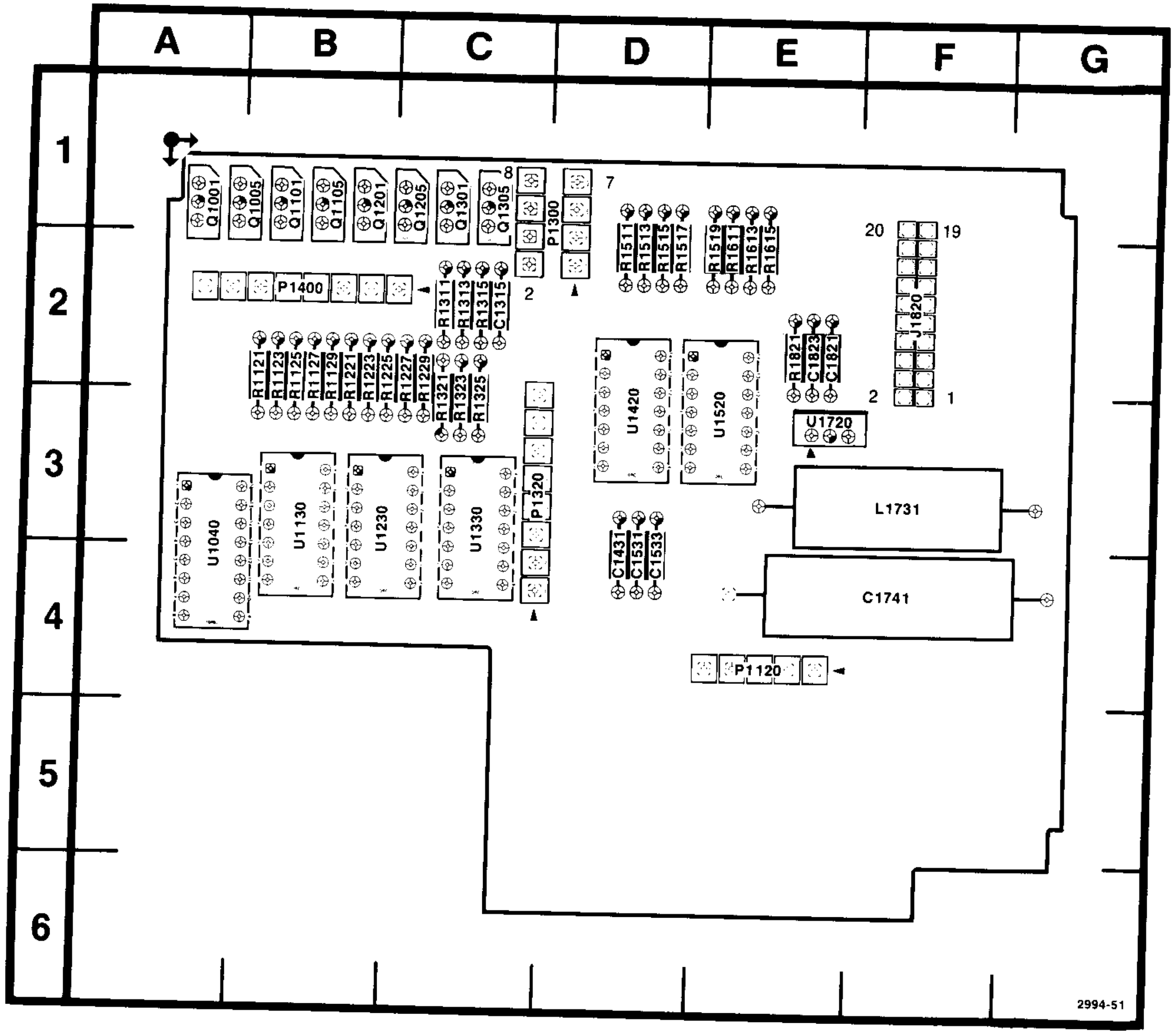


Fig. 10-8. Front Panel Drive Board (A12).

ASSY A12


Static Sensitive Devices
See Maintenance Section

COMPONENT NUMBER EXAMPLE

Component Number
A23 A2 R1234
Assembly Number — Subassembly Number (if used) — Schematic Circuit Number

Chassis-mounted components have no Assembly Number prefix—see end of Replaceable Electrical Parts List

Table 10-16
COMPONENT REFERENCE CHART

A12 ASSY — FRONT PANEL DRIVE BOARD ⟨11⟩

CIRCUIT NUMBER	SCHEMATIC LOCATION	BOARD LOCATION	CIRCUIT NUMBER	SCHEMATIC LOCATION	BOARD LOCATION
C1315	C7	C2	R1127	I8	B2
C1431	E7	D4	R1129	H9	B2
C1531	F7	D4	R1221	I9	B2
C1533	C7	D4	R1223	H8	B2
C1741	D7	F4	R1225	I8	B2
C1821	E7	E2	R1227	H7	C2
C1823	D7	E2	R1229	I7	C2
J1820	B3	F2	R1311	I9	C2
L1731	C7	F3	R1313	I8	C2
P1120	K1	E4	R1315	I7	C2
P1300	K3	D1	R1321	H9	C3
P1320	K5	C3	R1323	H8	C3
P1400	K9	B2	R1325	H7	C3
P1400	K10	B2	R1511	J2	D2
P1820	A1	F2	R1513	J2	D2
Q1001	J10	A1	R1515	J2	D2
Q1005	J8	B1	R1517	J3	D2
Q1101	J9	B1	R1519	J3	E2
Q1105	J9	B1	R1611	J4	E2
Q1201	J7	B1	R1613	J4	E2
Q1205	J9	C1	R1615	J4	E2
Q1301	J8	C1	R1821	C7	E2
Q1305	J7	C1	U1040	E5	A4
R1121	H10	B2	U1130	H10	B3
R1123	I10	B2	U1230	H8	B3
R1125	H8	B2	U1330	H8	C3
			U1420	H2	D3
			U1520	H3	E3
			U1720	D7	E3

A12 FP Drive

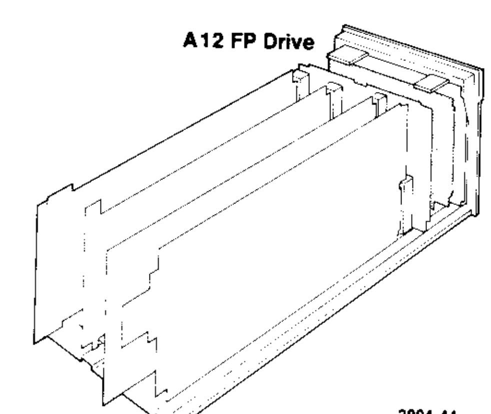


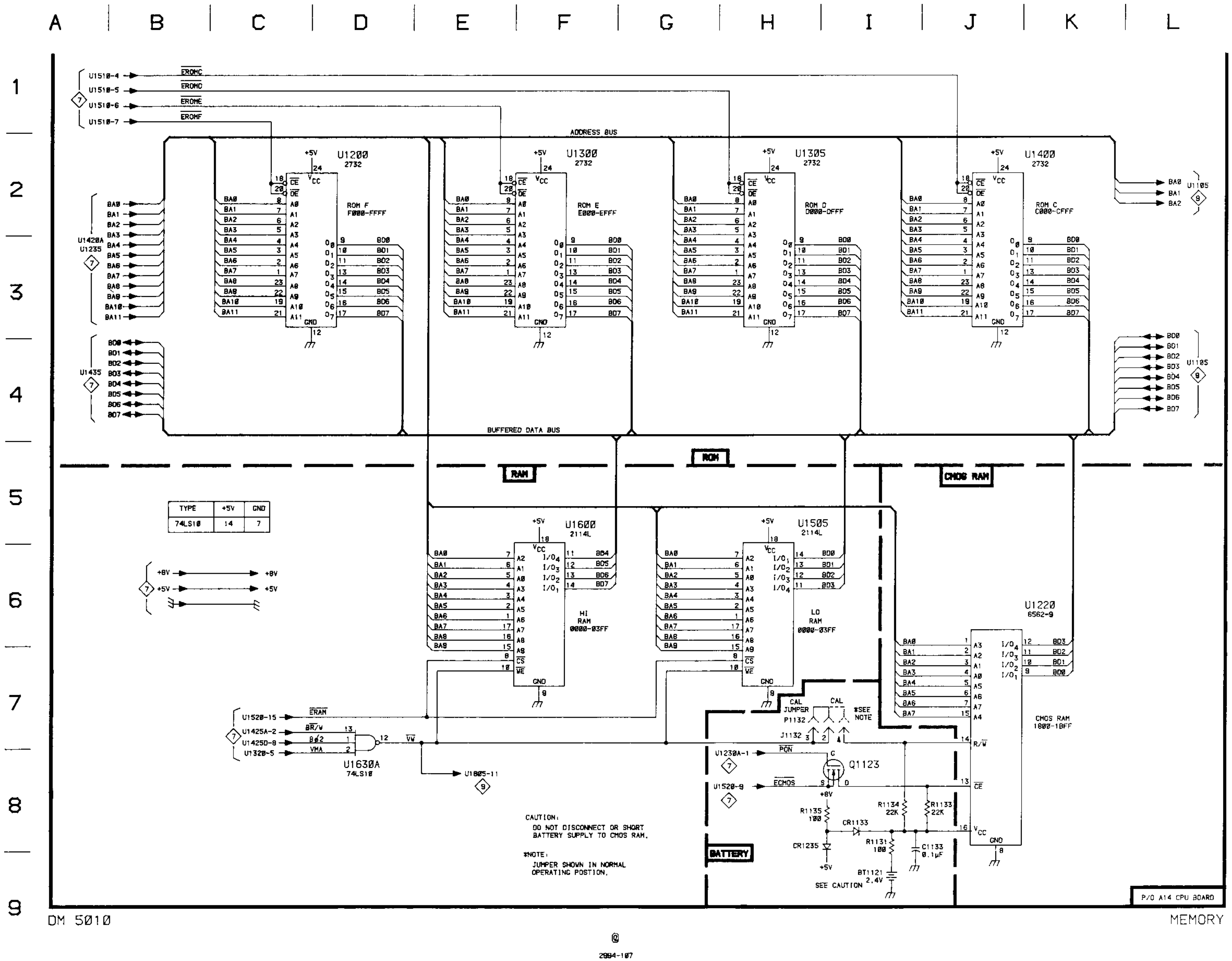
Table 10-11
COMPONENT REFERENCE CHART
(See Fig. 10-6)

