SPECIFICATION

Instrument Description

The Tektronix DC 5010 is a programmable universal counter/timer plug-in. It features reciprocal frequency, Period, Ratio, and Events B During A measurements to 350 MHz. For timing measurements, the time interval, width, risetime and falltime functions feature 3.125 nsec single-shot resolution. For these measurements, averaging and identical A and B channels provide increased accuracy. Also included is a time manual mode, as well as three 350 MHz totalize modes (A, A+B, and A−B). The DC 5010 also has an auto-trigger feature, a probe-compensation feature, an auto averages function, and an extensive set of automatic power-up self tests.

The DC 5010 is an IEEE 488 (GPIB) Digital Interface programmable counter that allows any manually selectable function or mode to be operated over the GPIB bus, including all input conditioning controls.

The IEEE standard identifies the interface functions of an instrument on the GPIB in terms of interface function subsets. The subsets are defined in the standard. The subsets that apply to the DC 5010 are listed in Table 1-5 at the end of this section.

The DC 5010 has a DVM mode that reads out the channel A and channel B trigger level voltages. Shaped outputs and an arming input are available at the front panel. Also available at the front panel is a signal for use with the probe compensation function.

The operating modes and front-panel settings of the DC 5010 can be set and read by programming mnemonics set to it in ASCII code over the bus. The DC 5010 connects to the bus when installed in a GPIB-compatible TM 5000-Series power module.

The DC 5010 can be equipped with an optional, oven-controlled, 10 MHz crystal oscillator to obtain an even more stable and precise internal time base.

Instrument Options

Option 01 replaces the internal 10 MHz time base (clock) circuit with a self-contained proportional temperature controlled oven oscillator for increased accuracy and stability.

Standard Accessories

1 Instruction Manual

1 Reference Guide

1 Cable Assembly, bnc-to-slide on connector

NOTE

Refer to the tabbed Accessories page at the rear of this manual for more information.

Performance Conditions

The limits stated in the Performance Requirements columns of the following tables are valid only if the DC 5010 has been calibrated at an ambient temperature between +20°C and +30°C and is operating at an ambient temperature between 0°C and +50°C, unless otherwise stated.

Information given in the Supplemental Information and Description columns of the following tables is provided for user information only and should not be interpreted as Performance Check requirements.

The DC 5010 must be operated or stored in an environment whose limits are described under Environmental Characteristics.

Allow at least 30 minutes warm-up time for operation to specified accuracy, 60 minutes after storage in a high-humidity environment.

Safety Certification

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

Table 1-1
ELECTRICAL CHARACTERISTICS

Characteristics	Performance Requirements		Supplemental Information
CHANNEL A and CHANNEL B INPUTS (also see Rise/Fall MEASUREMENT MODE INPUT SPECIFICATION)			
Input Frequency Range			
Coupling	50 Ω	1 MΩ	
DC	>0 to ≥350 MHz	>0 to ≥300 MHz	
AC	100 kHz to ≥350 MHz	16 Hz to ≥300 MHz	
Input Sensitivity			1 MΩ performance is from a 25 Ω source impedance.
Sinewave	50 Ω (Term low)	1 MΩ (Term high)	
Coupling / Attenuation			Typical sensitivity is 50 mV p-p ±20 mV.
DC X1	≤25 mV rms*	≤25 mV rms to 200 MHz ≤42 mV rms from 200 MHz to 300 MHz	
	≤70 mV p-p pulse*	≤70 mV p-p pulse (<200 MHz)	
X5	≤125 mV rms*	≤125 mV rms to 200 MHz ≤210 mV rms from 200 MHz to 300 MHz	
	≤350 mV p-p pulse*	≤350 mV p-p pulse	
AC X1	≤25 mV rms*	≤25 mV rms to 200 MHz 42 mV rms to 300 MHz	
	+3 dB at ≤100 kHz	+3 dB at ≤16 Hz	
	≤70 mV p-p pulse	≤70 mV p-p pulse (<200 MHz)	
X5	≤125 mV rms*	≤125 mV rms to 200 MHz 210 mV rms to 300 MHz	
	+3 dB at ≤100 kHz	+3 dB at ≤16 Hz	
	≤350 mV p-p pulse	≤350 mV p-p pulse (≤200 MHz)	
Dynamic Range			
Attenuation			
X1			70 mV p-p to 4 V p-p
X5			350 mV p-p to 20 V p-p
Trigger Level Range			
Attenuator			
X1	≥+2 V to ≤−2 V		In approximately 4 mV steps.
X5	≥+10 V to ≤−10 V		In approximately 20 mV steps.
Trigger Level Accuracy	±2% of reading for a dc input voltage ± 40 mVx atten.		Trigger level is calibrated in ± slope and is firmware compensated in − slope.

*0°C to 40°C; sensitivity decreases by 31% for 40°C to 50°C.

Table 1-1 (cont)

Characteristics	Performance Requirements	Supplemental Information
Auto Trigger Range (A or B)	20 Hz to ⩾350 MHz Minimum signal required for Auto Trigger is 100 mV p-p. In Ratio mode, with Channel B frequency ⩾200 MHz, the Auto Trigger will provide a CHA B level within ±24 mV of the 50% point.	Trigger point is set (once) to a nominal 50% of the p-p input signal. For signals dc to 20 Hz (inclusive), level will still be set between 0% and 100%, but not necessarily near 50%. A ten-bit DAC is used, giving nominal 4 mV steps (X attenuation factor).
Operating Range Attenuation		
X1	+2 V to −2 V (dc + peak ac)	
X5	+10 V to −10 V (dc + peak ac)	
AC Coupling	50 Ω input dc ⩽±2 V (dc plus peak ac) times attenuator 1 MΩ input ⩽42 V dc + peak ac	
Maximum Allowable Input (Damage Level) 50 Ω		In 50 Ω input mode, 50 Ω overvoltage protection trips in 1 M input impedance for signals greater than approximately ±2 V times attenuator dc + peak ac to 200 kHz.
Attenuation / Impedance		
X1 / 50 Ω	Vpk ⩽2 V	dc to 350 MHz
X1 / 1 MΩ		±42 V dc + peak ac, dc to 200 kHz ±2 V dc + peak ac, 2 MHz to 300 MHz
X5 / 50 Ω	Vpk ⩽10 V	±10 V dc + peak ac, dc to 350 MHz
X5 / 1 MΩ		±42 V dc + peak ac, dc to 1 MHz ±10 V dc + peak ac, 1 MHz to 300 MHz
Input Impedance 50 Ω	50 Ω approximately ±3% dc	VSWR approximately 1.5:1, dc to 350 MHz
50 Ω ac		Bleeder resistor results in ≈390 kΩ dc input resistance.
1 MΩ	1 MΩ approximately ±1% 23 pF approximately ±10% (2.2 pF)	For inputs greater than ±5 Vdc + peak ac, input impedance becomes approximately 300 kΩ 1000 pF, X1. Input C from X1 to X5 are equal by approximately ±1%.

Table 1-1 (cont)

Characteristics	Performance Requirements	Supplemental Information
Bandwidth Limit		Above 20 MHz minimum signal increases 40 dB/decade to ≈1 V p-p. Above approximately 80 MHz no amount of input signal can cause triggering.
Channel Isolation, Crosstalk	50 Ω, Pos Slope, DC Coupling, X1	No effect when both signals are below 100 MHz and ≤2 Vpk-pk. For ≤1 Vpk-pk signals between 100 MHz and 350 MHz (CH A) or 300 MHz (CH B), there is no effect if the slower signal has a square edge or a slew rate ≥80 V/μsec.

