Tektronix®

DM 5120/5520

Programmable
Digital Multimeter

INSTRUCTION MANUAL

Tektronix®
COMMITTED TO EXCELLENCE

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

DM 5120/5520
Programmable
Digital Multimeter

INSTRUCTION MANUAL

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

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/Tektonix, Japan
700000	Tektronix Holland, NV, Heerenveen, The Netherlands

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WARNING

The following servicing instructions are for use by qualified personnel only. To avoid personal injury, do not perform any servicing other than that contained in operating instructions unless you are qualified to do so. Refer to Operators Safety Summary prior to performing any service.

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LIST OF TABLES

OPERATORS SAFETY SUMMARY

The general safety information in this part of the summary is for both operating and servicing personnel. Specific warnings and cautions will be found throughout the manual where they apply, but may not appear in this summary. Safety information applies to both the DM 5120 and DM 5520 unless noted otherwise.

TERMS

In This Manual

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

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

As Marked on Equipment

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

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

SYMBOLS

In This Manual

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

As Marked on Equipment

DANGER—High voltage.

Protective ground (earth) terminal.

ATTENTION—refer to manual.

Power Source

This product is intended to operate from a power module connected to a power source (DM 5120) or from a power source (DM 5520) that will not apply more than 250 volts rms between the supply conductors or between either supply conductor and ground. A protective ground connection by way of the grounding conductor in the power cord is essential for safe operation.

Grounding the Product

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

Danger Arising from Loss of Ground

Upon loss of the protective-ground connection, all accessible conductive parts can render an electric shock.

Use the Proper Power Cord (DM 5520)

Use only the power cord and connector specified for your product. Use only a power cord that is in good condition. See Operating Instructions section for the power cord configuration. Refer cord and connector changes to qualified service personnel.

Use the Proper Fuse

To avoid fire hazard, use only the fuse of correct type, voltage rating and current rating as specified in the Maintenance section of this manual or in the parts list of the DM5120/5520 Service Manual.

Refer fuse replacement to qualified service personnel.

Do Not Operate in Explosive Atmospheres

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

Do Not Operate Without Covers

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

SERVICE SAFETY SUMMARY

FOR QUALIFIED SERVICE PERSONNEL ONLY
Refer also to the preceding Operator Safety Summary.

Do Not Service Alone

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

Use Care When Servicing With Power On

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

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

Power Source

This product is intended to operate in a power module connected to a power source (DM 5120) or from a power source (DM 5520) that will not apply more than 250 volts rms between the supply conductor and ground. A protective ground connection by way of the grounding conductor in the power cord is essential for safe operation.

SPECIFICATION

Introduction

This section of the manual contains a general description of the Tektronix DM 5120/5520 Programmable Digital Multimeter and complete electrical, environmental, and physical specifications. Standard accessories are also listed.

Instrument Description

The Tektronix DM 5120/5520 is a programmable five function autoranging digital multimeter. The DM 5120 is designed to operate in three compartments of a Tektronix TM 5000-series power module. The DM 5520 is a monolithic version of the DM 5120.

NOTE

Information in this manual applies to both the DM 5120 and DM 5520 unless otherwise noted.

The DM 5120/5520 can be manually programmed from the front panel or remotely programmed via the general purpose interface bus (GPIB). Recommended controllers are the Tektronix 4041 or an IBM PC-compatible, such as the Tektronix PEP 301, with Tektronix GURU software and GPIB interface card. When properly installed, the DM 5120/5520 is compatible with other devices that meet IEEE Standard 488.1-1987. The DM 5120/5520 complies with Tektronix technical standards on codes and formats.

At 6 1/2 digit resolution, the DM 5120/5520 LED display can display ±3,029,999 counts. The range of this analog-to-digital (A/D) converter is greater than the normal ±1,000,000-count A/D converter used in many 6 1/2 digit DMMs.

The DM 5120/5520 can make these basic measurements:

- DC voltage measurements from 100 nV to 300 V.
- Resistance measurements from 100 μΩ to 300 MΩ.
- TRMS AC voltage measurements from 1 μV to 300 V.
- DC current measurements from 1 nA to 3A.
- TRMS AC current measurements from 1 nA to 3 A.

Features

Some important DM 5120/5520 features include:

- 10 Character Alphanumeric Display—Easy to read 14-segment LEDs used for readings and front panel messages.
- High Speed Measurement Rate—1000 readings per second at 3 1/2 digits into Data Store.
- Data Store—Can store up to 500 readings and is accessible over the GPIB.
- NULL—Used to cancel offsets or establish baselines. A null value can be programmed from the front panel or over the GPIB.
- Filter—The weighted average digital filter can be set from the front panel or over the bus.
- Digital Calibration—The instrument may be digitally calibrated from either the front panel or over the bus.
- User Programmable Default Conditions—Any instrument measurement configuration can be established as the power-up default conditions.
- Offset Compensated Ohms—Used to correct for small error voltages in the measurement circuit.
- Text Mode—Used to send operator prompts to the DM 5120/5520 display over the bus.

Standard Accessories

(1) Instrument Manual 070-7240-00
(1) Instrument Interfacing Guide 070-7317-00
(1) Reference Guide 070-7318-00
(1) Set Meter Leads 012-0921-00

Optional Accessories

(1) Service Manual 070-7319-00
(1) Kelvin Test Lead Set 012-1296-00
(1) Set replacement meter leads 012-0941-00
(1) BNC to dual banana adapter 103-0090-00

IEEE 488 (GPIB) Function Capability

The DM 5120/5520 is capable of being remotely programmed via the digital interface specified in the IEEE Standard 488.1-1987, "Standard Digital Interface for Programmable Instrumentation." In this manual, the 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 that apply to the DM 5120/5520 are listed in Table 1-1.

NOTE

Refer to IEEE Standard 488.1-1987 for more detailed information. The standard is published by the Institute of Electrical and Electronics Engineers, Inc., 345 East 47th Street, New York, New York 10017.

Table 1-1
INTERFACE FUNCTION SUBSETS

Function	Subset	Capability
Source Handshake	SH1	Complete capability.
Acceptor Handshake	AH1	Complete capability.
Basic Talker	T6	Responds to Serial Poll, Untalk if My Listen Address (MLA) is received.
Extended Talker (Secondary address)	TE0	No capability.
Basic Listener	L4	Unlisten if My Talk Address (MTA) is received.
Extended Listener (Secondary address)	LE0	No capability.
Service Request	SR1	Complete capability.
Remote-Local	RL1	Complete capability, including Local Lockout.
Parallel Poll	PP0	Does not respond to Parallel Poll.
Device Clear	DC1	Complete capability.
Device Trigger	DT1	Complete capability.
Controller	C0	No compatibility.
Electrical Interface	E2	Three-state driver capability.

ELECTRICAL CHARACTERISTICS

Performance Conditions

The characteristics in this specification are valid with the following conditions:

1. The instrument must have been calibrated at an ambient temperature between +22°C and +24°C.
2. The instrument must be in a non-condensing environment whose limits are described under Environmental.
3. Allow two hours warm-up time for operation to specified accuracy; two hours after exposure to or storage in high humidity (condensing) environment.
4. Specifications are valid with only those connections to the instrument that are required to verify each specification.

Items listed in the Performance Requirements column of the following tables are verified by completing the Performance Check in the Service manual. Items listed in the Supplemental Information column may not be verified in the manual; they are either explanatory notes or performance characteristics for which no limits are specified.

ELECTRICAL

DC Voltage

Characteristics	Performance Requirements	Supplemental Information
ACCURACY (6 1/2 digit)[1]		
24 hour 23° ±1°C		24 hour specifications are relative to calibration standards.
300 mV range	±(0.002% of reading +20 counts)[2]	
3 V range	±(0.0013% of reading +10 counts)	
30 V range	±(0.0015% of reading +10 counts)	
300 V range	±(0.003% of reading +10 counts)	
90 days 18-28°C		
300 mV	±(0.005% of reading +20 counts)[2]	
3 V	±(0.003% of reading +20 counts)	
30 V	±(0.006% of reading +20 counts)	
300 V	±(0.009% of reading +20 counts)	
1 year 18-28°C		
300 mV	±(0.008% of reading +20 counts)[2]	
3 V	±(0.0038% of reading +20 counts)	
30 V	±(0.008% of reading +30 counts)	
300 V	±(0.009% of reading +30 counts)	
Temperature Coefficient[3]		
0-18°C, 28-50°C		
300 mV	±(0.0006% of reading +10 counts)/°C	
3 V	±(0.0004% of reading +1 count)/°C	
30 V	±(0.0013% of reading +3 counts)/°C	
300 V	±(0.0013% of reading +1 count)/°C	
CMRR	>120 dB at DC, 50 Hz or 60 Hz (±0.05%).	With a 1 kΩ unbalance in either lead.
NMRR	>60 dB at 50 Hz or 60 Hz (±0.05%)	
ANALOG SETTLING TIME	<1 ms (<2 ms on 300 mV range), to 0.01% of step change.	
MAXIMUM RESOLUTION		0.1 μV.
INPUT RESISTANCE		
300 mV		>1 GΩ
3 V		>1 GΩ
30 V		11 MΩ
300 V		10.1 MΩ

1 For 5 1/2 digit accuracy, divide 6 1/2 digit count error by 10. For 4 1/2 digit accuracy, count error is 5 (except 15 on 300 mV range). For 3 1/2 digit accuracy, count error is 5.
2 When properly nulled.
3 In the range of 0°C to 18°C the instrument accuracy = basic accuracy +/- Temperature Coefficient X (18°C–ambient temperature). In the range of 28°C to 50°C the instrument accuracy = basic accuracy +/- Temperature Coefficient X (ambient temperature–28°C).

ELECTRICAL (Cont)

DC Voltage (Cont)

Characteristics	Performance Requirements	Supplemental Information
LINEARITY		
23°C ±1°C	10 ppm of range for 3 V, 30 V, 300 V ranges, 15 ppm of range for 300 mV range	Linearity is defined as the maximum deviation from a straight line between the readings at zero and full range.
MAXIMUM INPUT VOLTAGE		
Hi to Lo	300 VDC or 425 V (DC plus Peak AC) whichever is less.	
Lo to Gnd	350 V (DC plus Peak AC).	

AC Voltage (True RMS) AC Coupled

Characteristics	Performance Requirements	Supplemental Information
ACCURACY (5 1/2 digits)[1] For 300 mV, 3 V, 30 V, and 300 V range		−3 dB bandwidth typically 300 kHz.
1 year 18-28°C		For sinewave inputs greater than 2000 counts.
20 Hz to 50 Hz	±(2% of reading +100 counts)	
50 Hz to 200 Hz	±(0.3% of reading +100 counts)	
200 Hz to 10 kHz	±(0.15% of reading +100 counts)	
10 kHz to 20 kHz	±(0.4% of reading +200 counts)	For the 3 Volt range, 10 kHz to 20 kHz, the accuracy is ±(0.3% of reading +200 counts)
20 kHz to 100 kHz[2]	±(1.5% of reading +300 counts)	For sinewave inputs greater than 20,000 counts
Temperature Coefficient[3]		
0-18, 28-50°C	< ±(0.1 times applicable accuracy specification)/°C below 20 kHz. < ±(0.2 times) for 20 kHz to 100 kHz.	
Crest Factor		≤3:1
Nonsinusoidal measurement accuracy (crest factor <3), fund freq <1 kHz	Add to base accuracy.	
300 mV, 3 V	±(0.25% of reading)	
30 V, 300 V	±(0.6% of reading)	
MAXIMUM RESOLUTION		1 μV

1 For 4 1/2 digit accuracy, divide count error by 10. For 3 1/2 digit accuracy, count error is 5. In 3 1/2 and 4 1/2 digit modes, specifications apply for inputs greater than 200 Hz.
2 Specification for 300 mV range is +/−(2% of reading +300 counts).
3 See footnote 3 on page 1-3.

ELECTRICAL (Cont)

AC Voltage (True RMS) AC Coupled (Cont)

Characteristics	Performance Requirements	Supplemental Information
INPUT IMPEDANCE		
Hi to Lo		1 MΩ shunted by <120 pF
Lo to GND		>10^9Ω paralleled by <400 pF
CMRR	>60 dB at 50 or 60 Hz (±0.05%)	With 1 KΩ unbalance in either lead.
SETTLING TIME		1 second to within 0.1% of change in reading.
MAXIMUM INPUT VOLTAGE		
Hi to Lo	300 V RMS (425 V peak), 10^7 V_{rms}-Hz product, whichever is less.	
Lo to GND	350 V (DC plus Peak AC) or 5 × 10^5 max. V_{rms}-Hz product, whichever is less.	

dB (AC Voltage)

Characteristics	Performance Requirements	Supplemental Information
ACCURACY		
1 year 18-28°C		
-34 to +49 dB (20 mV to 300 V)		
20 Hz to 20 kHz	±0.2 dB	
20 kHz to 100 kHz	±0.4 dB	
-54 to -34 dB (2 mV to 20 mV)		
20 Hz to 20 kHz	±1.1 dB	
20 kHZ to 100 kHz		±3 dB typical
Maximum Resolution		0.01 dB
Reference Level (default)		
ACV		1 V RMS=0 dB

ELECTRICAL (Cont)

Ohms

Characteristics	Performance Requirements	Supplemental Information
ACCURACY (6 1/2 digits)[1]		Automatic 2 or 4 wire ohms measurement capability
24 hours 23°C ±1°C[2]		
300Ω[3]	±(0.0025% of reading +20 counts)	4 wire measurement mode accuracy
3 kΩ	±(0.0025% of reading +20 counts)	4 wire measurement mode accuracy
30 kΩ	±(0.0025% of reading +20 counts)	4 wire measurement mode accuracy
300 kΩ	±(0.006% of reading +20 counts)	
3 MΩ	±(0.007% of reading +20 counts)	
30 MΩ	±(0.06% of reading +50 counts)	
300 MΩ	±(2.0% of reading +5 counts)	Resolution limited to 5 1/2 digits
90 days 18-28°C		
300Ω[3]	±(0.008% of reading +20 counts)	4 wire measurement mode accuracy
3 kΩ	±(0.005% of reading +20 counts)	4 wire measurement mode accuracy
30 kΩ	±(0.005% of reading +20 counts)	4 wire measurement mode accuracy
300 kΩ	±(0.02% of reading +20 counts)	
3 MΩ	±(0.02% of reading +20 counts)	
30 MΩ	±(0.1% of reading +50 counts)	
300 MΩ	±(2.0% of reading +5 counts)	Resolution limited to 5 1/2 digits
1 year 18-28°C		
300Ω[3]	±(0.01% of reading +20 counts)	4 wire measurement mode accuracy
3 kΩ	±(0.007% of reading +20 counts)	4 wire measurement mode accuracy
30 kΩ	±(0.007% of reading +20 counts)	4 wire measurement mode accuracy
300 kΩ	±(0.021% of reading +20 counts)	
3 MΩ	±(0.021% of reading +20 counts)	
30 MΩ	±(0.1% of reading +50 counts)	
300 MΩ	±(2.0% of reading +5 counts)	Resolution limited to 5 1/2 digits
Temperature Coefficient[4]		
0-18, 28-50°C		
300Ω	±(0.001% of reading +7 counts)/°C	
3 kΩ	±(0.001% of reading +1 count)/°C	
30 kΩ	±(0.001% of reading +1 count)/°C	
300 kΩ	±(0.004% of reading +1 count)/°C	
3 MΩ	±(0.004% of reading +1 count)/°C	
30 MΩ	±(0.03% of reading +1 count)/°C	
300 MΩ	±(0.3% of reading +1 count)/°C	

1 For 5 1/2 digit accuracy divide 6 1/2 digit count error by 10. For 4 1/2 digit accuracy, count error is 5 (except 15 on 300 Ω range). For 3 1/2 digit accuracy, count error is 5.
2 Relative to calibration standards.
3 When properly nulled.
4 See footnote 3 on page 1-3.

ELECTRICAL (Cont)

Ohms (Cont)

Characteristics	Performance Requirements	Supplemental Information
OFFSET COMPENSATION		Requires proper zeroing
300Ω to 30 kΩ range		±10 mV on 300Ω range ±100 mV on 3 kΩ and 30 kΩ range
OPEN CIRCUIT VOLTAGE		≤5.5 volts
MAXIMUM RESOLUTION		100 μΩ
LINEARITY		Linearity is defined as the maximum deviation from a straight line between the readings at zero and full scale. 20 ppm of range for 300Ω to 30 kΩ ranges at 23°C ±1°C
MAXIMUM INPUT VOLTAGE	300 V RMS or 425 V peak, whichever is less.	
SHORT CIRCUIT CURRENT		
300 Ω		1.7 mA
3 kΩ		1.7 mA
30 kΩ		160 μA
300 kΩ		50 μA
3 MΩ		5 μA
30 MΩ		0.5 μA
300 MΩ		0.5 μA

DC Current

Characteristics	Performance Requirements	Supplemental Information
ACCURACY (5 1/2 digits)[1]		
1 year 18-28°C		Maximum Voltage Burden
300 μA	±(0.09% of reading +20 counts)	0.4 V
3 mA	±(0.05% of reading +10 counts)	0.4 V
30 mA	±(0.05% of reading +10 counts)	0.4 V
300 mA	±(0.05% of reading +10 counts)	0.5 V
3 A	±(0.09% of reading +10 counts)	2.0 V
Temperature Coefficient[2]		
0-18, 28-50°C	<±(0.1 times applicable accuracy specification)/°C	
MAXIMUM RESOLUTION		1 nA
MAXIMUM INPUT	3 A (250 V)	3 A, 250 V fuse protected

1 4 1/2 digit count error is 20; 3 1/2 digit count error is 5.
2 See footnote 3 on page 1-3.

ELECTRICAL (Cont)

AC Current (True RMS) AC Coupled

Characteristics	Performance Requirements	Supplemental Information
ACCURACY (5 1/2 digits)[1] (For 3 mA, 30 mA, 300 mA, 3 A)		The specified accuracies are correct for nonsinusoidal measurements on fundamental frequencies <1 kHz and crest factor <3, (except on the 300 μA range where 2.2% must be added to the specified accuracy).
1 year 18-28°C		
20 Hz to 45 Hz	±(2% of reading +100 counts)	
45 Hz to 10 kHz	±(0.6% of reading +100 counts)	
(For 300 μA range)		
20 Hz to 45 Hz	±(2% of reading +100 counts)	
45 Hz to 1 kHz	±(0.9% of reading +100 counts)	
1 kHz to 10 kHz	±(4.0% of reading +100 counts)	
Temperature Coefficient[2]		
0-18, 28-50°C	<±(0.1 times applicable accuracy specification)/°C .	
Crest Factor (up to 2/3 fullscale)		≤3:1
MAXIMUM RESOLUTION		1 nA
MAXIMUM VOLTAGE BURDEN		
300 μA		0.4 V
3 mA		0.4 V
30 mA		0.4 V
300 mA		0.5 V
3 A		2.0 V
SETTLING TIME		1 second to within 0.1% of change in reading.
MAXIMUM INPUT	3 A (250 V)	3 A, 250 V fuse protected
dB (CURRENT) ACCURACY		
1 year 18-28°C 20 Hz to 10 kHz		
–9.9 to 69 dB (320 μA to 3 A)	±0.2 dB	
–54 to –9.9 dB (2 μA to 320 μA)	±0.9 dB	
MAXIMUM RESOLUTION		0.01 dB
REFERENCE LEVEL (Default)		1 mA = 0 dB

1 For sinewave inputs greater than 2000 counts. For 4 1/2 digit accuracy, divide count error by 10. For 3 1/2 digit accuracy, count error is 5. In 3 1/2 and 4 1/2 digit modes, specifications apply for sinewave inputs greater than 200 Hz.

2 See footnote 3 on page 1-3.

ELECTRICAL (Cont)

GPIB Characteristics

Characteristics	Performance Requirements	Supplemental Information
INTERFACE	Conforms to IEEE-488.1 1987. See Table 1-1 for the supported subsets.	

Miscellaneous

Characteristics	Performance Requirements	Supplemental Information
WARMUP TIME		2 hours to rated accuracy
POWER CONSUMPTION (DM 5120 Only)		11 watts
MAXIMUM READING (6 1/2 digits)		±3029999 counts

MAXIMUM READING RATES[1]
DCV, DCA, ACV, ACA READINGS/SECOND

	Continuous Into Internal Buffer AutoCal:		External Trigger Into Internal Buffer AutoCal:		Triggered Via IEEE-488 Bus AutoCal:	
Resolution	Off	On	Off	On	Off	On
3 1/2-digit	1000	1000	196	73	72	45
4 1/2-digit	333	333	138	63	63	41
5 1/2-digit	35 (29)	8.2 (7.5)	40 (33)	9 (7.5)	29 (26)	8.2 (7.5)
6 1/2-digit[2]		8.2 (7.5)		0.25 (0.2)		0.25 (0.2)

OHMS READINGS/SECOND

	Continuous Into Internal Buffer AutoCal:		External Trigger Into Internal Buffer AutoCal:		Triggered Via IEEE-488 Bus AutoCal:	
Resolution	Off	On	Off	On	Off	On
3 1/2-digit	40	24	47	23	32	19
4 1/2-digit	38	18	39	18	29	16
5 1/2-digit	16 (13)	9.5 (7.5)	15 (14)	9.5 (7.5)	13 (12.5)	9 (7.5)
6 1/2-digit[2]		9 (7.5)		0.3 (0.25)		0.3 (0.25)

Offset Compensated Ohms: Rates are 0.5 times normal mux on ohms rates.

1 Reading rates are for on-range on-scale readings with internal filter off, for 3 V, 3 kΩ, and 3 mA ranges. 6 1/2- and 5 1/2-digit rates are for 60 Hz operation. Values in parentheses are for 50 Hz operation.

2 Internal filter on.

ELECTRICAL (Cont)

Source Power Requirements (DM 5520 Only)

Characteristics	Performance Requirements	Supplemental Information
VOLTAGE RANGES		Selectable 100 V, 120 V, 220 V, and 240 V nominal line ±10%.
LINE FREQUENCY		48 - 400 Hz.
MAXIMUM POWER CONSUMPTION		Approximately 120 W.
FUSE DATA		
100 V, 120 V Ranges		1.0 A, 3AG, fast blow, 250 V.
220 V, 240 V Ranges		0.5 A, 3AG, slow blow, 250 V.

PHYSICAL

Environmental

Characteristics	Description
TEMPERATURE	Meets MIL-T-28800D, class 5.
Operating:	0°C to +50°C
Non-Operating:	−40°C to +71°C
HUMIDITY:	95% RH, 11°C to 30°C 75% RH to 40°C 45% RH to 50°C Exceeds MIL-T-28800D, class 5, non-condensing.
ALTITUDE:	Exceeds MIL-T-28800D, class 5.
Operating:	4.6 km (15,000 ft.)
Non-Operating:	15 km (50,000 ft.)
VIBRATION[1]	0.38 mm (0.015") peak-to-peak, 5 Hz to 55 Hz, 75 minutes. Meets MIL-T-28800D, class 5, when installed in qualified power modules.[2]
SHOCK[1]	30 g's (1/2 sine) 11 ms duration, 3 shocks in each direction along 3 major axes, 18 total shocks. Meets MIL-T-28800D, class 5 when installed in qualified power modules.[2]
BENCH HANDLING[3]	12 drops from 45°, 4" or equilibrium, whichever occurs first. Meets MIL-T-28800D, class 5, when installed in qualified power modules.[2]
TRANSPORTATION[3]	Qualified under National Safe Transit Association Preshipment Test Procedures 1A-B-1 and 1A-B-2.