P/O A14 ASSY — CPU BOARD ⟨9⟩

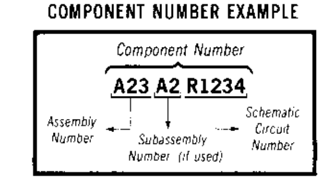
CIRCUIT NUMBER	SCHEMATIC LOCATION	BOARD LOCATION	CIRCUIT NUMBER	SCHEMATIC LOCATION	BOARD LOCATION
C1723*	C4	K4	R1623*	C5	J4
J1721	C4	L4	S1515	D6	H3
J1723	C5	L4			
P1011	K5	A3	U1100	J5	B2
P1721	C3	L4	U1105	H5	C2
P1723	C5	L4	U1110	J7	B3
			U1605	I1	K2
Q1121	J7	C4	U1610	F6	J3
			U1630	G1	J5
R1101	G7	C1	U1720	D3	K4
R1121	H6	C4			
R1123*	J7	C4	W1820	K2	L2
R1611	D6	J3			

P/O A14 ASSY also shown on ⟨7⟩ ⟨8⟩

*See Parts List for serial number ranges.



COMPONENT NUMBER EXAMPLE



Chassis-mounted components have no Assembly Number prefix—see end of Replaceable Electrical Parts List

Static Sensitive Devices
See Maintenance Section

COMPONENT REFERENCE CHART

2994-107

Table 10-14
REAR INTERFACE CONNECTOR ASSIGNMENTS ISOLATION BOARD (A15)

FUNCTION	PIN B		PIN A	FUNCTION
GROUND	16		16	$\overline{\text{EXTRIG}}$ *
	15		15	
	14		14	
	13		13	
+26V DC	12		12	+26V DC
COLLECTOR LEAD OF PNP SERIES PASS	11		11	BASE LEAD OF PNP SERIES PASS
	10		10	EMITTER LEAD OF PNP SERIES PASS
GROUND	9		9	GROUND
	8	TM 5000 BARRIER SLOT	8	
COLLECTOR LEAD OF NPN SERIES PASS	7		7	EMITTER LEAD OF NPN SERIES PASS
PWR	6		6	BASE LEAD OF NPN SERIES PASS
	5		5	
GROUND	4		4	GROUND
	3		3	
+8 FILTERED VDC	2		2	+8 FILTERED VDC
	1		1	

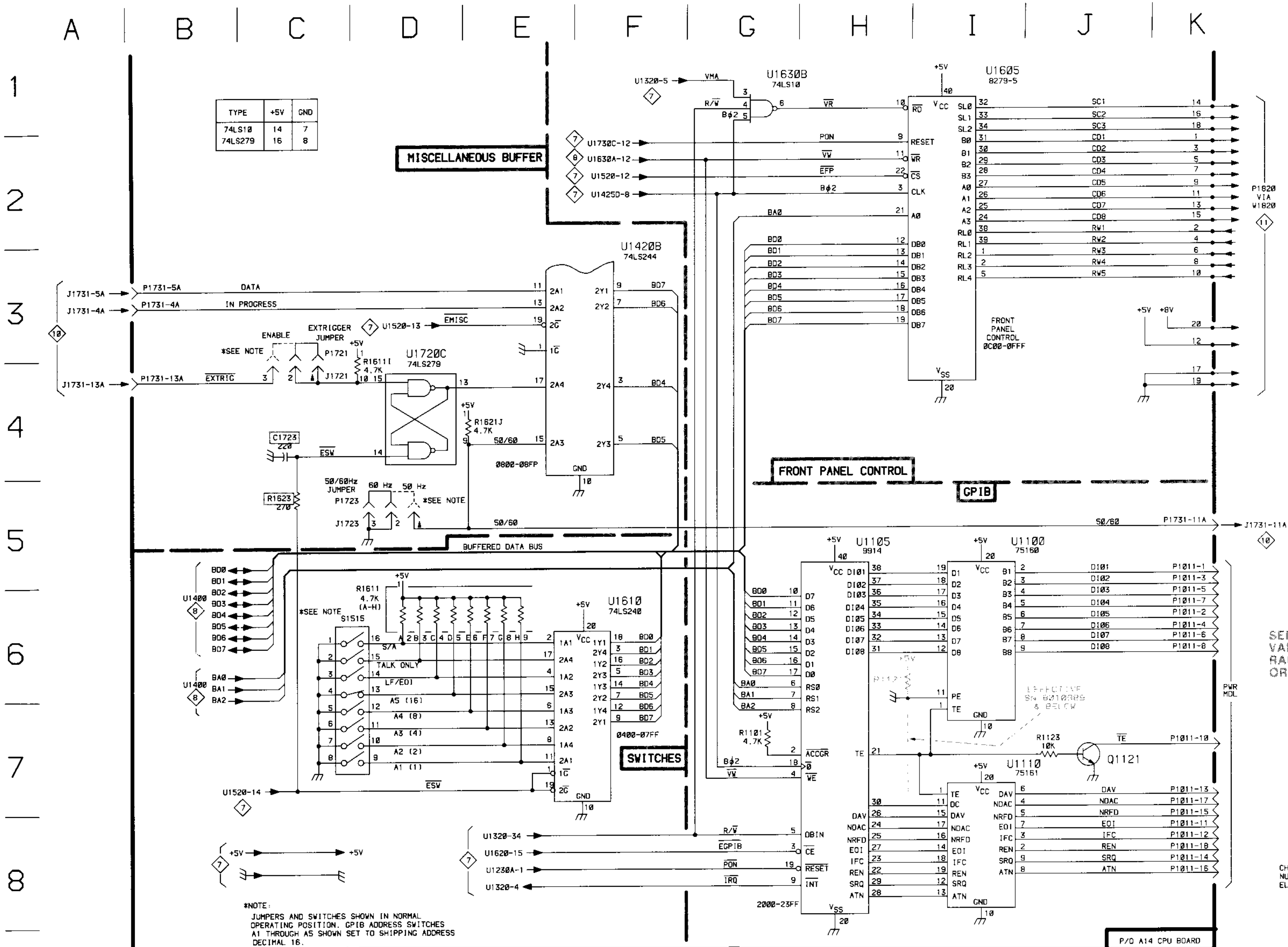
*REQUIRES INSTALLATION OF INTERNAL JUMPER.

PLUG-IN REAR VIEW

Table 10-15
REAR INTERFACE CONNECTOR ASSIGNMENTS ADC BOARD (A17)

FUNCTION	PIN B		PIN A	FUNCTION
HI INPUT	28		28	LO INPUT
	27		27	
	26		26	
	25		25	
	24		24	
	23		23	
	22		22	
	21		21	
	20		20	
	19	DM	19	
	18	BARRIER	18	
	17	SLOT	17	
	16		16	
	15		15	
	14		14	

PLUG-IN REAR VIEW



SEE PARTS LIST FOR EARLIER VALUES AND SERIAL NUMBER RANGES OF PARTS OUTLINED OR DEPICTED IN GREY.