RISE/FALL MEASUREMENT MODE INPUT SPECIFICATION

Characteristics		Performance Requirements		Supplemental Information
Range Coupling		50 Ω	1 MΩ	In this mode, the input amplifiers are commoned to the CH A bnc. CH B bnc is an open circuit.
DC		4.0 nsec to 2.5×10^4 sec	5 nsec to 2.5×10^4 sec	
AC		4.0 nsec to 18 μsec	5 nsec to 22 msec	AC measurements near the slower limit are not recommended, because they become duty cycle dependent.
Frequency		50 Ω	1 MΩ	Upper frequency limit is essentially a limit on the repetition rate at which rise/fall edges may occur.
DC		20 Hz to >80 MHz	20 Hz to >80 MHz	
AC		100 kHz to >80 MHz	16 Hz to >80 MHz	Lower limit is a limit on the ability to acquire peak voltage levels. Once levels are set, rise/fall will work down to ≤0 Hz.
Input Sensitivity Coupling	Attenuation	50 Ω	1 MΩ	1 MΩ response is from 25 Ω source impedance.
DC	X1	50 mV rms 140 mV p-p pulse	25 mV rms 70 mV p-p pulse	Both channel modes set the same.
	X5	250 mV rms 700 mV p-p pulse	125 mV rms 350 mV p-p pulse	50 Ω input impedance is maintained via an internal power-splitter causing X2 attenuation.
AC	X1	50 mV rms +3 dB at 20 kHz 140 mV p-p pulse	25 mV rms +3 dB at 16 Hz 70 mV p-p pulse	These specifications apply only when both channels have the same setup.
	X5	250 mV rms +3 dB at 20 kHz 700 mV p-p pulse	125 mV rms +3 dB at 16 Hz 350 mV p-p pulse	

Table 1-1 (cont)

Characteristics		Performance Requirements		Supplemental Information
Dynamic Range		50 Ω	1 MΩ	
Attenuation	X1	140 mV p-p to 8 V p-p	70 mV p-p to 4 V p-p	Maxima are centered at zero volts. Minimum measurable rise/fall signal amplitude is ten times greater than minimum dynamic range.
	X5	700 mV p-p to 10 V p-p	350 mV p-p to 20 V p-p	
Trigger Level Range		50 Ω	1 MΩ	50 Ω, ×5, only ±5 V of the trigger level range is usable because only ±5 V is allowed as an input.
Attenuation	X1	+4 V to −4 V ≈8 mV steps	+2 V to −2 V ≈4 mV steps	When using 50 Ω input mode, the displayed trigger level is 1/2 true trigger level due to 50 Ω power splitter divider action.
	X5	(+5 V to −5 V) +20 V to −20 V ≈40 mV steps	+10 V to −10 V ≈20 mV steps	
Operating Range		50 Ω	1 MΩ	For 10% and 90% trigger point. For inputs less than minimum, 10% and 90% points are not achievable due to sensitivity. Mimimum signal is 10 times minimum dynamic range.
Attenuation	X1	1.4 V p-p minimum, +4 V to −4 V dc + peak ac max	700 mV p-p minimum, +2 V to −2 V dc + peak ac max	
	X5	7.0 V p-p minimum, +5 V to −5 V dc + peak ac max	3.5 V p-p minimum, +10 V to −10 V dc + peak ac max	
Maximum Allowable Input (Damage Level) Attenuation X1	Impedance 50 Ω			±4 V dc + peak ac, dc to 80 MHz
	1 MΩ			See CHANNEL A and CHANNEL B inputs
X5	50 Ω			±5 V dc + peak ac, dc to 80 MHz[a]
	1 mΩ			See CHANNEL A and CHANNEL B inputs
Input Impedance Channel A				Channel B is an open circuit.
	1 MΩ	500 kΩ, ±2% 47 pF, ±10%		X5 probe becomes X9 X10 probe becomes X19
	50 Ω	50 Ω, ±3%		

GENERAL

Probe Compensation Output Jack		5 V p-p nominal. 110 Hz nominal. 1 ms width nominal.

Table 1-1 (cont)

Characteristics	Performance Requirements	Supplemental Information
Arming Input Required Signal Input	low ⩽0.4 volts high ⩾2.4 volts (TTL)	Maximum voltage V_{pk} <10 volts.
Pulse Response	Pulse width ⩾100 ns	
Shaped Output		⩾100 mV typically to 350 MHz into 50 Ω load. Delay from front-panel input to shaped output. CH A 7.2 nsec typically CH B 7.0 nsec typically CH B commoned from CH A 7.6 nsec typically.
External Clock Input	⩾500 mV rms into 1 kΩ (ac coupled) 1, 5, or 10 MHz	
10 MHz Clock Output	low ⩽0.4 V high ⩾2.4 V (TTL) (pins 15B and 15A (gnd))	Drives 1 TTL load.
Phase Modulated Clock (time interval functions)		⩾3 ns p-p jitter induced onto 1 MHz reference. (Test point on rear of Auxiliary board.)

STANDARD INTERNAL TIME BASE

Characteristics	Performance Requirements	Supplemental Information
Frequency at calibration	10 MHz $\pm 1 \times 10^{-7}$	10 MHz
Error Terms		
Temperature Stability (0°C to +50°C)	$\pm 5 \times 10^{-6}$	
Aging	⩽1 X 10^{-6}/year	
Adjustment Resolution	$\pm 5 \times 10^{-8}$	

OPTIONAL INTERNAL TIME BASE

Characteristics	Performance Requirements	Supplemental Information
Frequency at calibration	10 MHz $\pm 2 \times 10^{-8}$	With proportional oven
Error terms:		
Temperature Stability (0°C to +50°C)	$\pm 2 \times 10^{-7}$ after warmup	
Warm-up Time	Within $\pm 2 \times 10^{-7}$ of final frequency in less than 10 minutes when cold started at 25°C ambient.	

Table 1-1 (cont)

Characteristics	Performance Requirements	Supplemental Information
Aging At time of shipping	1×10^{-8}/day maximum.	
After 30 days of continuous operation	4×10^{-8}/week maximum	
After 60 days of continuous operation.	$<1 \times 10^{-6}$/year maximum	
Short Term Stability		$\leq 1 \times 10^{-9}$ rms based on 60 consecutive 1 second measurements.
Adjustment Resolution	$\pm 2 \times 10^{-8}$	
Adjustment Range		Sufficient for 8 years of aging.
FUNCTIONS		
Frequency A Range	$\leq$36 μHz to $\geq$350 MHz	
Resolution		$\pm LSD \pm 1.4 \times \frac{\text{A Trig Jitter Error}}{N}$ X (Freq. A)^2
Accuracy		Resolution ±(Timebase Error × Freq. A)
Period A Range	3.125 ns to 7.6 hours	
Repetition Rate	$\geq$350 MHz	
Clock Period Counted		3.125 ns
Resolution		$\pm LSD^b \pm \frac{1.4 \times \text{A Trig Jitter Error}}{N}$
Accuracy		Resolution ±(Timebase Error) × Period A
Ratio B/A		Averaged by A
Range	10^{-8} to 10^{9} with correct decimal point displayed. (10^{-11} to 10^{12} without decimal point.)	
Frequency Range A	<36 μHz to >350 MHz.	
Frequency Range B	<300 Hz to >350 MHz.	
Resolution		$\pm LSD \pm \frac{1.4 \times \text{B Trig Jitter Error} \times \text{Freq. B}}{N}$
Accuracy		Same as Resolution

Table 1-1 (cont)

Characteristics	Performance Requirements	Supplemental Information
Time A → B		
Range	2.0 nsec[c] to 7.6 hours	
Resolution		±LSD + $\frac{1}{\sqrt{N}}$ (±A Trigger Jitter Error ±B Trigger Jitter Error)
Accuracy		Resolution ±(Timebase Error × Time Interval) ±Channel Delay Mismatch[d] + B Trigger slew error-A Trigger slew error
Clock Period counted		3.125 nsec
Minimum Time A → B	0.0 ± 2.0 nsec[c]	
Minimum Time B → A	⩽12.5 nsec	(⩾70 MHz Rep. Rate)
Channel Delay Mismatch		
Internal	⩽2 nsec nominal, without null	
Front Panel (Shaped Out)		⩽500 ps
Events B Dur A		Averaged by A
Range	10^{-8} to 10^{9}	
Maximum B Frequency	>350 MHz	
Minimum B Frequency	<300 Hz	
Maximum A Frequency	>80 MHz	
Minimum A Pulse Width	⩽4.0 nsec	
Minimum $\overline{A}$ Pulse Width	⩽8.5 nsec	
Resolution		+LSD + $\frac{\text{Freq B}}{\sqrt{N}}$ (±A Start Trigger Jitter error ± A Stop Trigger Jitter Error)
Accuracy		Resolution + Freq B (Stop Slew Rate Error −Start Slew Rate Error) + Freq B × (5 ±2 nsec)
Width A		
Range	⩽4 nsec to 7.6 hours	Taken at 50% trigger point.
Repetition Rate	⩾50 MHz	
Resolution		±LSD + $\frac{1}{\sqrt{N}}$ (±Start edge Trigger Jitter Error ± Stop Edge Trigger Jitter Error)
Accuracy		Resolution ± Timebase Error × Width A + (Stop Slew Rate Error − Start Slew Rate Error) ±2 nsec
Clock period counted		3.125 nsec
Minimum Time Stop Edge to Start Edge	⩽1.6 nsec	

Table 1-1 (cont)