1 Requires retainer clip.
2 Refer to TM 5000 power module specifications.
3 Without power module.

PHYSICAL (Cont)

Environmental (Cont)

Characteristics	Description
EMC[1]	Within limits of F.C.C Regulations Part 15, Subpart J, Class A; VDE 0871 Class B; and MIL-461B (1980) for RE01, RE02, CE01, CE03, RS01, RS03, CS01, CS02, and CS06.
ELECTRICAL DISCHARGE	6 kV maximum discharge applied to operating instrument from an ESD source per IEC 801-2 (150 Ω/150 pf).
SAFETY SPECIFICATIONS	Shall meet the following safety standards:
U.S.A	UL1244 (Electrical and Electronic measuring and test equipment).
Canada	CSA 556B (Electrical Bulletin).
International	IEC 348 (Electronic measuring apparatus).

Mechanical

Characteristics	Description
NET WEIGHT:	
DM 5120	2.1 kg (5.75 lbs)
DM 5520	5.3 kg (14.3 lbs)
OVERALL DIMENSIONS:	
DM 5120	
Height:	12.7 cm (5.0 in)
Width:	20.3 cm (8.0 in)
Length:	29.2 cm (11.5 in)
DM 5520	
Height:	14.0 cm (5.5 in)
Width:	23.4 cm (9.2 in)
Length:	44.4 cm (17.5 in)

1 System performance subject to exceptions of power module and/or other plug-ins.

OPERATING INSTRUCTIONS

Introduction

This section provides installation and operation instructions for the DM 5120/5520, describes the functions of the front-panel controls and connectors, and gives some examples of basic DMM operation under local control. The information in this section assumes the instrument is not connected to the GPIB. Complete information for programming the DM 5120/5520 via the GPIB (General Purpose Interface Bus) is in the Programming section of this manual.

PREPARATION FOR USE

Installation and Removal—DM 5120 Only

NOTE

The DM 5120 is designed to operate only in a TM 5000-Series power module. Refer to the power module instruction manual before installing the DM 5120.

The DM 5120 is calibrated and ready for use when received. It operates in three compartments of any TM 5000-Series GPIB compatible power module. Refer to the power module instruction manual for line voltage requirements and power module operation.

CAUTION

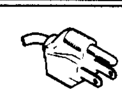
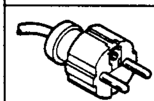
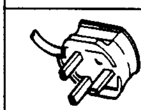
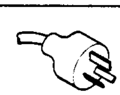
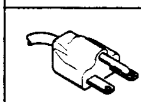
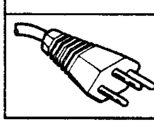
To prevent damage to the DM 5120, turn the power module off before installation or removal. Do not use excessive force to install or remove.

Check to see that the plastic barriers on the interconnecting jacks of the selected power module compartments match the cutouts in the DM 5120 circuit board edge connectors. If these do not match, do not insert the instrument until the reason is determined. When the units are properly matched, align the DM 5120 chassis with the upper and lower guides of the selected compartments. Insert the DM 5120 into the power module and press firmly to seat the circuit board edge connectors in the power module interconnecting jacks. Apply power to the DM 5120 by actuating the power switch on the power module.

To remove the DM 5120 from the power module, pull both release latches on the front panel until the interconnecting jack disengages. The instrument will then slide straight out.

Power Cords—DM 5520 Only

The DM 5520 is shipped with the power cord option as ordered by the customer (see Fig. 2-1). Verify that the instrument power cord is the proper cord for use with the available power.

PLUG CONFIGURATION	USAGE	LINE VOLTAGE	REFERENCE STANDARDS	OPTION NUMBER
	North American 120/15A	120V	ANSI C73.11 NENA 5-15-P IEC 83	Standard
	Universal Euro 240V/ 10-16A	240V	CEE (7).II.IV.VII IEC 83	A1
	UK 240V/ 13A	240V	BS 1363 IEC 83	A2
	Australian 240V/ 10A	240V	AS C112	A3
	North American 240V/ 15A	240V	ANSI C73.20 NEMA 6-15-P IEC 83	A4
	Switzerland 220V/ 6A	220V	SEV	A5

6759-13

Fig. 2-1. Power cords.

Line Voltage Selection/Fuse Replacement—DM 5520 Only

NOTE

The DM 5520 contains fuses in the voltage selector/fuse holder assembly located on the rear panel. The instrument also contains internal fuses; refer qualified service personnel to the Maintenance section of this manual for information on internal fuse replacement.

The line voltage selector is part of the line cord plug assembly, located on the rear of the power module. Verify that the voltage shown in the selector window is correct for the line voltage available.

If the displayed voltage selection is incorrect or the fuse needs replacement, perform the following procedure. Refer to Fig. 2-2.

1. Make certain that the power switch (on rear of unit) is turned off and the line cord is not plugged into the line voltage connector.
2. Remove the voltage selector/fuse holder by pushing the latch/release bar toward the selection window. The selector/fuse holder should release and move slightly out of the socket. Remove the voltage selector/fuse holder from the assembly.
3. Pull the fuse block and fuse from the voltage selector/fuse holder. Remove the fuse from the fuse block. Make certain a replacement fuse has the proper ratings for the selected line voltage (refer to Specifications for fuse rating). Insert fuse into fuse block.
4. The line voltage selections are printed on the end of the fuse box. Rotate the fuse box and reinstall it so that the proper line voltage selection is visible through the selection window.
5. Reinstall the voltage selector/fuse holder.
6. Verify that the correct line voltage is visible through the line voltage selector window.

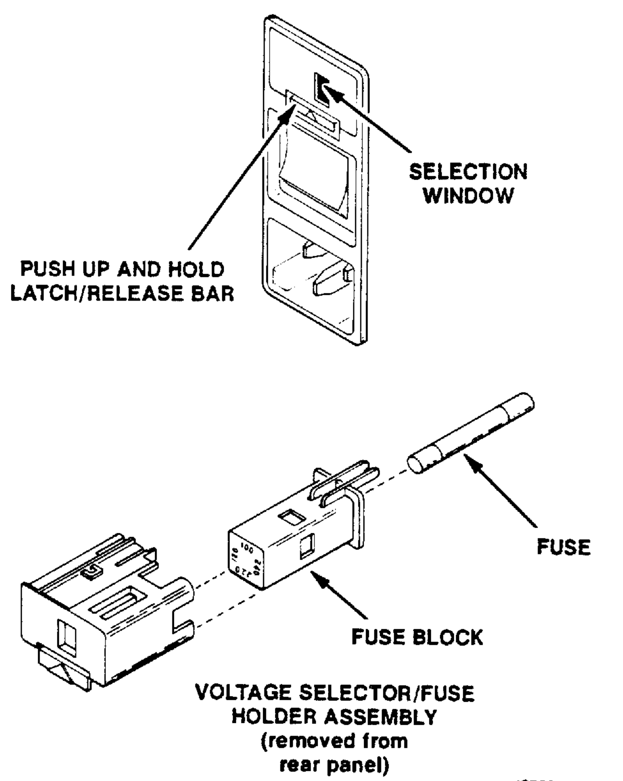


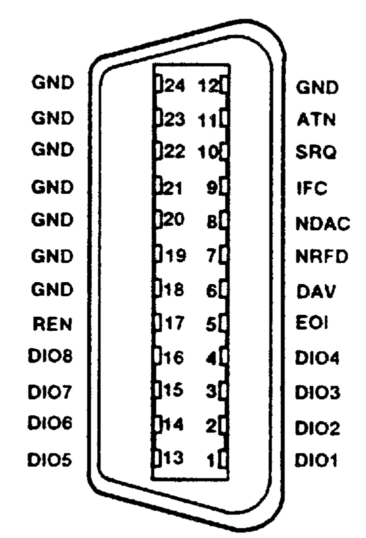
Fig. 2-2. Line voltage selection/fuse replacement.

Turn-On Procedure

After completing the appropriate Preparation For Use instructions, install the power cord and connect it to the proper power outlet. Turn on the power switch on the instrument rear panel.

IEEE 488 (GPIB) Connector —DM 5520 Only

Figure 2-3 shows the pin assignments for the rear panel GPIB connector.



Rear panel GPIB connector viewed from rear or power module (IEEE Standard No. 488).

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Fig. 2-3. Rear panel GPIB connector.

Repackaging For Shipment

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

If the original package is unfit for reuse or unavailable, repackage the instrument as follows:

Wrap the instrument with polyethylene sheeting or other suitable material to protect the exterior finish. Obtain a carton of corrugated cardboard of adequate strength and having inside dimensions no less than six inches more than the dimensions of the instrument. Cushion the instrument by tightly packing dunnage or urethane foam between the carton and instrument, on all sides. Seal the carton with shipping tape or use an industrial stapler.

The carton test strength for your instrument is:
275 pounds per square inch

Power Up Sequence

When powered on, the DM 5120/5520's microprocessor performs a diagnostic routine (self test) to check the functionality of the ROM, RAM and EEPROM. If no ROM, RAM or EEPROM errors are found, the microprocessor goes on to check the functionality of the other instrument hardware.

If a ROM or RAM error is found, an error code is displayed in the front-panel display. The instrument will not respond to input from the front panel or the GPIB interface. Internal errors detected after the ROM and RAM tests have passed will be reported to both the front panel and the GPIB. The instrument will respond to input and attempt to function in spite of the error. An error code may be removed from the display by pressing the INST ID key, by starting a numeric entry, by incrementing the selected parameter, or by a transition into the remote state (REMS).

Instrument Settings at Power Up

When the DM 5120/5520 is turned on and has passed the self test, the instrument functions and parameters are set up to the previously saved setup conditions. These setup conditions will be either the factory default setup or a setup that was programmed by the user.

At the factory, a basic instrument setup is internally programmed and saved into the DM 5120/5520. Initially, the instrument will power up with these factory setup conditions (Table 2-1). You can override these factory default conditions by saving your own setup running the front-panel Program 30 (SAVE CURRENT SETTINGS). To again return to the factory default conditions, you must run Program 37 (RESET), then Program 30 (SAVE CURRENT SETTINGS). The DM 5120/5520 will only power up to the setup conditions that were last saved using Program 30. You can return the instrument to the last saved setup by running Program 38 (INIT) or by sending INIT over the GPIB interface.

Table 2-1
FACTORY DEFAULT CONDITIONS

FUNCT	DCV	READ	ADC
RANGE	4	DATFOR	ON
DIGIT	6	RQS	ON
AUTOCAL	ON	ERRSTAT	ON
INTFILT	ON	OVER	OFF
FILTER	OFF	FULL	OFF
FILTERVAL	10	HALF	OFF
NULL	0	OPC	OFF
NULLVAL	+000.0000E+0	RDY	OFF
TRIGGER	EXT,CONT	TEXT	" "
DELAY	0	KEY	15
BUFSZ	CIRCULAR	USER	OFF
STOINT	175		

NOTE

The DM 5120/5520 is initially set for an IEEE address of 16. The line frequency is set to 60 Hz.

Saving Instrument Setups

Each function of the DM 5120/5520 retains the last measurement configuration that it was set to (such as range, zero value, filter value, etc). Switching back and forth between functions will not affect the unique configuration of each function. However, those configurations will be lost when the instrument is turned off unless you have saved them by running Program 30 (SAVE CURRENT SETTINGS). See Using Front Panel Programs, in this section, for complete information on running Program 30.

IEEE Address and Line Frequency

Any IEEE address and line frequency setting can be saved as default conditions by running Program 30

(SAVE CURRENT SETTINGS). See Using Front Panel Programs, in this section, for complete information on Program 31 (IEEE ADDRESS/TERMINATION) and Program 32 (50/60 Hz).

NOTE

An "UNCAL" error will set the IEEE address to 16 and the line frequency to 60Hz.

CONTROLS, CONNECTORS, AND DISPLAY

All controls, connectors, and displays (indicators) used for local (manual) operation of the DM 5120/5520 are located on the front panel (See Figure 2-4). The following describes the function of each front panel control, connector, and display.

(1) Display

The DM 5120/5520 uses a 10-digit LED alphanumeric display. The display can have the following information:

1. The current reading.
2. If a command or other error situation occurs, the error number will be displayed for a short period of time.
3. If the INST ID button is pressed, the GPIB address and terminator is displayed followed by the codes and formats version and firmware version.
4. If one of the program modes is selected, the display will hold value to be changed or other information/prompts needed to complete the information transaction with the instrument.
5 If a reading is in progress the right-hand decimal point is illuminated.
6. If the CAL LOCK is off, the CAL LOCK lights in the display will be lit.

(2) GPIB Indicators

There are two GPIB indicators on the front panel.

1. The remote indicator. This indicates when the instrument is in remote state.
2. The addressed indicator. This indicates when the instrument is being addressed to talk or listen.

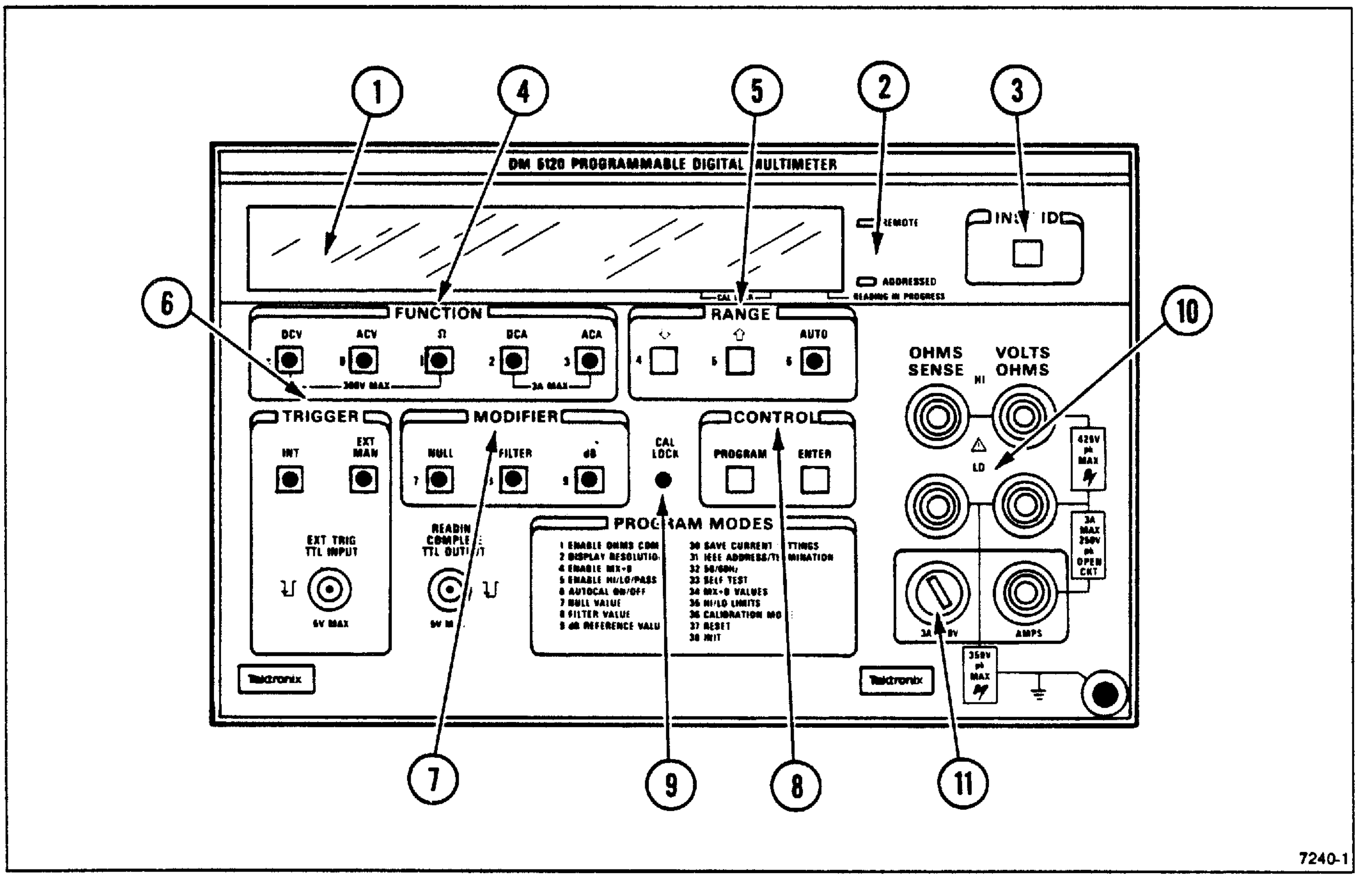


Fig. 2-4. Controls and Connectors.

(3) INST ID

Causes the DM 5120/5520 to display its GPIB address and terminator followed by the codes and formats version and firmware version.

NOTE

The FUNCTION, RANGE, and MODIFIER keys each have the secondary purpose of functioning as one of the numeric-entry keys for the Program Mode.

(4) FUNCTION Keys

The FUNCTION keys select the desired operating mode for the instrument. When the function controlled by a key is selected, the LED in the key will light.

DCV (±) Selects the DC voltage function when the instrument is not in program mode. If the instrument is in program mode, the key will toggle the sign of any number that is being input.

ACV (0) Selects the AC voltage function when the instrument is not in program mode. If the instrument is entering a value the number 0 is input to the instrument.

Ω (1) Selects the OHMS function when the instrument is not in program mode. If the instrument is entering a value, the number 1 is input to the instrument.

DCA (2) Selects the DC current function. If the instrument is entering a value, the number 2 is input to the instrument.

ACA (3) Selects the AC current function. If the instrument is entering a numeric value, the number 3 is input to the instrument.

(5) RANGE Keys

If the PROGRAM key is pressed first, the ⇓, ⇑ or AUTO keys will enter numeric values 4, 5, or 6 respectively.

⇓ (DECREMENT) (4) Reduces the range to the next lower (more sensitive) range. If the range is at the most sensitive range, no change will occur.

⇑ (INCREMENT) (5) Increases the range to the next higher (less sensitive) range. If the range is at the least sensitive (highest) range, no change will occur to the range.

AUTO (6) Puts the instrument into autorange mode which will select the most sensitive range that does not cause an overrange condition.

(6) TRIGGER Keys

INT Select an internal trigger source for the instrument. The instrument will also be put into continuous trigger mode.

EXT/MAN Selects the external trigger source for the instrument. The instrument will also be put into one shot mode (one reading for each trigger) triggers are into to the instrument through the trigger input connector. When in the EXT trigger mode, each press of the EXT/MAN button will create a trigger and one reading will be taken.

(7) MODIFIER Keys

In the program mode, the NULL. FILTER, and dB keys are used to modify the instrument functions.

NULL (7) Subtracts the null value from the reading and displays the result (null value). When the NULL function is pressed, the present reading becomes the null value. If the NULL function is entered through the NULL VALUE program (Program Mode 7), a user selected value will be used for the null value. When NULL is selected the NULL LED will light. If the null value is +1 Volts, it will take an input voltage of +1 volt to get a reading on the front panel of 0 Volts.

Displayed reading = Reading before null calculation – null value.

FILTER (8) Turns on and off the internal weighted average filter. The formula for the filter is:

Displayed value = Last reading + (New reading – Last reading)/Filter value

Last reading = Last displayed reading

New reading = New reading from the converter

Filter value = Filter value entered using program mode 8.

dB (9) Converts any of the AC function readings into a dB reading. If the dB key is pressed when in the DC voltage function an error message will be displayed on the front panel.

The formula describing the relationship between dB and voltage is:

dB = 20 log (input/reference)

input = the AC input voltage or current reading and reference = the 0 dB AC reference voltage or current.

The reference value can be changed using program mode 9. The factory defaults for AC voltage reference is 1 V and for AC current is 1 mA.

8 CONTROL Keys

The control keys allow use of the secondary numeric functions of the FUNCTION, RANGE, and MODIFIER keys.

PROGRAM Enters the front-panel program mode. Using the numeric keys, enter the program number. When the instrument has enough information to determine which of the programs is desired, the setting program will start.

ENTER Terminates an entry or confirms that the action performed by the program is the desired action. If you want to terminate an action before it is executed, press the PROGRAM key. The program will be terminated without making a change or performing the action.

9 CAL LOCK Switch

Calibration of the DM 5120/5520 can only be done if the CAL LOCK switch is in the proper position. See the service manual for details. If CAL LOCK is off the CAL LOCK lights in the display will be lit.

10 INPUT CONNECTORS

The input connectors are intended to be used with safety shrouded test leads to help minimize the possibility of contact with live circuits. See test requirements under Basic Measurements in the this section.

VOLTS OHMS HI and LO	These connectors are used for making DC volts, AC volts, and resistance measurements.
AMPS and LO	These connectors are used for making DC current and AC current measurements.
OHMS SENSE HI and LO	These connectors are used with the OHMS HI and LO connectors to make four-wire resistance measurements.
EXTERNAL TRIGGER TTL INPUT	This BNC connector is used to apply pulses to trigger the DM 5120/5520 to take one or more readings, depending on the selected trigger mode.
READING COMPLETE TTL OUTPUT	This BNC output connector provides a TTL-compatible negative-going pulse when the DM 5120/5520 has completed a reading. It is useful for triggering other instrumentation.

11 FUSE HOLDER

Contains the current circuit protection fuse (3 A, 250 V). See the Maintenance section for fuse replacement information.

BASIC MEASUREMENTS

The following paragraphs describe the basic procedures for making voltage, resistance, current, and dB measurements. Table 2-2 shows the GPIB Range Number to use for setting a selected function range. For detailed explanation of GPIB commands, see the Programming section.

Table 2-2
FUNCTION/RANGE vs RANGE NUMBER

GPIB RANGE NUM	FUNCTION						
	DCV	ACV	OHMS	DCA	ACA	ACVDB ACADB	OHMS-COMP
0	AUTO	AUTO	AUTO	AUTO	AUTO	AUTO	AUTO
1	300 mV	300 mV	300	300 uA	300 uA	AUTO	300
2	3 V	3 V	3 K	3 mA	3 mA	AUTO	3 K
3	30 V	30 V	30 K	30 mA	30 mA	AUTO	30 K
4	300 V	300 V	300 K	300 mA	300 mA	AUTO	30 K
5	300 V	300 V	3 M	3 A	3 A	AUTO	30 K
6	300 V	300 V	30 M	3 A	3 A	AUTO	30 K
7	300 V	300 V	300 M	3 A	3 A	AUTO	30 K

High Energy Circuit Safety Precautions

To optimize safety when measuring voltage in high energy distribution circuits, read and use the directions in the following warning.

WARNING

Dangerous arcs of an explosive nature in a high energy circuit can cause severe personal injury or death. If the meter is connected to a high energy circuit when set to a current range, low resistance range or any other low impedance range, the circuit is virtually shorted. Dangerous arcing can also result when the meter is set to a voltage range if minimum voltage spacing is reduced, or if maximum input voltage limits are exceeded.

When making measurements in high energy circuits use test leads that meet the following requirements:

- Test leads should be fully insulated.
- Only use test leads that can be connected to the circuit (e.g. alligator clips, spade lugs, etc.) for hands-off measurements.
- Do not use test leads that decrease voltage spacing. This diminishes arc protection and creates a hazardous condition.

Use the following sequence when testing power circuits:

1. De-energize the circuit using the regular installed connect-disconnect device such as the circuit breaker, main power switch, etc.
2. Attach the test leads to the circuit under test. Use appropriate safety rated leads for this application.
3. Set the DMM to the proper function and range.
4. Energize the circuit using the installed connect-disconnect device and make measurements without disconnecting the DMM.
5. De-energize the circuit using the installed connect-disconnect device.
6. Disconnect the test leads from the circuit under test.

WARNING

The maximum common-mode input voltage (the voltage between input LO and chassis ground) is 350 V peak. Exceeding this value may create a shock hazard.

Warm Up Period

The DM 5120/5520 is usable immediately when it is first turned on. However, the instrument must be allowed to warm up for at least two hours to achieve rated accuracy.

Null

The null feature serves as a means of baseline suppression by allowing a stored offset value to be subtracted from subsequent readings. When the NULL key is pressed the instrument takes the currently displayed reading as baseline value. All subsequent readings represent the difference between the applied signal level and the stored baseline. To enter a predefined null value use Program 7.