STATIC SENSITIVE DEVICES SEE MAINTENANCE SECTION

COMPONENT NUMBER EXAMPLE

COMPONENT NUMBER
A23 A2 R1234
ASSEMBLY NUMBER — SUBASSEMBLY NUMBER (IF USED) — SCHEMATIC CIRCUIT NUMBER

CHASSIS-MOUNTED COMPONENTS HAVE NO ASSEMBLY NUMBER PREFIX—SEE END OF REPLACEABLE ELECTRICAL PARTS LIST

COMPONENT REFERENCE CHART

PARTS LOCATION GRID

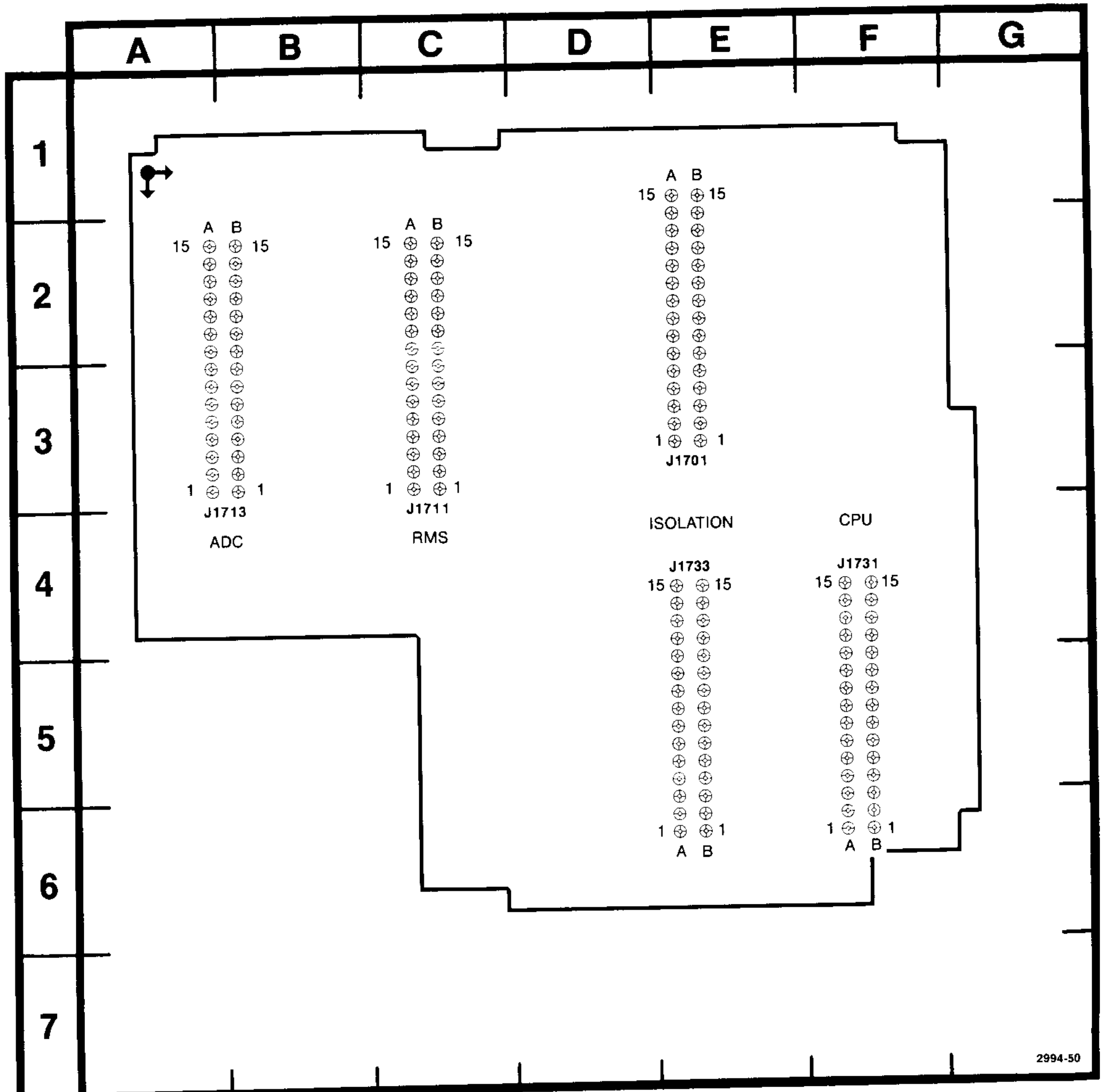


Fig. 10-7. Main Interconnect Board (A13).

ASSY A13

Static Sensitive Devices
See Maintenance Section

COMPONENT NUMBER EXAMPLE

Component Number
A23 A2 R1234
Assembly Number
Subassembly Number (if used)
Schematic Circuit Number

Chassis-mounted components have no Assembly Number prefix—see end of Replaceable Electrical Parts List

Table 10-12
COMPONENT REFERENCE CHART

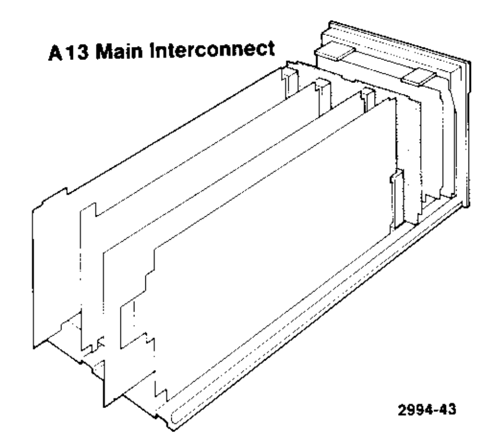
A13 ASSY — MAIN INTERCONNECT BOARD ⟨10⟩

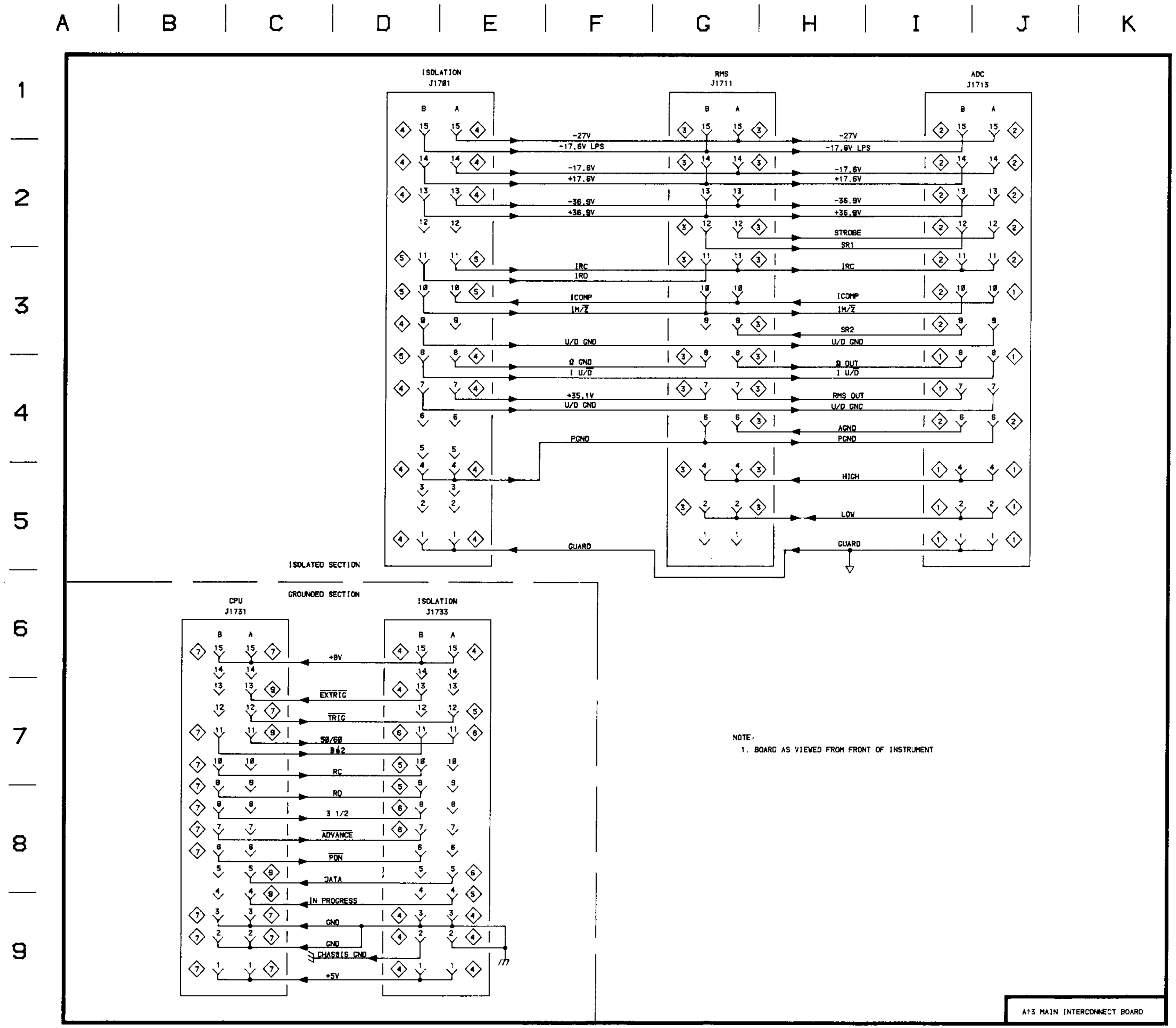
CIRCUIT NUMBER	SCHEMATIC LOCATION	BOARD LOCATION	CIRCUIT NUMBER	SCHEMATIC LOCATION	BOARD LOCATION
J1701	E1	E3	J1731	C6	E5
J1711	G1	C4	J1733	E6	E4
J1713	J1	B4			

Table 10-13
REAR INTERFACE CONNECTOR ASSIGNMENTS CPU BOARD (A14)

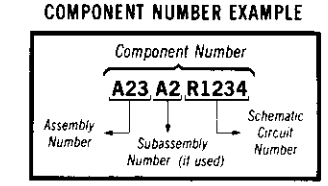
FUNCTION	PIN	PIN	FUNCTION
DIO1	1	2	DIO5
DIO2	3	4	DIO6
DIO3	5	6	DIO7
DIO4	7	8	DIO8
	9	1Ø	
EOI	11	12	IFC
DAV	13	14	SRQ
NRFD	15	16	ATN
NDAC	17	18	REN
	19	2Ø	

PLUG-IN REAR VIEW





COMPONENT NUMBER EXAMPLE



Chassis-mounted components have no Assembly Number prefix—see end of Replaceable Electrical Parts List.