Characteristics	Performance Requirements	Supplemental Information
Totalize A Range	0 to 10^9 counts	(to 8.7 × 10^{12} with no decimal point.)
Repetition Rate	0 to ≥350 MHz	See CHANNEL A and CHANNEL B INPUTS for pulse specifications.
Totalize[e] A+B Range	0 to 10^9 (A + B ≤10^9)	(to 8.7 × 10^{12} with no decimal point.)
Repetition Rate (A or B)	0 to ≥350 MHz	See CHANNEL A and CHANNEL B INPUTS for pulse specifications.
Totalize[e] A−B Range	−10^8 to 10^9	(−8.7 × 10^{12} to 8.7 × 10^{12} with no decimal point or minus indication.) Note: either A ≥10^{12} or B ≥^{12} will lead to overflow, independent of the value of (A−B). See CHANNEL A and CHANNEL B INPUTS for pulse specifications.
Repetition Rate (A or B)	≥350 MHz	
Rise/Fall A Range	4.0 ns → 10^4 sec (dc coupling) 50 Ω 5.0 ns → 10^4 sec (dc coupling) "1 MΩ".	Risetime of "1 MΩ" is ≈4.5 ns
Repetition Rate	Minimum time between rising (falling) edges is 14.5 ns (70 MHz)	
Trigger Points	Trigger levels are automatically set to the 90% and 10% points of the incoming signal, to a resolution that depends on the incoming signal amplitude.	In this mode Channels A and B are commoned. This changes the input characteristics. See RISE/FALL MEASUREMENT MODE INPUT SPECIFICATION.
Resolution		±LSD + $\frac{1}{\sqrt{N}}$ (±Start Trig Jitter Error ±Stop Trigger Jitter Error)
Accuracy		Resolution ±(Timebase Error X TI) ±2 nsec ±4 mV / slew rate A (near 10%) ±4 mV / slew rate A (near 90%)
Time Manual Range	3.125 ns to 3.125 × 10^4 sec (≈8 hours)	
Resolution		3.125 nsec clock is counted, but usable resolution is ≈ ±10 ms due to START/STOP buttons
Probe Comp Accuracy		×5 probe, 1.5% nominal. ×10 probe, 3% nominal. ×100 probe, 30% nominal.

Table 1-1 (cont)

Characteristics	Performance Requirements	Supplemental Information

Resolution and Accuracy Definitions

$$\text{Trigger Jitter Error (seconds rms)} = \frac{\sqrt{(e_{n1})^2 + (e_{n2})^2}\ \text{Volts rms}}{|\text{Input slew rate at trigger point}|\ (\text{volts/sec})}$$

where (e_{n1}) = 140 μV rms typical counter input noise for 1 MΩ filter on; 240 μV rms typical for 1 MΩ filter off; 340 μV rms typical for 50 Ω.

(e_{n2}) = V rms noise voltage of users input signal at trigger point, measured with the appropriate bandwidth.

Note: Best usable resolution is ±1 psec in Time Interval (TI) modes.

$$\text{Slew Rate Error (seconds)} = \left|\frac{^{*}\text{trigger level error (Volts)}}{\text{Input slew rate at trigger point}}\right|\ (\text{volts/sec})$$

*Trigger level error =

Alll functions except WIDTH A and EVENTS B DUR A	pos slope	trigger accuracy times attenuation factor
	neg slope	(trigger accuracy ±10 mV) times attenuation factor
WIDTH A, 	start edge stop edge	trigger accuracy times attenuation factor (trigger accuracy + hyst) times attenuation factor
	start edge	(trigger accuracy + hyst) times attenuation factor
	stop edge	trigger accuracy times attenuation factor
EVENTS B DUR A	Same as WIDTH A, except each number is multiplied by Freq B	
Note:	Trigger Accuracy, (see CHANNEL A and CHANNEL B INPUTS) Input hysteresis is typically 50 mV p-p times attenuation, maximum 70 mV p-p times attenuation.	
	Internal slew rate = 800 ps (50 Ω) 1.3 nsec (1 MΩ) 18 nsec (20 MHz filter)	

N = Number of Averages

The minimum number of averages is selected by the AVERAGES button and the ⇧⇩ buttons in decade steps from 1 to 10^9. At Channel A repetition rates above approximately 250 Hz the actual number of averages will be:

$N \approx [\text{FREQ A (Hz)} \times 4\ \text{msec}] + \text{AVGS}$

N = AVGS setting (below 250 Hz)

This typically leads to better than expected resolution in the displayed answer for small N with only minimal impact on measurement time. Arming must be used when measuring only one event out of a pulse train (multiple events) with signals ⩾250 Hz.

Table 1-1 (cont)

Characteristics	Performance Requirements	Supplemental Information
In the AUTO mode the counter measures with a fixed measurement time of about 300 msec (or the time for one event, whichever is greater).		
$N \leqslant$ Freq A (Hz) $\times$ .3 seconds (N always $\geqslant 1$)		
LSD:		
FREQ	$\frac{(\text{Freq A})^2}{N \times 3.2 \times 10^8}$	
PER	3.125 nsec for $N \leqslant 10$, $\frac{10\text{ nsec}}{N}$ for $N > 10$	
RATIO	$\frac{\text{Freq A}}{\text{Freq B} \times N}$	
TIME A→B & RISE/FALL A	3.125 nsec for $N \leqslant 10$, $\frac{10\text{ nsec}}{\sqrt{N}}$ for $N > 10$	
WIDTH A	3.125 nsec for $N \leqslant 10$, $\frac{10\text{ nsec}}{\sqrt{N}}$ for $N > 10$	
EVENTS B DUR A	$\frac{\text{Period B}}{\text{Width A} \times N} \times$ Events B dur A	
Time Base Error: The sum of all the errors specified for the time base used.		

[a]Over voltage protection still functions, but in rise/fall, (50 Ω and ×5) it may not always protect the 25 Ω series input resistor.
[b]With 10^9 Averages selected, LSD can be as small as 31.25 attosec.
[c]Can be set to 0.0 ns by use of "NULL" function.
[d]Can be removed by use of "NULL".
[e]The B channel will not count events until after the first valid A channel count.

Table 1-2
MISCELLANEOUS

Characteristics	Description	
Power Requirements	TM 500 series power module	TM5000 series power module
DC 5010	Not	14.5 W
DC 5010 Opt 01	Allowed	19.3 W
Recommended Calibration Interval		2000 hours or 6 months whichever occurs first
Minimum Display Time		100 msec (typical)
Auto Averages Measurement Time		300 msec (typical)
GPIB Data Output Rate		≈10 readings/sec max

Table 1-3
ENVIRONMENTAL[a]

Characteristics	Description	
Temperature		Meets MIL-T-28800B, class 5.
Operating	0°C to +50°C	
Non-operating	−55°C to +75°C	
Humidity	95% RH, 0°C to 30°C 75% RH to 40°C 45% RH to 50°C	Exceeds MIL-T-28800B, class 5.
Altitude		Exceeds MIL-T-28800B, class 5.
Operating	4.6 km (15,000 ft)	
Non-operating	15 km (50,000 ft)	
Vibration	0.38 mm (0.015") peak to peak, 5 Hz to 55 Hz, 75 minutes.	Exceeds MIL-T-28800B, class 5 when installed in qualified power modules.[b]
Shock	30 g's (1/2 sine), 11 ms duration, 3 shocks in each direction along 3 major axes, 18 total shocks.	Meets MIL-T-28800B, class 5 when installed in qualified power modules.[b]
Bench Handling[c]	12 drops from 45°, 4" or equilibrium, whichever occurs first.	Meets MIL-T-28800B, class 5.
Transportation[c]	Qualified under National Safe Transit Association Preshipment Test Procedures 1A-B-1 and 1A-B-2.	
EMC	Within limits of MIL-461A, with exceptions [d], and F.C.C. Regulations, Part 15, Subpart J, Class A. Unused plug-in compartments must be filled with blank plug-ins.	
Electrical Discharge	20 kV maximum charge applied to instrument case.	

[a]With power module.
[b]Refer to TM 5000-Series power module specifications.
[c]Without power module.
[d]Within 4 dB of REO2 at 130 MHz and 960 MHz. Within 20 dB of REO2 at 320 MHz.

Table 1-4
PHYSICAL CHARACTERISTICS

Characteristics	Description
Finish	Anodized aluminum chassis.
Net Weight (nominal) DC 5010 Option 01	 3 lb. 7 oz. 3 lb. 11 oz.
Nominal Overall Dimensions Height Width Length	 126.0 mm (4.96 inches) 134.5 mm (5.29 inches) 278.8 mm (10.98 inches)
Enclosure Type and Style per MIL-T-28800B Type Style	 III E (Style F in rackmount power module)

Table 1-5
IEEE 488 (GPIB) INTERFACE FUNCTION SUBSETS

Function	Subset	Capability
Source Handshake	SH1	Complete.
Acceptor Handshake	AH1	Complete.
Basic Talker	T6	Responds to Serial Poll.
Basic Listener	L4	Unlisten if My Talk Address (MTA) is received.
Service Request	SR1	Complete.
Remote-Local	RL1	Complete
Parallel Poll	PP0	Does not respond to Parallel Poll.
Device Clear	DC1	Complete
Device Trigger	DT1	Complete
Controller	C0	No controller function.

