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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

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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

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	(50/60 Hz jumper in 50 Hz position)
	≥40 dB at 60 Hz, ±0.2 Hz	(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.

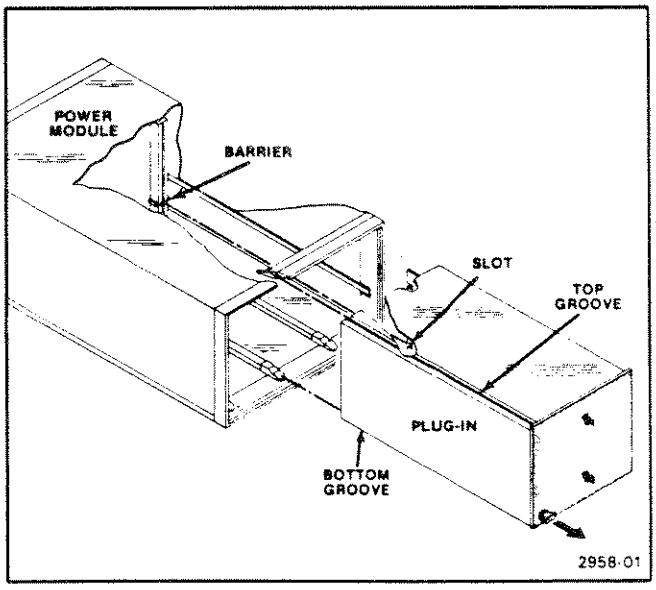


Fig. 2-1. Plug-in installation and removal.

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
	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.

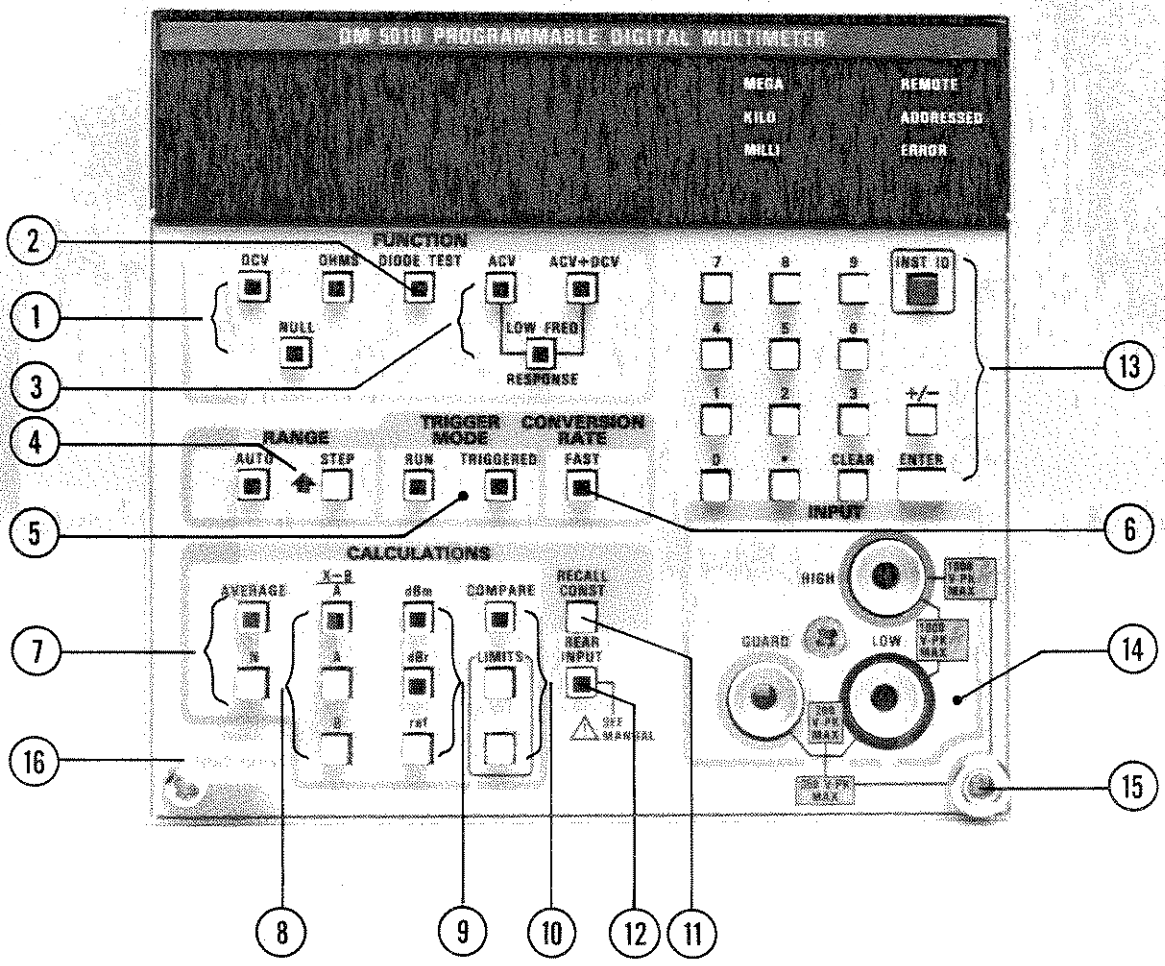
ERROR illuminates when an internal error, self test error, or operating error occurs. The left area of the window also displays front panel error codes indicating the type of error. See Table 2-2 in Operators Familiarization in this section of the manual.