Static Sensitive Devices
See Maintenance Section

PARTS LOCATION GRID

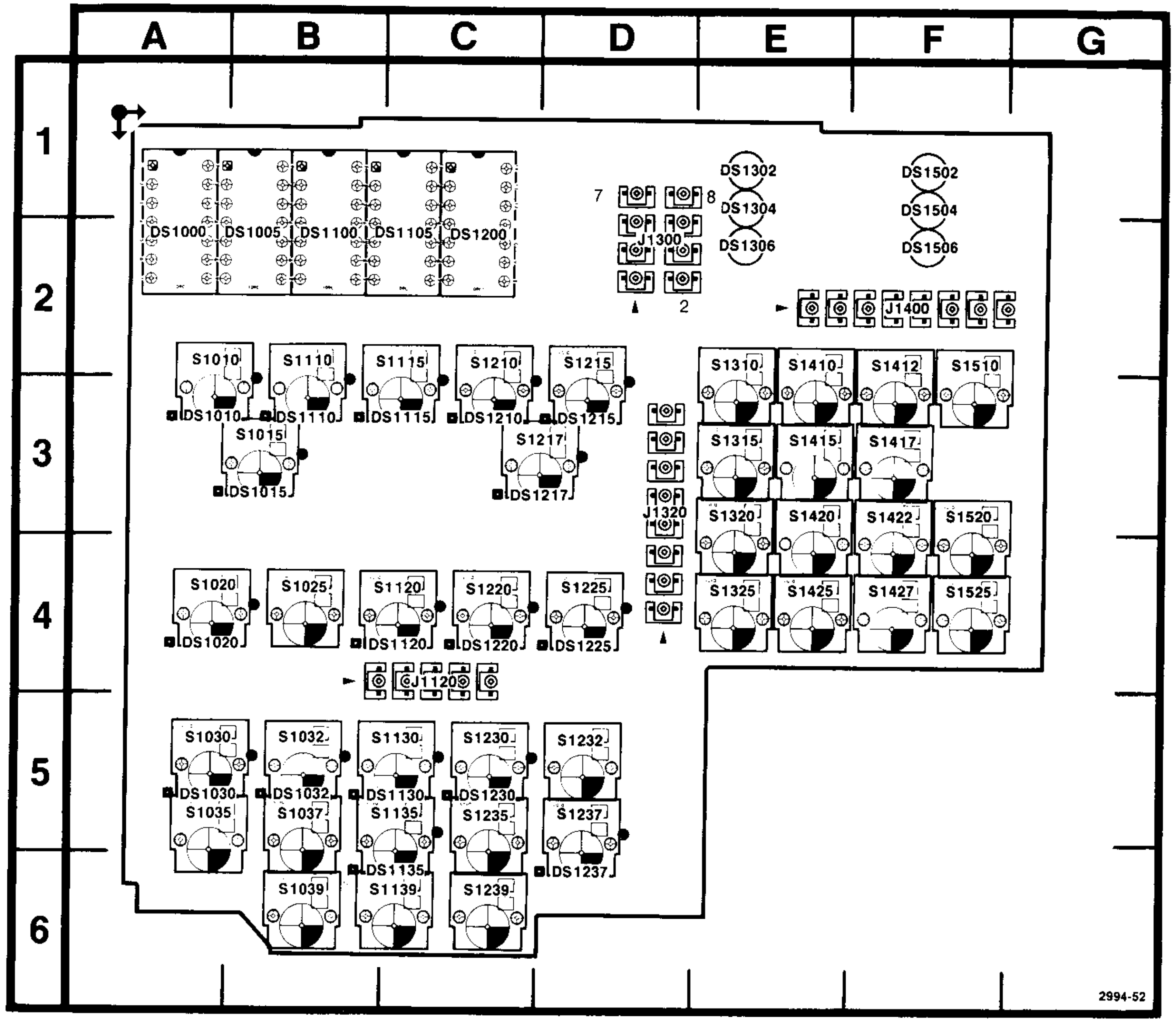
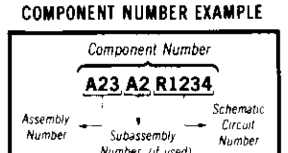


Fig. 10-9. Front Panel Board (A11).

ASSY A11

Static Sensitive Devices
See Maintenance Section

COMPONENT NUMBER EXAMPLE



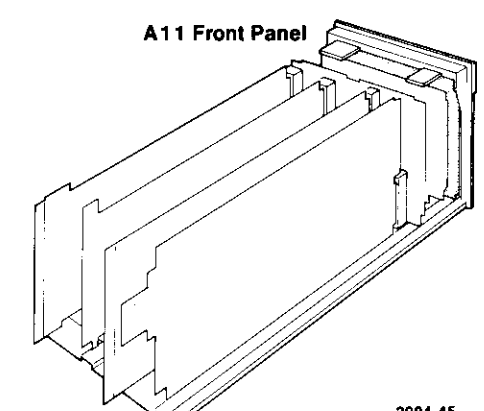
Chassis-mounted components have no Assembly Number prefix—see end of Replaceable Electrical Parts List

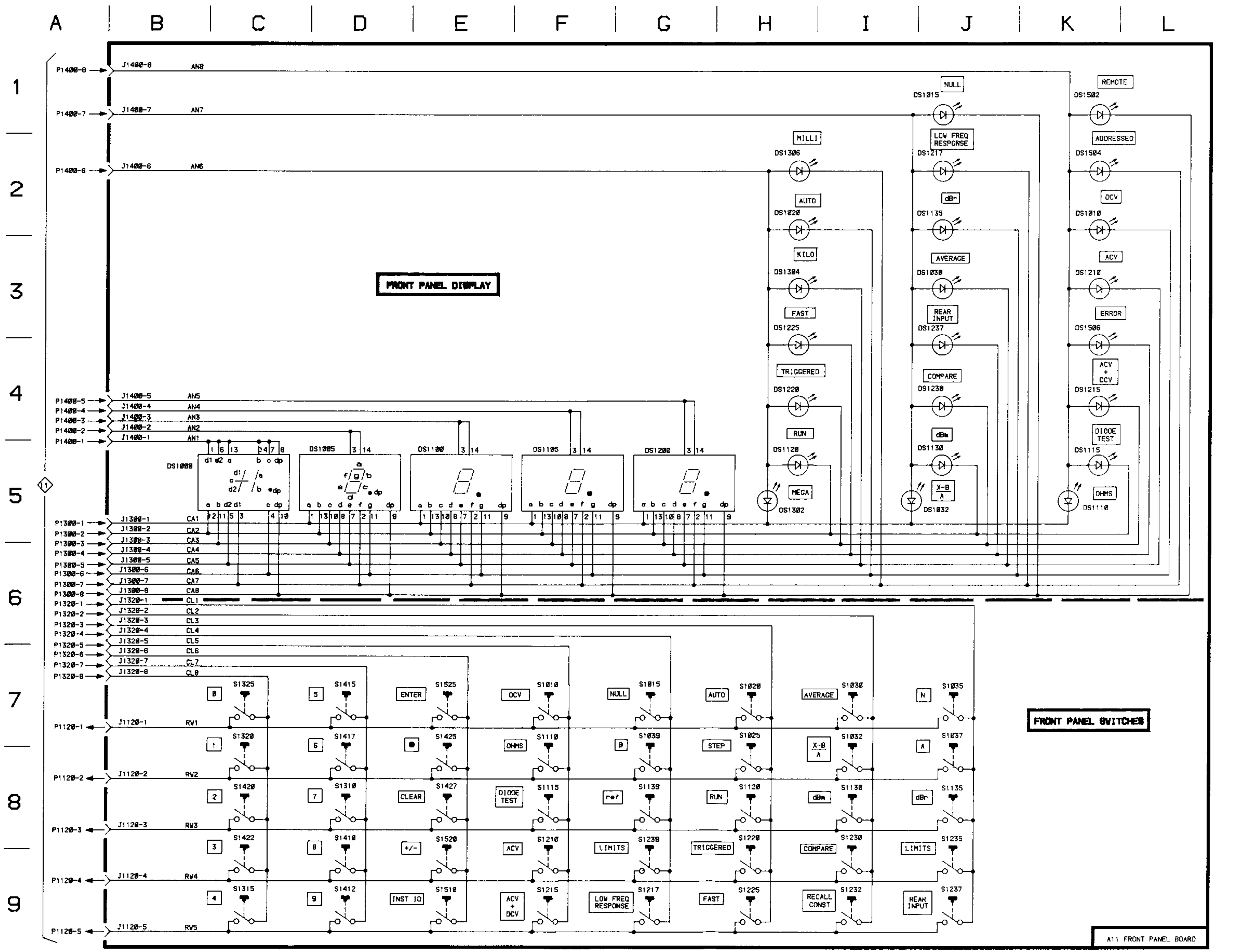
Table 10-17
COMPONENT REFERENCE CHART

A11 ASSY — FRONT PANEL BOARD ⟨12⟩

CIRCUIT NUMBER	SCHEMATIC LOCATION	BOARD LOCATION	CIRCUIT NUMBER	SCHEMATIC LOCATION	BOARD LOCATION
DS1000	B5	A2	S1025	H7	B4
DS1005	D5	B2	S1030	I7	A5
DS1010	K2	A3	S1032	I7	B5
DS1015	J1	B3	S1035	J7	A5
DS1020	H2	A4	S1037	J7	B5
DS1030	J3	A5	S1039	G7	B6
DS1032	J5	B5	S1110	F7	B2
DS1100	E5	B2	S1115	F8	C2
DS1105	F5	C2	S1120	H8	C4
DS1110	K5	B3	S1130	I8	C5
DS1115	K5	C3	S1135	J8	C5
DS1120	H5	C4	S1139	G8	C6
DS1130	J5	C5	S1210	F8	C2
DS1135	J2	C6	S1215	F9	D2
DS1200	G5	C2	S1217	G9	D3
DS1210	K3	C3	S1220	H8	C4
DS1215	K4	D3	S1225	H9	D4
DS1217	J2	D3	S1230	I8	C5
DS1220	H4	C4	S1232	I9	D5
DS1225	H3	D4	S1235	J8	C5
DS1230	J4	C5	S1237	J9	D5
DS1237	J3	D6	S1239	G8	C6
DS1302	H5	E1	S1310	D8	E2
DS1304	H3	E1	S1315	C9	E3
DS1306	H2	E2	S1320	C7	E3
DS1502	K1	F1	S1325	C7	E4
DS1504	K2	F1	S1410	D8	E2
DS1506	K3	F2	S1412	D9	F2
			S1415	D7	E3
J1120	B7	C4	S1417	D7	F3
J1300	B5	D2	S1420	C8	E3
J1320	B6	D3	S1422	C8	F3
J1400	B4	F2	S1425	E7	E4
			S1427	E8	F4
S1010	F7	A2	S1510	E9	F2
S1015	G7	B3	S1520	E8	F3
S1020	H7	A4	S1525	E7	F4

A11 Front Panel





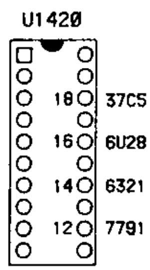
COMPONENT NUMBER EXAMPLE

Component Number
A23 A2 R1234
Assembly Number — Subassembly Number (if used) — Schematic Circuit Number

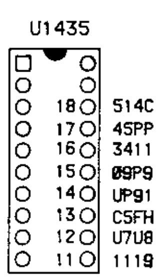
Chassis-mounted components have no Assembly Number prefix—see end of Replaceable Electrical Parts List

Static Sensitive Devices
See Maintenance Section

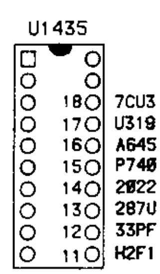
START/STOP
U151Ø-13



START/STOP
U151Ø-6



START/STOP
U151Ø-7



■ AFTER TESTS ARE COMPLETED, RETURN NOP JUMPER TO DISABLE POSITION.