OPERATING INSTRUCTIONS

INTRODUCTION

First Time Inspection

Inspect the instrument for visible damage (dents, scratches, etc.). Keep the original shipping container and packing material for future use. If the instrument is damaged, notify the carrier and the nearest Tektronix Service Center or representative.

Repackaging for Shipment

Should it become necessary to return the instrument to a Tektronix Service Center for service or repair, attach a tag to the instrument showing the owner (with address) and the name of the individual to be contacted, complete instrument serial number, option number, and a description of the service required.

If the original container and packaging material is unfit for use or not available, repackage the instrument as follows:

1. Obtain a carton of corrugated cardboard having inside dimensions no less than six inches more than the instrument dimensions; this will allow for cushioning. The shipping carton test strength for your instrument is 200 pounds.

2. Surround the instrument with polyethylene sheeting to protect the finish.

3. Cushion the instrument on all sides by tightly packing dunnage or urethane foam between carton and instrument, allowing at least three inches on all sides.

4. Seal the carton with shipping tape or industrial staples.

5. Mark the shipping carton "FRAGILE INSTRUMENT" to indicate special handling.

Operating and Non-Operating Environments

The instrument may be operated, stored, or shipped within the environmental limits stated in the Specification section of this manual. However, the counter should be protected at all times from temperature extremes which can cause condensation to occur within the instrument.

PREPARATION FOR USE

Rear Interface Considerations

A slot between pins 21 and 22 on the rear connector identifies this instrument as a member of the TM 5000 counter family. If you desire to use your counter to build a system, insert a family barrier key (Tektronix Part No. 214-1593-02) in the corresponding position of the selected power module jack in order to prevent plug-ins belonging to a different family from being used in that compartment of the power module.

WARNING

To avoid electric shock, disconnect the power module power cord before inserting the family barrier key in the power module jack. Refer the barrier key insertion to qualified service personnel.

The DC 5010 has the following rear interface input and output features:

Arming Input

10 MHz Clock Output

External Clock Input (1, 5, 10 MHz)

Prescaler Function

Reset Input

NOTE

Rear interface information will be found in the Maintenance section of this manual. Refer the interface connections to qualified service personnel.

Installation and Removal

The DC 5010 can only be used in the TM 5000-Series power modules.

NOTE

Refer to the Operator's Safety Summary in the front of this manual before installing this instrument in the power module.

Refer to the power module instruction manual and make sure that the line jumpers are positioned correctly for the line voltage in use. Check the counter and the power module for the proper fuses. Be certain that the power plug for the power module has the proper grounding conductor.

CAUTION

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

Check to see that the plastic barrier keys on the interconnecting jack of the selected power module compartment match the cutouts in the rear interface connector for the counter. If they do not match, do not insert the counter until the reason is investigated.

If the cutouts and barrier keys match, align the chassis of the counter with the upper and lower guides of the selected compartment. See Fig. 2-1. Insert the counter into the compartment and press firmly to seat the rear interface connector. Apply power by operating the POWER switch on the power module.

The plastic lockouts (see Fig. 2-1) prevent programmable instruments from being used in the TM 500-Series (manual instruments) Power Module.

To remove the counter from the power module, turn off the POWER switch, pull the release latch knob (located in the lower left front corner) until the interconnecting jack disengages. Pull the counter straight out of the power module compartment.

FRONT PANEL OPERATION

The following information is a brief, functional description of the front panel display, controls, and connectors (See Fig. 2-2).

FRONT PANEL DISPLAY

(1) Display

The display contains nine seven-segments LEDS and eight annunciators. All measurement results are displayed with the best possible resolution. The readout (result) for the

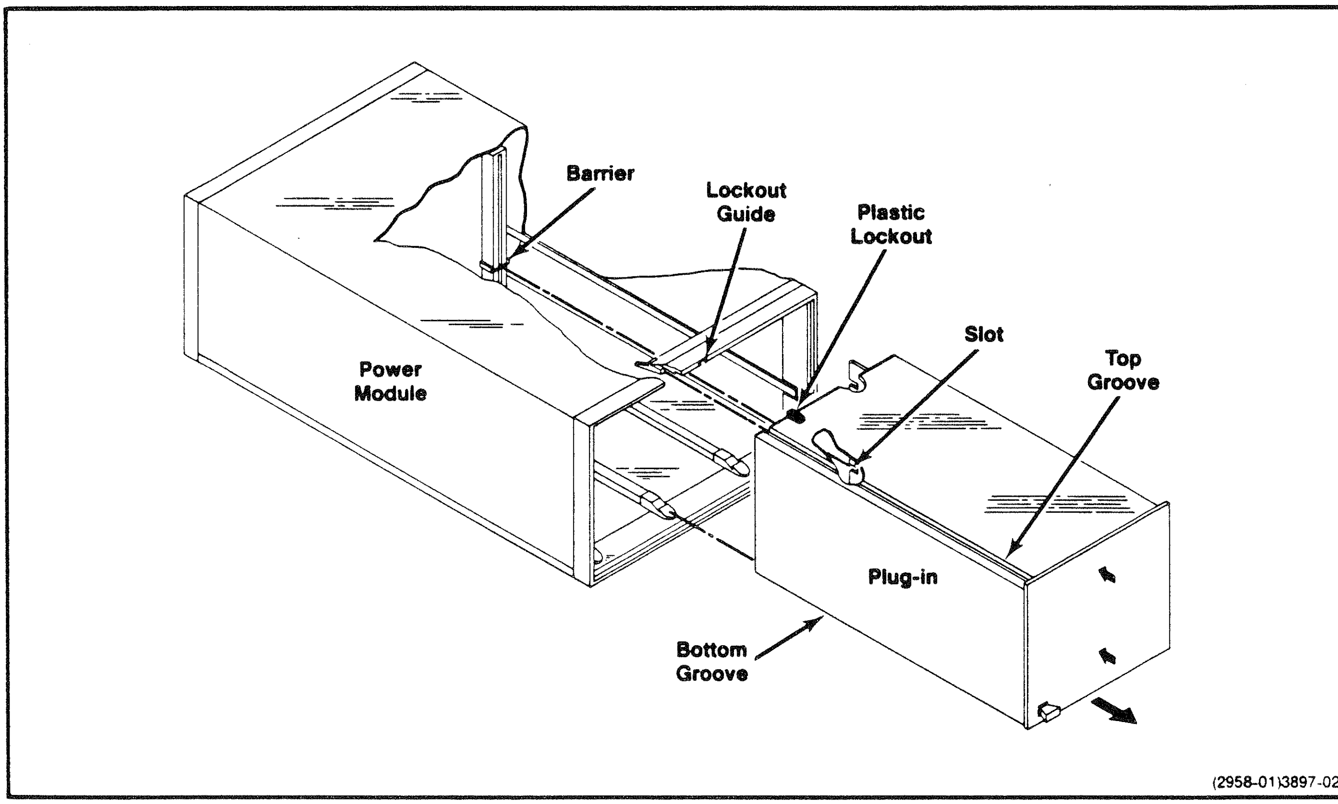

Fig. 2-1. Plug-in installation and removal.