A baseline level can be established (via input levels or manually entered values) for any or all measurement functions and is remembered by each function. For example, a 10 V baseline can be established on DCV, a 5 V baseline can be established on ACV and a 10 kΩ baseline can be established on Ω (OHMS). These levels will not be cancelled by switching back and forth between functions. Once a baseline is established for a measurement function, that stored level will be the same regardless of what range the DM 5120/5520 is on. For example, if 1 V is established as the baseline on the 3 V range, then the baseline will also be 1 V on the 30 V through 300 V ranges. A NULL baseline level can be as large as full range.

NOTE

The following discussion on dynamic range is based on a display resolution of 6 1/2 digits. At 5 1/2d resolution, the number of counts would be reduced by a factor of 10. At 4 1/2d resolution, counts would be reduced by a factor of 100 and 3 1/2d resolution would reduce counts by a factor of 1000.

By design, the dynamic measurement range of the DM 5120/5520, at 6 1/2d resolution, is 6059998 counts. With NULL disabled, the displayed reading range of the instrument is ±3029999 counts. With NULL enabled, the DM 5120/5520 has the capability to display ±6059998 counts. This increased display range ensures that the dynamic measurement range of the measurement is not reduced when using a NULL baseline value. The following two examples will use the maximum allowable NULL values (3029999 counts and -3029999 counts) to show that dynamic measurement range will not be reduced. It is important to note that the increased display range does not increase the maximum allowable input level to the instrument. For example, on the 3 V range, the DM 5120/5520 will always overrange when more than ±3.029 V is connected to the input.

NOTE

It is possible to program and display a null value that exceeds 3,029,999 counts. However "OVERFLOW" will appear if a measurement is attempted.

Example 1: The instrument is set to the 3 V DC range and a maximum -3.029999 V is established as the NULL value. When -3.029999 V is connected to the input of the DM 5120/5520, the display will read 0.000000 V. When +3.029999 V is connected to the input, the display will read +6.059998 V. Thus, the dynamic measurement range of the DM 5120/5520 is 0 V to 6.059 V which is 6059998 counts.

Example 2: The instrument is still set to the 3 V DC range, but a maximum +3.029999 V is the NULL level. When +3.029999 V is connected to the input of the DM 5120/5520, the display will read 0.000000 V. When -3.029999V is connected to the input, the display will read -6.059998 V. Thus the dynamic measurement range of the instrument is -6.059 V to 0 V, which is still 6059998 counts.

NULL Correction—The DM 5120/5520 must be properly nulled when using the 300 mV DC or the 300 Ω range in order to achieve rated accuracy specifications. To use NULL for NULL correction, perform the following steps:

1. Disable NULL, if presently enabled, by pressing the NULL key. The NULL indicator will turn off.
2. Select the 300 mV DC or the 300 Ω range.
3. Connect the test leads to the DM 5120/5520 input and short them together. If four-wire resistance measurements are to be made, connect and short all four leads together. Allow any thermals to stabilize.

NOTE

At 5 1/2 and 6 1/2-digit resolution, low level measurement techniques need to be employed. Use Kelvin test leads or shielded test leads. See Low-Level Measurement Considerations in this section.

4. Press the NULL key. The display will read NULL.
5. Remove the short and connect the test leads to the signal or resistance to be measured.

NOTE

Test lead resistance is also compensated for when nulling the 300 Ω range with the above procedure.

Baseline Levels—Baseline values can be established by either applying baseline levels to the instrument or by setting baseline values with the front panel NULL program. See Program 7 (NULL) under Using Front Panel Programs for the complete procedure for using the NULL program. To establish a baseline level by applying a level to the DM 5120/5520, perform the following steps:

1. Disable NULL, if presently enabled, by pressing the NULL key. The NULL indicator will turn off.
2. Select a function and range that is appropriate for the anticipated measurement.
3. Connect the desired baseline level to the input of the DM 5120/5520 and note that level on the display.

4. Press the NULL key. The display will NULL and the NULL indicator will be enabled. The previously displayed reading will be the stored baseline. The NULL baseline value will also be stored in Program 7, replacing the previous NULL value.

WARNING

With NULL enabled, a hazardous voltage baseline level (±40 V or more), not displayed, may be present on the input terminals. If not sure what is applied to the input, assume that a hazardous voltage is present.

5. Disconnect the stored signal from the input and connect the signal to be measured in its place. Subsequent readings will be the difference between the stored value and the applied signal.

NOTE

Disabling NULL cancels the NULL baseline value on that selected function. However, since the NULL value is automatically stored in Program NULL, the NULL baseline value can be retrieved by using the program as long as the NULL key is not again pressed (see Using Front Panel Programs, Program 7 (NULL) for details). Pressing the NULL key, thus enabling NULL, will wipe out the previous baseline value in Program 7. Baselines established on other functions are not affected.

To store a new baseline on a selected function, NULL must first be disabled and then enabled again. The new value will be stored with the first triggered conversion. The baseline value will also be stored as the NULL value in Program 7, cancelling the previously stored value.

Setting the range lower than the suppressed value will overrange the display; the instrument will display the overrange message under these conditions.

When the NULL key is pressed to enable NULL, the NULL indicator light will blink until an on scale reading is available to use as a NULL level.

Filter

The DM 5120/5520 incorporates two filters; a digital filter controlled from either the front panel or over the IEEE-488 bus, and an internal filter controlled exclusively from over the bus.

Digital Filter—The DM 5120/5520 utilizes a digital filter to attenuate excess noise present on input signals. This filter is a weighted average type.

The factory default filter weighting is 1/10, but can be changed to a weighting from 1 (1/1) to 1/99 with the use of the FILTER program. While in the program mode, the DM 5120/5520 will only display the denominator of the filter weighting. For example, if the current filter weighting is 1/10, the FILTER program will display it as the value 10. Thus, filter value as used in this discussion refers to the values displayed by the DM 5120/5520 when in the FILTER program mode.

A filter value can be set for any or all measurement functions and is remembered by each function. For example, a filter value of 20 can be set for DCV and a filter value of 55 can be set for ACV. These filter values will not be cancelled by switching back and forth between functions.

An advantage of using the filter is to stabilize the reading of a noisy input level. A consideration of filter usage is that the larger the weighting, the longer the response time of the display. Perform the following procedure to use the filter:

1. If it is desired to check and/or change the filter value, utilize Program FILTER as explained under heading Using Front Panel Programs, Program 8 (FILTER VALUE).

2. Press the FILTER key. The FILTER indicator will turn on.

NOTE

When the filter is enabled, readings will be filtered before being displayed. See Digital Filter Theory.

Pressing the FILTER key a second time will disable the filter.

After a reading is triggered (continuous or one-shot), the FILTER indicator light will blink for three time constants. A time constant is measured in readings. The number of readings in one time constant is equal to the filter value. For example, for a filter value of 10, one time constant is equal to 10 readings and three time constants would be equal to 30 readings. The blinking duration will be shorter in the 3 1/2d mode since that has the fastest reading rate.

In a continuous trigger mode, a reading that is outside the filter window will cause the FILTER indicator to blink for one time constant.

Digital Filter Theory—The mathematical representation of the weighted average digital filter is as follows:

$$AVG(t) = AVG(t-1) + \frac{(\text{new reading} - AVG(t-1))}{F}$$

Where,

AVG(t) = displayed average
AVG(t–1) = old displayed average
F = weighting factor (filter value)

As with any filter, the DM 5120/5520 digital filter will affect reading response time. The step response for this filter is of the form:

$$\text{Step response} = 1 - K^{(n+1)}$$

Where,

"K" is a constant based on the filter weighting factor

$$K = 1 - \left(\frac{1}{F}\right)$$

"n" is the reading number.

The step occurs when n=0. n=1 is the first reading after the step, n=2 is the second reading, etc.

Therefore:

$$\text{step response} = 1 - \left(1 - \frac{1}{F}\right)^{n+1}$$

Example:

F=10
n=5

$$1 - \left(1 - \frac{1}{10}\right)^{6}$$

Five readings after the step occurs, the display will be at ≈47% of the step change. After 10 readings (n=10), the display will be at ≈68% and after 20 readings, the display will be at ≈88%. The more the readings, the closer the display will be to the step change.

To speed the response to large step changes, the DM 5120/5520 digital filter employs a "window" around the display average. As long as new readings are within this window, the displayed value is based on the weighted average equation. If a new reading is outside of this window, the displayed value will be the new reading, the weighted averaging will start from this point. The step response was one reading to this change. The window in the DM 5120/5520 filter is 10,000 counts for 6 1/2d resolution, 1000 counts for 5 1/2d, 100 counts for 4 1/2 d and 10 counts for 3 1/2d.

Internal Filter—In addition to the front panel digital filter, an internal running average digital filter is used when making high resolution and high sensitivity measurements. The enable/disable status of the filter is controlled over the IEEE bus. However, under factory default conditions, the instrument powers up with the filter enabled. When enabled, this filtering only occurs when the instrument is in the 5 1/2 or 6 1/2-digit resolution mode.

NOTE

The front panel FILTER indicator light does not turn on when the internal filter is activated. The indicator is only used with the front panel digital filter.

Controlling the internal filter (on/off) over the IEEE bus is explained in Section 3, Programming.

In a one-shot trigger mode, the DM 5120/5520 will not output a reading until both filters have settled. Three time constants are used to allow the filters to settle. A time constant is measured in readings. The number of readings in one time constant is equal to the filter value. For example, for a filter value of 10, three time constants would be equal to 30 readings. If both the internal filter and the front panel filter are in use, the time constant is the sum of both filter values.

Filter windows for the internal filter function in the same manner as the windows for the front panel filter. However, the window sizes of the internal filter are much smaller than the front panel filter window sizes.

DC Voltage Measurements

The DM 5120/5520 can be used to make DC voltage measurements in the range of ±100 nV to ±300 V. Use the following procedure to make DC voltage measurements.

1. Select the DC volts function by pressing the DCV key.
2. Select a range that will cover the expected voltage by pressing the ⇑ or ⇓ Range key or press the AUTO Range key to use autorange.

NOTE

The 300 mV range requires NULL to be set in order to achieve rated accuracy.

3. Connect the signal to be measured to the selected input terminals as shown in Figure 2-5.

4. Take the reading from the display.

Low-Level Measurement Considerations

Accuracy Considerations—For sensitive measurements, other external considerations besides the DM 5120 will affect the accuracy. Effects not noticeable when working with higher voltages are significant in nanovolt and microvolt signals. The DM 5120/5520 reads only the signal received at its input; therefore, it is important that this signal be properly transmitted from the source. The following paragraphs indicate factors which affect accuracy, noise, source resistance, thermal EMFs and stray pickup.

Noise and Source Impedance—The limit of sensitivity in measuring voltages with the DM 5120/5520 is determined by the noise present. The noise voltage at the DM 5120/5520 input increases with source impedance.

For high impedance sources, the generated noise can become significant when using the most sensitive range (300 mV, 6 1/2d) of the DM 5120/5520. As an example of determining e_r (noise voltage generation due to Johnson noise of the source resistance), assume that the DM 5120/5520 is connected to a voltage source with an internal resistance of 1 MΩ. At a room temperature of 20°C, the p-p noise voltage generated over a bandwidth of 1Hz will be:

$$e_r = 6.35 \times 10^{-10} \sqrt{R \times f}$$

$$e_r = 6.35 \times 10^{-10} \sqrt{(1 \times 10^6)\ (1)}$$

$$e_r = 0.635\ \mu V$$

Thus, an e_r of 0.635 μV would be displayed at 6 1/2d resolution as an additional six digits of noise on the DM 5120/5520. To compensate for the displayed noise, use digital filtering and then NULL out the settled offset.

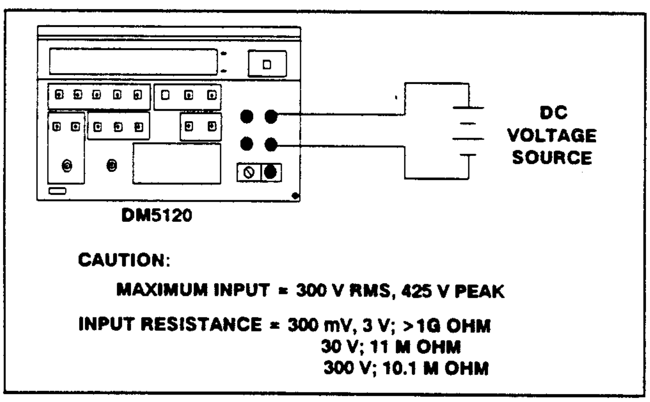


Fig. 2-5. DC Voltage Measurements.

Shielding—AC voltages which are extremely large compared with the DC signal may erroneously produce a DC output. Therefore, if there is AC interference, the circuit should be shielded with the shield connected to the DM 5120/5520 input LO (particularly for low-level sources). Improper shielding can cause the DM 5120/5520 to behave in one or more of the following ways:

1. Unexpected offset voltages.

2. Inconsistent readings between ranges.

3. Sudden shifts in reading.

To minimize pickup, keep the voltage source and the DM 5120/5520 away from strong AC magnetic sources. The voltage induced due to magnetic flux is proportional to the area of the loop formed by the input leads. Therefore, minimize the loop area of the input leads and connect each signal at only one point.

Thermal EMFs—Thermal EMFs (thermoelectric potentials) are generated by thermal differences between the junction of dissimilar metals. These can be large compared to the signal which the DM 5120/5520 can measure. Thermal EMFs can cause the following problems:

1. Instability or NULL offset is much higher than expected.

2. The reading is sensitive to (and responds to) temperature changes. This can be demonstrated by touching the circuit, by placing a heat source near the circuit or by a regular pattern of instability (corresponding to heating and air-conditioning systems or changes in sunlight).

3. To minimize the drift caused by thermal EMFs, use copper leads to connect the circuit to the DM 5120. A banana plug is generally suitable and generates just a few microvolts. A clean copper conductor such as #10 bus wire is about the best for this application. The leads to the input may be shielded or unshielded, as necessary. Refer to Shielding.

4. Widely varying temperatures within the circuit can also create thermal EMFs. Therefore, maintain constant temperatures to minimize these thermal EMFs. A cardboard box around the circuit under test also helps by minimizing air currents.

5. The NULL control can be used to null out constant offset voltages.

Resistance Measurements

The DM 5120/5520 can make resistance measurements from 100 μΩ to 300 MΩ. The DM 5120/5520 provides automatic selection of 2-terminal or 4-terminal resistance measurements. This means that if the ohms sense leads are not connected, the measurement is done 2-terminal. If the sense leads are connected, the measurement is done 4-terminal. For 4-terminal measurements, rated accuracy can be obtained as long as the maximum lead resistance does not exceed the values listed in Table 2-3. For best results on the 300 Ω, 3 kΩ, and 30 kΩ ranges, it is recommended that 4-terminal measurements be made to eliminate errors caused by the voltage drop across the test leads which will occur when 2-terminal measurements are made. The Kelvin Test Lead Set is ideal for low resistance 4-terminal measurements (optional accessory, see page 1-1).

Offset-Compensated Ohms—Offset-compensated ohms is used to compensate for voltage potentials (such as thermal EMF's) across the device under test. This feature eliminates errors due to a low level external voltage source configured in series with the unknown resistor. Offsets up to 10 mV on the 300 Ω range and up to 100 mV on the other ranges can be corrected with offset-compensation. This feature can be used for both 2-terminal and 4-terminal resistance measurements up to 30 kΩ. Offset-compensation is selected through front panel Program 1 (ENABLE OHMS COMP).

During ohms offset compensated resistance measurement, the DM 5120/5520 performs the following steps for each conversion:

1. Makes a normal resistance measurement of the device. In general, this consists of sourcing a current through the device, and measuring the voltage drop across the device.
2. Turns off the internal current source and again measures the voltage drop across the device. This is the voltage caused by an external source.
3. Calculates and displays the corrected resistance values.

Offset-Compensated ohms not only corrects for small error voltages in the measurement circuit, but also compensates for thermal voltages generated within the DM 5120/5520. In normal ohms, these thermal EMF offsets are accounted for during calibration. Therefore, enabling offset-compensation will cause these offsets to appear in the readings, especially the 300 Ω range. After offset-compensation is enabled, the DM 5120 should be properly nulled.

To make resistance measurements, proceed as follows:

1. Select the ohms function by pressing the Ω key.
2. Select a range consistent with the expected resistance or use autorange.
3. Turn offset-compensation on or off as needed, using Program 1.

NOTE

If offset-compensation is being used, the 300 Ω, 3 kΩ, and 30 kΩ ranges require NULL to be set in order to achieve the best accuracy.

4. For 2-terminal measurements connect the resistance to the instrument as shown in Figure 2-6. For 4-terminal measurements connect the resistance to the instrument as shown in Figure 2-7.

CAUTION

The maximum input voltage between the HI and LO input terminals is 425 V peak or 300 V rms Do not exceed these values or instrument damage may occur.

5. Take the reading from the display.

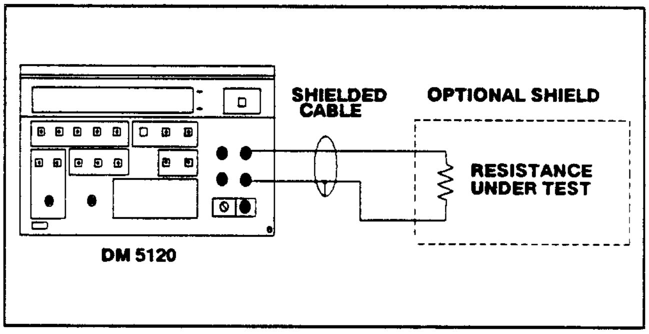


Fig. 2-6. Two-Terminal Resistance Measurements.

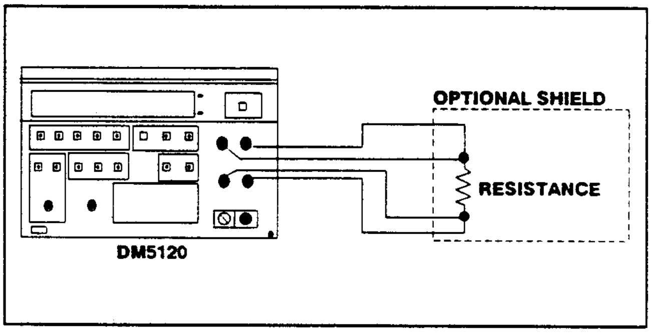


Fig. 2-7. Four-Terminal Resistance Measurements.

Table 2-3
RESISTANCE RANGES

Range	6 1/2d Resolution	Nominal I-Short	Maximum Test Lead Resistance (Ohm) for <1 Count Error (6 1/2d)
(1)300Ω	100μΩ	1.7 mA	1
(2)3kΩ	1mΩ	1.7 mA	3
(3)30kΩ	10mΩ	160 μA	10
(4)300kΩ	100mΩ	50 μA	30
(5)3MΩ	1Ω	5 μA	100
(6)30MΩ	10Ω	0.5 μA	300
(7)300MΩ	1kΩ*	0.5 μA	3 k

** 5 1/2 resolution only*
NOTES: Typical open circuit voltage is 5 V. GPIB range number shown in parentheses. Sending Range Auto or Range 0 = Auto Range.

With ohms compensation active (Program 1), the Ω indicator light will blink when the ohms function is selected.

Table 2-3 shows the current output for each resistance range.

It helps to shield resistance greater than 100 kΩ to achieve a stable reading. Place the resistance in a shielded enclosure and electrically connect the shield to the LO input terminal of the instrument.

Diode Test—The 3 kΩ range can be used to test diodes as follows:

1. Select the 3 kΩ range.
2. Forward bias the diode by connecting the red terminal of the DM 5120/5520 to positive side of the diode. A good diode will typically measure between 300 Ω to 1 kΩ.
3. Reverse bias the diode by reversing the connections on the diode. A good diode will overrange the display.

TRMS AC Voltage Measurements

The instrument can make TRMS AC voltage measurements from 1 μV to 300 V. To measure AC volts, proceed as follows:

1. Select the AC volts function by pressing the ACV key.
2. Select a range consistent with the expected voltage or use autorange.
3. Connect the signal to be measured to the selected input terminals as shown in Figure 2-8.

NOTE

There is a small amount of offset (typically 150 counts at 5 1/2d) present when using the ACV function. Do not NULL this level out. Ac voltage offset is explained under the TRMS Considerations heading.

4. Take the reading from the display.

Clarifications of TRMS ACV Specifications

Maximum Allowable Input—The graph in Fig. 2-9 summarizes the maximum input based on the 10^7 V • Hz specification.

Settling Time—1 sec to within 0.1% of change in reading. This time specification is for analog circuitry to settle and does not include A/D conversion time.

NOTE

See TRMS Considerations.

When making TRMS ac voltage measurements below 45Hz, enable the front panel filter modifier to obtain stable readings. A filter value of 10 is recommended.

To make low frequency ac measurements in the range of 10 Hz to 20 Hz:

- The ACV function must be selected.
- Digital filtering must be used to obtain a stable reading.
- Allow enough settling time before taking the reading.

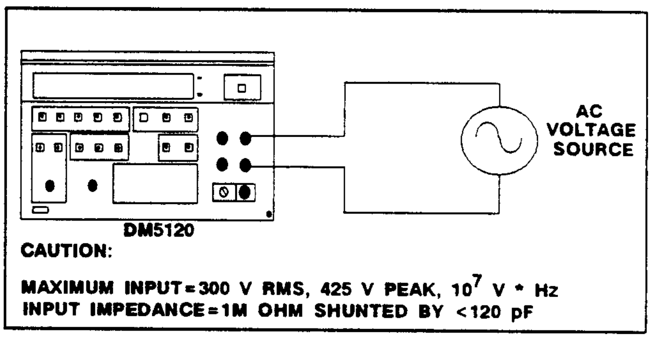


Fig. 2-8. TRMS AC Voltage Measurement.

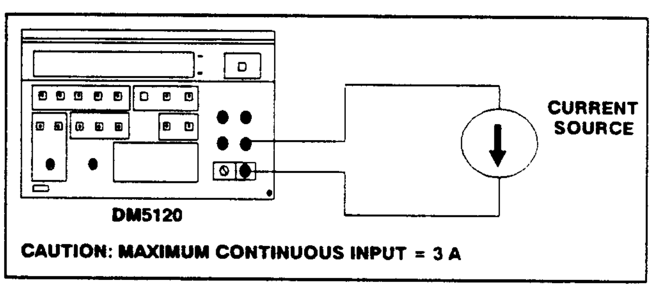


Fig. 2-9. Current Measurements.

Current Measurements (DC or TRMS AC)

The DM 5120/5520 can make dc or TRMS ac current measurements from 1 nA (at 5 1/2d resolution) to 3 A. Use the following procedure to make current measurements.

1. Select the dc current or ac current function by pressing the DCA or ACA key respectively.
2. Select a range consistent with the expected current or use autorange.
3. Connect the signal to be measured to the selected input terminals as shown in Figure 2-10.
4. Take the reading from the display.

dB Measurements

The dB measurement mode makes it possible to compress a large range of measurements into a much smaller scope. AC dB measurements can be made with the instrument in the ACV or ACA function The relationship between dB and voltage and current, can be expressed by the following equations:

$$dB = 20 \log \left(\frac{V_{in}}{V_{ref}} \right)$$

$$dB = 20 \log \left(\frac{I_{in}}{I_{ref}} \right)$$

At the factory the instrument is set up to be a dBV meter when ACV dB is selected. dBV is defined as decibels above or below a 1 V reference. The instrument will read 0 dB when 1 V is applied to the input. The 1 V reference is the factory default reference. With ACA dB selected, the factory default reference is 1 mA The instrument will read 0 dB when 1 mA is applied to the input.

Reference levels other than 1 V and 1 mA can be established. There are two methods that can be used to establish a dB reference. One method is to use the null feature. This simply consists of applying a signal to the instrument and pressing the NULL key. That suppressed level is the dB reference (0 dB point). The alternate method is to utilize the front panel dB program and enter the desired reference value. An advantage of using the dB program is that a source is not needed to establish a reference.