Function	Illuminated Multiplier	Selected Range			
DCV	• MILLI			200 mV	
		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.			

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) **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:

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

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:

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

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

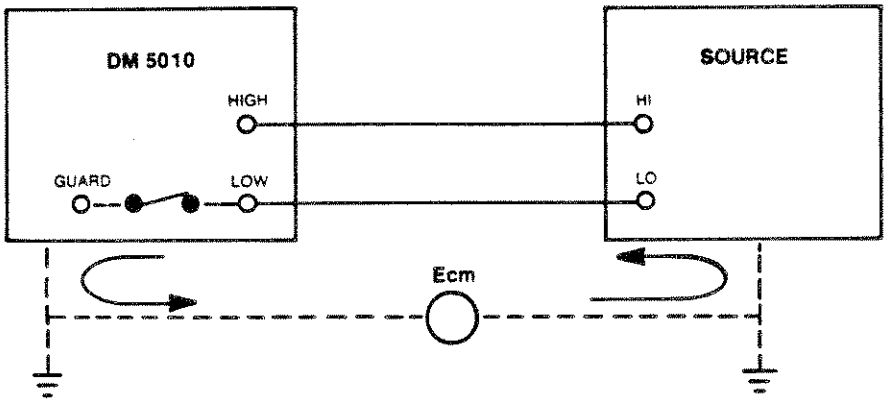
To help eliminate shock hazard from voltages measured by the DM 5010:

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

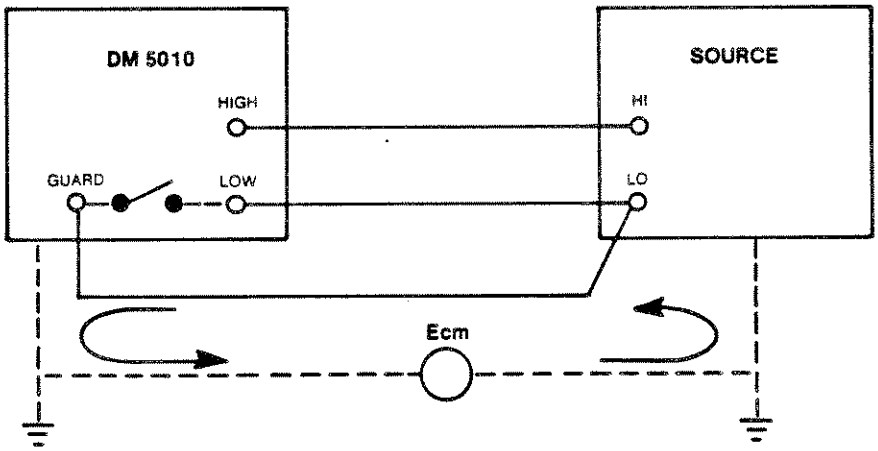
2. *Disconnect test probes from the circuit-under-test before disconnecting probes from the DM 5010, or before removing the DM 5010 from the power module.*