@

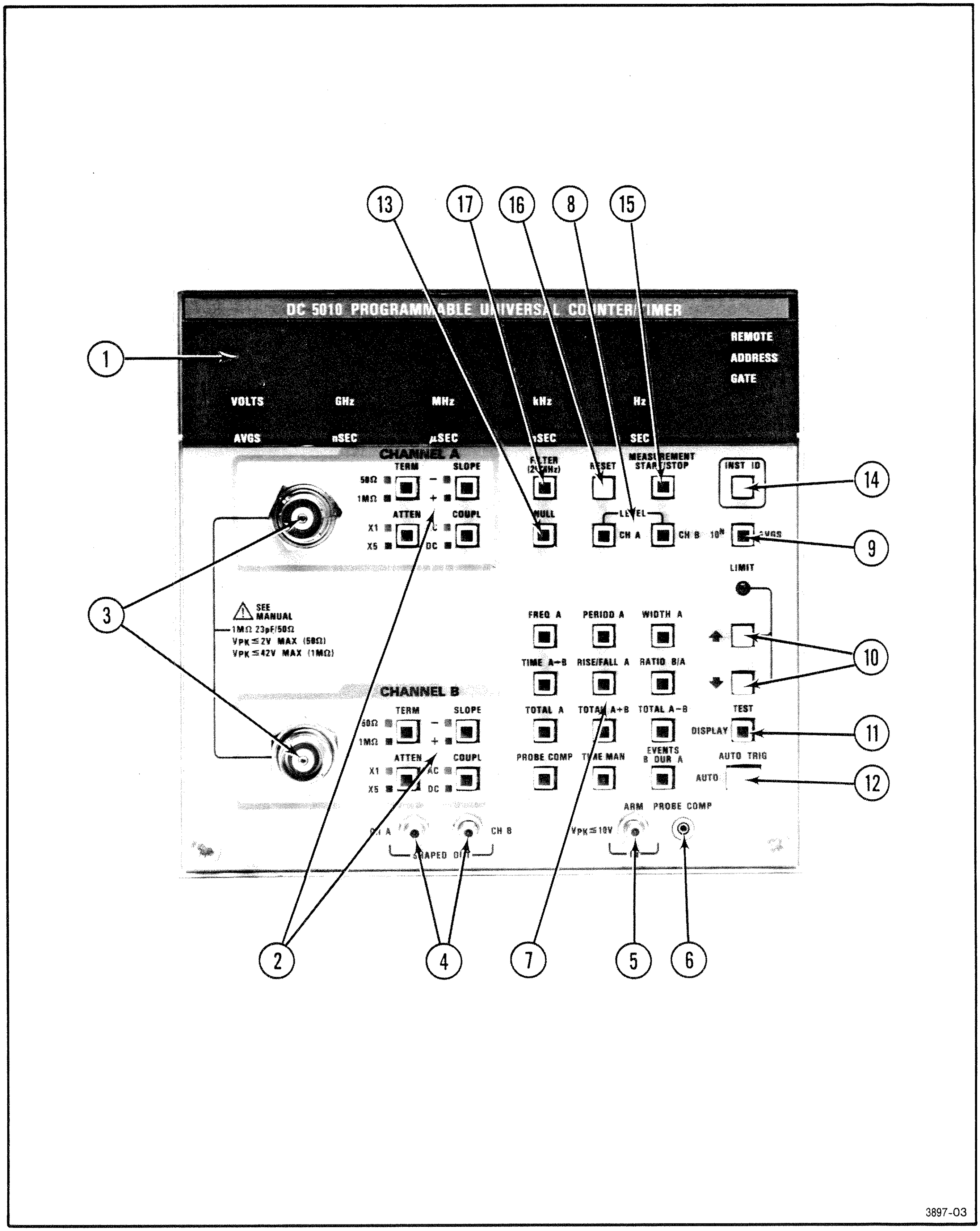

Fig. 2-2. DC 5010 front panel display, controls and connectors.

measurement is always displayed in a right-hand justified format with the decimal point automatically positioned. Displayed count overflow is indicated by a flashing display. In measurements such as Time A→B, where the number of resolved digits increases more slowly with an increase in averaging, only correct (resolvable) digits are displayed.

Five of the annunciators are used to indicate the units of measurements: Hz/SEC for Hertz or seconds, kHz/mSEC for kilohertz or milliseconds, MHz/μSEC for megahertz or microseconds, GHz/nSEC for gigahertz or nanoseconds, and VOLTS/AVGS for (trigger level) Volts, and (the exponent of) the number of Averages.

The GATE annunciator, when illuminated, indicates that the counter is in the process of accumulating counts for the measurement.

The REMOTE annunciator indicates the instrument is in a remotely-programmed state, when illuminated. The ADDRESS light indicates that the instrument is actually being addressed over the GPIB bus.

In addition to displaying the measurement results, the counter uses the extreme left three digits of the seven-segment LED display to indicate internal or operating error codes. The two digits (extreme left-digit Channel A and the extreme right-digit Channel B) on the display report the results of compensating external signal probes. See Self Test Display and Probe Compensation.

In addition, many of the front-panel pushbuttons are illuminated.

FRONT PANEL CONTROLS

(2) TERM, SLOPE, ATTEN, and COMPL (CHANNEL A and CHANNEL B)

TERM–50 Ω, 1 MΩ (termination). When unlighted, selects 1 MΩ, 23 pF; when lighted, selects 50 Ω. Allows user to properly terminate 50 Ω inputs when required. (Unit will automatically revert to 1 MΩ, 23 pF in the event of an overload.)

ATTEN–X1, X5. When unlighted, selects X5; when lighted, selects X1. Allows the signal to be applied directly to the amplifier without attenuation or attenuated by a factor of five. The attenuator effectively increases the input hysteresis and trigger level range by a factor of five.

SLOPE −,+. When unlighted, selects +; when lighted, selects −. This button selects the slope of the signal at the trigger level crossing, which is recognized as a countable event. CHANNEL A slope also selects between risetime (+ Slope) and fall time (− Slope); it must be set before the RISE/FALL A button is pushed.

COUPL–AC, DC. When unlighted selects DC; when lighted selects AC. DC is direct coupled. AC inserts a capacitor in series with the input which allows small signals with large dc offsets to be measured.

FRONT PANEL CONNECTORS

(3) CHANNEL A - CHANNEL B (Identical in performance)

1 MΩ 23 pF/50 Ω. Signal input connectors.
Vpk ±2 V max (50 Ω)
Vpk ±42 V max (1 MΩ)

(4) CH A, SHAPED OUT - CH B, SHAPED OUT (Shaped Out A/B/COM)

These outputs provide an exact replica of the internal signal that is being measured. It is an aid to proper triggering on complex waveforms. The outputs provide a 100 mV signal near ground from 50 Ω (200 mV unterminated). These are full bandwidth outputs, and function well beyond 350 MHz.

(5) ARM, IN - Vpk ≤10 V (Arming TTL)

This input (normally high) allows the counter to measure only when in the high state. When in the low state, this input prevents the counter from measuring. (Alternatively, this input may be provided through the rear interface.)

(6) PROBE COMP

This test point provides a rectangular waveform (≈5 volts) that can be used in conjunction with the "PROBE COMP" function to compensate test probes (see Probe Compensation in this section.)

FRONT PANEL PUSH BUTTONS

(7) Function Pushbuttons

FREQ A (Frequency A). Measures the period of the Channel A signal, calculates and then displays frequency.

PERIOD A. Measures and displays the period of the Channel A signal.

WIDTH A. Measures the width of a pulse on Channel A. When CHANNEL A SLOPE is +, the positive pulse width is measured. When CHANNEL A SLOPE is negative, the negative pulse width is measured.

TIME A + B. Measures the time between the first occurrence of an event on Channel A and the first succeeding event on Channel B.

RISE/FALL A (Risetime A - Falltime A). Automatically measures the risetime/falltime (10% and 90%) of the signal appearing on CHANNEL A. The appropriate trigger levels are measured and calculated at the time the button is pressed. If the signal amplitude changes, the button may be pressed again. When CHANNEL A SLOPE is +, risetime is measured; for falltime, press CHANNEL A SLOPE = (−) before pressing RISE/FALL A. Since this measurement uses the B channel, its settings are automatically updated to match those of CHANNEL A. After pressing RISE/FALL A, the user is free to modify either CHANNEL A or CHANNEL B separately to suit special measurement needs, though the result may no longer be a traditional Rise/Fall time. (See Risetime A and Falltime A later in this section).

RATIO B/A. Measures and displays the ratio of events occurring on Channel B divided by the events occurring on Channel A over the same time interval.

The three totalize modes of operation count the events that are the occurrences of pulses on Channel A and B.

TOTAL A (Totalized A). In Total A, only Channel A events are displayed.

TOTAL A+B. Displays the total number of events on Channel A plus the total number of events on Channel B. Channel B events are counted only after the first valid Channel A event.

TOTAL A−B. Displays the total number of events on Channel A minus the total number of events on Channel B. Channel B events are counted only after the first valid Channel A event. If A-B is negative, a minus sign is lighted.

NOTE

After a TOTALIZE button is pushed, the START/STOP button lights to indicate a "STOPped" condition. It must then be pressed to start the Totalize process.

Also, the number of digits displayed is "scaled" by the AVGS setting. This scaling does not affect the actual count process, and therefore may be changed while counting without losing counts. Even when counting has been stopped, the display may be moved to the right or left.

PROBE COMP. When in this mode, a visual indication is given (in the display area) that allows the user to easily compensate attached high impedance probes. (See Probe Compensation in this section.)

TIME MAN (Time Manual). Measures time after pressing the MEASUREMENT START/STOP pushbutton (once to start and once to stop). The accumulated count (time) is not reset until the RESET pushbutton is depressed. Like the Totalize modes, this function defaults to the STOPped state when first selected, as indicated by the START/STOP button being illuminated.

EVENTS B DUR A (Events B During A). Measures the number of occurrences of pulses on Channel B during the time interval where the Channel A input signal is greater than (+ SLOPE) or less than (− SLOPE) the Channel A trigger level.

(8) LEVEL CH A, CH B

Displays the chosen trigger level. Trigger level settings may be set for either channel by depressing the appropriate LEVEL button and then using the increment or decrement buttons (labeled 10). To exit this mode, the user can press the LEVEL A (B) button a second time or press any function button.

(9) AVGS (Averages)

Pressing this button displays the current AVGS setting and readies the instrument for a new setting. The user can then choose between several modes.

AUTO - (push the AUTO button, a −1 will be displayed). This mode provides the best resolution possible with a measurement time of approximately 300 mS.