The following procedure explains how to use the null feature to establish a reference:

1. Apply a voltage or current signal, that is to be used as the dB reference, to the input of the DM 5120.
2. Press the NULL key. The NULL indicator will turn on and the display will null. The reference is now whatever the applied signal is.
3. Disconnect the signal from the instrument.

Program 9 allows the user to check or change the dB reference of the instrument. The recommended programmable voltage reference range is from 10 μV to 9.99999 V. The recommended programmable current reference range is from 10 nA to 9.99999 mA. See Using Front Panel Programs, Program 9 (dB REFERENCE).

AC dB Measurments—Perform the following steps to make dB measurements:

1. Select the ACV or ACA function.
2. Check and/or change the dB reference as previously explained.
3. Connect the signal to be measured to the input of the DM 5120/5520.
4. Enable the dB measurement mode by pressing the dB key.
5. Take the dB reading from the display.

CAUTION

With dB enabled, a hazardous voltage baseline level (±40 V or more), not displayed, may be present on the input terminals. If not sure what is applied to the input, assume that a hazardous voltage is present.

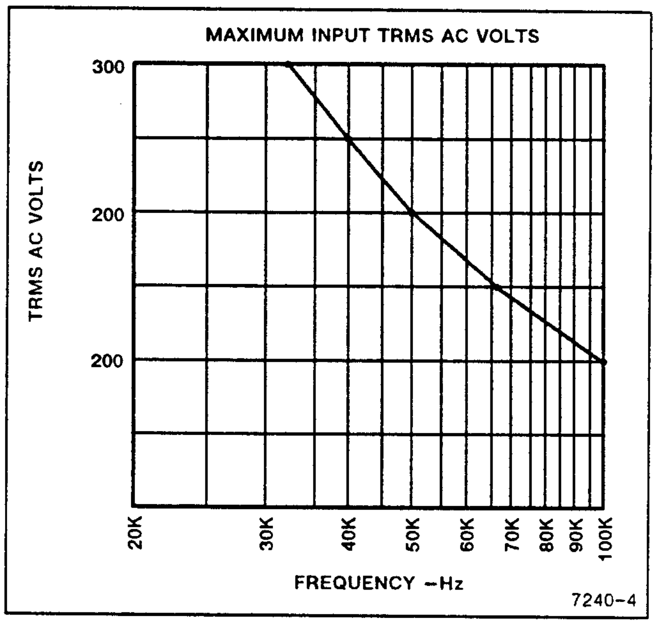


Fig. 2-10. Maximum TRMS AC Volts Versus Frequency.

dBm Measurements—dBm is defined as decibels above or below a 1 mW reference. dB measurements can be made in terms of impedance rather than voltage or current. Because the instrument cannot directly establish impedance reference, a voltage reference must be calculated and established for a particular impedance reference. Use the following equation to calculate the voltage reference needed for a particular impedance reference:

For 0 dBm, $V_{ref} = \sqrt{1\ \text{mW} \cdot Z_{ref}}$

Example: Calculate the voltage reference needed to make dBm measurements referenced to 600 Ω.

$$\text{For 0 dBm, } V_{ref} = \sqrt{0.001\ \text{W} \cdot 600\Omega} = \sqrt{.6} = .77456\ \text{V}$$

Once the necessary voltage reference is known, it can be established in the DM 5120/5520 with the dB program. Subsequent dBm readings will be referenced to the corresponding impedance reference. Table 2-4 lists the voltage references needed for some commonly used impedance references.

dBW Measurements—dBW is defined as decibels above or below a 1 W reference. dBW measurements are made in the same manner as dBm measurements; that is, calculate the voltage reference for a particular impedance and set the instrument to it with the dB program. The only difference between dBm and dBW is the reference point; 1 mW vs 1W. The following equation can be used to calculate the voltage reference:

For 0 dBW, $V_{ref} = \sqrt{1\text{W} \cdot Z_{ref}}$

Table 2-4
CORRESPONDING VOLTAGE REFERENCE LEVELS FOR IMPEDANCE REFERENCES

Reference Impedance (Ω)	Reference Voltage Level for: 0 dBm	0 dBW
8	0.0894	2.828
50	0.2236	
75	0.2739	
150	0.3873	
300	0.5477	
600	0.7746	
1000	1.0000	

V_{ref} for 0 dBm $= \sqrt{10^{-3}\text{W} \cdot Z_{ref}}$

V_{ref} for 0 dBW $= \sqrt{Z_{ref}}$

TRMS Considerations

Most DMMs actually measure the average value of an input waveform but are calibrated to read its RMS equivalent. This poses no problems as long as the waveform being measured is a pure, low-distortion sine wave. For complex, nonsinusodial waveforms, however, measurements made with an averaging type meter can be grossly inaccurate. Because of its TRMS measuring capabilities, the DM 5120/5520 provides accurate AC measurements for a wide variety of AC input waveforms.

TRMS Measurement Comparison—The RMS value of a pure sine wave is equal to 0.707 times its peak value. The average value of such a waveform is 0.637 times the peak value. Thus, for an average-responding meter, a correction factor must be designed in. This correction factor, K, can be found by dividing the RMS valued by the average value as follows:

$$K = 0.707/0.637 = 1.11$$

By applying this correction factor to an averaged reading, a typical meter can be designed to give the RMS equivalent. This works fine as long as the waveform is a pure sine, but the ratios between the RMS and average values of different waveforms is far from constant, and can vary considerably.

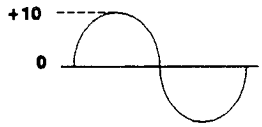
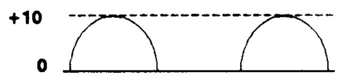
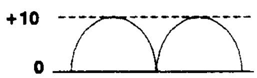
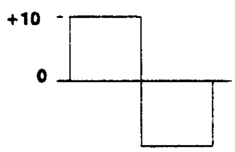
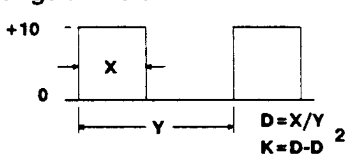
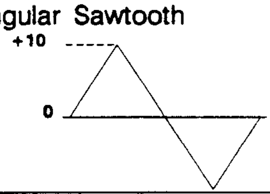
Table 2-5 shows a comparison of common types of waveforms. For reference, the first waveform is an ordinary sine wave with a peak amplitude of 10 V. The average value of the voltage is 6.37 V, while its RMS value is 7.07 V. If we apply the 1.11 correction factor to the average reading, it can be seen that both meters will give the same reading, resulting in no error in the average-type meter reading.

The situation changes with the half-wave rectified sine wave. As before, the peak value of the waveform is 10 V but the average value drops to 3.18 V. The RMS value of this waveform is 3.86 V but the average responding meter will give a reading of 3.53 V (3.18 x 1.11), creating an error of 11%.

A similar situation exists for the rectified square wave, which has an average value of 5 V and an RMS value of 5.0 V. The average responding meter gives a TRMS reading of 5.55 V (5 x 1.11), while the DM 5120/5520 gives a TRMS reading of 5 V. Other waveform comparisons can be found in Table 2-5.

AC Voltage Offset—The DM 5120/5520, at 5 1/2 resolution, will typically display 150 counts of offset on AC volts with the input shorted. This offset is

Table 2-5
COMPARISON OF AVERAGE AND TRMS METER READINGS

Waveform	AC Coupled Peak Value	RMS Value	*Average Responding Meter Reading	AC Coupled TRMS Meter Reading	Averaging Meter Percent Error
Sine  	10 V	7.07 V	7.07 V	7.07 V	0%
Half-Wave Sine  	10 V	3.86 V	3.90 V	3.86 V	1%
Full-Wave Sine  	10 V	3.08 V	2.98 V	3.08 V	3.2%
Square  	10 V	10.00 V	11.10 V	10.00 V	11%
Rectified Square Wave  	10 V	5.00 V	5.55 V	5.00 V	11%
Rectangular Pulse  	10 V	$10 \bullet \sqrt{K}$	22.2K	$10 \bullet \sqrt{K}$	$\left[\frac{2.22K^{3/2}-K}{K}\right] \times 100$
Triangular Sawtooth  	10 V	5.77 V	5.55 V	5.77 V	4%

caused by the offset of the TRMS converter. This offset will not affect reading accuracy and should not be nulled out using the null feature. The following equation expresses how this offset (V_{offset}) is added to the signal input (V_{in}):

$$\text{Displayed reading} = \sqrt{(V_{in})^2 + (V_{offset})^2}$$

Example: Range = 2 VAC
Offset = 150 counts (1.5 mV)
Input = 200 mV RMS

$$\text{Display reading} = \sqrt{(200\ \text{mV})^2 + (1.5\ \text{mV})^2}$$

$$= \sqrt{0.04\ \text{V} + (2.25 \times 10^{-6}\text{V})}$$

$$= .20005\ \text{V}$$

The offset is seen as the last digit which is not displayed at 5 1/2d resolution. Therefore, the offset is negligible. If the null feature was used to null the display, the 150 counts of offset would be subtracted from V_{in} resulting in an error of 150 counts in the displayed reading.

Crest Factor—The crest factor of a waveform is the ratio of its peak value to its RMS value. Thus, the crest factor specifies the dynamic range of a TRMS instrument. For sinusoidal waveforms, the crest is 1.414. For a symmetrical square wave, the crest factor is unity.

The crest factor of other waveforms will, of course, depend on the waveform in question because the ratio of peak to RMS value will vary. For example, the crest factor of a rectangular pulse is related to its duty cycle; as the duty cycle decreases, the crest factor increases. The DM 5120/5520 has a maximum crest factor of 3, which means the instrument will give accurate TRMS measurements of rectangular waveforms with duty cycles as low as 10%.

dB Applications

Measuring Circuit Gain/Loss—Any point in a circuit can be established as the 0 dB point. Measurements in that circuit are then referenced to that point expressed in terms of gain (+dB) or loss (-dB). To set the null dB point proceed as follows:

1. Place the DM 5120/5520 in ACV and dB.
2. Connect the DM 5120/5520 to the desired location in the circuit.
3. Press the NULL key. The display will read 0 dB.
4. Gain/loss measurements can now be made referenced to the 0 dB point.

Measuring Bandwidth—The DM 5120/5520 can be used to determine the bandwidth of an amplifier as follows:

1. Connect a signal generator and a frequency counter to the input of the amplifier.
2. Set the DM 5120/5520 to ACV and autorange.
3. Connect the DM 5120/5520 to the load of the amplifier.
4. Adjust the frequency of the signal generator until a peak AC voltage reading is measured on the DM 5120/5520. This is the center frequency.
5. Press the dB key and then press the NULL key. The 0 dB point is now established.
6. Increase the frequency input until the DM 5120/5520 reads -3.00 dB. The frequency measured on the frequency counter is the high-end limit of the bandwidth.
7. Decrease the frequency input until the dB reading again falls to -3.00 dB. The frequency measured on the signal generator is the low-end limit of the bandwidth.

NOTE

The bandwidth of the DM 5120/5520 is typically 300 kHz. Do not use this application to check amplifiers that exceed the bandwidth of the DM 5120.

Determining Q—The Q of a turned circuit can be determined as follows:

1. Determine the center frequency and bandwidth as explained in the previous application (Measuring Bandwidth).
2. Calculate Q by using the following formula:
   Q = Center Frequency/Bandwidth

USING FRONT PANEL PROGRAMS

There are 17 programs available from the front panel of the DM 5120/5520. These programs are listed in Table 2-6. The following paragraphs describe and explain the operation of each program.

Program Selection

Program selection is accomplished by pressing the PROGRAM key followed by the key(s) that corresponds to the program number or name. For example, to select Program 31 (IEEE ADDRESS/

TERMINATION), press the PROGRAM key and then the "3" and "1" keys.

Table 2-6
FRONT PANEL PROGRAMS

Program	Description
1 (ENABLE OHMS COMP)	Toggles the Ohms compensation mode for the Ohms function.
2 (DISPLAY RESOLUTION)	Change display resolution (3 1/2d, 4 1/2d, 5 1/2d, or 6 1/2d).
4 (ENABLE MX+B)	Enable MX+B program.
5 (ENABLE HI/LO/PASS)	Enable/disable HI/LO/Pass program.
6 (AUTOCAL ON/OFF)	Turns on/off internal calibration function.
7 (NULL VALUE)	Sets the value that is used by the instrument when the NULL key is pressed.
8 (FILTER VALUE)	Selects the value (1−99) used by the digital FILTER.
9 (dB REFERENCE VALUE)	Enters the dB reference value.
30 (SAVE)	Save current instrument set up.
31 (IEEE ADDRESS/ TERMINATION)	Recall/modify IEEE address/ termination.
32 (50/60 Hz)	Recall/modify line frequency setting (50/60Hz).
33 (SELF TEST)	Enter self-test program.
34 (MX+B VALUES)	Recall/modify MX+B program values.
35 (HI/LO LIMITS)	Recall/modify HI/LO limits.
36 (CALIBRATION MODE)	Enter digital calibration mode.
37 (RESET)	Returns DM5120 to factory default conditions.
38 (INIT)	Returns the DM 5120/5520 to the power on state.

Data Entry

Program data is applied from the front panel using the data keys. The data keys consist of the keys labeled with the ± polarity sign and numbers 0 through 9. Data entry is accomplished by pressing the appropriate number key at each cursor location. Cursor location is indicated by the bright, flashing display digit. The cursor moves one digit to the right every time a number is entered. After entering a number at the least significant display digit, the cursor will move back to the most significant digit. Polarity (± key) can be changed with the cursor at any display character. Plus (+) is implied and thus, not displayed.

Once a program is selected, the following general rules will apply:

1. A displayed program condition can be entered by pressing the ENTER key.
2. Program conditions that prompt the user with a flashing digit (cursor) can be modified using the data keys (0 through 9). Polarity (± key) can be changed with the cursor on any character. Plus (+) is implied and thus, not displayed.
3. Programs that contain alternate conditions can be displayed by pressing one of the range keys. Each press of one of these keys toggles the display between the two available conditions.
4. A program will be executed when the pressed ENTER key causes the instrument to exit the program.
5. A program can be exited at any time and thus not executed, by pressing the PROGRAM key.

Program 1 (ENABLE OHMS COMP)

The ohms offset compensation program is used to compensate for voltage potentials (such as thermal EMFs) across the resistance to be measured. This feature can be used for both 2-terminal and 4-terminal resistor measurements up to 30 kΩ. Additional information on ohms offset compensation is located under Basic Measurements, Resistance Measurements. Perform the following steps to use the ohms offset compensation program:

1. Press the PROGRAM key. The following prompt will be displayed:

   PROGRAM?

2. Press the 1 (Ω) key. The current status of ohms compensation will be displayed. For example, if compensation is currently disabled, the following message will be displayed:

   COMP OFF

3. If the alternate status is desired, press any one of the Range keys. The alternate status will be displayed as follows:

   COMP ON

4. With the desired compensation status displayed, press the ENTER key.

   a. If ohms offset compensation was enabled, the instrument will be placed in the ohms function with the Ω indicator light flashing.

   b. If ohms offset compensation was disabled, the instrument will return to the previous operating state. When the ohms function is selected, the Ω indicator light will not flash.

NOTE

The Ω indicator light reveals the status of ohms offset compensation. With the ohms function selected, a flashing Ω light indicates that compensation is enabled, and conversely, a non-flashing Ω light indicates that compensation is disabled.

The status of ohms offset compensation can be saved as a power up default condition by running Program 30.

Program 2 (DISPLAY RESOLUTION)

Program 2 selects the number of display resolution digits. The resolution available is dependent on function and range. Table 2-7 lists the display resolution available for the various function/range combinations. Display resolution can be set for each function and is remembered by each function as long as the instrument remains powered up. Resolution can be remembered after power-down by running Program 30 (Save). To change the display resolution, perform the following procedure:

1. Set the instrument to the desired function and range.

2. Press the PROGRAM key. The following prompt will be displayed:

   PROGRAM?

3. Enter Program 2 by pressing the "2" key. The current resolution status will then be displayed. For example, if the selected function is currently set for 6 1/2 digits of resolution, the following message will be displayed:

   6 1/2d

4. If an altered resolution is desired, use the manual Range keys to display the resolution. The ⇓ Range key decreases resolution, while the ⇑ Range key increases resolution.

5. With the desired resolution displayed, press the ENTER key. The instrument will return to the previously selected function and range.

Table 2-7
DISPLAY RESOLUTION

Function	Available Range	Resolution
DCV	All	3 1/2d, 4 1/2d, 5 1/2d, 6 1/2d
ACV	All	3 1/2, 4 1/2d, 5 1/2d
Ω	300 Ω, 3 kΩ, 30 kΩ, 300 kΩ	3 1/2d, 4 1/2d, 5 1/2d, 6 1/2d
	3 MΩ, 30 MΩ	5 1/2d, 6 1/2d
	300 MΩ	5 1/2d
DCA	All	3 1/2d, 4 1/2d, 5 1/2d
ACA	All	3 1/2d, 4 1/2d, 5 1/2d

Program 4 (ENABLE MX+B)

This program allows the operator to automatically multiply normal display readings (X) by a constant (M) and add a constant (B) The result (Y) will be displayed in accordance with the formula, Y=MX+B. This program is useful when slope calculations are required for a series of measurements. The values of M and B can be changed by utilizing Program 34. Perform the following steps to enable the MX+B feature:

1. Set the DM 5120/5520 to the desired function and range.

2. Connect the signal to be measured (X)to the input of the DM 5120/5520.

3. If the values of M and B need to be checked or changed, do so using Program 34.

4. Press the PROGRAM key. The following prompt will be displayed:

   PROGRAM?

5. Enter Program 4 by pressing the "4" key. The current status of the MX+B program will be displayed. For example, if the MX+B is currently disabled, the following message will be displayed:

   MX+B OFF

6. Any range key will toggle the display to the alternate MX+B status. Therefore, press a Range key and the following message will be displayed:

   MX+B ON

7. With the message "MX+B ON" displayed, press the ENTER key to enable MX+B. The instrument will return to the function initially set.

8. All subsequent readings (Y) will be the result of the equation: Y = MX + B.

NOTE

The MX + B feature can be disabled by again running Program 4. While in the program, press a range key until the message "MX + B OFF" is displayed and then press the ENTER key.

Once MX + B has been enabled, the DM 5120/5520 will show the value of Y. If the value of Y is larger than can be handled by the particular range, the overrange message will be displayed, indicating the instrument must be switched to a higher range.

User selected values of M and B will be stored within the DM 5120/5520 until the power is turned off (unless saved by Program 30). These constants will be used whenever MX + B is enabled. Note however, that the value of B is scaled according to the range in use. Example: A value of 19.00000 entered for B is actually 19.00000 V with the instrument on the 30 V range and 190.0000 V with the instrument on the 300.0000 V range.

An example of readings that will be obtained when MX + B is enabled is shown in Table 2-8. Each of the obtained values for Y assumes the following constants: M = +1.5; B = +5. To divide a number use an M value <1. To subtract a value, make B a -number.

Table 2-8
EXAMPLE MX + B READINGS

DM 5120/5520 Range and Function	Normal Reading (X)	MX + B* Reading (Y)
30 VDC	8.00000 VDC	17.00000 VDC
30 VDC	-5.00000 VDC	-2.50000 VDC
30 VAC	6.29999 VAC	14.45000 VAC
30 kΩ	4.00000 kΩ	11.00000 kΩ

**where M = +1.5; B = +5.*

Program 5 (ENABLE HI/LO/PASS)

Program 5 is used to enable the HI/LO/PASS program. With this program, the DM 5120/5520 will indicate whether or not a specific reading falls within a prescribed range. The factory default LO limit is a negative full scale reading, with the actual value dependent on function and range. Conversely, the factory default HI limit is a positive full scale reading. With these ± full scale limits, the DM 5120/5520 will display the HI or LO message for overrange readings and the PASS message for on-range readings. The HI and LO limits can be set to any on-range value with Program 35 HI/LO LIMITS).

This feature is especially useful for component evaluation, where certain component tolerances must be observed. Once the limits are programmed into the instrument, the operator need only monitor the display messages to determine the integrity of the device. Perform the following procedure to enable Program 5:

1. Select the desired function and range, and zero the instrument, if desired. These operating parameters cannot be changed once the program is active without exiting the program.
2. If the limits need to be checked or changed, do so using Program 35.
3. Press the PROGRAM key. The following prompt will be displayed:

   PROGRAM?

4. Enter Program 5 by pressing the "5" key. The following message will be displayed briefly:

   HI LO PASS

5. At this point, the instrument will run the program. No numeric readings will be displayed. Instead, one of the following messages will be displayed:

   a. If the measured value is less than the low limit, the following message will be displayed:

   LO

   b. If the measured value is greater than the high limit, the following message will be displayed:

   HI

   c. If the measured value falls within the high and low limits, the following message will be displayed:

   PASS

6. To disable the program, press the function key that has the indicator light on. This will disable the program without changing the measurement parameters (i.e. function, range, etc.) of the instrument. Pressing another parameter key will also disable the Program mode, but the DMM settings will change.

NOTE

Limits can be set using Program 35 with or without Program 5 enabled.

User selectable values of LO and HI will be stored within the DM 5120/5520 until the power is turned off (unless saved by Program 30). These constants will be used whenever HI/LO/PASS is enabled. (Note however, that the value of LO and HI are scaled according to the range in use.)

Pressing any of the front panel controls, except dB (unless in AC), and ENTER, will disable the program and select the feature associated with that key.

Program 6 (AUTOCAL ON/OFF)

The AUTOCAL ON/OFF will turn on or off the internal autocal function. AUTOCAL OFF will increase the number of readings per second by 4 times; however, it reduces the accuracy and immunity to short term drift. AUTOCAL must be ON to obtain maximum accuracy from the instrument. AUTOCAL works by taking 4 conversions. The conversions are the input signal, internal voltage reference, input LO and reference LO. These four conversions are used in calculations to compute the displayed reading. If AUTOCAL is turned OFF, the last signal LO, reference and reference LO conversions are used to calculate the next reading.

To change the status of the AUTOCAL function, perform the following steps:

1. Press the PROGRAM key. The following prompt will be displayed:

   PROGRAM?

2. Enter Program 6 by pressing the 6 (AUTO) key. The current AUTOCAL status will then be displayed. For example, if AUTOCAL is on, the following message will be displayed:

   AUTOCAL ON

3. Press one of the RANGE keys to change the status. The alternate status will be displayed as follows:

   AUTOCAL OFF

4. To enter the displayed AUTOCAL status, press the ENTER key. The instrument will return to the previous operating state.

NOTE

With AUTOCAL OFF, the internal null and calibration are affected by changing the nominal input level, especially on ohms and the 300 VDC range. Whenever the applied input level changes, press the selected function key to perform an AUTOCAL routine, otherwise substantial errors may result. Null and calibration may also be affected by time. Thus, it is recommended that the selected function key be pressed periodically.

Program 7 (NULL VALUE)

Program 7 allows the user to check or modify the null value. See Controls and Connectors description in this section for a complete explanation of the null modifier. Once a null value is set on a measurement function, that null level is the same on all the ranges. Example: If 1 V DC is set to the null value of the 3 V DC range, the null value in the program will be displayed as 1.000000. On the 30 V DC range the null value will still be 1 V DC, but will be expressed as 01.00000 in the program.

To set the null value, perform the following steps:

1. Press the PROGRAM key. The following prompt will be displayed:

   PROGRAM?

2. Enter Program 7 by pressing the "7" key. The current null value will then be displayed. Example: if the instrument is on the 30 V DC range and the current null value is +3 V DC, the following message will be displayed:

   03.00000 Z

3. If it is desired to retain the displayed null value, press the ENTER key. The instrument will return to the previous operating state with the null modifier enabled. The displayed reading will reflect the entered null value.

4. To modify the null value, enter the new value using the numeric keys and press the ENTER key. The instrument will return to the previously defined state with the null modifier enabled using the newly entered null value.