Rear-Interface Measurements ⚠

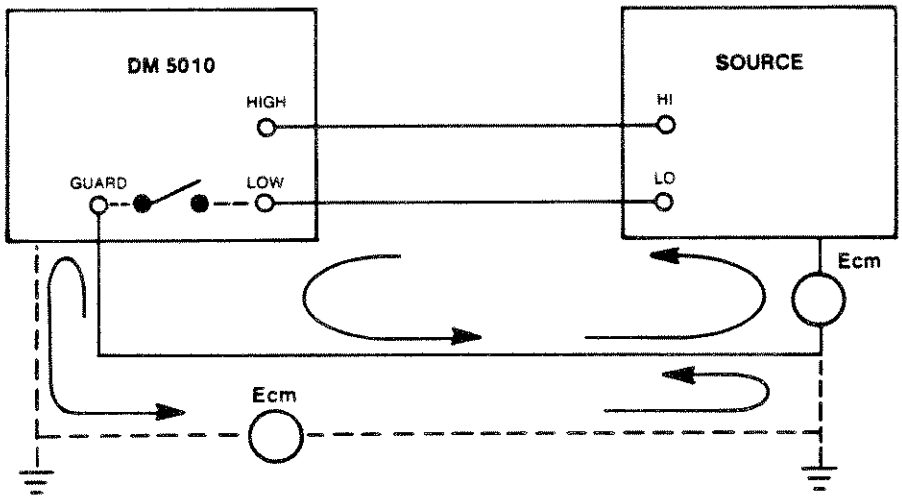
If the REAR INPUT button is pressed (illuminated), signals applied to the rear interface pins 28B (Hi) and 28A (Lo) on the ADC board (A17) are measured. If the button is not illuminated, signals are measured via the front-panel input connectors.



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	0.2 V
2 kΩ	0.12 mA to 0.1 mA	
20 kΩ	9.2 μA to 10 μA	
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.

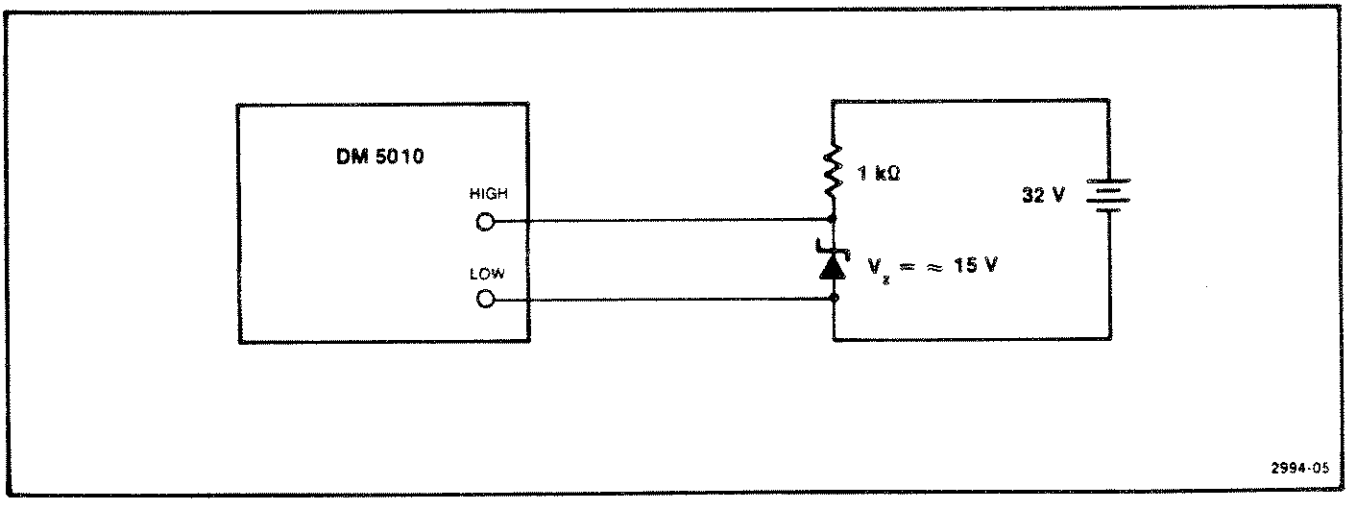


Fig. 2-5. Setup for calculation example 1.