0 - (decrement exponent to zero). The selected measurement is made with at least one event. This is the mode to be used for single-shot measurements. At most frequencies, more than one event will actually be averaged; see the Specification section for further detail.

10^n,n=1 to 9 - Provides selection of minimum number of averages in decade steps.

The increment/decrement keys are used to increase or decrease the exponent to the next legal setting.

NOTE

The AVGS settings affects the number of digits displayed for Totalize measurements. When in Auto on n=0, the first nine digits to the left of the decimal point are displayed. When n=1 to 9, the measurement result is "scaled" by 10^n and displayed.

(10) ⬆

This button increments the appropriate trigger level if LEVEL CH A-CH B is selected, or the number of averages if AVGS has been selected. Voltage levels are incremented or decremented in steps of 4 mV X attenuating setting.

⬇ This button decrements the appropriate trigger level if LEVEL CH A-CH B is selected, or the number of averages if AVGS has been selected.

LIMIT

This light goes on whenever either the increment (↑) or decrement (↓) button has incremented or decremented a setting to its limit. This light goes out when increment (↑) or decrement (↓) button is released.

(11) TEST/DISPLAY

When either of the LEVEL CH A, LEVEL CH B buttons or the AVGS button is lighted, this button alternates what is being displayed in the seven-segment readout. Pressing it once makes the readout revert back to displaying the functional results (frequency, period, etc.) while still leaving the increment/decrement buttons active. Pressing the button again will alternate the display back to showing the voltage level or averages exponent. This allows the user to view either the parameter being changed or the effect of that change on the functional results.

When the LEVEL buttons or the AVGS button is unlighted, the TEST/DISPLAY button is used to select the Test mode. In this mode a portion of the power up test (all but the RAM portion) is repeated. If an error is ever encountered, the test stops, with the appropriate error code displayed. To exit Test mode, push any other function key.

(12) AUTO TRIG/AUTO

If the LEVEL buttons and the AVGS button are unlighted, pressing this button causes an auto trigger on both Channel A and Channel B (the maximum and minimum peak values of the Channel A and B input signals are measured and the trigger levels are set at the midpoints). If LEVEL CH A is selected, pressing this button causes an Auto trigger on Channel A only, and similarly for LEVEL B lighted. If AVGS is lighted, pressing the button enters a −1, which is the code for Auto Averages.

NOTE

Serial Number B0 41329 & Below

When the DC 5010 is operated in RATIO A/B, TOTAL A+B, or TOTAL A−B mode and negative trigger slope is selected on the B channel, the AUTO TRIGGER function may not set the B trigger level properly. It is recommended under these circumstances to set the B trigger level manually or by one of the following sample programs if a controller is used:

Serial Number B0 41329 & Below

4050 Series Controllers:

```
600 REM    SET B TRIGGER LEVEL
610 PRINT @20:"AUTO;CHA B;MIN?;MAX?"
620 INPUT @20:M1,M2
630 L=(M2-M1)/2+M1-0.024
640 PRINT @20:"CHA B;LEVEL ";L
```

4041 Controller:

```
600 Rem    SET B TRIGGER LEVEL
610 Input prompt "AUTO;CHA B;MIN?;MAX?" #20:M1,M2
620 L=(M2-M1)/2+M1-0.024
630 Print #20:"CHA B;LEVEL ";L
```

Manual Method: **Serial Number B0 41329 & Below**

a. Perform an AUTO TRIGGER with Channel B Trigger in positive slope.

b. Press the B LEVEL button and note the value displayed.

c. Switch Channel B Trigger Slope to negative and manually set the level to the above noted value minus 0.048 volts.

(13) NULL

Pressing the NULL button stores the present measurement result and then subtracts that number from all subsequent measurements (while the button remains lighted). It is most useful in Time A→B measurements, where it can be used to null out systematic errors such as unequal cable lengths and channel mismatches; however, it is available in all measurement functions.

The averages setting may be changed without losing the NULL stored measurement. Now, the instrument will be subtracting two numbers of differing resolution. Since the result of such a subtraction actually has the resolution of the lesser resolution number, that is the one that the counter automatically uses to determine how many digits to display.

Pressing the button again will re-null the result.

To exit the Null mode, press any function button (including that of the function already chosen).

(14) INST ID

This pushbutton, when pressed, displays the current GPIB address and message terminator selected in the DC 5010. It will send an SRQ if enabled, even when in Local Lockout, and it's therefore a useful way for an operator to signal the controller during the running of a program.

(15) MEASUREMENT START/STOP

This pushbutton can be used in all of the Function modes except Probe Comp and Test. When it's lighted, measurement is in the "STOPped" state. Pressing the button causes a "STOPped", Totalize, or Time Manual measurement to "Start" from the displayed result. Other measurements (except Probecomp and Test) will "Start" a new measurement. When "Started", pressing the button causes all measurements (except Probecomp and Test) to stop counting. When "STOPped", Totalize and Time Manual measurements read the final count in the count chains and update the display one more time.

(16) RESET

When a measurement has been stopped, this pushbutton, when pressed, will initiate another single measurement. If RESET is pressed while the counter is in the middle of a measurement, the current measurement will be aborted and a new measurement started. RESET, while pressed, also provides a segment test for all the front panel LEDs, including pushbuttons and annunciators.

(17) FILTER (20 MHz) (CHANNEL A and CHANNEL B)

When this button is lighted, the bandwidth of both channels is reduced to 20 MHz. This allows rejection of high frequency noise. It may also be used when initially setting Auto trigger levels or Rise/Fall levels for a signal with overshoot or undershoot.

OPERATORS FAMILIARIZATION

INTRODUCTION

General Operating Characteristics

The DC 5010 is a programmable universal counter based on a microprocessor system. The counter is capable of 11 measurement functions with full nine-digit resolution, plus two specialized functions; probe compensations (PROBE COMP) and self-test (TEST).

The microprocessor system automatically sets the measurement gate interval, performs the necessary calculations on the acquired data, and causes the result to be displayed with the best possible resolution for the selected measurement FUNCTION, number of averages (AVGS), and operating conditions.

Self Test Display

When power is applied, one of the error codes listed in Table 2-1 may appear in the display window if the counter fails its self-test routine. Refer the error code condition to qualified service personnel.

NOTE

At power up, a signal with a large dc offset voltage connected to the input terminals for either channel may cause the entire input signal to be outside the triggering level range. If this condition exists, an error code may be displayed. If any of these conditions occur, disconnect all inputs and reapply power. This error condition can also be caused by a low level ARM input signal during power-up.

NOTE

Refer error code conditions to qualified service personnel.

Table 2-1

FRONT-PANEL DISPLAY ERROR CODES

Serial I/O Fault	313
Channel A Counter Integrity	320-324, 329
Channel B Counter Integrity	330-334, 339
System RAM Error U1410	340
System RAM Error U1610	341
System RAM Error U1311	342
ROM placement error U1610	361
ROM placement error U1102	374
ROM placement error U1201	375
ROM placement error U1410	380
ROM checksum error U1610	381
ROM checksum error U1102	394
ROM checksum error U1201	395

INPUT CONSIDERATIONS

Maximum Safe Input Voltage Limits ⚠

CAUTION

To avoid instrument damage, make certain that the input voltages to the front panel connectors or rear interface inputs do not exceed their specified limits. See Specification section.

The outer shell of the front panel bnc connectors is connected to earth ground through the ground connection for the power module power cord.

Always use a step-down isolation transformer (less than 15 V output) when measuring power line frequencies (50 or 60 Hz).

Be careful with high-frequency, high-amplitude signals (above 80 MHz). The front panel maximum safe input voltage at these high frequencies is 4 V, peak-to-peak times attenuator setting.

Connecting External and Internal Signal Sources

The DC 5010 can be used to measure input signals to either channel from the front panel. The SLOPE, TERM, ATTEN, and COUPL pushbuttons are effective in conditioning the signal.

If a high impedance signal probe is to be used between the front panel bnc connectors and the measurement source, use a probe capable of compensating for the input capacitance of the counter (less than 24 pF). A probe is recommended for all digital logic applications; the TEKTRONIX P6125 has been designed specifically for these counters, and its use is recommended. The counter has been designed, however, to properly trigger on ECL signals even when a X10 attenuator probe is used.

MEASUREMENT CONSIDERATIONS

Input Coupling, Noise, and Attenuation

You can use either the ac coupling (AC COUPL) or dc coupling (DC COUPL) mode to couple the input signal to the CHANNEL A or CHANNEL B input amplifiers. If the signal to be measured is riding on a dc level, its amplitude limits may not fall within the triggering level range. The AC COUPL mode should be used for repetitive signals having a fixed frequency and a constant duty cycle, or for signals riding on a large dc level. Slope selection is relatively unimportant when measuring the frequency or period of sine-waves. The 50 Ω Termination is selected for high frequency 50 Ω systems, while 1 MΩ is selected for high impedance probes and for other high impedance situations. When in 50 Ω, the internal termination resistor could be damaged if the user accidentally applied an overly large signal. To prevent this, the DC 5010 automatically reverts to 1 MΩ for most signals that might damage the 50 Ω resistor. See the Specification section for more detail.