NOTE

The factory default power up null value is 0000.000. If it is desired to have a different null value displayed on power up, modify the null value using Program 7 followed by Program 30 to save it.

Program 8 (FILTER)

Program 9 (FILTER) allows the user to modify the weighting of the digital filter. Valid filter values are from 1 to 99. More information concerning the filter can be found in the Basic Measurements part of this section.

Perform the following steps to check and/or modify the filter value.

1. Select the desired function.
2. Press the PROGRAM key. The following prompt will be displayed:

   PROGRAM?

3. Enter Program 8 by pressing the "8" key. The current filter value will then be displayed. Example: If the filter value is 5, the following message will be displayed:

   05 F

4. If it is desired to retain the displayed filter value, proceed to step 5. If it is desired to modify the filter value, do so using the numeric keys.
5. With the desired filter value displayed, press the ENTER key. The instrument will return to the previously defined state when the filter is enabled.
6. To check or change the filter value of another function, select the function and repeat steps 2 through 5.

NOTE

The factory default power up filter value is 10. If it is desired to have a different filter value on power up, change the filter value using Program 8 followed by Program 30 to save it.

Entering a filter value of 00 will default the filter value back to the previous value and return the instrument to the previously defined state with the filter disabled.

Program 9 (dB REFERENCE VALUE)

Program 9 (dB) allows the user to check and/or modify the dB reference. The programmable voltage reference can be up to 9.999999 V and the programmable current reference can be up to 9.999999 mA Detailed information on dB measurements is provided in the Basic Measurements part of this section. Perform the following steps to use this program:

1. Press the PROGRAM key. The following prompt will be displayed:

   PROGRAM?

2. Press the dB key. The current reference level will be displayed. Example: If the reference is 1 V or 1 mA, the following message will be displayed:

   1.000000dB

3. Modify, if desired, the dB reference level and press the ENTER key. The recommended reference range is 10 μV to 9.999999 V and 10 nA to 9.999999 mA The instrument will return to the previously defined state.

   ENTERED

NOTE

The factory default power up voltage reference is 1.000000 V with the instrument in ACV and 1.000000 mA with ACA selected. If it is desired, to have a different reference on power up, modify the reference using Program dB followed by Program 30 to save it.

Program 30 (SAVE CURRENT SETTINGS)

Program 30 saves current instrument conditions set up by the user. These user programmed conditions will then replace the previously saved default conditions on power up. Also, sending INIT over the IEEE-488 bus will return the instrument to these saved conditions.

The following instrument operating parameters are saved by this program:

Function
Range
Resolution
Null status (on/off) and value
Filter status (on/off) and value
ACdB status (on/off) and reference value
IEEE address and termination
Line frequency setting
MX+B status (on/off) and values
HI/LO limits
Ohms compensation status (on/off)

Perform the following procedure to use the save program:

1. Set up the instrument as desired or run Program 37 (RESET) to return the instrument to the factory default conditions.
2. Press the PROGRAM key. The following prompt will be displayed:

   PROGRAM?

3. Enter Program 30 by pressing the "3" and "0" keys. The following message will be displayed briefly:

   SAVE

4. The following message will then be displayed:

   ENTER?

5. To save the instrument set up conditions, press the ENTER key. Pressing any other key will exit the program without saving the settings. The following message will be displayed briefly:

   ENTERED

6. If the ENTER key is pressed, the conditions set up in step 1 will be saved and the instrument will now power up with these new settings.

To return the instrument to the factory power up default conditions, use Program 37 (RESET) and save the conditions using Program 30.

When using this program, make sure that the rest of the instrument is in the desired operating state.

Program 31 (IEEE ADDRESS/ TERMINATION)

Program 31 allows the GPIB address and termination to be checked and/or modified. The interface can be set to any primary address from 0 to 30. A change is temporary until Program 30 is run. Detailed information on the IEEE-488 bus is provided in Section 3. Perform the following steps to use the program:

1. Press the PROGRAM key. The following prompt will be displayed:

   PROGRAM?

2. Enter Program 31 by pressing the "3" and "1" keys. The IEEE address value will be displayed. Example: If the current primary address of the instrument is 16, the following message will be displayed:

   16 IE

3. If it is desired to retain the displayed address value, proceed to step 4. To change the address value, use the numeric keys to enter the address number (0 to 30).

4. With a valid address displayed, press the ENTER key. The instrument will display prompts for the terminator (EOI or LF).

NOTE

If an invalid number is entered, the address is redisplayed.

5. To change the terminator, press any of the RANGE keys to toggle between EOI and LF.

6. Press the ENTER key to end the terminator selection and exit Program 31.

To change the default address of the instrument, select the desired IEEE address and termination using this program, then Program 30 (or PONSAVE over the IEEE bus) to save it. Cycling power, Program 37 (RESET), or sending INIT or RESET over the GPIB bus will have no effect on the new default address and termination.

If the IEEE address/termination is changed but not saved:

a. Cycling power will return the instrument to the default address.

b. Program 37 (RESET), or INIT sent over the bus will not have any effect on the current address.

c. Sending RESET over the bus will not change the current IEEE address, and will save that address as the power up default address.

An "UNCAL" error will default the IEEE address to 16, the termination to LF, and the line frequency setting to 60 Hz.

Program 32 (50/60 Hz)

The DM 5120/5520 does not automatically detect the power line frequency upon power up. This program allows the user to check the line frequency setting of the instrument and to select the alternate frequency. The instrument can be set to either 50 Hz or 60 Hz. Perform the following steps to check and/or change the line frequency setting of the DM 5120/5520.

1. Press the PROGRAM key. The following prompt will be displayed:

   PROGRAM?

2. Enter Program 32 by pressing the "3" and "2" keys. The current line frequency setting will then be displayed. If the instrument is currently set to 60 Hz, the following message will be displayed:

   FREQ=60 Hz

3. If the displayed frequency setting matches the available line frequency, proceed to step 4. If the alternative line frequency setting is needed, press one of the Range keys. The display will toggle to the alternate frequency setting as shown:

   FREQ=50 Hz

4. With the correct frequency setting displayed, press the ENTER key. The instrument will return to the previous operating state.

NOTE

To change the default line frequency setting of the instrument, select the desired setting using this program and then Program 30 (or PON-SAVE over the IEEE bus) to save it. Cycling power, Program 37 (RESET), or sending INIT or RESET over the GPIB bus will not have any effect on the new default setting.

If the line frequency setting is changed but not saved:

a. Cycling power, or sending INIT over the bus will return the instrument to the default setting.

b. Program 37 (RESET) will not have any effect on the current setting.

c. Sending RESET over the bus will not change the current line frequency setting, and will save that setting as the default setting.

An "UNCAL" error will default the IEEE address to 16, the termination to LF, and the line frequency setting to 60 Hz.

Program 33 (SELF TEST)

Program 33 is a diagnostic self-test program for use by service technicians for troubleshooting service problems. Service technicians should refer to the DM 5120 Service Manual for details of using this program.

Program 34 (MX+B VALUES)

This program allows the operator to check/change the M and B values for the MX+B feature (Program 4) of the DM 5120/5520. The factory factory power up default value of M is 1.000000 and the value of B is 0000000. To check/change the values of M and B, proceed as follows:

1. Press the PROGRAM key. The following prompt will be displayed:

   PROGRAM?

2. Enter Program 34 by pressing the "3" and "4" keys. The current value of M will now be displayed. If the factory default value is the current value of M, then the following message will be displayed:

   1.000000M

3. If it is desired to retain the displayed M value, proceed to step 4. If it is desired to modify the M value, do so using the numeric keys. Note that valid M values are in the range of -9.999999 to +9.999999.

4. With a M value displayed, press the ENTER key.

5. The current B value will now be displayed. If the factory default value is the current B value, the following message will be displayed:

   0000.000B

   Decimal point position is determined by the range that the instrument was on when this program was selected.

6. If it is desired to retain the displayed B value, proceed to step 7. If it is desired to modify the value of M, do so using the numeric keys. Note that the B value range is from $\pm 0.0001 \times 10^{-3}$ to ± 9999.999 (including zero).

7. With a valid B value displayed, press the ENTER key. The instrument will return to the previously defined state of operation.

NOTE

User selected values of M and B will be stored within the DM 5120/5520 until the power is turned off (unless saved by Program 30). These constants will be used whenever MX+B is enabled. Note however, that the value of B is scaled according to the range in use. Example: A value of 19.00000 entered for B is actually 19.00000 V with the instrument on the 30 V range and 190.0000 V with the instrument in the 300 V range.

The user can set the values for M and B as the power up default values by running Program 30.

Program 35 (HI/LO LIMITS)

Program 35 is used to set the high and low limits for the HI/LO/PASS program (Program 5). The factory default limits are +3029999 counts (HI limit) and -3029999 counts (LO limit). The actual value of the limits is dependent on the range. For example, the factory default HI limit on the 3 V range is 3.029999 V, while the factory default HI limit on the 30 V range is 30.29999 V. Perform the following procedure to set HI and LO limits:

1. Place the DM 5120/5520 in the function and range that the HI/LO/PASS program (Program 5) will be used.

2. Press the PROGRAM key. The following prompt will be displayed:

   PROGRAM?

3. Enter Program 35 by pressing the "3" and "5" keys. The current LO limit will be displayed. For example, if the LO limit is the factory default value, the following message will be displayed:

   -303.0000 LO

   Decimal point position is determined by the range that the instrument was on when this program was selected.

4. If it is desired to retain the displayed LO limit, proceed to step 5. Otherwise, modify the displayed value using the data keys. The LO limit must be in the range of -3029999 to +3029999 counts.

5. With the desired LO limit displayed, press the ENTER key. The current HI limit will be displayed. For example, if the LO limit is the factory default value, the following message will be displayed:

   303.0000 HI

   Decimal point position is determined by the range that the instrument was on when this program was selected.

6. If it is desired to retain the displayed HI limit, proceed to step 7. Otherwise, modify the displayed value using the data keys. The HI limit must be in the range of -3029999 to +3029999 counts.

7. With the desired HI limit displayed, press the ENTER key. The instrument will return to the previous operating state.

NOTE

User selected limits will be stored in the DM 5120 until power is turned off (unless saved by Program 30). These constants will be used whenever Program 5 (ENABLE HI/LO/PASS) is enabled.

Limits set by the user will become the power up default limits by running Program 30 (SAVE CURRENT SETTINGS).

Entering an invalid value will result with the instrument using the power up default limit.

Program 36 (CALIBRATION MODE)

This program is used to calibrate the instrument. If the CAL LOCK is off, error 260 will be displayed on the front panel and the program will not be entered.

For more information on the calibration and the CALIBRATION MODE program see the section on calibration in the service manual.

Program 37 (RESET)

Program 37 resets instrument set up parameters to factory default conditions. The factory default conditions are listed in Table 2-1.

NOTE

Also see Program 38 (INIT) which puts the instrument into the power-on state, which may or may not be the same as the factory default conditions.

Perform the following steps to run Program 37.

1. Press the PROGRAM key. The following prompt will be displayed:

   PROGRAM?

2. Enter Program 37 by pressing the "3" and "7" keys. The following message will be displayed briefly:

   RESET

3. The following prompt will then be displayed:

   ENTER?

4. Press the ENTER key. The following message will be displayed briefly and the instrument will return to the factory default conditions:

   ENTERED

NOTE

Program 37 (RESET) can be aborted by pressing any front panel key, except the ENTER key, when the prompt "ENTER?" is displayed. The instrument will return to the previous operating state.

Once the instrument is reset to the factory default conditions with this program, Program 30 must be run if it is desired to have the factory default conditions on subsequent power ups.

Program 37 (RESET) will have no effect on the current IEEE address and line frequency setting.

Program 38 (INIT)

Program 38 puts the DM 5120/5520 into the current power-on state. The only exception is that the power-on SRQ is not asserted.

The actual settings of the instrument depend on the settings of the instrument the last time that Program 30 (SAVE CURRENT SETTINGS) or Program 37 (RESET) was run from the front panel, or PONSAVE or RESET was sent over the IEEE bus.

Perform the following steps to run this program:

1. Press the PROGRAM key. The following prompt will be displayed:

   PROGRAM?

2. Enter Program 38 by pressing the "3" and "8" keys. The following message will be displayed briefly:

   INIT

3. The following prompt will then be displayed:

   ENTER?

4. Press the ENTER key. The following message will be displayed briefly and the instrument will return to the power-on state:

   ENTERED

NOTE

Program 38 (INIT) can be aborted by pressing any front panel key, except the ENTER key, when the prompt "ENTER?" is displayed. The instrument will return to the previous operating state.

FRONT PANEL TRIGGERING

With the instrument properly configured over the IEEE-488 bus, readings can be triggered from the front panel using the ENTER key. The following paragraphs provide general procedures for one-shot front panel triggering and front panel triggering into data store.

NOTE

The procedures in this section require IEEE-488 bus programming. Refer to Section 3, particularly the paragraphs on Trigger and Storage/Reading Commands for details on programming the instrument over the bus.

One-Shot Triggering

On power up, the instrument is in the continuous trigger mode with the conversion rate determined by the internal time base. To place the instrument in a state where each press of the ENTER key will trigger one reading, perform the following general procedure:

1. Place the instrument in the desired function and range.
2. Place the instrument in "one-shot on external trigger" by sending TRIGGER EXT,ONE over the IEEE-488 bus.
3. Each press of the ENTER key will trigger one reading.

Triggering Readings Into Data Store

The front panel ENTER key can be used to trigger readings into data store. In the one-shot trigger mode, each press of the ENTER key will store one reading in the buffer. In the continuous trigger mode, the ENTER key will start the storage process at the rate that was programmed over the IEEE-488 bus. Perform the following general procedure to trigger readings into data store from the front panel:

1. Place the instrument in the desired function and range.
2. Place the instrument in the appropriate trigger mode:

   a. To store one reading in the buffer after each press of the ENTER key, send TRIGGER EXT,ONE (one-shot on external trigger) over the bus.

   b. To store a series of readings in the buffer after the ENTER key is pressed, send TRIGGER EXT, CONT (continuous on external trigger) over the bus.

3. Configure the storage interval and buffer size of the data store by sending the appropriate STOINT and BUFSZ commands over the bus (see STOINT and BUFSZ commands in Section 3).
4. Press the ENTER key to either store one reading in the buffer or to start storage of a series of readings.

EXTERNAL TRIGGERING

The DM 5120/5520 has two external BNC connectors on the front panel associated with instrument triggering. The EXT TRIG TTL INPUT connector allows the instrument to be triggered by other devices, while the READING COMPLETE TTL OUTPUT connector allows the instrument to trigger other devices.

External Trigger

The DM 5120/5520 may be triggered on a continuous or oneshot basis. For each of these modes, the trigger stimulus will depend on the selected trigger mode. In the continuous trigger mode, the instrument takes a continuous series of readings. In the one-shot mode, only a single reading is taken each time the instrument is triggered.

The external trigger input requires a falling edge pulse at TTL logic levels, as shown in Figure 2-11. Connections to the EXT TRIG TTL INPUT jack should be made with a standard BNC connector. If the instrument is in the external trigger mode, it will be triggered to take readings while in either a continuous or one-shot mode when the negative-going edge of the external trigger pulse occurs.

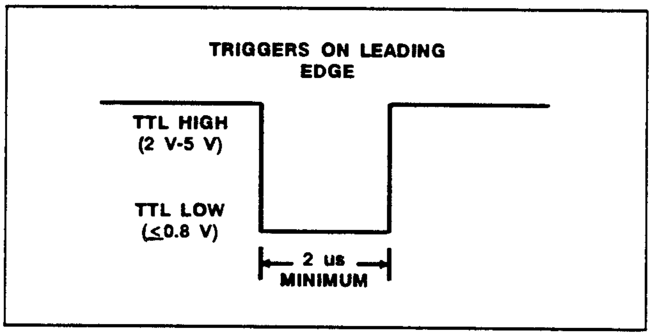


Fig. 2-11. External Trigger Pulse Specifications.

To use the external trigger, proceed as follows:

1. Connect the external trigger source to the EXT TRIG TTL INPUT connector. The shield (outer) part of the connector is connected to digital common. Since an internal pull-up resistor is used, a mechanical switch may be used. Note however, that debouncing circuitry will probably be required to avoid improper triggering.

CAUTION

Do not exceed 30 V between digital common and chassis ground, or instrument damage may occur.

2. Place the instrument in the TRIGGER EXT,ONE mode (one-shot on external trigger) or the TRIGGER EXT,CONT mode (continuous on external trigger).

3. To trigger the instrument, apply a pulse to the external trigger input. The instrument will process a single reading each time the pulse is applied (one-shot), or start a continuous series of readings.

NOTE

External triggering can be used to control the fill rate in the data store mode with the data store enabled and one shot mode selected, each trigger will cause a reading to be stored.

Reading Complete

The DM 5120/5520 has an available output pulse that can be used to trigger other instrumentation. A single TTL-compatible negative-going pulse (see Figure 2-12) will appear at the READING COMPLETE TTL OUTPUT jack each time the instrument completes a reading. To use the voltmeter complete output, proceed as follows:

1. Connect the DM 5120/5520 to the instrument to be triggered with a suitable shielded cable. Use a standard BNC connector to make the connection to the DM 5120/5520.

CAUTION

Do not exceed 30 V between the VOLTMETER COMPLETE common (outer ring) and chassis ground or instrument damage may occur.

2. Select the desired function, range, trigger mode, and other operating parameters, as desired.
3. In a continuous trigger mode, the instrument will output pulses at the conversion rate; each pulse will occur after the DM 5120/5520 has completed a conversion.
4. In a one-shot trigger mode, the DM 5120/5520 will output a pulse once each time it is triggered.

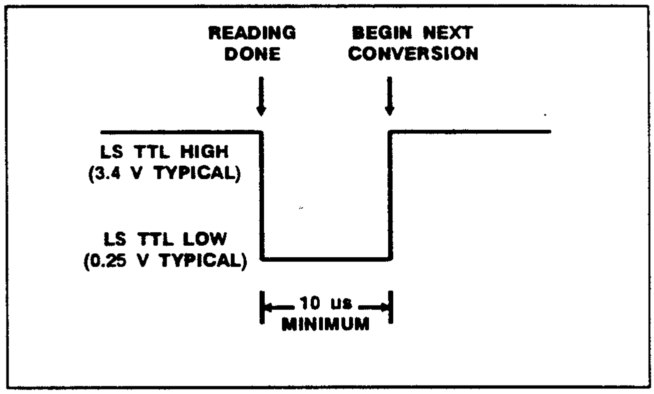


Fig. 2-12. Voltmeter Complete Pulse Specifications.

PROGRAMMING

Introduction

This manual section provides the information required for programming the TEKTRONIX DM 5120/5520 Programmable Digital Multimeter via the IEEE-488 bus. The IEEE-488 interface function subsets for the DM 5120/5520 are listed in Section 1. In this manual, the IEEE-488 digital interface is called the General Purpose Interface Bus (GPIB). Message protocol over the GPIB is specified and described in the IEEE-Standard 488.1-1987, *Standard Digital Interface for Programmable Instrumentation.*

The information in this section assumes that the reader is knowledgeable in GPIB bus communication and has some experience in programming the system.

IEEE-728 Standard (the IEEE recommended practice for code and format conventions for use with IEEE-488) is used in programming the DM 5120/5520. TM 5000 instruments are designed to communicate with any bus-compatible controller that can send and receive ASCII messages (commands) over the IEEE-488 bus. These commands program the instruments or request information from the instruments.

Recommended controllers for use in programming the DM 5120/5520 are the Tektronix 4041; or an IBM PC-compatible, such as the Tektronix PEP 301, with the Tektronix GURU (GPIB User's Resource Utility for the IBM PC) software and GPIB interface card.

Commands for TM 5000 programmable instruments are designed for compatibility among instrument types. The same commands are used in different instruments to control similar functions. In addition, commands are specified in mnemonics that are related to the functions implemented. For example, the INIT command initializes instrument settings to their power-on states.

Instrument commands are presented in this manual section 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.

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 instrument functions.

The DM 5120/5520 is shipped with the primary GPIB address set to 16. TM 5000 instruments are shipped with the message terminator set to LF with EOI. (Message terminators are described in Messages and Communications Protocol (in this section) The address and terminator settings are stored in non-volatile RAM. To display the current address and terminator, press the INST ID key. The GPIB primary address and message terminator can be changed using PROGRAM CONTROL key and the numbered keys and the up/down arrow keys. For information, refer to the Operating Instructions section in this manual.

COMMANDS

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

- Measurement Setting commands—control instrument settings.
- User Interface Setting commands—control the GPIB interface settings and the front panel.
- Query/Output—request data.
- Operational—cause a particular action.

When the instrument is in the remote state, it provides a response or executes all commands as appropriate. In the local state, only query/output commands are executed; setting and operational commands generate error responses, since instrument functions are under front panel control.

CAUTION

The DM 5120/5520 does not accept abbreviated commands like other products in the TM 5000 series. Make sure that your programs and error handlers can handle error messages with ERROR in the response instead of ERR.

Command Functional Groups

The following list of commands is arranged by functional group; some functional group lists are also divided into subgroups.

FUNCTION SETTING COMMANDS

FUNCT DCV or DCV
Selects the DC Volts Function.

FUNCT ACV or ACV
Selects the AC Volts Function.

FUNCT OHMS or OHMS
Selects the OHMS Function.

FUNCT DCA or DCA
Selects the DC Current Function

FUNCT ACA or ACA
Selects the AC Current Function

FUNCT ACVDB or ACVDB
Selects the AC Voltage Function with a conversion to DBV

FUNCT ACADB or ACADB
Selects the AC Current Function with a conversion to DB.

FUNCT OHMSCOMP or OHMSCOMP
Selects the OHMS Function with thermal offset compensation of the OHMS reading.

FUNCT?
Returns the function setting of the meter. Response: FUNCT DCV;, FUNCT ACV;, FUNCT OHMS;, FUNCT DCA;, FUNCT ACA;, FUNCT ACVDB;, FUNCT ACADB;, or FUNCT OHMSCOMP;.

RANGE SETTING COMMANDS

RANGE AUTO | <range num>
Sets the range of a selected function. Actual set range depends on the FUNCTion and RANGE arguments. <range num>: 0 - 7. If argument is 0, range setting is Automatic (AUTO). See Table 3-3 in the Detailed Command List.

RANGE?
Returns the value of the range parameter. Response: RANGE AUTO; or RANGE <range num>;.

DIGIT <digit number>
Sets the number of digits displayed and the resolution of the DM 5120/5520. <digit number>: 3 - 6. The number of digits actually displayed depends on the range and function settings. If the number of digits is not available for a combination of range and function, the closest available number of digits is selected. See Table 3-1 in the Detailed Command List.

DIGIT?
Returns the value of the DIGIT parameter (last one sent is not the actual number of digits displayed). Response: DIGIT <digit number>;. For example if DCA is the function and DIGIT 6 is sent, the DIGIT? query would return DIGIT 6, even though only 5 digits are displayed.

FILTER SETTING COMMANDS

INTFILT ON|OFF
Enables or disables the action of the internal filter. This filter must be on to obtain maximum accuracy from the DM 5120/5520.

INTFILT?
Returns the value of the INTFILT parameter. Response: INTFILT ON; or INTFILT OFF;.

FILTER ON|OFF
Enables or disables the internal digital filter. The amount of filtering is determined by the FILTERVAL parameter. This command is global for all functions.

FILTER?
Returns the state of the digital filter. Response: FILTER ON; or OFF;.

FILTERVAL <filter value>
Sets the number of readings used by the digital filter. <filter value>: 1-99. These values are the numerators of the filter weighting parameter values from 1/1 to 1/99. A different FILTERVAL value parameter can be stored for each function. See Operating Instructions section for a detailed explanation of this parameter.

FILTERVAL?
Returns the value of the FILTERVAL parameter for the selected function. Response: FILTERVAL <filter value>; .