SIGNATURE TABLE 10A
SIGNATURE VERSION 1.0

- FOR TESTING: MICROPROCESSOR, ROMs, AND ADDRESS DECODING.
- ON ASSEMBLY: A14, CPU BOARD.
- EQUIPMENT REQUIRED: SA 5Ø1 SIGNATURE ANALYZER
  TM 5ØØØ SERIES POWER MODULE
  EXTENDER CABLE (Ø67-Ø645-Ø2)
- ELECTRICAL CONDITIONS NECESSARY TO PERFORM TEST: +5V SUPPLY REGULATING PROPERLY.
- DM 5Ø1Ø SETUP: NOP JUMPER IN ENABLE POSITION.
- SA 5Ø1 SETUP: GND TO TP1531.
  THRESHOLD = TTL.
  QUALIFIER OFF.
  CLOCK (SEE STEP 1,2,3)
  START AND STOP TIED TOGETHER. MAKE CONNECTION TO CPU BOARD AS INDICATED IN INDIVIDUAL TESTS.
  START, STOP AND CLOCK SLOPE - REFER TO INDIVIDUAL TESTS.

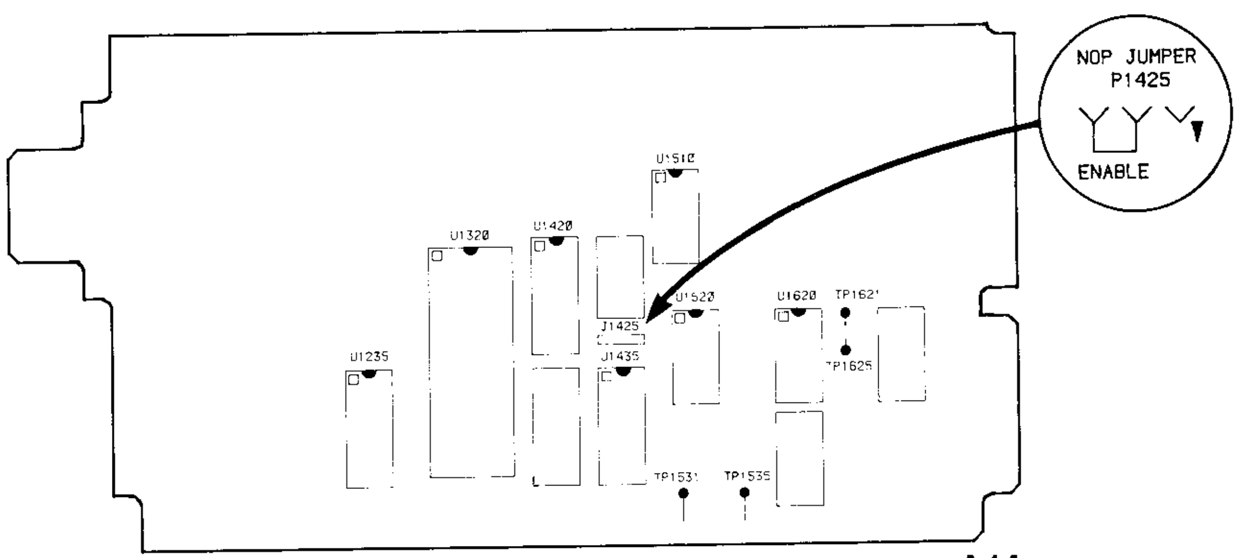
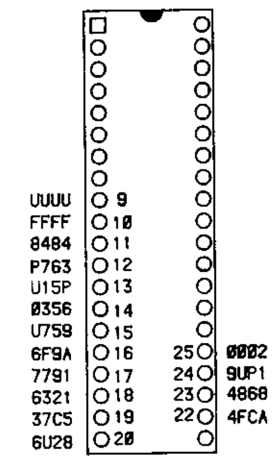


Fig. 10-10. CPU board signature analysis.

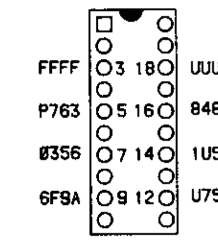
1. SA START
SA STOP
SA CLOCK (TP1535)

+5V ØØØ3
GND ØØØØ

START/STOP
U151Ø-13



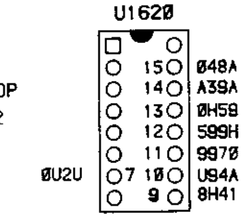
START/STOP
U151Ø-13



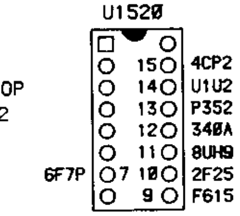
2. SA START
SA STOP
SA CLOCK (U132Ø-37)

+5V 755U
GND ØØØØ

START/STOP
U151Ø-12



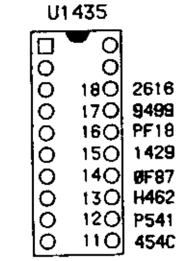
START/STOP
U151Ø-12



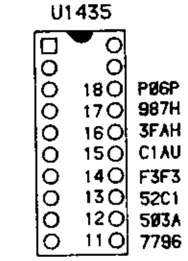
3. SA START
SA STOP
SA CLOCK (TP1535)

+5V P254
GND ØØØØ

START/STOP
U151Ø-4



START/STOP
U151Ø-5



SIGNATURE TABLE 10B
SIGNATURE VERSION 1.0

- FOR TESTING: RANGE SHIFT REGISTERS.
- ON ASSEMBLIES: A15, ISOLATION BOARD.
  A16, RMS BOARD.
  A17, ADC BOARD.
  FOR EACH TEST, PLACE THE BOARD ON EXTENDER BOARD(S).
- EQUIPMENT REQUIRED: SA 5Ø1 SIGNATURE ANALYZER.
  TM 5ØØØ - SERIES POWER MODULE.
  DM 5Ø1Ø SERVICE KIT (Ø67-1Ø52-ØØ)
  EXTENDER CABLE (Ø67-Ø645-Ø2).
- DM 5Ø1Ø SETUP: SIGNATURE ANALYZER SWITCH (ON CPU BOARD) TO SIGNATURE ANALYSIS POSITION. DO NOT CHANGE THE OTHER SWITCHES.
- SA 5Ø1 SETUP: THRESHOLD = TTL.
  QUALIFIER OFF.
  CLOCK ⌐_ - CONNECT TO TP1535 ON CPU BOARD.
  START ⌐_ - CONNECT TO TP1621 ON CPU BOARD.
  STOP _⌐ - CONNECT TO TP1625 ON CPU BOARD.
  GND - CONNECT TO TP1531 ON CPU BOARD.
  SEE FIG. 1Ø-1Ø, CPU BOARD.

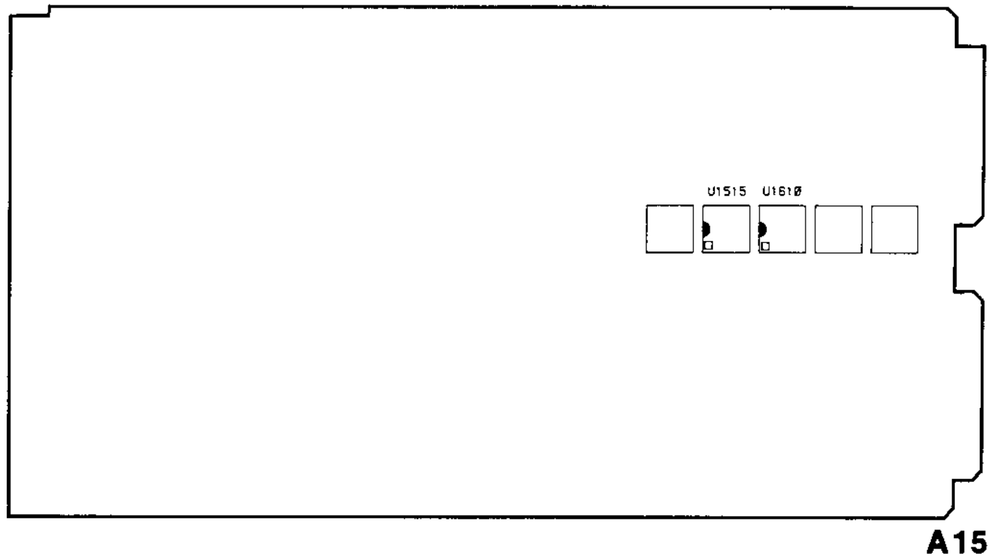
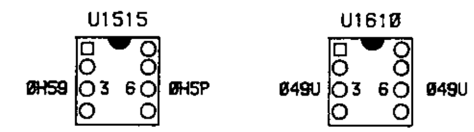


Fig. 10-11. Isolation board signature analysis.