If the signal frequency or duty cycle changes, the triggering point may shift, stopping the measurement process. Use the DC COUPL mode for low frequency ac signals, signals with a low duty cycle, and during any time interval measurement (Time A→B, Rise/Fall A, Events B Dur A, and Width A).

Noise may be coupled to the input amplifiers along with the signal to be measured. Noise may originate from the operating environment, the signal source, or be caused by improper connections. If the noise is of sufficient amplitude, it can result in inaccurate measurements due to false triggering. See Fig. 2-3. The DC 5010 has a 20 MHz low pass filter (FILTER) that is helpful in removing or reducing noise.

The linear operating range describes the voltage limits that will allow proper triggering without distortion. The minimum signal amplitudes are defined by the input sensitivity requirements for the AC COUPL and DC COUPL modes for either the 1 MΩ or 50 Ω Termination selection (see the Specification section). Proper use of the ATTEN (attenuation) controls will ensure operation within the maximum limits; ±2.0 V for X1 ATTEN, ±10 V for X5 ATTEN.

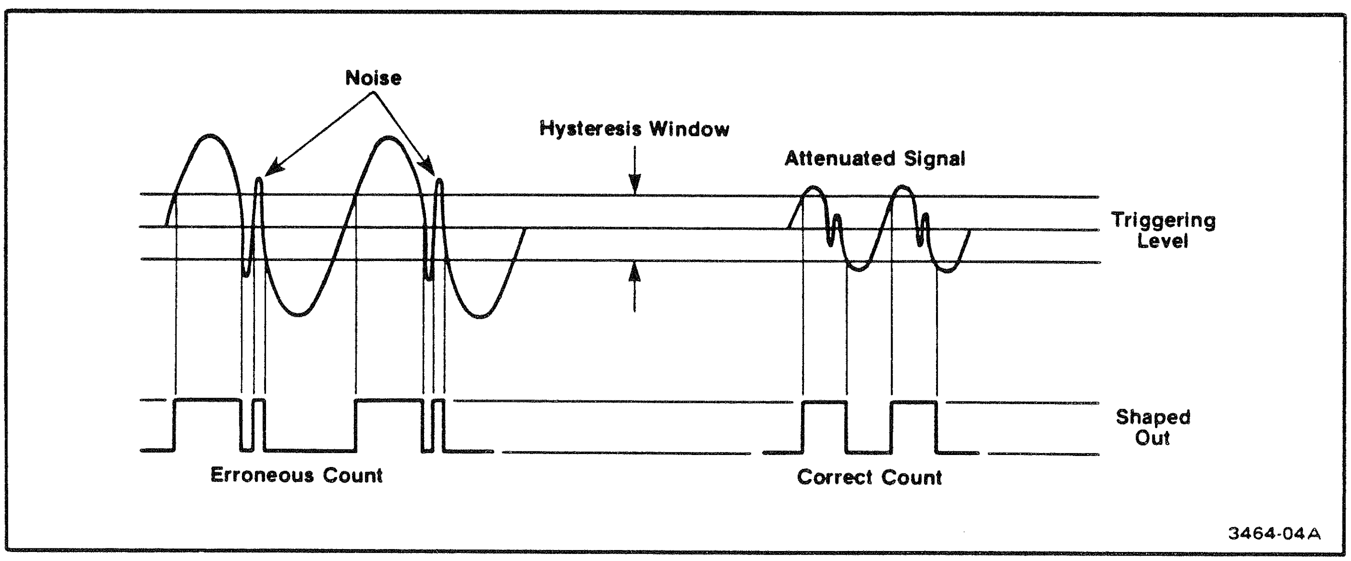

Fig. 2-3. Advantages in signal attenuation.

Triggering the Counter

The dc triggering level is determined by the SLOPE and LEVEL selection, or by the AUTO TRIG button.

The LEVEL CH A and CH B buttons, in conjunction with the increment (↑), and decrement (↓) buttons, are used to move the triggering hysteresis window continuously up or down through a ±2.0 V range in 4 mV steps. The hysteresis window is typically 50 mV peak-to-peak. To determine the exact trigger level settings, push LEVEL CH A (or LEVEL CH B); the respective levels will be displayed. To return to the measurement cycle, press the LEVEL CH A or LEVEL CH B button again (whichever is lighted); pressing any function button will also return the instrument to the measurement mode.

When the AUTO TRIG button is activated, the microprocessor performs a software routine to determine the maximum and minimum limits of the Channel A and Channel B input voltage swings. Then the routine automatically sets the triggering levels of each channel to 50% (+24 mV for + slope, −24 mV for − slope) of its respective measured minimum and maximum values when making frequency, period, and totalize measurements. AUTO TRIG is also useful for pulse width measurements (WIDTH A mode) and TIME A→B measurements. Successful use of the Auto Trig here requires signal amplitudes of at least twice the effective hysteresis. Thus, signals with amplitudes greater than 140 mV peak-to-peak are typically necessary. This is because the actual trip level of the hysteresis window is set exactly at the 50% point for Width and Time A→B.

Figure 2-4 illustrates typical trigger level settings and shows the importance of setting trigger levels properly in order to avoid errors due to input signal risetimes (falltimes), or where the transition times of the start and stop pulses are different (or just slow). Observation of the SHAPED OUT signals on an oscilloscope, while setting the trigger levels on slow but complex waveforms, aids in reducing trigger setting difficulties.

The use of the Auto Trig, though very convenient, does not reduce the need to consider input noise amplitudes, coupling, impedance matching, and attenuation factors. Large amounts of overshoot and ringing of the input signal may cause erroneous counts due to an undesirable level setting. The median value of the input signal may be displayed. For mid-point settings, the low frequency limit for the Auto Trig mode is 10 Hz. Below 10 Hz, the automatic triggering level will still be set between the signals maximum and minimum, but not necessarily at the 50% point. For dc inputs, the level determination provided by auto trigger once again becomes correct.

Reducing Measurement Errors

As an aid in reducing measurement errors, keep in mind the following factors.

- Use the ATTEN controls and high impedance, attenuator type probes when measuring signals from high impedance circuits.
- Use the 50 Ω TERMination control for low impedance, high frequency 50 Ω systems.
- Consider trigger errors caused by input signals with slow rise or fall times.
- Use the 20 MHz FILTER to reduce high frequency noise.
- Average the measurement over a larger number of cycles of the input signal (greater number of AVGS)
- Maintain the counter environment at a constant temperature.
- For greater stability, allow extra instrument warm-up time (> 1/2 hour).
- Substitute the standard time base with the optional, higher stability time base.
- Apply a 1 MHz, 5 MHz, or 10 MHz external time reference standard (NBS) to the rear interface inputs.
- Recalibrate, if necessary.

MEASUREMENT EXAMPLES

Frequency A and Period A

When the counter is in either the FREQ A or PERIOD A modes, it always measures the period of the Channel A input signal. For FREQ A, the microprocessor computes the frequency as:

$$f = \frac{1}{T} \quad (T = \text{period})$$

and displays the answer in frequency units. For PERIOD A, the answer is displayed in units of time. The 320 MHz internal clock insures very high resolution in both frequency and period. For period measurements of fast signals with 10^9 Averages, this resolution is ±31.25 attosecs (31.25 × 10^{18} sec).