BASELINE CONTROL AND CALIBRATION COMMANDS

NULL ON|OFF|0| <null value>
Enables or disables the adjustable baseline calculation program. Each function can have a different null baseline value. Sending NULL OFF or NULL 0 disables null baseline feature. Sending NULL ON enables the feature and uses current value of NULLVAL. Sending NULL and a number (other than 0) enables null feature and sets value of NULLVAL to that value.

NULL?
Returns the state of the NULL function. Response: NULL 0; or <null value>. NULL 0 means the NULL function is disabled. Any other value means the NULL function is enabled and set to that value.

NULLVAL ACQUIRE|<null value>
Sets the null value used by the NULL function. Sending NULL ACQUIRE sets null value to the latest reading. Sending NULL and a number sets null value to that value.

NULLVAL?
Returns the value of the NULLVAL parameter. The value returned is dependent on the function selected at the time the query is sent. Response: NULLVAL <null value>;.

AUTOCAL ON|OFF
Enables or disables the routine that automatically zeros the instrument and calibrates it to an internal standard.

AUTOCAL?
Returns the value of the AUTOCAL parameter. Response: AUTOCAL ON; or AUTOCAL OFF;.

CAL {FIRST,<cal value>}|{SECOND, <cal value>}|{LAST,<cal value>}
Causes the input to do a digital calibration on the DM 5120/5520 using the voltage on the input as the voltage reference. Refer to the Detailed Command List in this section.

NOTE

If the voltage reference is not connected to the input and the CAL command is sent, the instrument will try to do the calibration using whatever voltage is on the input. This will affect the accuracy of the instrument until a valid voltage reference is supplied and the CAL command is sent again. Use this command with caution. If you want to zero the instrument to the system use the NULL command. The CAL command can be locked out with the CAL front panel recessed button.

TRIGGER COMMANDS

TRIGGER <source>,<mode>
Sets the trigger mode and source. The mode can be CONT (continuous) or ONE (single shot). If the CONT mode is selected, the DM 5120/5520 runs continuously after being triggered. If the ONE argument is sent, the instrument acquires only one reading. See the FILTER, INTFIL, AUTOCAL commands for more information. The trigger source can be TALK or EXT. When TALK is sent, the instrument goes into TADS (Talk Address State) and creates a trigger to start the conversion sequence. The DM 5120/5520 will not trigger on a serial poll response. When EXT is sent, an external trigger starts the conversion. With EXT source selected, pressing the [ENTER] key on the front panel can start the conversion.

TRIGGER?
Returns the state of the TRIGGER function. Response: TRIGGER <source>,<mode>.

DT TRIG | OFF
Creates a trigger when GET is sent over the GPIB and enabled by DT TRIG. When DT is enabled, it is OR'd with any of the trigger sources by the TRIGGER command. As an example, if TRIG EXT,ONE is selected and DT TRIG is selected, either an external trigger or sending GET over the GPIB will cause one reading.

DT?
Returns status of DT parameter. Response: DT TRIG; or DT OFF;.

DELAY COMMANDS

DELAY <delay time>
Sets the delay time between the receipt of a trigger and the start of a conversion. <delay time>: 0 - 65000 ms.

DELAY?
Returns the value of the DELAY parameter. Response: DELAY <delay time>;.

STORAGE/READING COMMANDS

BUFSZ CIRCULAR | <buffer_size>
Sets the size of the data buffer in memory. Sending BUFSZ CIRCULAR or BUFSZ 0 makes the buffer circular and sets it to full size (500). If more than 500 readings are stored in the buffer, the pointer will wrap around to the beginning of the buffer and start to write over the old readings.

If the <buffer size> argument is any number 1 through 500, the buffer becomes a linear buffer the size of the argument. When the buffer is full, data is no longer stored in the buffer and any new readings are not written into the buffer. All readings from the buffer will start from the first physical location in the buffer. This includes operation with a circular buffer. Sending the BUFSZ command will clear the buffer and prepare it to receive readings. If BUFSZ 0 is sent this is the same as BUFSZ CIRCULAR.

BUFSZ?
Returns the value and type of the reading storage buffer. Response: BUFSZ CIRCULAR; or BUFSZ <buffer size>;.

STOINT <interval time>
Sets the length of the storage interval (the length of time between storage readings). <interval time>: 1-999999 ms. If the ONE argument is selected, the readings are stored one for each trigger received and the TRIGGER command must be set to ONE (one shot mode). If a storage interval is selected, a reading is stored at the selected interval and the instrument TRIGGER command must be set to CONT (continuous mode). See Detailed Command List for additional details before using this command.

STOINT?
Returns the state of the STOINT function. Response: STOINT <interval time>;

BUFAVE?
Returns the average of all the readings in the storage buffer. Response: BUFAVE <average value>;.

BUFCNT?
Returns number of readings stored in the storage buffer. Response: BUFCNT <number of readings>;. The BUFCNT will return the storage index when in circular storage mode.

BUFMIN?
Returns the minimum value of all the readings in the storage buffer. Response: BUFMIN <minimum buffer value>;.

BUFMAX?
Returns the maximum value of all the readings in the storage buffer. Response: BUFMAX <maximum buffer value>;.

NOTE

The BUFAVE, BUFMIN and BUFMAX queries will not output a reading until the buffer is full. The bus will be held off until a reading is ready.

READ ADC | ONESTORE | ALLSTORE
Sets up the way that readings are transferred over the GPIB interface and the source of the readings. If ADC (Analog to Digital Converter) is sent, the readings are talked from the Converter. If the ONESTORE argument is sent, the next reading is returned from the storage buffer. If the ALLSTORE argument is sent, all the readings from the buffer are sent. When all the readings have been read from the buffer, the buffer resets back to the beginning.

READ?
Returns the state of the READ function. Response: READ ADC | ONESTORE | ALLSTORE;.

DATFOR ON | OFF
Turns on and off formatting of the data. Sending DATFOR OFF causes the numeric value of the reading to be returned in scientific notation (1.00E2). Sending DATFOR ON causes the reading to be format with the function information and the buffer location. If a buffer location of 000 is returned, the reading came directly from the ADC conversion and was not stored in the storage buffer.

DATFOR?
Returns the state of the FORMAT function. Response: DATFOR ON; or DATFOR OFF;.

SEND
SEND supplies one trigger regardless of the trigger setting and queues the requirement for a reading in the next talk. When the instrument is "talked"

each requirement for a reading will cause a reading to be output.

ERROR/EVENT REPORTING COMMANDS

RQS ON|OFF
Enables/disables Service Request operation. If RQS is ON, events/errors are reported using SRQ at the end of command execution; if OFF, errors are queued until an error query is sent or until RQS is turned back on.

RQS?
Returns the RQS (Service Request) status. Response: RQS ON; or RQS OFF;.

ERRSTAT ON|OFF
Enables or disables the reporting of ERRORS. This command will affect the reporting of any syntax error or internal event.

ERRSTAT?
Returns the state of the error status reporting function. Response: ERRSTAT ON; or ERRSTAT OFF;.

ERROR? or EVENT?
Returns the highest priority error in the error queue. Response: ERROR <number>; or EVENT <number>. If <number> is 0, there are no errors to report. See the Detailed Command List for the rules covering the ERROR and EVENT reporting.

OVER ON|OFF
Enables or disables the reporting of an overrange condition.

OVER?
Returns the state of the overrange reporting function. Response: OVER ON; or OVER OFF;.

FULL ON|OFF
Enables or disables the reporting of a full buffer. When FULL ON is sent and the readings buffer fills up, an event will be reported by asserting the SRQ line and waiting for a serial poll to report the error. The FULL event will not be reported by the CIRCULAR buffer. If RQS is off and FULL is ON the event will be queued in priority order waiting for an EVENT? or ERROR? to report the event.

FULL?
Returns the state of the full buffer reporting function. Response: FULL ON; or FULL OFF;.

HALF ON|OFF
Enables or disables the reporting of a buffer half full. If the argument is ON and when the reading buffer is half full the event will be reported over the GPIB interface by asserting the SRQ line (RQS ON) or by sending a response to an EVENT or ERROR query when RQS is off. A buffer is considered half full when 50% of the allocated buffer space is filled. HALF will not be reported by a CIRCULAR buffer that is HALF way to the wrap point.

HALF?
Returns the state of the half full buffer reporting function. Response: HALF ON; or HALF OFF;.

OPC ON|OFF
Enables or disables the reporting of an operation complete event. When OPC ON is sent and a reading is complete, SRQ is asserted (If RQS is ON) so that the controller can come and get the reading. If RQS is OFF the event is reported using the EVENT or ERROR query. This will allow the DM 5120/5520 to use a large delay time to get a reading and then report to the controller that the reading is ready to be transferred.

OPC?
Returns the state of the operation complete reporting function. Response: OPC ON; or OPC OFF;.

RDY ON|OFF
Enables or disables the bus ready reporting function. If the function is ON when the instrument is ready to take a reading and all commands have been executed, the event is reported.

RDY?
Returns the state of the bus ready reporting function. Response: RDY ON; or RDY OFF;.

USER ON|OFF
Enables/disables SRQ when the INST ID front-panel key is pressed. The USER function allows operator input to the controller without a keyboard. The user can be prompted using the front panel display and then press the ID button to continue.

USER?
Returns the state of the USER function. Response: USER ON; or USER OFF;.

FRONT PANEL CONTROL COMMANDS

TEXT "<characters>"
Allows messages to be sent to the front-panel display. The argument can contain up to 10 characters enclosed with quote marks. Sending TEXT " " clears any displayed characters and sets the instrument back to the normal instrument display.

TEXT?
Returns the display mode and the characters displayed if enabled. Returns its response in the form TEXT "<characters>";.

KEY <key value>;

Allows the user to simulate pushing of the front panel buttons over the GPIB interface. The keys are accessed by sending a number that corresponds to the desired button. See Detailed Command List Table 3-2 for key values.

NOTE

Text must be cleared from the display before the KEY command can be used. Send TEXT " " to clear display.

KEY?

The button query will return the values of the last button command sent or the last button pressed on the front panel. Response: KEY <key value>;. If the button command has not been sent, the last front-panel button pressed is returned. If there is no valid button response, 15 will be returned.

SETTING SAVE AND RESET COMMANDS

PONSAVE

The PONSAVE command saves the present front panel value to EEPROM. If power is removed after the save command is sent, the instrument will power up to the state that it was in when the save command was sent.

RESET

The RESET command restores the instrument to the factory default setting. The GPIB address, GPIB termination and power line frequency parameters are not affected by the RESET command and will remain at their present value. A PONSAVE must be sent to the instrument if the instrument is to power up in the factory default state.

INIT

Sending INIT places the DM 5120/5520 into the power on state. This state is the union of the commands affected by the PONSAVE and the factory default of the remaining commands. The INIT command also clears the input/output buffer and any errors except the power on event. The RESET command returns the instrument to the power on state.

SYSTEM COMMANDS

ID?

Returns the identification of the instrument in the form: ID TEK/<model number>,<Tek Codes and Format version>,<firmware version>,<installed options (if any)>.

SET?

Returns the value of all the adjustable commands that support a query.

TEST?

Starts a self test of the instrument and returns the status of the self test. Response: TEST 0 for no error or TEST 1 for a failed self test.

Control/Command Associations

Figure 3-1 shows the DM 5120/5520 front panel key and command relationships.

Detailed Command Descriptions

Each DM 5120/5520 command, like those in all TM 5000 instruments, begins with a header, which is a word or acronym that describes the function implemented. Following the header, many commands require an argument, which is a word or number that specifies the desired state for the function. The commands are presented alphabetically on the following pages. In this presentation, the following notations are used to represent elements of the IEEE-488 bus communications between the DM 5120/5520 and the controller.

<GET>	The Group Execute Trigger interface message (decimal code 8 transmitted with attention asserted).
<NRF>	A number that can be transmitted or accepted by the DM 5120/5520. Numbers may be NR1 (integer), NR2 (decimal), and NR3 (with exponent) formats. (See ANSI Standard X3.42.) Carets (< and >) are not part of the format; they are used in this manual to enclose an element for which the user must substitute the appropriate characters.
:	Data that is linked to the previous argument uses the colon as a delimiter.
|	A vertical line is used in a series of two or more units, to separate the units; any one unit must be selected and sent as part of the command message. Do not include the line in the message.
{ and }	Braces indicate a grouping of arguments and variables. Do not include the braces in the message.
[and]	Brackets indicate optional data. Do not include the brackets in the message.

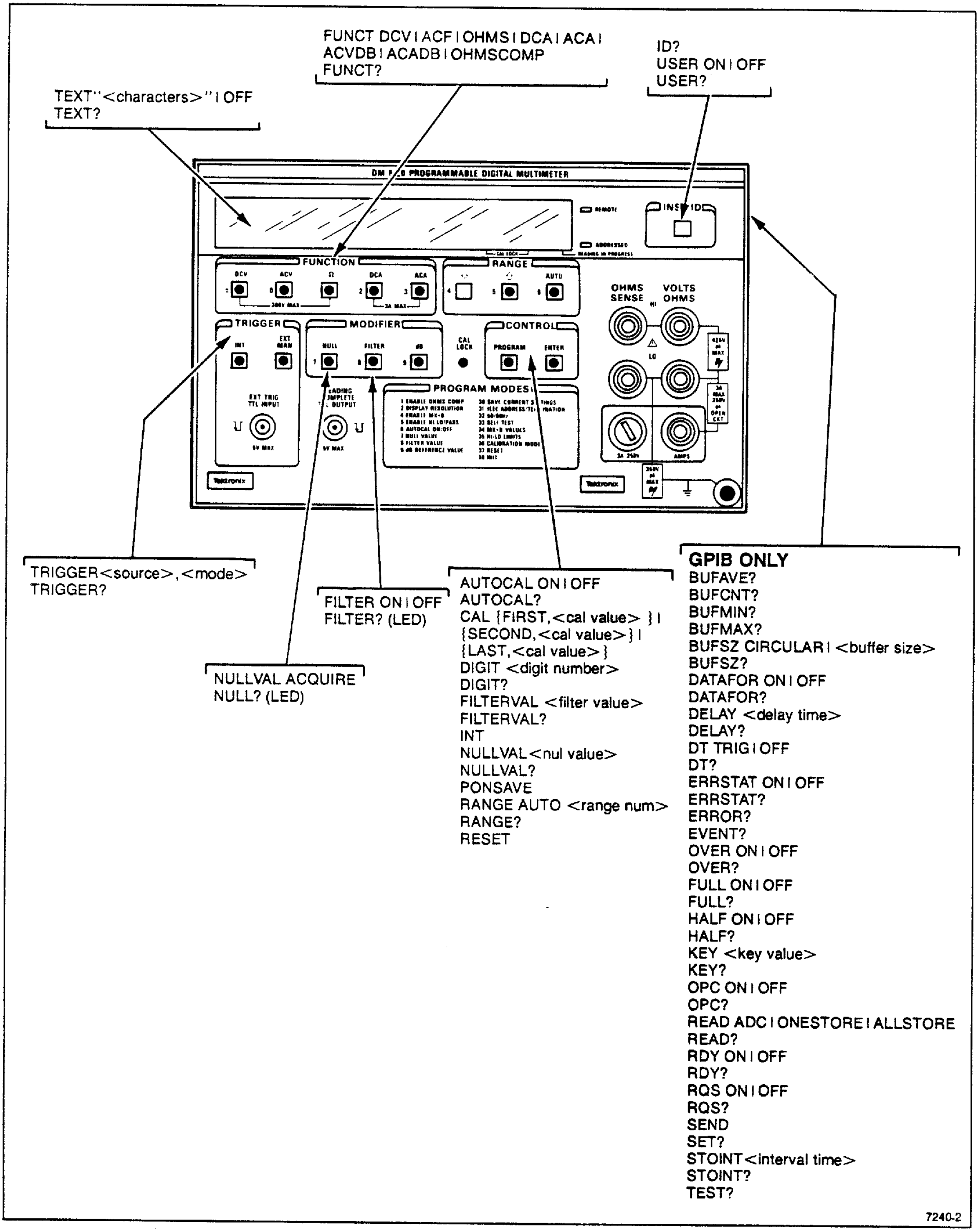


Fig. 3-1. Command Associations to Controls.

DETAILED COMMAND LIST

AUTOCAL

Command Type:
Measurement setting or query

Setting Syntax:
AUTOCAL ON
AUTOCAL OFF

Examples:
AUTOCAL ON
AUTOCAL OFF

Query Syntax:
AUTOCAL?

Query Response (one of the following):
AUTOCAL ON;
AUTOCAL OFF;

Discussion:

This command will enable and disable the routine that automatically zeros the instrument and calibrates it to an internal standard. The AUTOCAL function can cause a single conversion to take 4 integrations. The four integrations are Signal, Signal 0, Reference, Reference 0. These four readings are combined to provide a conversion. To get the maximum number of readings per second from the DM 5120/5520 turn AUTOCAL OFF; to get maximum accuracy turn AUTOCAL ON. When AUTOCAL is OFF the last correction is applied to the value from the integration to get the reading. AUTOCAL should remove any offset voltages internal to the A to D converter and signal path.

BUFAVE?

Command Type:
Query

Query Syntax:
BUFAVE?

Query Response:
BUFAVE <average value>;

Examples:
BUFAVE 6.76

Discussion:

This query will return the average of all the readings in the storage buffer.

NOTE

The BUFAVE query will not output a reading until the buffer is full. The bus will be held off until a reading is ready.

BUFCNT?

Command Type:
Query

Query Syntax:
BUFCNT?

Query Response:
BUFCNT <number of readings>;

Examples:
BUFCNT 45

Discussion:

This query will return the number of readings stored in the storage buffer. BUFCNT will return the storage index when in circular storage mode.

BUFMIN?

Command Type:
Query

Query Syntax:
BUFMIN?

Query Response:
BUFMIN <minimum buffer value>;

Examples:
BUFMIN 99

Discussion:

This query will scan the storage buffer and return the minimum value of the storage buffer.

BUFMAX?

Command Type:
Query

Query Syntax:
BUFMAX?

Query Response:
BUFMAX <maximum buffer value>;

Examples:
BUFMAX 99998

Discussion:

The BUFMAX? query will scan the buffer and return the maximum value of readings in the storage buffer.

NOTE

The BUFMIN and BUFMAX queries will not output a reading until the buffer is full. The bus will be held off until a reading is ready.

BUFSZ

Command Type:
Measurement setting or query

Setting Syntax:
BUFSZ CIRCULAR
BUFSZ <buffer size>

Examples:
BUFSZ CIRCULAR
BUFSZ 256

Query Syntax:
BUFSZ?

Query Response (one of the following):
BUFSZ CIRCULAR;
BUFSZ 256;

Discussion:

This command sets the size of the data buffer in memory. If CIRCULAR is the argument, the buffer is set to the full size (500) and made into a circular buffer. If more than 500 readings are stored in the buffer, the pointer wraps around to the beginning of the buffer and starts to write over the old readings.

If a value is included as the argument, the buffer becomes a linear buffer the size of the argument. When the buffer is full, data is no longer stored in the buffer and any new readings are not written into the buffer. All readings from the buffer will start from the first physical location in the buffer. This includes operation with a circular buffer. Sending the BUFSZ command will clear the buffer and prepare it to receive readings. If BUFSZ 0 is sent this is the same as BUFSZ CIRCULAR.

CAL

Command Type:
Operational

Setting Syntax:
CAL FIRST <cal value>
CAL SECOND <cal value>
CAL LAST <cal value>

Examples:
CAL FIRST 10
CAL SECOND -5
CAL LAST 0

Discussion:

The CAL command will cause the input to do a digital calibration on the DM 5120/5520 using the voltage on the input as the voltage reference. To do a calibration on the instrument, a reference for two or three points must be supplied. The value of the voltage reference for each point is supplied to instrument in the argument "cal value".

The SECOND parameter is used for DC Volts only. If the SECOND parameter is used while calibrating a function other than the DC function, there is no effect to the calibration.

The CAL function will not work if the front panel CAL switch is off. When CAL is enabled, the second and third decimal points in the display will be on (second and third LED from the right side of the display). If CAL is off and the CAL function command is sent, an error is returned to the controller. CAL cannot be used with the RANGE AUTO, FUNCTIONS ACV dB, ACA dB or OHMSCOMP ranges.

NOTE

If the voltage reference is not connected to the input and the CAL command is sent, the instrument will try to do the calibration using whatever voltage is on the input. This will affect the accuracy of the instrument until a valid voltage reference is supplied and the CAL command is sent again. Use this command with caution. If you want to zero the instrument to the system use the NULL command. The CAL command can be locked out with the CAL front panel recessed button.

NOTE

Calibration must be done in this order: 1) CAL FIRST + Full Scale, 2) CAL SECOND – Full Scale, 3) CAL LAST 0 V.

DATFOR

Command Type:
Measurement setting or query

Setting Syntax:
DATFOR ON
DATFOR OFF

Examples:
DATFOR ON
DATFOR OFF

Query Syntax:
DATFOR?

Query Response (one of the following):
DATFOR ON;
DATFOR OFF;

Discussion:

This command turns on and off formatting of the data. If DATFOR is OFF, data is returned using the numeric value of the reading in NR3 format. If the argument is set ON, the reading is formatted with the function information and the buffer location. If a buffer location of 000 is returned, the reading came directly from the ADC conversion and was not stored in the storage buffer. The location of the decimal and the value of the exponent is unique for each range of a specific function. If you know the function, the position of the decimal point and the value of the exponent can be used to determine the range of the instrument when the reading was taken. Here is the syntax of the reading responses.

<NR3 reading value>[:<function info>:
<NR1 buffer location>];

function info = <status><function>

status = O|N|Z (Overrange, Normal, Zeroed)

function = DCV | ACV | OHM | OCO | OHMSCOMP | DCA | DBV | DBA

NR3 reading value = <NR3> (Placement of decimal point and exponent points to the range.)

NR1 buffer location = <NR1> (000 to 500)

If the DM 5120/5520 returns a reading that is all 9's, an overrange condition exists (9.999999E+99).

If the DM 5120/5520 returns –0.000000E+9, the read ONESTORE or ALLSTORE is set and there is no reading in the buffer to return.

DELAY

Command Type:
Measurement setting or query

Setting Syntax:
DELAY <delay time>

Examples:
DELAY 65000
DELAY 3

Query Syntax:
DELAY?

Query Response:
DELAY <delay time>;

Discussion:

This command sets the delay time between the receipt of a trigger and the start of a conversion. This allows a time delay to be built into the measurement to allow settling time. The argument and response are in milliseconds.

DIGIT

Command Type:
Measurement setting or query

Setting Syntax:
DIGIT <digit number>

Examples:
DIGIT 3
DIGIT 6

Query Syntax:
DIGIT?

Query Response:
DIGIT <digit number>;

Discussion:

This command determines the number of digits displayed and the resolution of the DM 5120/5520. The actual displayed digits will depend on the Range and Function of the DM 5120/5520. If the number of digits is not available for a combination of range and function, the closest available number of digits will be selected. The table below shows the relationship of Range and Function to number of digits. The value of the DIGIT parameter sent is returned from the DIGIT query even though the number of digits displayed is different. That way if the Function and or Range parameters change, the number of digits will be correct for the DIGIT parameter sent. See Table 3-1.

The number of digits returned over the GPIB interface will always be seven. The number of digits may not be "REAL"; however the reading will reflect the actual value of the conversion. This is allowed because the user may want to do his own processing on the raw converter data without pre-processing by the DM 5120/5520.

As an example if FUNCT DCA is selected and DIGIT 6 is selected, the actual digits displayed would be 5. A query would return DIGIT 6; the number of digits transferred over the GPIB interface would be 7.