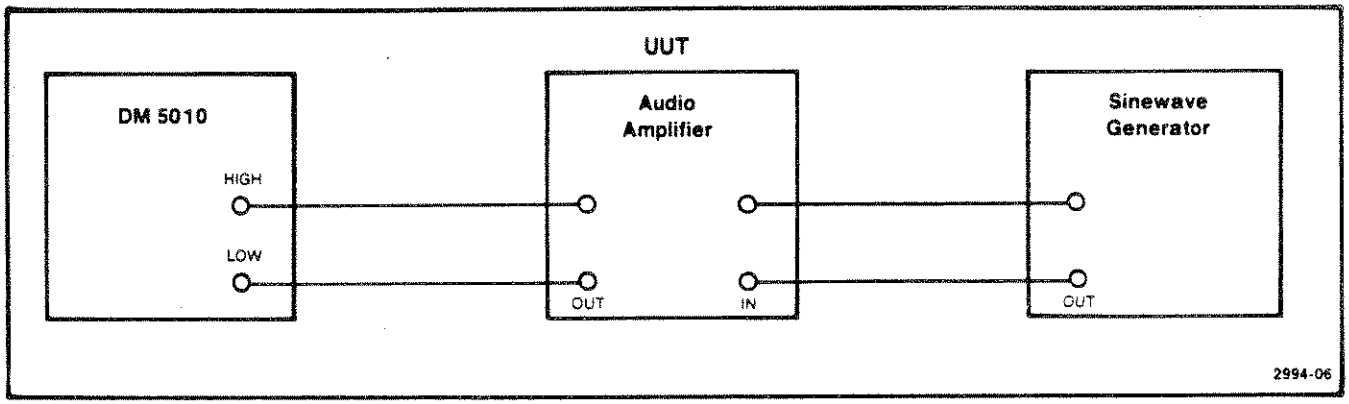


Fig. 2-6. Setup for calculation example 2.

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.