1. CONNECT U1515-5 (ISOLATED -27V) TO TP 1531 (CHASSIS GROUND) ON CPU BOARD.

+5V 35PP
GND ØØØØ



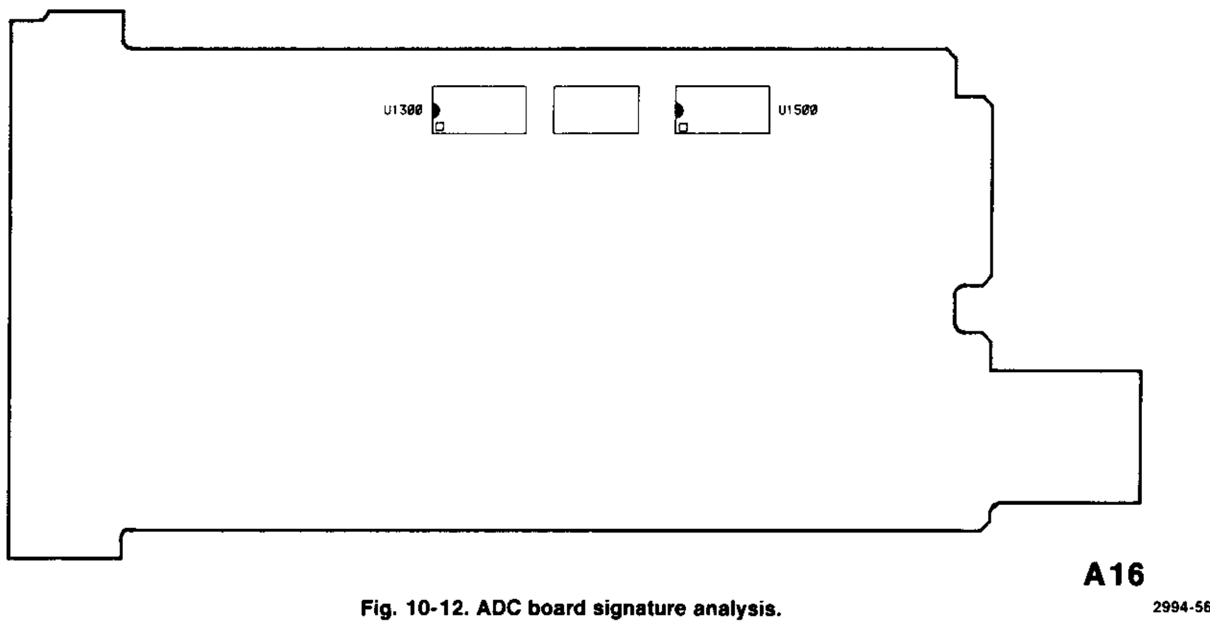
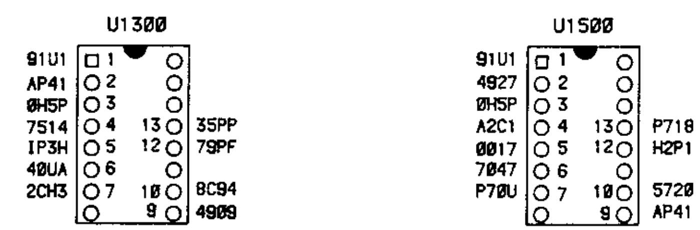


Fig. 10-12. ADC board signature analysis.

2. CONNECT U15ØØ-8 (ISOLATED -27V) TO TP1531 (CHASSIS GROUND) ON CPU BOARD.



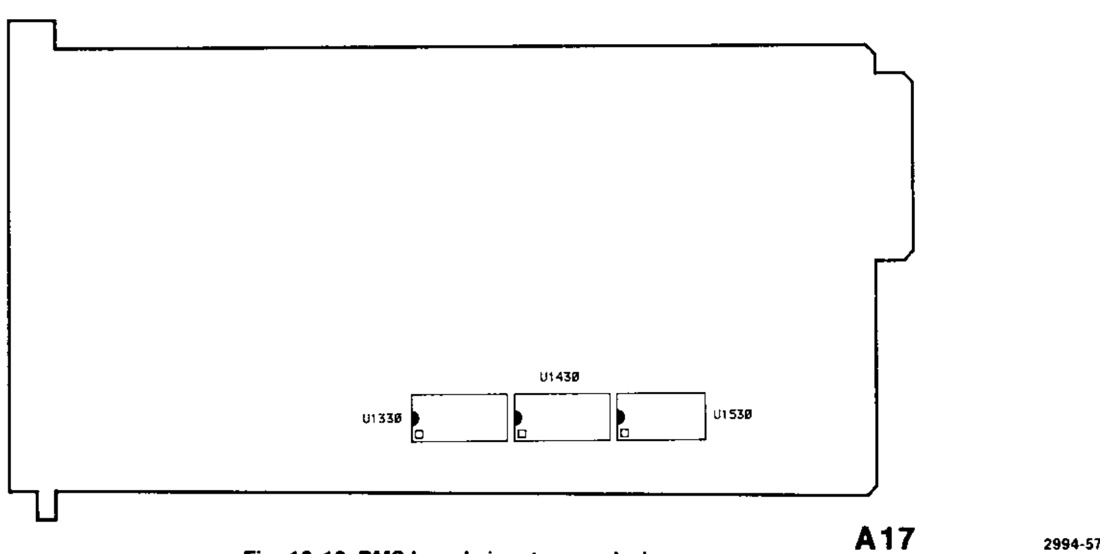
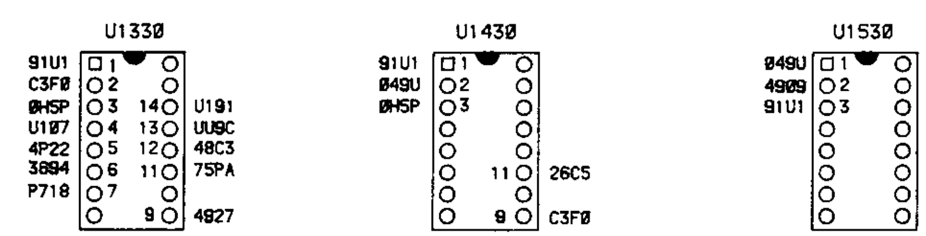


Fig. 10-13. RMS board signature analysis.

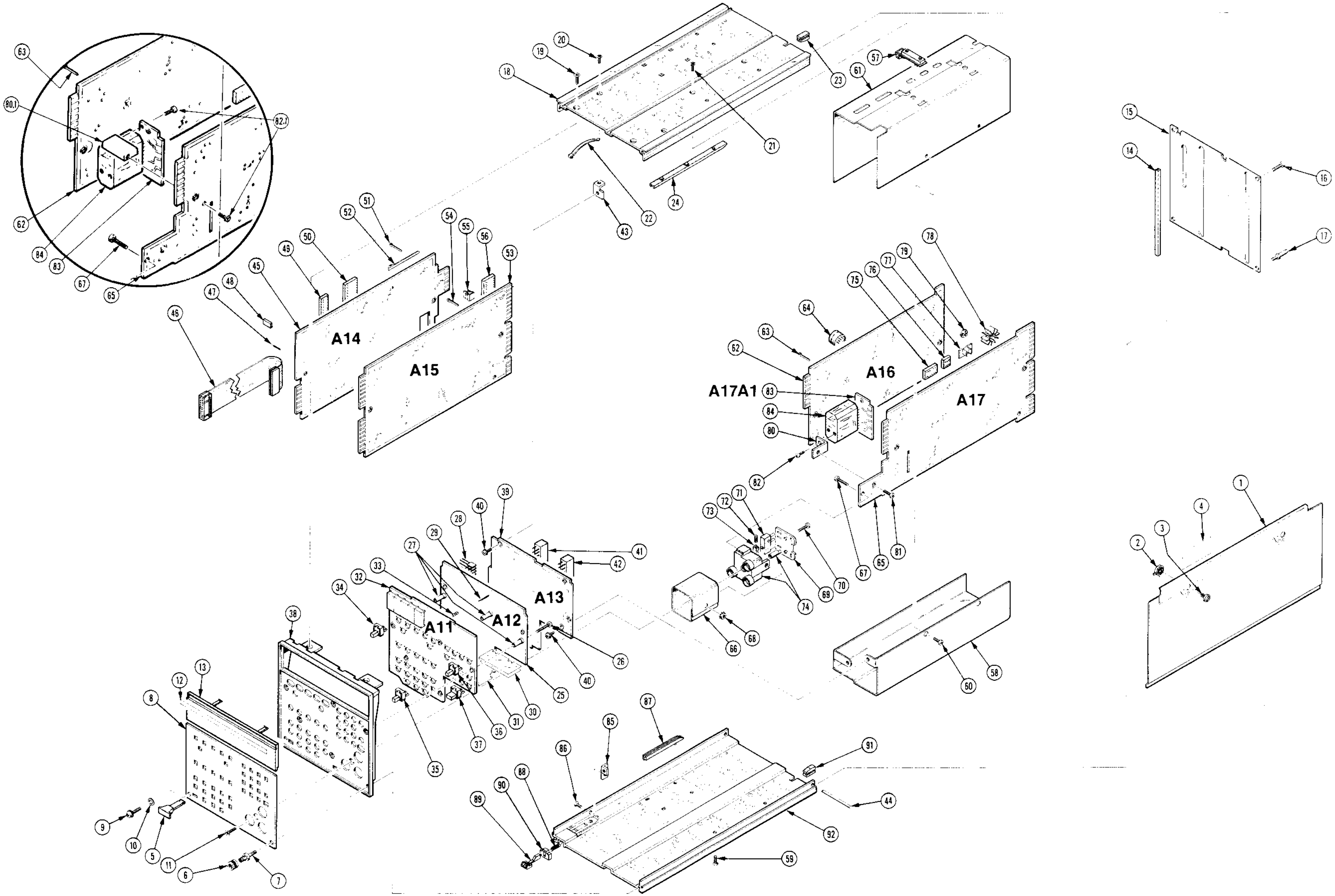
3. CONNECT U133Ø-8 (ISOLATED -27V) TO TP1531 (CHASSIS GROUND) ON CPU BOARD.



■ AFTER TESTS ARE COMPLETED, RESET THE SIGNATURE ANALYSIS SWITCH.

TABLE 10B

FIG. 1 EXPLODED



REPLACEABLE MECHANICAL PARTS

PARTS ORDERING INFORMATION

Replacement parts are available from or through your local Tektronix, Inc. Field Office or representative.

Changes to Tektronix instruments are sometimes made to accommodate improved components as they become available, and to give you the benefit of the latest circuit improvements developed in our engineering department. It is therefore important, when ordering parts, to include the following information in your order: Part number, instrument type or number, serial number, and modification number if applicable.

If a part you have ordered has been replaced with a new or improved part, your local Tektronix, Inc. Field Office or representative will contact you concerning any change in part number.

Change information, if any, is located at the rear of this manual.

SPECIAL NOTES AND SYMBOLS

X000 Part first added at this serial number

00X Part removed after this serial number

FIGURE AND INDEX NUMBERS

Items in this section are referenced by figure and index numbers to the illustrations.

INDENTATION SYSTEM

This mechanical parts list is indented to indicate item relationships. Following is an example of the indentation system used in the description column.