Table 3-1
ACTUAL DIGITS vs SELECTED DIGITS

DIGITS SELECTED	FUNCTION DCV	ACV	OHMS (1-4)	OHMS (5-6)	DCA	ACA	ACVDB ACADB	OHMS-COMP
3	3	3	3	5	3	3	5	5
4	4	4	4	5	4	4	5	5
5	5	5	5	5	5	5	5	5
6	6	5	6 (1-6)	5 (6)	5	5	5	6

DT

Command Type:
User interface setting or query

Setting Syntax:
DT TRIG
DT OFF

Examples:
DT TRIG
DT OFF

Query Syntax:
DT?

Query Response (one of the following):
DT TRIG;
DT OFF;

Discussion:

Creates a trigger when <GET> is sent over the GPIB and enabled by DT TRIG. When DT is enabled, it is OR'd with any of the trigger sources by the TRIGGER command. As an example, if TRIG EXT ONE is selected and DT TRIG is selected, an external trigger will cause one reading, or sending <GET> over the GPIB will cause one reading.

ERROR? EVENT?

Command Type:
Query

Query Syntax:	Query Response :
ERROR?	ERROR <number>;
EVENT?	EVENT <number>;

Discussion:

The error query will return a number representing the error or event.

1. If RQS is ON, the ERROR? response is paired with the SRQ status byte. The ERROR response will not be returned until a serial poll is performed and the SRQ status byte is returned to the controller.

   a. If RQS is ON and an erroneous command is sent to the instrument, sending ERROR? at this point will return ERROR 0; (no error to report) until a serial poll is returned. Then sending ERROR? will cause the instrument to return ERROR <number>;. The error number will match the status byte returned and give more information on the type of error. It will return the error only once.

   b. If there is more than one error waiting to be serviced, the first error will be returned first. The highest priority error is returned next.

   c. If an error occurred with RQS ON and a serial poll has been performed, the error number is queued and waits for an ERROR? to be sent. If another serial poll is performed, the queued error number is lost. If the status byte = "nothing to report", an error query is sent and the response will be ERROR 0. If the status byte is a valid status byte, ERROR <error number> will be returned.

2. If RQS is OFF, the ERROR? will return the highest priority error. If more than one error of a certain priority level happens, the oldest error is lost and the newest error of that priority level will be returned when ERROR? is sent.

3. Turning RQS ON and OFF will not cause any errors to be lost but will only enable or disable the assertion of the SRQ line.

4. If OVER, FULL, HALF, USER, OPC or ERRSTAT commands are turned off and then back on (disabled and then enabled again), any errors pending before the commands were turned off and affected by the command would be lost except for the power on event.

ERRSTAT

Command Type:
User interface setting or query

Setting Syntax:
ERRSTAT ON
ERRSTAT OFF

Examples:
ERRSTAT ON
ERRSTAT OFF

Query Syntax:
ERRSTAT?

Query Response (one of the following):
ERRSTAT ON;
ERRSTAT OFF;

Discussion:

This command will enable or disable the reporting of ERRORS. This command will affect the reporting of any syntax error or internal event.

If ERRSTAT is OFF and a syntax error is reported, the ERROR is not reported, but is lost and the instrument will be quiet about any error. The only exception to this is the power-on event. If ERRSTAT is turned OFF and power on has not been queued, when ERRSTAT is turned back ON, the power-on event would then be reported.

FILTER

Command Type:
Measurement setting or query

Setting Syntax:
FILTER ON
FILTER OFF

Examples:
FILTER ON
FILTER OFF

Query Syntax:
FILTER?

Query Response (one of the following):
FILTER ON;
FILTER OFF;

Discussion:

This command enables or disables the internal digital filter. The amount of filtering is determined by the FILTERVAL parameter. The filter is a digital filter that does a weighted average of a number of input readings. This command is global for all functions.

See filters discussion in Operating Instructions section for more information.

FILTERVAL

Command Type:
Measurement setting or query

Setting Syntax:
FILTERVAL <filter value>

Examples:
FILTERVAL 40

Query Syntax:
FILTERVAL?

Query Response (one of the following):
FILTERVAL <filter value>;

Discussion:

This command will set the number of readings used by the digital filter enabled by the FILTER command. The DM 5120/5520 will maintain storage for a FILTERVAL parameter for each function. The DC voltage function can have a different amount of filtering than the AC voltage function. The filter is a simple weighted low pass filter, the filter value is the number of conversion needed for 1 Time constant. Filter value = <NRF> (1 to 99).

The filter is described by the formula:
AVG(t) = AVG(t-1) + ((new reading – AVG(t-1)) / F

Where:
F = FILTERVAL value (weighting factor)
AVG(t) = displayed average
AVG(t-1) = old displayed average

FULL

Command Type:
User interface setting or query

Setting Syntax:
FULL ON
FULL OFF

Examples:
FULL ON
FULL OFF

Query Syntax:
FULL?

Query Response (one of the following):
FULL ON;
FULL OFF;

Discussion:

This command will enable or disable the reporting of a full buffer. If the argument is ON when the readings buffer fills up an event will be reported by asserting the SRQ line and waiting for a serial poll to report the error. The FULL event will not be reported by the CIRCULAR buffer when it wraps around to the beginning of the buffer space. If RQS is off and FULL is ON the event will be queued in priority order waiting for an EVENT? or ERROR? before reporting the event.

FUNCT

Command Type:
Measurement setting or query

Setting Syntax:
FUNCT DCV
FUNCT ACV
FUNCT OHMS
FUNCT DCA
FUNCT ACA
FUNCT ACVDB
FUNCT ACADB
FUNCT OHMSCOMP

Examples:
FUNCT DCV
FUNCT ACV
FUNCT OHMS
FUNCT DCA
FUNCT ACA
FUNCT ACVDB
FUNCT ACADB
FUNCT OHMSCOMP

Query Syntax:
FUNCT?

Query Response (one of the following):
FUNCT DCV;
FUNCT ACV;
FUNCT OHMS;
FUNCT DCA;
FUNCT ACA;
FUNCT ACVDB;
FUNCT ACADB
FUNCT OHMSCOMP;

Discussion:

The FUNCT command allows the function of the DM 5120 to be set. The arguments can also be used alone to set the function of the instrument as shown below.

LIST OF FUNCTIONS

DCV
Set the DM 5120/5520 into the DC Volt Function

ACV
Set the DM 5120/5520 into the AC Volts Function

OHMS
Set the DM 5120/5520 into the OHMS Function

DCA
Set the DM 5120/5520 into the DC Current Function

ACA
Set the DM 5120/5520 into the AC Current Function

ACVDB
Set the DM 5120/5520 into the AC Voltage Function with a conversion to DBV

ACADB
Set the DM 5120/5520 into the AC Current Function with a conversion to DB

OHMSCOMP
Set the DM 5120/5520 into the OHMS Function with Thermal offset compensation of the ohms reading.

HALF

Command Type:
User interface setting or query

Setting Syntax:
HALF ON
HALF OFF

Examples:
HALF ON
HALF OFF

Query Syntax:
HALF?

Query Response (one of the following):
HALF ON;
HALF OFF;

Discussion:

This command will enable or disable the reporting of a buffer half full. If the argument is ON and when the reading buffer is half full the event will be reported over the GPIB interface by asserting the SRQ line (RQS ON) or by sending a response to an EVENT? that RQS is off. A buffer is considered half full when 50% of the allocated buffer space is filled. HALF will not be reported by a CIRCULAR buffer that is half way to the wrap point.

ID?

Command Type:
Query

Query Syntax:
ID?

Query Response:
ID TEK/DM5120,V81.1,FV1.0;.

Discussion:

The ID? query will return the ID string for the DM 5120/5520. The breakdown of the string is as follows:

ID = Command header

TEK = Manufacturer of the instrument

DM5120 = Model number of the instrument

V81.1 = Codes and formats version this instrument conforms to.

FV1.0 = The firmware version that is in this instrument.

If an option is included with the instrument it would follow using a comma as the delimiter.

INIT

Command Type:
Operational

Setting Syntax:
INIT

Discussion:

The INIT command will place the DM 5120/5520 into the power on state. This state is the union of the commands affected by the PONSAVE and the factory default of the remaining commands. The INIT command will also clear any input/output buffer and any errors except the power on event.

To return the instrument to the factory default settings, use the RESET command. Be sure to send PONSAVE after RESET if you want the instrument to power up with the factory setup.

INTFILT

Command Type:
Measurement setting or query

Setting Syntax:
INTFILT ON
INTFILT OFF

Examples:
INTFILT ON
INTFILT OFF

Query Syntax:
INTFILT?

Query Response (one of the following):
INTFILT ON;
INTFILT OFF;

Discussion:

This command will enable or disable the action of the internal filter. The internal filter is a running average filter. It is used to get the maximum accuracy from the meter by averaging out converter noise and internal noise.

NOTE

This filter must be on to obtain maximum accuracy from the DM 5120/5520.

KEY

Command Type:
User interface setting or query

Setting Syntax:
KEY < key value >;

Examples:
KEY 8
KEY 14

Query Syntax:
KEY?

Query Response (one of the following):
KEY 8;
KEY 14;

Discussion:

The KEY command allows the user to simulate pushing of the front panel buttons over the GPIB interface. The keys are accessed by sending a number that corresponds to the desired button. The buttons are defined as below. No button KEY response is sent at power on and after INIT or RESET.

Table 3-2
KEY VALUE TO KEY PRESSES

0 ACV FUNCTION	8 FILTER MODIFIER
1 OHMS FUNCTION	9 dB MODIFIER
2 DCA FUNCTION	10 DCV FUNCTION
3 ACA FUNCTION	11 ENTER CONTROL
4 (DECREMENT)	12 PRGM CONTROL
5 (INCREMENT)	13 EXT
6 AUTO	14 INT
7 NULL MODIFIER	15 NO BUTTON pressed

The 15 response is included to allow the KEY 15 query response to be used as a command without causing an error.

The button query will return the values of the last button command sent or the last button pressed on the front panel.

NOTE

Text must be cleared from the display before the KEY command can be used. Send TEXT " " to clear display.

If the button command has not been sent, the last button pressed by the user will be returned. If there is no valid button response, 15 will be returned.

NULL

Command Type:
Measurement setting or query

Setting Syntax:
NULL ON
NULL OFF
NULL 0
NULL <null value>

Examples:
NULL ON
NULL OFF
NULL 0
NULL 3

Query Syntax:
NULL?

Query Response (one of the following):
NULL 0;
NULL <null value>;

Discussion:

This command enables and disables the adjustable base line calculation program. Each of the functions can have its own null baseline value. When NULL is enabled, the value of the NULLVAL parameter applied to the input connector will cause 0 to be displayed. If the argument is 0, filter is turned off. If a number is the argument, the null function is enabled and the value of the NULLVAL parameter becomes the number. If the argument is ON, NULL is enabled with the present value of NULLVAL. If the argument is OFF, the NULL function is disabled. This command was modified to maintain compatibility with the DM 5010.

When using the query NULL?, if NULL 0 is returned, the NULL function is disabled. If any other value is returned, the NULL function is enabled and set to the value returned.

NULLVAL

Command Type:
Measurement setting or query

Setting Syntax:
NULLVAL ACQUIRE
NULLVAL <null value>
<null value> ::= <NRF> (Range ± full scale for the selected range)

Examples:
NULLVAL ACQUIRE
NULLVAL 3

Query Syntax:
NULLVAL?

Query Response (one of the following):
NULLVAL <null value>;

Discussion:

The NULLVAL command sets the baseline used by the NULL function. If a number is the argument, the value of the NULLVAL parameter is set to the value of the argument. Each function has its own storage for a NULLVAL parameter. This allows each function to keep its own baseline value. The ACQUIRE argument will take the latest reading and use it for the null value.

The query will return the value of the NULLVAL parameter. Each function can have its own NULLVAL parameter so the value returned can be dependent on the function selected at the time the query is sent.

OPC

Command Type:
User interface setting or query

Setting Syntax:
OPC ON
OPC OFF

Query Syntax:
OPC?

Query Response (one of the following):
OPC ON;
OPC OFF;

Discussion:

This command will enable or disable the reporting of an OPERATION COMPLETE event. If the function is ON and when a reading is complete SRQ will be asserted (If RQS is ON) so that the controller can obtain the reading. If RQS is OFF the event is reported using the EVENT or ERROR query. This will allow the DM 5120/5520 a large delay time to acquire a reading and report to the controller when the reading is ready for transfer.

OVER

Command Type:
User interface setting or query

Setting Syntax:
OVER ON
OVER OFF

Query Syntax:
OVER?

Query Response (one of the following):
OVER ON;
OVER OFF;

Discussion:

This command will enable or disable the reporting of a measurement overflow condition.

PONSAVE

Command Type:
Operational

Setting Syntax:
PONSAVE

Discussion:

The PONSAVE command will take the present front panel value and save it to EEPROM. If power is removed after the PONSAVE command is sent, the instrument will power up to the state that it was when the PONSAVE command was sent.

The following class of commands and other parameters are saved using the PONSAVE command.

- Measurement settings commands
- FILTERVAL for each function
- NULLVAL for each function
- 50/60 Hz operation
- GPIB Address and Termination

RANGE

Command Type:
Measurement setting or query

Setting Syntax:
RANGE AUTO | <range number>

Examples:
RANGE AUTO
RANGE 5

Query Syntax:
RANGE?

Query Response (one of the following):
RANGE AUTO;
RANGE <range number>;

Discussion:

This command will set the range of the DM5120. Range num = (range 1 to 7). The actual range that is set will depend on the Function and the Range argument. If the argument is 0, the range is set to Automatic (AUTO).

See Table 3-3.

Table 3-3
FUNCTION/RANGE vs RANGE NUMBER

RANGE	FUNCTION						
	DCV	ACV	OHMS	DCA	ACA	ACVDB ACADB	OHMS-COMP
0	AUTO	AUTO	AUTO	AUTO	AUTO	AUTO	AUTO
1	300 mV	300 mV	300	300 uA	300 uA	AUTO	300
2	3 V	3 V	3 K	3 mA	3 mA	AUTO	3 K
3	30 V	30 V	30 K	30 mA	30 mA	AUTO	30 K
4	300 V	300 V	300 K	300 mA	300 mA	AUTO	30 K
5	300 V	300 V	3 M	3 A	3 A	AUTO	30 K
6	300 V	300 V	30 M	3 A	3 A	AUTO	30 K
7	300 V	300 V	300 M	3 A	3 A	AUTO	30 K

RDY

Command Type:
User interface setting or query

Setting Syntax:
RDY ON
RDY OFF

Examples:
RDY ON
RDY OFF

Query Syntax:
RDY?

Query Response:
RDY ON;
RDY OFF;

Discussion:

This command will enable or disable the bus ready reporting function. If the function is ON, when the instrument is ready to take a reading and all commands have been executed, it will report the event.

READ

Command Type:
Measurement setting or query

Setting Syntax:
READ ADC
READ ONESTORE
READ ALLSTORE

Examples:
READ ADC
READ ONESTORE
READ ALLSTORE

Query Syntax:
READ?

Query Response:
READ ADC;
READ ONESTORE;
READ ALLSTORE;

Discussion:

This sets up the way that readings are transferred over the GPIB interface and the source of the readings. If ADC (Analog to Digital Converter) is sent as the argument, the readings are talked from the converter. If the ONESTORE argument is sent, the next reading is returned from the storage buffer. If the ALLSTORE argument is sent, all the readings from the buffer are sent. When all the readings have been read from the buffer, the buffer resets back to the beginning and if another reading is asked for, the first reading from the buffer is returned. There are three ways to reset the buffer back to the beginning:

1. When the end of the buffer is reached, the pointer is reset back to the beginning of the buffer.
2. If the READ command is received.
3. If the BUFSZ or STOINT command is received.

NOTE

The internal storage precision exceeds the 6.5 digits resolution normally output by the instrument. The full internal precision is used with the BUFMIN, BUFMAX and BUFAVE queries. This can result in the value returned apparently having more precision than the reading used to calculate the results. Because of the higher internal precision of the internal storage, this is normal operation and should be allowed for in any program that uses the BUFMIN, BUFMAX or BUFAVE function.

If the controller asks for the readings when ALLSTORE is enabled, the instrument will wait until the buffer is full before outputting the reading.

RESET

Command Type:
Operational

Setting Syntax:
RESET

Discussion:

The RESET command restores the instrument to the factory default setting. The GPIB address, GPIB termination and power line frequency parameters are not affected by the RESET command and will remain at their present value. A PONSAVE must be sent after the RESET command if the instrument is to power up in the factory default state. The commands and parameters affected by the RESET command are :

- Measurement settings commands
- FILTERVAL for each function
- NULLVAL for each function
- User interface settings

RQS

Command Type:
User interface setting or query

Setting Syntax:
RQS ON
RQS OFF

Examples:
RQS ON
RQS OFF

Query Syntax:
RQS?

Query Response:
RQS ON;
RQS OFF;

Discussion:

The RQS command masks the reporting of events using the SRQ line to interrupt the controller. If RQS is OFF, no event will cause the SRQ line to be asserted. If RQS is ON any event that is enabled (turned on) can assert the SRQ line. The RQS command allows the instrument to hold off reporting events using SRQ when the controller is processing time-critical data. Some controllers will interrupt a data transfer in the middle if the SRQ line is asserted. This may cause a problem with some applications. When RQS is off, events can be stacked so that when RQS is turned back on, the events could be reported. Also if RQS is off, the ERROR? can be used to get events from the DM 5120/5520. This allows controllers that do not handle SRQ well to poll the instruments to find out if an error or event has occurred. The RQS is a global mask of SRQ reporting. Other commands can be used to enable or disable certain types of events and errors. RQS will turn off the reporting of errors using SRQ but will not affect the value of the other event controlling commands.

SEND

Command Type:
Operational

Setting Syntax:
SEND

Examples:
SEND —> <reading data>;
EVENT?;SEND —> EVENT 000;<reading data>;
SEND;ID?;SEND;EVENT?;
—> <reading data>;ID TEK/DM5120,V81.1,FV1. 0;
<reading data>;EVENT 401;

Discussion:

SEND supplies one trigger regardless of the trigger setting and queues the requirement for a reading in the next talk. When the instrument is "talked", each requirement for a reading will cause a reading to be output.

SET?

Command Type:
Query

Query Syntax:
SET?

Query Response (one of the following):
See Discussion

Discussion:

This query will return the value of all the adjustable commands that support a query. The response to the SET? will be in the form: <FUNCT?> <RANGE?> <DIGIT?> <AUTOCAL?> <INIT-FILT?> <FILTER?> <FILTERVAL?> <NULL?> <NULLVAL?> <TRIGGER?> <DT?> <DELAY?> <BUFSZ?> <STOINT?> <READ?> <DATFOR?> <RQS?> <ERRSTAT?> <OVER?> <FULL?> <HALF?> <OPC?> <RDY?> <TEXT?> <KEY?> <USER?>

where each element of the response is a valid query response to the listed query.

STOINT

Command Type:
Measurement setting or query

Setting Syntax:
STOINT ONE
STOINT <interval time>

Examples:
STOINT 1
STOINT 999999

Query Syntax:
STOINT?

Query Response:
STOINT <interval time>;

Discussion:

This command sets the length of the storage interval (the length of time between storage readings). Interval time = <NRF> (Range 1 ms to 999999 ms). If the ONE argument is selected, the readings are stored one for each trigger received and the TRIGGER command must be set to ONE (one shot mode). If a storage interval is selected, a reading is stored at the selected interval and the instrument TRIGGER command must be set to CONT (continuous mode).

The interval time is not used if triggering is one shot.

The following conditions will prevent a data store operation and cause a settings conflict error—STOINT is set between 1 and 14 with one of the these setups:

1. FUNCTION is set to OHMS, ACVDB, ACADB or OHMSCOMP.
2. RANGE AUTO.
3. BUFSZ CIRCULAR.
4. DIGIT is set to 5 or 6.

Also, if STOINT is set to 1 or 2, DIGIT 4 will cause a conflict error.

NOTE

Sending STOINT or BUFSZ enables data store operations and any data in the storage buffer is lost.

NOTE

Data store operations are terminated with the following conditions:

1. When the number of reading in the BUFSZ command is satisfied. (The circular buffer will not be satisfied.)

2. Any measurement setting command is sent. (i.e., FUNCT, DIGITS, READING)

TEST?

Command Type:
Query

Query Syntax:
TEST?

Query Response (one of the following):
TEST 0;
TEST 1;

Discussion:

This command will start a self test of the instrument and return the status of the self test. The TEST? response shows 0 if no error and 1 if a failed self test.

TEXT

Command Type:
User interface setting or query

Setting Syntax:
TEXT <"characters">

Example:
TEXT "TEST_STRNG"

Query Syntax:
TEXT?

Query Response:
TEXT "TEST_STRNG";

Discussion:

The TEXT command will allow the display to be used to present information to the user. Sending TEXT " " will clear any displayed characters and set the instrument back to the normal display. If an argument is sent in quotes, the characters in quotes will be displayed on the front panel display. The maximum number of characters is 10. If more than 10 characters are sent to the instrument, an error will be reported by the instrument. Sending a double quote (" ") will insert a single quote into the string.

TRIGGER

Command Type:
Measurement setting or query

Setting Syntax:
TRIGGER <source>,<mode>
TRIGGER <source>,<mode>

Examples:
TRIGGER TALK,CONT
TRIGGER TALK,ONE
TRIGGER EXT,CONT
TRIGGER EXT,ONE

Query Syntax:
TRIGGER?

Query Response (one of the following):
TRIGGER <source>,<mode>;
TRIGGER <source>,<mode>;

Discussion:

This command will set the DM 5120/5520 trigger mode and source. The mode can be continuous or single shot. If the CONT mode is selected, the DM 5120/5520 waits for the selected trigger; when it is received the DM 5120/5520 starts a conversion and runs on a continuous basis. If the ONE mode is sent, the instrument will, when a trigger is received, acquire one and only one reading. The number of conversions will depend on the settings. See the FILTER, INTFIL, AUTOCAL commands for more information. The trigger source allows the instrument to start the conversion from a number of trigger sources.

TALK = When the instrument goes into TADS (Talk Address State) the instrument will create a trigger to start the conversion sequence. The DM 5120/5520 will not trigger on a serial poll response.

EXT = Allows an external trigger to start the conversion. If this trigger source is selected, pressing the [ENTER] key on the front panel can start the conversion. Rules controlling the trigger function are:

1. If TRIGGER EXT,CONT is sent and the buffer is disabled, a trigger is automatically supplied by the instrument to start the conversion.
2. If TRIGGER EXT,CONT is sent and the buffer is enabled then a trigger needs to be supplied to start the conversion.
3. If TRIGGER TALK,CONT is sent, a trigger is needed from the selected source to start the conversion.
4. All the single shot modes require a trigger before a reading is taken.

A trigger overrun error will occur if the instrument is in one shot mode and a trigger is received while a reading is in progress.

If readings are being input into the buffer and a Storage Interval (STOINT) is set and the storage interval is less than the conversion time, an error will occur (SHORT TIME).

USER

Command Type:
User interface setting or query

Setting Syntax:
USER ON
USER OFF

Examples:
USER ON
USER OFF

Query Syntax:
USER?

Query Response (one of the following):
USER ON;
USER OFF;

Discussion:

The USER command sets the instrument up so that pressing the ID key on the front panel will cause an event to be reported. ERROR 403 will be returned if the ERROR? is sent. The assertion of SRQ and the error/event reporting function of the USER command follows the same rules as other errors and events. If RQS is OFF, the SRQ line is not asserted and the event will be reported when the ERROR? is sent. The USER function allows operator input to the controller without a keyboard. The user can be prompted using the front panel display and then press the ID button to continue. When ID is pressed, the SRQ line is asserted and the controller will be interrupted to handle the SRQ. At this point the serial poll byte is returned to clear the SRQ and queue the error number if the user desires it. The serial poll byte will be decimal 67.

MESSAGES AND COMMUNICATION PROTOCOL

Command Separator

A message consists of one command or a series of commands, followed by a message terminator. Commands in multiple command messages must be 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?;

Address and Message Terminator Selection

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 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 messages. 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.

The DM 5120/5520 is shipped from the factory with a GPIB address of 16; the terminator is LF (with EOI).