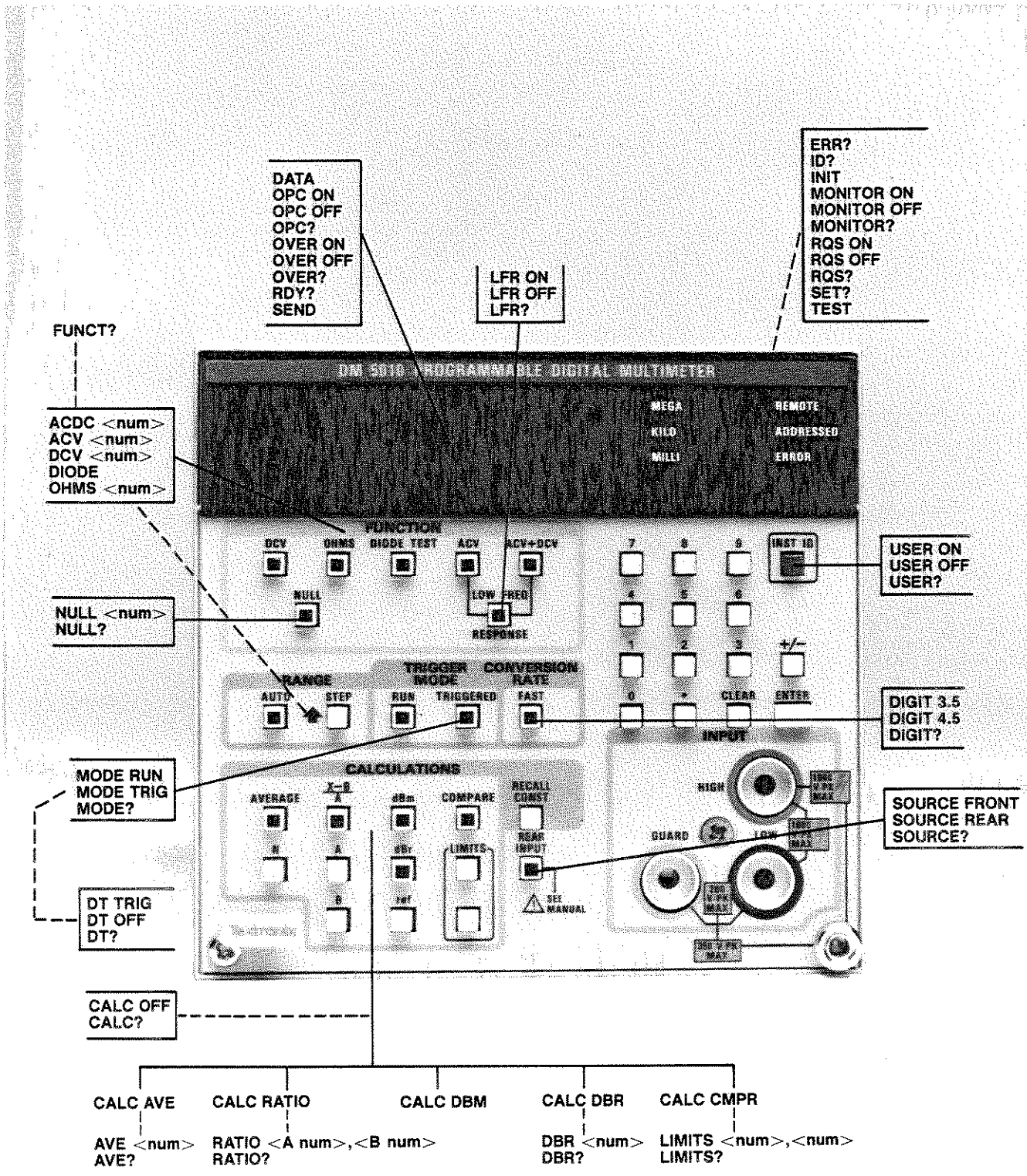


Fig. 3-1. Instrument commands and relationship to front panel controls.

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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 (±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).

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

- 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.

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

- 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.

$RQS_{SP}ON$

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: $RQS_{SP}ON;$

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

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

$_{SP\ SP}ON$

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

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

$_{SP}USER_{SP}OFF$

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.

$2,3$

$2_{SP}3$

$2,_{SP}3$

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 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.

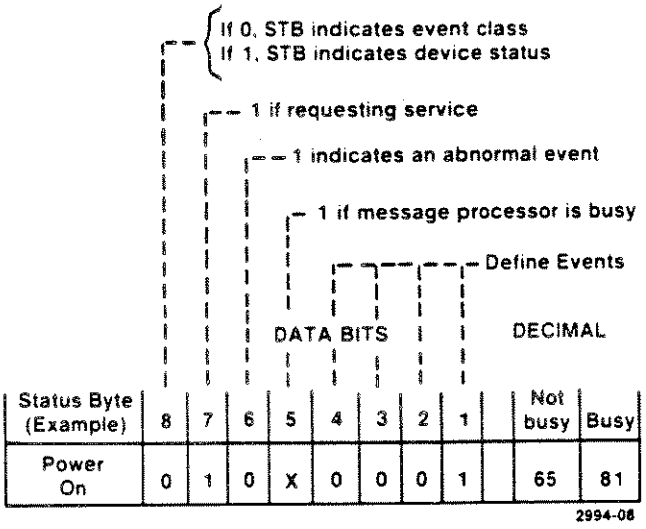


Fig. 3-2. Definition of STB bits.

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 B4 B3 B2 B1	B7 B6 B5 = 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	
0 0 0 0	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)
0 0 0 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)
0 0 1 0	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)
0 0 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)
0 1 0 0	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)
0 1 0 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)
0 1 1 0	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)
0 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 0 0 0	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 0 0 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 0 1 0	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 0 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 0 0	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 0 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 0	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)	1 7 RUBOUT 7 (DEL) 7F (127)

ADDRESSED COMMANDS

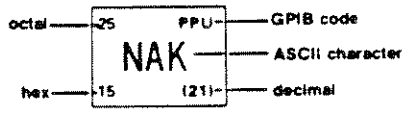
UNIVERSAL COMMANDS

LISTEN ADDRESSES

TALK ADDRESSES

SECONDARY ADDRESSES OR COMMANDS

KEY TO CHART



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
```