1 2 3 4 5 Name & Description

Assembly and/or Component
Attaching parts for Assembly and/or Component
- - - * - - -
Detail Part of Assembly and/or Component
Attaching parts for Detail Part
- - - * - - -
Parts of Detail Part
Attaching parts for Parts of Detail Part
- - - * - - -

Attaching Parts always appear in the same indentation as the item it mounts, while the detail parts are indented to the right. Indented items are part of, and included with, the next higher indentation. The separation symbol - - - * - - - indicates the end of attaching parts.

Attaching parts must be purchased separately, unless otherwise specified.

ITEM NAME

In the Parts List, an Item Name is separated from the description by a colon (:). Because of space limitations, an Item Name may sometimes appear as incomplete. For further Item Name identification, the U.S. Federal Cataloging Handbook H6-1 can be utilized where possible.

ABBREVIATIONS

"	INCH	ELCTRN	ELECTRON	IN	INCH	SE	SINGLE END
#	NUMBER SIZE	ELEC	ELECTRICAL	INCAND	INCANDESCENT	SECT	SECTION
ACTR	ACTUATOR	ELCTLT	ELECTROLYTIC	INSUL	INSULATOR	SEMICOND	SEMICONDUCTOR
ADPTR	ADAPTER	ELEM	ELEMENT	INTL	INTERNAL	SHLD	SHIELD
ALIGN	ALIGNMENT	EPL	ELECTRICAL PARTS LIST	LPHLDR	LAMPHOLDER	SHLDR	SHOULDERED
AL	ALUMINUM	EQPT	EQUIPMENT	MACH	MACHINE	SKT	SOCKET
ASSEM	ASSEMBLED	EXT	EXTERNAL	MECH	MECHANICAL	SL	SLIDE
ASSY	ASSEMBLY	FIL	FILLISTER HEAD	MTG	MOUNTING	SLFLKG	SELF-LOCKING
ATTEN	ATTENUATOR	FLEX	FLEXIBLE	NIP	NIPPLE	SLVG	SLEEVING
AWG	AMERICAN WIRE GAGE	FLH	FLAT HEAD	NON WIRE	NOT WIRE WOUND	SPR	SPRING
BD	BOARD	FLTR	FILTER	OBD	ORDER BY DESCRIPTION	SQ	SQUARE
BRKT	BRACKET	FR	FRAME or FRONT	OD	OUTSIDE DIAMETER	SST	STAINLESS STEEL
BRS	BRASS	FSTNR	FASTENER	OVH	OVAL HEAD	STL	STEEL
BRZ	BRONZE	FT	FOOT	PH BRZ	PHOSPHOR BRONZE	SW	SWITCH
BSHG	BUSHING	FXD	FIXED	PL	PLAIN or PLATE	T	TUBE
CAB	CABINET	GSKT	GASKET	PLSTC	PLASTIC	TERM	TERMINAL
CAP	CAPACITOR	HDL	HANDLE	PN	PART NUMBER	THD	THREAD
CER	CERAMIC	HEX	HEXAGON	PNH	PAN HEAD	THK	THICK
CHAS	CHASSIS	HEX HD	HEXAGONAL HEAD	PWR	POWER	TNSN	TENSION
CKT	CIRCUIT	HEX SOC	HEXAGONAL SOCKET	RCPT	RECEPTACLE	TPG	TAPPING
COMP	COMPOSITION	HLCPS	HELICAL COMPRESSION	RES	RESISTOR	TRH	TRUSS HEAD
CONN	CONNECTOR	HLEXT	HELICAL EXTENSION	RGD	RIGID	V	VOLTAGE
COV	COVER	HV	HIGH VOLTAGE	RLF	RELIEF	VAR	VARIABLE
CPLG	COUPLING	IC	INTEGRATED CIRCUIT	RTNR	RETAINER	W/	WITH
CRT	CATHODE RAY TUBE	ID	INSIDE DIAMETER	SCH	SOCKET HEAD	WSHR	WASHER
DEG	DEGREE	IDENT	IDENTIFICATION	SCOPE	OSCILLOSCOPE	XFMR	TRANSFORMER
DWR	DRAWER	IMPLR	IMPELLER	SCR	SCREW	XSTR	TRANSISTOR

CROSS INDEX - MFR. CODE NUMBER TO MANUFACTURER

Mfr. Code	Manufacturer	Address	City, State, Zip Code
01536	TEXTRON INC CAMCAR DIV SEMS PRODUCTS UNIT	1818 CHRISTINA ST	ROCKFORD IL 61108
05820	EG AND G WAKEFIELD ENGINEERING	60 AUDUBON RD	WAKEFIELD MA 01880
06383	PANDUIT CORP	17301 RIDGELAND	TINLEY PARK IL 60477
09922	BURNDY CORP	RICHARDS AVE	NORWALK CT 06852
13103	THERMALLOY CO INC	2021 W VALLEY VIEW LANE P O BOX 34829	DALLAS TX 75234
22526	DU PONT E I DE NEMOURS AND CO INC DU PONT CONNECTOR SYSTEMS	30 HUNTER LANE	CAMP HILL PA 17011
71785	TRW INC TRW CINCH CONNECTORS	1501 MORSE AVE	ELK GROVE VILLAGE IL 60007
72228	AMCA INTERNATIONAL CORP CONTINENTAL SCREW CO DIV	459 MT PLEASANT	NEW BEDFORD MA 02742
75915	LITTELFUSE INC	800 E NORTHWEST HWY	DES PLAINES IL 60016
78189	ILLINOIS TOOL WORKS INC SHAKEPROOF DIVISION	ST CHARLES ROAD	ELGIN IL 60120
80009	TEKTRONIX INC	4900 S W GRIFFITH DR P O BOX 500	BEAVERTON OR 97077
83385	MICRODOT MANUFACTURING INC GREER-CENTRAL DIV	3221 W BIG BEAVER RD	TROY MI 48098
83486	ELCO INDUSTRIES INC	1101 SAMUELSON RD	ROCKFORD IL 61101
93907	TEXTRON INC CAMCAR DIV	600 18TH AVE	ROCKFORD IL 61101
98978	INTERNATIONAL ELECTRONIC RESEARCH CORP SUB OF DYNAMICS CORP OF AMERICA	135 W MAGNOLIA BLVD	BURBANK CA 91502
TK0435	LEWIS SCREW CO	4114 S PEORIA	CHICAGO IL 60609
TK0502	CONNOR SPRING AND MFG CO	9400 NE COLFAX	PORTLAND OR 97220

Fig. & Index No.	Tektronix Part No.	Serial/Assembly No. Effective	Dscont	Qty	12345 Name & Description	Mfr. Code	Mfr. Part No.
1-1	337-2807-00			2	SHIELD,ELEC:SIDE,PLUG-IN UNIT	80009	337-2807-00
-2	105-0932-00			4	LATCH,PANEL:SIDE	80009	105-0932-00
-3	214-3364-00			4	FASTENER,LATCH:ACETAL,SIL GRAY	80009	214-3364-00
-4	334-4460-00			2	MARKER,IDENT:MKD GPIB ADDRESS SWITCH	80009	334-4460-00
-5	366-1851-01			1	KNOB,LATCH:IVORY GY,0.625 X 0.25 X 1.09	80009	366-1851-01
-6	220-0633-00			1	NUT,PLAIN,KNURL:0.25-28 X 0.375 OD,BRS NP	80009	220-0633-00
-7	355-0170-00			1	STUD,SHLDR&STEP:BINDING POST	80009	355-0170-00
-8	333-2736-00			1	PANEL,FRONT:	80009	333-2736-00
					(ATTACHING PARTS)		
-9	213-0875-00			1	SCR,ASSEM WSHR:6-32 X 0.5,TAPTITE,PNH,STL	83486	ORDER BY DESCR
-10	210-1365-00			2	WASHER,FLAT:0.141 ID X 0.266 OD X 0.5,AL	80009	210-1365-00
-11	211-0537-00			1	SCREW,MACHINE:6-32 X 0.375,TRH,STL	TK0435	ORDER BY DESCR
					(END ATTACHING PARTS)		
-12	334-4032-00			1	MARKER,IDENT:MKD DM510P PROGRAMMABLE	80009	334-4032-00
-13	378-0159-04			1	LENS,LED DSPL:RED W/MARKING	80009	378-0159-04
-14	255-0581-00			AR	PLASTIC CHANNEL:0.156 X 0.156,POLYETHYLENE	80009	255-0581-00
-15	333-2822-00			1	PANEL,REAR:	80009	333-2822-00
					(ATTACHING PARTS)		
-16	213-0868-00			2	SCREW,TPG,TF:6-32 X 0.375 L,FILH,STL	93907	ORDER BY DESCR
-17	386-3657-01			2	SUPPORT,PLUG-IN:	93907	ORDER BY DESCR
					(END ATTACHING PARTS)		
-18	426-1799-00			1	FR SECT,PLUG-IN:TOP	80009	426-1799-00
					(ATTACHING PARTS)		
-19	211-0541-00			2	SCREW,MACHINE:6-32 X 0.25,FLH,100 DEG,STL	TK0435	ORDER BY DESCR
-20	211-0105-00			2	SCREW,MACHINE:4-40 X 0.188,FLH,100 DEG	TK0435	ORDER BY DESCR
-21	213-0815-00			2	SCREW,TPG,TR:4-20,0.188L,PLASTITE,FLH,STL	72228	ORDER BY DESCR
					(END ATTACHING PARTS)		
-22	214-1061-00			1	CONTACT,ELEC:GROUNDING,CU BE	80009	214-1061-00
-23	214-3089-00			1	LOCKOUT,PLUG-IN:PLASTIC	80009	214-3089-00
-24	351-0604-00			2	GUIDE,CKT BOARD:PLASTIC	80009	351-0604-00
-25	----- -----			1	CKT BOARD ASSY:FP DRIVER(SEE A12 REPL)		
					(ATTACHING PARTS)		
-26	211-0017-00			5	SCREW,MACHINE:4-40 X 0.75,PNH,STL	93907	ORDER BY DESCR
					(END ATTACHING PARTS)		
					CKT BOARD ASSY INCLUDES:		
-27	361-1086-00			5	.SPACER,SLEEVE:0.65 L X 0.125 ID,BRS	80009	361-1086-00
-28	----- -----			1	CONN,RCPT,ELEC:(SEE A12J1820 REPL)		
-29	----- -----			29	CONTACT,ELEC:(SEE A12P1120,P1300,P1320, P1400 REPL)		
-30	342-0584-00			1	INSULATOR,PLATE:SHIELD,POLYESTER	80009	342-0584-00
-31	337-2940-00			1	SHIELD,ELEC:CIRCUIT BOARD	80009	337-2940-00
-32	----- -----			1	CKT BOARD ASSY:FRONT PANEL(SEE A11 REPL)		
-33	----- -----			29	.SOCKET,PIN TERM:(SEE A11J1120,J1300, .J1320,J1400 REPL)		
-34	----- -----			21	.SWITCH,PB ASSY:(SEE A11S1025,S1035, .S1037,S1039,S1139,S1232,S1235,S1239, .S1310,S1315,S1320,S1325,S1410,S1412, .S1415,S1417,S1420,S1422,S1425,S1427, .S1520 REPL)		
-35	----- -----			17	.SWITCH,PB ASSY:(SEE A11S1010,S1015,S1020, .S1135,S1030,S1032,S1110,S1115,S1120, .S1130,S1210,S1215,S1217,S1220,S1225, .S1230,S1237REPL)		
-36	----- -----			1	.SWITCH,PB ASSY:(SEE A11S1510 REPL)		
-37	----- -----			1	.SWITCH,PB ASSY:(SEE A11S1525 REPL)		
-38	386-4569-00			1	SUBPANEL,FRONT:	80009	386-4569-00
-39	----- -----			1	CKT BOARD ASSY:MAIN INTERCONNECT(SEE A13 RE		
					(ATTACHING PARTS)		
-40	211-0661-00			5	SCR,ASSEM WSHR:4-40 X 0.25,PNH,STL,POZ	01536	821-01655-024
					(END ATTACHING PARTS)		
					CKT BOARD ASSY INCLUDES:		
-41	----- -----			2	CONN,RCPT,ELEC:(SEE A13J1731,J1733 REPL)		
-42	----- -----			3	.CONN,RCPT,ELEC:(SEE A13J1701,J1711, .J1718REPL)		
-43	407-2555-00			2	BRACKET,ANGLE:CIRCUIT BOARD,AL	80009	407-2555-00
-44	343-0946-00			1	RETAINER,CKT BD:0.123 OD X 4.99 L W/5-40 TH D ONE END	80009	343-0946-00