Both the GPIB primary address and the message terminator are selected using the front panel keys (PROGRAM 31). To change the GPIB address and termination, use the following procedure:

1. Press the PROGRAM key. The following prompt will be displayed:

   PROGRAM?

2. Enter the number 31 by pressing the "3" and "1" keys. The current IEEE address value is displayed.
3. With the numeric keys enter the new address (0 to 30). The most-significant digit is first. The selected digit is brightened.
4. Press the ENTER key to select the displayed address and display the terminator.
5. If you want to change the terminator to the other selection (EOI or LF) momentarily press the ⇑, ⇓ or AUTO key.
6. Press the ENTER key to select the terminator and exit PROGRAM 31.

NOTE

The change to address and termination will be temporary. To make the change permanent, run PROGRAM 30 (SAVE CURRENT SETTINGS)

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 the format and the acceptable variations.

The instruments expect all commands to be encoded in ASCII, with either upper or lower case ASCII characters acceptable. All data output is in upper case (see Fig. 3-2). As previously discussed, a command consists of a header, followed if necessary, by arguments. A command with arguments must have a header delimiter, which 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, those characters 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. For example:

$_{SP}$RQS$_{SP}$ON$_{CR}$ $_{LF}$
$_{SP}$USER$_{SP}$OFF

ASCII & GPIB CODE CHART

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

* \| on some keyboards or systems

KEY

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

Tektronix
COMMITTED TO EXCELLENCE

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

TEKTRONIX STD 062-5435-00 4 SEP 80

Fig. 3-2. ASCII and IEEE (GPIB) Code Chart.

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

2,3
2SP3
2,SP3

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.

NR1 Signed or unsigned integers (including +0 and −0). Negative and unsigned integers are also interpreted as positive.
Examples: +1, 2, −1, −10.

NR2 Signed or unsigned decimal numbers. Unsigned decimal numbers are interpreted as positive.
Examples: −3.2, +5.0, 1.2

NR3 Floating point numbers expressed in scientific notation.
Examples: +1.0E-2, 1.0E2, 1.E-2, 0.01E+0

Link arguments can be used in place of scientific notation.
Examples: +10:MHZ, −.25:V, 2:KHZ.

Rounding of Numeric Arguments

The instrument rounds numeric arguments to the nearest unit of resolution and then checks for out-of-range conditions.

Message Protocol

Upon receipt by the instrument, a message is stored in the Input Buffer, then 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. Normally, execution of the settings occurs when the instrument processes the message terminator, *query-output command,* or an *operational command* in a message. The normal execution of settings is modified by the Device Trigger (DT) setting command.

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 information and putting it in the Output Buffer. Processing and execution then 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 thus 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 Input Buffer is full and it is holding off the rest of the controller's 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, asserts 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 the output. In this case, an acquisition instrument (a counter or a multimeter) returns a measurement if one is ready. If no measurement is ready, it will wait until a measurement is ready, then output the measurement. Non-acquisition TM 5000 instruments will return only this message.

Instrument Response to IEEE-488 Interface Messages

Interface messages and the effects of those messages on the instrument interface functions are defined in IEEE Standard 488.1-1987. Abbreviations from the standard are used in this discussion, which describes the effects of interface messages on instrument operation. Where appropriate, the GPIB code is listed, in decimal.

UNL—Unlisten (63 with ATN))
UNT—Untalk (95 with ATN)
When the UNL command is received, the instrument listener function goes to its idle state (unaddressed). In the idle state, the instrument will not accept instrument commands from the IEEE-488 bus.

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

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

IFC—Interface Clear (Bus pin 9)
When the IFC line is pulsed, the instrument is taken to an idle state. Pulsing IFC is the equivalent of sending UNT, UNL, SPD.

DCL—Device Clear (20 with ATN)
The Device Clear message restarts device-dependent message processing, resets the input and output buffers, clears any buffered settings waiting for the GET message, and clears the instrument status, except for the power- status.

NOTE

DCL and SDC should not reset the instrument to the power-on state. Use the INIT command to reset the instrument to the power-on state.

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)
If the instrument is in TRIGGERed mode (see TRIGGER command) and GET is received, a trigger is created and the conversion sequence is started. If a conversion is in progress, the conversion is restarted. Trigger overrun will be reported and the trigger will be ignored.

SPE—Serial Poll Enable (24 with ATN)
The SPE message enables the instrument to supply output serial poll status bytes when it is talk addressed.

SPD—Serial Poll Disable (25 with ATN)
The SPD message switches the instrument back to its normal operation of sending the data from the Output Buffer.

MLA—My Listen Address (Address + 32)
MTA—My Talk Address (Address + 64)
The primary listen and talk addresses are established by the instrument IEEE-488 bus address (set by front-panel key sequence). The current setting of the bus address ID displayed on the front panel when the INST ID key is pressed. When the instrument is addressed to talk or listen, the front panel ADDRESSED indicator is lighted.

LLO—Local Lockout (17 with ATN)
This causes the instrument to go to the Local With Lockout State (LWLS) or the Remote With Lockout State (RWLS) if REN is asserted.

REN—Remote Enable (GPIB pin 17)
If REN is true, the instrument may change to a remote state (from LOCS to REMS if the internal message return-to-local (rtl) is false, 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 changing to a local state. See Remote-Local Operations.

Remote-Local Operation

The Remote-Local functions of the DM 5120/5520 are controlled by the system controller and the front panel controls. There are four states associated with the Remote-Local functions of the DM 5120/5520: two "local" states and two "remote" states.

Local State (LOCS). While in LOCS, the front panel controls are under the control of the operator; the front panel settings can not be changed via setting commands from the bus. However, the instrument will respond to query commands via the GPIB bus (REN bus line need not be asserted). In a "local" state, all front panel controls are operational. If a remote command cannot be executed because the instrument is in a "local" state, an execution error will be reported to the controller.

Remote State (REMS). When the DM 5120/5520 receives its listen address, with the REN bus line asserted, and rtl is false, it enters the Remote State and the REMOTE indicator light is illuminated. While in REMS, the instrument responds to and executes all setting commands, queries, and interface messages. For all commands having corresponding front panel controls, the front panel is updated to display the new settings as the commands are executed. If the DM 5120/5520 is in REMS, there are three conditions under which it will return to the Local State (LOCS): 1) when any key is depressed by the operator, 2) when the instrument receives the Go To Local (GTL) interface message, or 3) if the REN bus line becomes unasserted (false).

NOTE

The DM 5120/5520 can be in either the Local State (LOCS) or Remote State (REMS) when the Local Lockout (LLO) interface message is received. If in LOCS and REN is asserted, it will enter the Local With Lockout State (LWLS) or if in REMS, it will enter the Remote With Lockout state (RWLS) when LLO is received. The LWLS and RWLS state transitions are completely controlled by the controller.

Local With Lockout State (LWLS). If the DM 5120/5520 enters the Local With Lockout State, the REMOTE indicator light will not be lit and the instrument operates exactly as it does in the Local State (LOCS).

Remote With Lockout State (RWLS). When the DM 5120 enters the Remote With Lockout State, the operator cannot return the instrument to local control by depressing a front-panel key. While in RWLS, the REMOTE indicator will be illuminated, all setting commands, queries, and interface messages will be executed, and all front-panel controls, except INST ID and the CAL ENABLE switches will be ignored. If the GTL message is received while in RWLS, the instrument goes to the Local With Lockout State (LWLS).

NOTE

The DM 5120/5520 returns to the Local State (LOCS) any time the REN bus line becomes unasserted (false).

INSTRUMENT STATUS REPORTING

Instrument status is available over the bus by two methods: serial poll or error query (ERROR? or EVENT?). Through the Service Request function (defined in the IEEE-488 Standard), the instrument may alert the controller that it requires 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. 3-3. Note that, when data bit 8 is set, the STB conveys Device Status information, which is contained in bits 1 through 4.

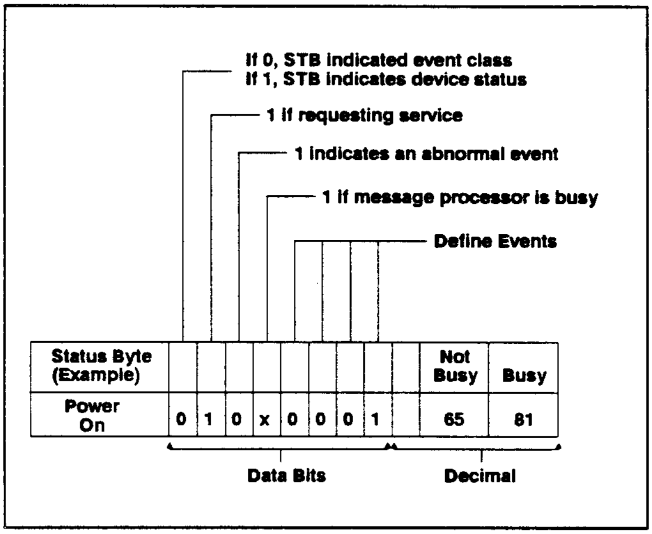


Fig. 3-3. Definition of STB Bits.

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 that the instrument has received a command which it cannot understand or implement under any circumstances. The command will not affect the state of the instrument.

Execution error indicates that the instrument has received a command which it understands, but cannot execute due to present state of the instrument or the argument is out of the range of the instrument.

Internal error indicates that the instrument has detected a hardware failure.

Internal warning indicates that the instrument has an internal error but the instrument is continuing to operate.

The power-on condition cannot be cleared by the Device Clear (DCL or SDC) message. The power-on condition is cleared by polling the status byte to the controller if RQS is ON or sending ERROR? or EVENT? and getting the response if RQS is OFF.

Serial Poll Response

Table 3-4 shows the replies received from the DM 5120/5520 in response to a Serial Poll.

Table 3-4
SERIAL POLL RESPONSE

Abnormal Conditions (ERRORS)	Busy Bit=0 Decimal	Busy Bit=1 Decimal
Command Error	97	113
Execution Error	98	114
Internal Error	99	115
Execution Warning	101	117
Internal Warning	102	118
Normal Conditions (EVENT)		
Nothing to Report	0	16
Power On	65	81
Operation Complete	66	82
User Request (USER ON)	67	83
Buffer Full (FULL ON)	198	214
Buffer Half Full (HALF ON)	199	215
Ready for Conversion (RDY ON) 72	200	216
Overflow Event	201	217

Bus Error Codes

Table 3-5 shows the error messages returned as arguments to the ERROR? query.

Table 3-5
BUS ERROR CODES

COMMAND ERRORS (100)
SRQ byte = 97 decimal or 113 decimal (busy bit set)

Error	Error Type	Priority	Description
101	Command header error	02	This error is returned when the keyword of a command is unknown or misspelled. (Incorrect syntax.)
102	Header delimiter error	02	This error is returned when the delimiter between the header and the argument is missing or the wrong character. (Incorrect syntax.)
103	Command argument error	01	This error is returned when the syntax of the argument is wrong. (Incorrect syntax.)
104	Argument delimiter error	02	This error is returned when the delimiter between arguments is the wrong character. (Incorrect syntax.)
106	Missing argument	02	This error is returned when a command is missing one of its arguments.

EXECUTION ERRORS (200)
SRQ byte 98 or 114 (Busy bit set)

Error	Error Type	Priority	Description
107	Invalid message unit delimiter	02	This error is returned when the delimiter between commands is missing or the wrong character.
201	Command not executable in local	03	This error is returned when a command cannot be executed while the instrument is under local control. This includes all of the commands that control the settings of the instrument. It does not include queries, RQS on, user on.
202	Settings lost due to rtl	03	This error is returned if the local button is pressed while a command is being set or executed.
204	Settings conflict	03	This error is returned if you try to execute a command that conflicts with the current mode of operation. This error replaces the System mode error.
205	Argument out of range	03	This error is returned if a numerical argument is out of the range of the instrument.
250	Invalid RANGE argument	03	This error is returned if the argument for the RANGE command is out of range.
251	Invalid DIGIT argument	03	This error is returned if the argument for the DIGIT command is out of range.
252	Invalid FILTERVAL argument	03	This error is returned if the argument for the FILTERVAL command is out of range.
253	Invalid ZEROVAL argument	03	This error is returned if the argument for the ZEROVAL command is out of range.
254	Invalid BUFSZ argument	03	This error is returned if the argument for the BUFSZ command is out of range.

Table 3-5 (Cont)
BUS ERROR CODES

EXECUTION ERRORS (200) (Cont)

Error	Error Type	Priority	STB	Description
255	Invalid STOINT argument		03	This error is returned if the argument for the STOINT command is out of range.
256	Invalid DELAY argument		03	This error is returned if the argument for the DELAY command is out of range.
257	DISPLAY argument too large		03	This error is returned if the argument for the DISPLAY command has too many characters in it.
258	Invalid BUTTON argument		03	This error is returned if the argument for the BUTTON command is out of range.
259	Calibration out of range		03	This error is returned if the value part of the CAL command is greater than 303000 count (6 1/2 digits).
260	CAL locked		03	This error is returned if the calibration lock jumper is set to the locked position and the CAL command is sent to the DM 5120/5520.

SYSTEM EVENTS (400)

Error	Error Type	Priority	STB	Description
401	Power on	01	65	This error is returned if the instrument has just powered on. This event cannot be masked.
402	Operation Complete	08	66	If the instrument has OPC set ON and a pending operation has completed, this event code will be returned. When the instrument is polled, the OPC SRQ byte is returned (66 or 82 [busy bit on]).
403	User Request	05	67	If USER ON is set and the front panel ID button is pushed, SRQ is asserted and after the instrument is polled, this event code will be returned. The SRQ byte returned by the poll is 67 or 83 (busy bit on).
450	Buffer Full	06	198	This error number is returned if the readings buffer is full when the FULL function is enabled.
451	Buffer Half Full	07	199	If the readings buffer is half full and the HALF function is enabled, this event is returned.
452	Ready for Conversion	09	199	If the DM 5120/5520 is ready for a conversion or trigger (the instrument is completely set up and no command is waiting for execution to be complete) and the RDY function is on, then this event is returned.
453	EEPROM failure	11	99	If the checksum of the EEPROM reads bad, this error will be reported at power-up.
454	Overflow error	12	201	If a converter overflow occurs this error is returned.

Table 3-5 (Cont)
BUS ERROR CODES

EXTERNAL WARNINGS (500)

Error	Error Type	Priority	Description
551	SHORT TIME	10	This error will be returned when the interval time (STOINT) is shorter than the conversion time of the DM 5120/5520.

INTERNAL WARNINGS (600)

Error	Error Type	Priority	Description
650	TRIG error	10	This error will be returned if a trigger is received while the instrument is processing a previous trigger. The trigger is ignored when in continuous mode so no trigger error would occur in continuous mode.

Power-on/Initial Conditions

When powered on, the microprocessor in the DM 5120/5520 performs a diagnostic routine (self test) to check the functionality of the ROM ,RAM and EEPROM. If no ROM, RAM or EEPROM error are found, the microprocessor goes on to check the functionality of the other instrument hardware. When the self test is finished, the instrument enters the local state (LOCS) with the following default settings:

FACTORY DEFAULT SETTINGS

FUNCT	DC V	READ	ADC
RANGE	4	DATFOR	ON
DIGIT	6	RQS	ON
AUTOCAL	ON	ERRSTAT	ON
INTFILT	ON	OVER	OFF
FILTER	OFF	FULL	OFF
FILTERVAL	10	HALF	OFF
NULL	0	OPC	OFF
NULLVAL	+000.0000E+0	RDY	OFF
TRIGGER	EXT,CONT	TEXT	" "
DELAY	0	KEY	15
BUFSZ	CIRCULAR	USER	OFF
STOINT	175		

The SRQ line on the GPIB is also asserted unless the GPIB address is set to 31 (ignore GPIB commands). If the instrument is polled by the controller, the status byte returned will be "0100 0001" (65 decimal; power-on SRQ).

If a ROM or RAM error is found, an error code is displayed in the front-panel display. The instrument will not respond to input from the front panel or the GPIB interface. Internal errors detected after the ROM and RAM tests have passed will be reported to both the front panel and the GPIB. The instrument will respond to input and attempt to function in spite of the error. An error code may be removed from the display by pressing the INST ID key, by starting a numeric entry, by incrementing the selected parameter, by pressing the clear key, or by a transition into the remote state (REMS).

TALKER LISTENER PROGRAMS

The following sample programs allow a user to send any of the commands listed in the Functional Command List and to receive the data generated.

Talker Listener Program For Tektronix 4041 Controllers

```
100   Rem DM 5120 TALKER/LISTENER
110   Rem DM 5120 PRIMARY ADDRESS 16
120     Init all
130     On srq then gosub srqhdl
140     Enable srq
150     Dim respons$ to 300
160     Input prompt "ENTER MESSAGE(S): ":message$
170     Print #16:message$
180   Rem input from device
190     Input #16:respons$
200     Print "RESPONSE: ";respons$
210     Goto 160
220   Rem  SERIAL POOL ROUTINE
230 Srqhdl:      poll stb,pri
240     Resume
250     End
```

Quick-BASIC Talker Listener Program For Tektronix PEP 301 Controllers

```
' ****************************************************************************
' ******************** DM 5120 TALKER/LISTENER PROGRAM ********************
' ****************************************************************************
' THIS PROGRAM REQUIRES THAT THE DM 5120 ADDRESS TO BE SET
' TO THE FACTORY DEFAULT OF 16.
COMMON SHARED IBSTA%, IBERR%, IBCNT%
ID$ = "TEKDEV1"
CALL IBFIND(ID$, BD%)
DM% = 16
CALL IBPAD(BD%, DM%)
ID$ = "GPIB0"
CALL IBFIND(ID$, GP%)
REMOTE% = 1
CALL IBSRE(GP%, REMOTE%)
CLS
DOOVER:
PRINT "**************************************************************************"
PRINT "****************** DM 5120 TALKER LISTENER PROGRAM ****************"
PRINT "**************************************************************************"
PRINT "RETURN TO EXIT: "
INPUT "ENTER MESSAGE(S)"; WRT$
CALL IBWRT(BD%, WRT$)
GOSUB CHECKGPIB
IF WRT$ = "" THEN GOTO TERMINATE
' ************************ INPUT FROM DEVICE *******************************
REPLY$ = SPACE$(255)
CALL IBRD(BD%, REPLY$)
GOSUB CHECKGPIB
GOSUB CHECKDM
PRINT : PRINT "INSTRUMENT REPLY "; REPLY$
PRINT : PRINT "Returned status byte:"; SPR%,
PRINT : PRINT ERRM$
GOTO DOOVER
' ************************** ERROR ROUTINES ********************************
CHECKDM:
ERRM$ = SPACE$(50)
CALL IBRSP(BD%, SPR%)
CALL IBWRT(BD%, "ERRM?")
CALL IBRD(BD%, ERRM$)
RETURN
CHECKGPIB:
IF IBSTA% >= 0 AND BD% >= 0 AND IBSTA% < &H4000 AND IBERR% <> 6 THEN RETURN
'no error to report
IF BD% < 0 THEN PRINT "device not installed - use IBCONF then reboot"
IF IBSTA% > 0 AND IBSTA% >= &H4000 THEN PRINT "timeout"
IF IBERR% = 6 THEN PRINT "timeout"
PRINT "gpib error "; IBERR%
IF IBERR% = 0 THEN PRINT "DOS error device not installed"
IF IBERR% = 1 THEN PRINT "function requires GPIB-PC to be CIC"
IF IBERR% = 2 THEN PRINT "no listener on write function"
IF IBERR% = 3 THEN PRINT "GPIB-PC not addressed correctly"
IF IBERR% = 4 THEN PRINT "invalid argument to function call"
IF IBERR% = 5 THEN PRINT "GPIB-PC not system controller as required"
IF IBERR% = 6 THEN PRINT "I/O operation aborted"
IF IBERR% = 7 THEN PRINT "non-existent GPIB-PC board"
IF IBERR% = 10 THEN PRINT "I/O started before previous operation completed"
IF IBERR% = 11 THEN PRINT "no capability for operation"
IF IBERR% = 12 THEN PRINT "file system error"
IF IBERR% = 14 THEN PRINT "command error during device call"
IF IBERR% = 15 THEN PRINT "serial poll status byte lost"
IF IBERR% = 16 THEN PRINT "SRQ stuck in on position"
INPUT "[ENTER] TO CONTINUE"; A$' if help$ then
RETURN
' ************************ TERMINATE PROGRAM *******************************
TERMINATE:
REMOTE% = 0
CALL IBSRE(GP%, REMOTE%)
PRINT "PROGRAM TERMINATED."
END
```

MAINTENANCE

Introduction

This section of the manual provides information on changing internal fuses, and on obtaining instrument servicing.

Calibration/Adjustment

Instrument calibration should be checked every 6 months or after 1000 hours of use, whichever occurs first.

Adjustment of internal circuits to specified accuracy, and/or calibration check should be performed at the factory. Before returning your instrument for any servicing, please contact your nearest Tektronix Service Center.

WARNING

To avoid fire hazard, use only the fuse of correct type, voltage rating, and current rating as specified on the instrument and in the fuse replacement instructions below.

Front Panel Current Fuse Replacement —DM 5120/5520

A fuse is located on the lower right side of the front panel. To reach the fuse, remove the cap with a screwdriver. If the fuse is blown, replace with a 3A, 250 V, 3 AG, fast blow fuse, Tektronix Part No. 159-0015-00.

Internal Fuse Replacement—DM 5520

WARNING

Before beginning this fuse replacement procedure, turn off the DM 5520, and disconnect the power cord from the power source.

On the bottom front edge of the cabinet, remove the Phillips screw just to the left of the cabinet bottom seam, as you face the front of the DM 5520.

Pull on both release latches on the front panel; the DMM assembly should move forward, out of the cabinet. Remove the DMM assembly.

The fuses are located under the cover on the right side of the DM 5520 (as you face the front of the unit). The side cover snaps onto the metal rails. Along each long edge of the cover, there are cutouts about one-half inch in length. Insert tweezers or a small straight-edge screwdriver into the cutout near the back edge of the cover, and carefully pry the cover away from the metal rails. Remove the cover.

Two fuses are located toward the rear of the exposed circuit board, mounted in fuse holders. To remove a fuse, carefully pull it out of the fuse holder. Correct fuse values are marked on the circuit board. Replacement fuses are:

- 1 A, 250 V, 3 AG, fast blow, Tektronix Part No. 159-0019-00
- 3/8 A, 250 V, 3 AG, slow blow, Tektronix Part No. 159-0200-00

After fuse replacement, re-install the side cover, as follows. Insert the front edge of the cover into the groove along the front edge of the unit. Then press the cover down over the rails.

To re-install the DMM assembly, stand the cabinet up on its rear panel. Insert the assembly into the cabinet, taking care to align the assembly rear edge connectors with the connectors inside the cabinet. When these are aligned, press the DMM assembly firmly into the cabinet to seat the connectors.

Reinstall the retaining screw in the bottom front edge of the DM 5520.

Internal Fuse Replacement—DM 5120

Remove the DM 5120 from the power module. The fuses are located under the cover on the right side of the DM 5120 (as you face the front of the unit. The side cover snaps onto the metal rails. Along each long edge of the cover, there are cutouts about one-half inch in length. Insert tweezers or a small straight-edge screwdriver into the cutout near the rear edge of the cover, and carefully pry the cover away from the metal rails. Remove the cover.

Three fuses are located toward the rear of the exposed circuit board, mounted in fuse holders. To remove a fuse, carefully pull it out of the fuse holder. Correct fuse values are marked on the circuit board. Replacement fuses are:

- 1 A, 250 V, 3 AG, fast blow, Tektronix Part No. 159-0019-00
- 3/8 A, 250 V, 3 AG, slow blow, Tektronix Part No. 159-0200-00

After fuse replacement, re-install the side cover, as follows. Insert the front edge of the cover into the groove along the front edge of the unit. Then press the cover down over the rails.