Fig. & Index No.	Tektronix Part No.	Serial/Assembly No. Effective	Dscont	Qty	12345 Name & Description	Mfr. Code	Mfr. Part No.
1-45	----- -----			1	CKT BOARD ASSY:PROCESSOR(SEE A14 REPL)		
-46	175-3884-00			1	.CA ASSY,SP,ELEC:20,28 AWG,6.65 L,RIBBON	80009	175-3884-00
-47	131-0993-00			4	.BUS,CONDUCTOR:SHUNT ASSEMBLY,BLACK	22526	65474-005
-48	----- -----			12	.TERMINAL,PIN:(SEE A14J1132,J1425,J1721, .J1723 REPL)		
-49	136-0751-00			4	.SKT,PL-IN ELEK:MICROCKT,24 PIN	09922	DILB24P108
-50	136-0757-00			3	.SKT,PL-IN ELEK:MICROCIRCUIT,40 DIP	09922	DILB40P-108
-51	----- -----			5	.TERM,TEST POINT:(SEE A14TP1531,TP1533, .TP1535,TP1621,TP1625 REPL)		
-52	343-0549-00			2	.STRAP,TIEDOWN,E:0.091 W X 4.0 L,ZYTEL	06383	PLT1M
-53	----- -----			1	CKT BOARD ASSY:CPU(SEE A15 REPL)		
-54	----- -----			1	.TERM,TEST POINT:(SEE A15TP1421 REPL)		
-55	344-0326-00			4	.CLIP,ELECTRICAL:FUSE,BRASS	75915	102071
-56	136-0751-00			1	.SKT,PL-IN ELEK:MICROCKT,24 PIN	09922	DILB24P108
-57	351-0654-00			4	GUIDE,CKT BOARD:PLASTIC,1.45 L	80009	351-0654-00
-58	337-2856-00			1	SHIELD,ELEC:CONVERTER,BOTTOM (ATTACHING PARTS)	80009	337-2856-00
-59	213-0815-00			2	SCREW,TPG,TR:4-20,0.188L,PLASTITE,FLH,STL	72228	ORDER BY DESCR
-60	211-0007-00			4	SCREW,MACHINE:4-40 X 0.188,PNH,STL (END ATTACHING PARTS)	TK0435	ORDER BY DESCR
-61	337-2857-00			1	SHIELD,ELEC:CONVERTER,TOP	80009	337-2857-00
-62	----- -----			1	CKT BOARD ASSY:RMS(SEE A16 REPL)		
-63	----- -----			3	.TERM,TEST POINT:(SEE A16TP1201,TP1503, .TP1701 REPL)		
-64	136-0241-00			1	.SKT,PL-IN ELEK:MICROCIRCUIT,10 CONT,PCB MT	71785	133-99-12-064
	672-1015-00			1	CIRCUIT BD ASSY:RELAY	80009	672-1015-00
-65	----- -----			1	.CKT BOARD ASSY:ADC(SEE A17 REPL)		
-66	337-2930-00			1	..SHIELD,ELEC:GUARD,FRONT ..(ATTACHING PARTS)	80009	337-2930-00
-67	211-0012-00			1	..SCREW,MACHINE:4-40 X 0.375,PNH,STL	TK0435	ORDER BY DESCR
-68	210-0586-00			1	..NUT,PL,ASSEM WA:4-40 X 0.25,STL CD PL ..(END ATTACHING PARTS)	78189	211-041800-00
-69	343-0944-00			1	..RETAINER,CONT:SWITCH,FIBER SHEET ..(ATTACHING PARTS)	80009	343-0944-00
-70	213-0088-00			1	..SCREW,TPG,TF:4-24 X 0.25,TYPE B,PNH ..(END ATTACHING PARTS)	83385	ORDER BY DESCR
-71	----- -----			1	..SWITCH,PUSH:(SEE A17S1731 REPL)		
-72	214-1157-00			1	..SPRING,HLCPS:0.137 OD X 0.36 L,MUW	TK0502	ORDER BY DESCR
-73	105-0875-00	B010100	B020979	1	..ACTR,PUSH SW:PLASTIC	80009	105-0875-00
	105-0875-01	B020980		1	..ACTR,PUSH SW:PLASTIC	80009	105-0875-01
-74	352-0620-00			1	..HOLDER,CONT/SW:BANANA JACK,PLASTIC	80009	352-0620-00
-75	136-0729-00			1	..SKT,PL-IN ELEK:MICROCKT,16 CONTACT	09922	DILB16P-108T
-76	136-0727-00			1	..SKT,PL-IN ELEK:MICROCKT,8 CONTACT	09922	DILB8P-108
-77	214-2496-00			4	..HEAT SINK,XSTR:TO-5,AL	98978	7-175-8A
-78	214-1291-00			1	..HEAT SINK,XSTR:TO-5,SIL BRZ PTD BLACK	05820	207SB
-79	342-0324-00			5	..INSULATOR,DISK:TRANSISTOR,NYLON	13103	7717-5N-BLUE
-80	407-2783-00	B010100	B021903	1	..BRACKET,CMPNT:RELAY	80009	407-2783-00
-80.1	407-3431-00	B021904		1	..BRACKET,RELAY:PLASTIC ..(ATTACHING PARTS)	80009	407-3431-00
-81	211-0008-00	B010100	B021903	1	..SCREW,MACHINE:4-40 X 0.25,PNH,STL	93907	ORDER BY DESCR
-82	211-0698-00	B010100	B021903	1	..SCREW,MACHINE:3-48 X 0.188,PNH,STL	TK0435	ORDER BY DESCR
-82.1	211-0008-00	B021904		2	..SCREW,MACHINE:4-40 X 0.25,PNH,STL ..(END ATTACHING PARTS)	93907	ORDER BY DESCR
-83	----- -----			1	.CKT BOARD ASSY:RELAY(SEE A17A1 REPL)		
-84	----- -----			1	..RELAY,ARMATURE:(PART OF A17)		
-85	407-2559-00			1	BRACKET,ANGLE:INTERFACE CKT BD,AL (ATTACHING PARTS)	80009	407-2559-00
-86	211-0105-00			1	SCREW,MACHINE:4-40 X 0.188,FLH,100 DEG (END ATTACHING PARTS)	TK0435	ORDER BY DESCR
-87	351-0653-00			2	GUIDE,CKT BOARD:PLASTIC,2.226 L	80009	351-0653-00
-88	214-3143-00			1	SPRING,HLEXT:0.125 OD X 0.545 L,XLOOP	80009	214-3143-00
-89	105-0866-00			1	LATCH,RETAINING:SAFETY	80009	105-0866-00
-90	105-0865-00			1	BAR,LATCH RLSE:	80009	105-0865-00
-91	214-3089-00			1	LOCKOUT,PLUG-IN:PLASTIC	80009	214-3089-00
-92	426-1800-01			1	FR SECT,PLUG-IN:W/SPRING & EYELET	80009	426-1800-01

Fig. & Index No.	Tektronix Part No.	Serial/Assembly No. Effective	Dscont	Qty	12345 Name & Description	Mfr. Code	Mfr. Part No.
1-					STANDARD ACCESSORIES		
	003-0120-00			1	LEAD,TEST:ONE PAIR	80009	003-0120-00
	070-2994-01			1	MANUAL,TECH:INSTR,DM5010	80009	070-2994-01
	070-3542-00			1	MANUAL,TECH:REFERENCE,DM5010	80009	070-3542-00