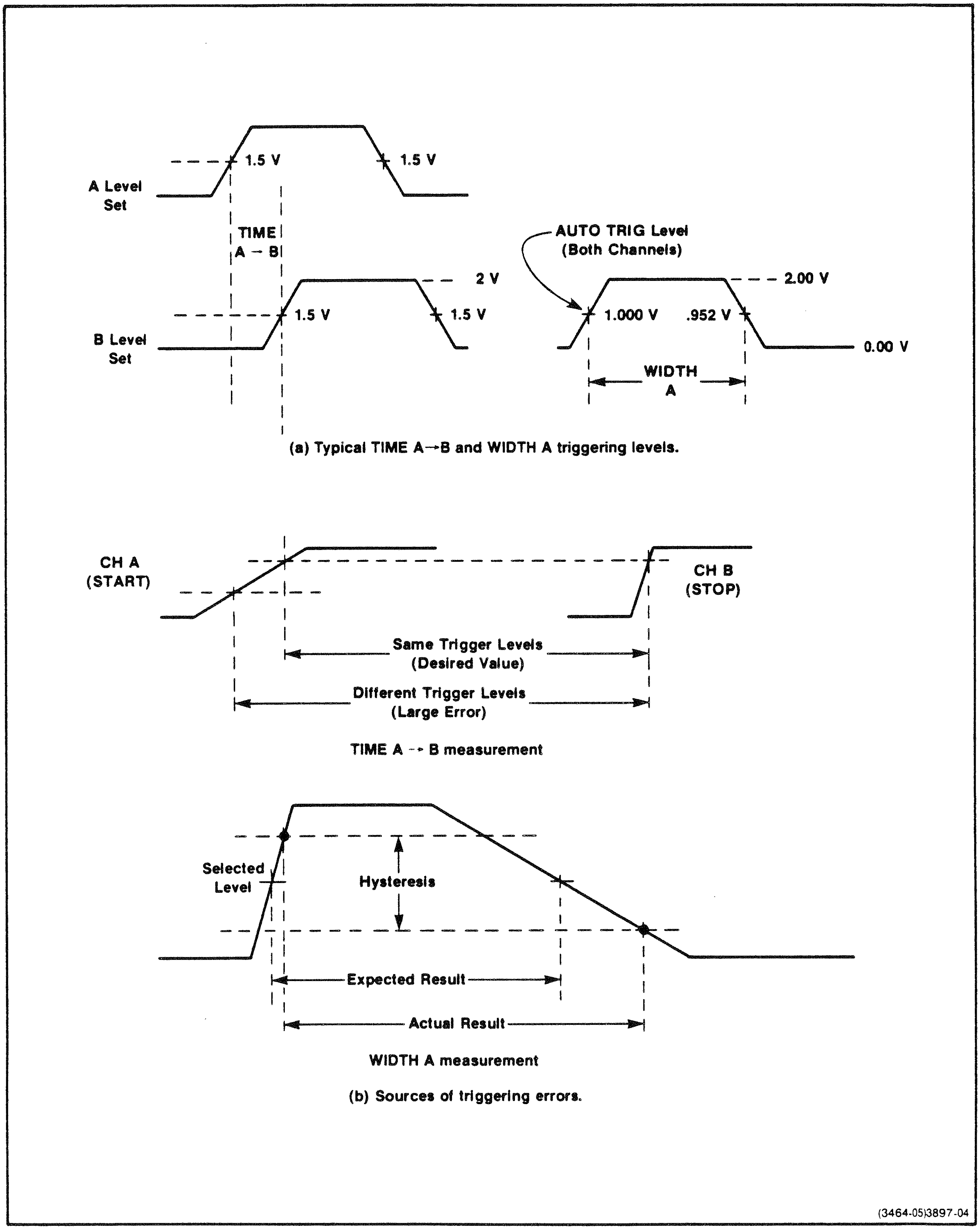

Fig. 2-4. Typical triggering levels and sources of triggering errors.

Ratio B/A

In Ratio B/A mode, the counter measures the number of events on both channels during the time it takes to accumulate the selected number of Channel A events (averaged by A events). The total number of Channel B events is then divided by the total number of Channel A events and the answer displayed without units of time or frequency.

The ratio range is from 10^{-8} to 10^{9}. Applying the higher frequency to Channel B produces a ratio greater than one; applying the lower frequency to Channel B produces a ratio less than one. For better resolution, apply the higher frequency signal to Channel B.

Width A and Time A → B (Time Interval)

Figure 2-5 illustrates measurements for the WIDTH A and TIME A → B functions. The WIDTH A function measures the time interval between the first selected positive or negative edge (± SLOPE) of the waveform applied to Channel A and the next opposite polarity edge.

The TIME A → B function measures the time interval between the first selected occurrence (± SLOPE) of an event on Channel A to the first selected occurrence (± SLOPE) of an event on Channel B. The measurement can be averaged (AVGS) by the selected number of Channel A events because there is one Channel B event per Channel A event.

When either the WIDTH A, TIME A → B, or RISE/FALL A function is activated, the microprocesor turns on an internal pseudo-random noise generator that phase modulates the internal 3.125 ns time base, allowing the counter to measure without error, input signals that otherwise would be synchronous with its time base. See Fig. 2-5.

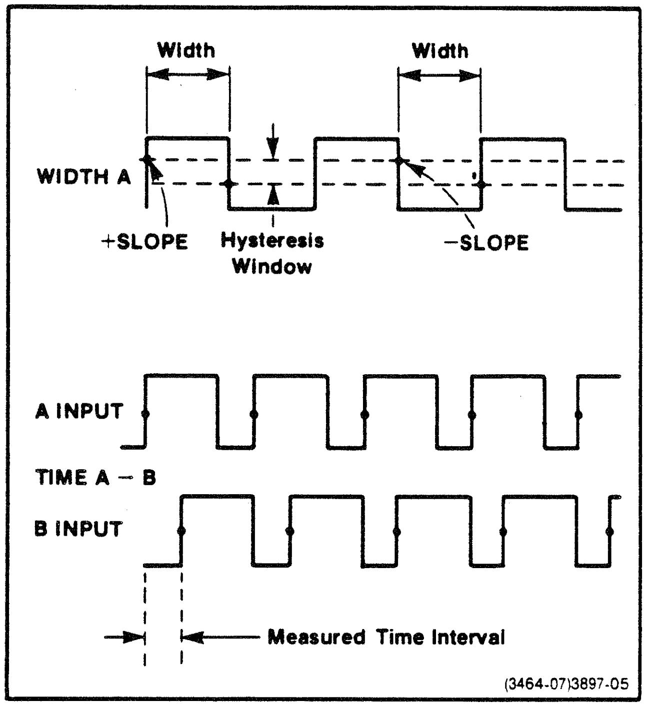

Fig. 2-5. Measurement examples for WIDTH A and TIME A → B.

In Fig. 2-6 the time interval (4.68525 ns, WIDTH A) would not be measured with a non-modulated time base any more accurately with averaging than it could have been by making a single-shot measurement (AVGS = 0). Using the pseudo-random phase-modulated clock pulses, and setting the AVGS switch greater than 1, causes the counter in this example to count one clock pulse one-half of the time and two clock pulses one-half of the time. For example, if AVGS is set to 10 (10^1) the total time for the count is at least

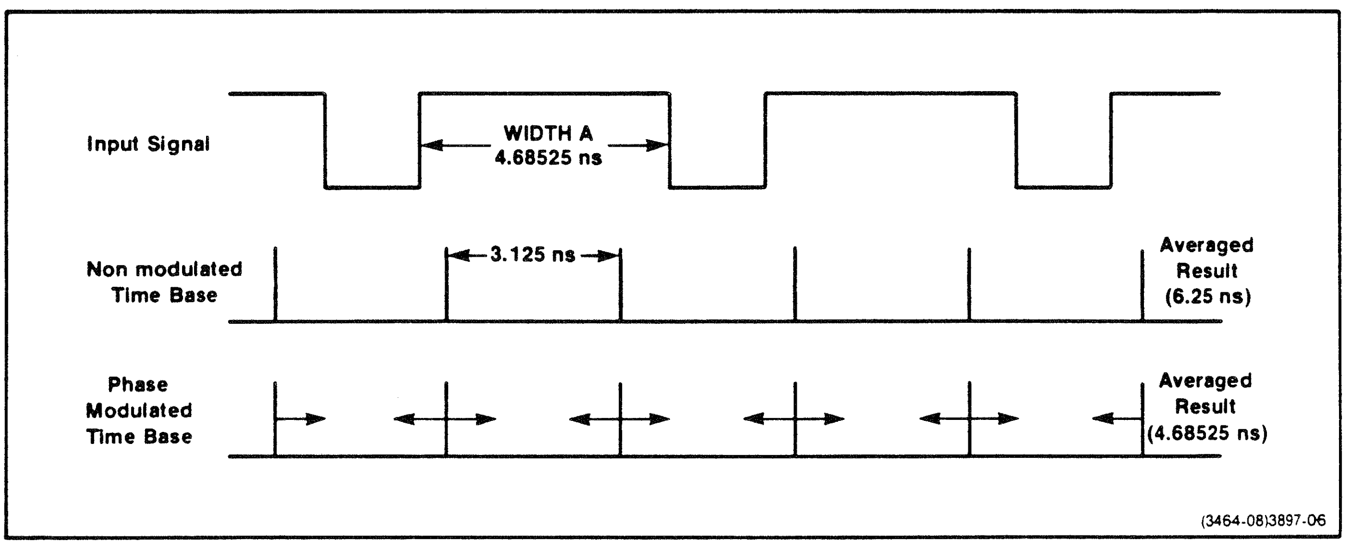

Fig. 2-6. Measurement example for synchronous input signals.

46.8525 ns. Ten averages yields 15 counts (5 counts + 10 counts). Dividing the total count by the number of averages, the average (count/interval) of each count corresponds to 3.125 nsec. The answer, is then (15/10 × 3.125 = 4.68525, which on the DC 5010 would be displayed as 4.6 nsec.

Null

Pressing the NULL button stores the present measurement result and then subtracts that number from all subsequent measurements (while the button remains lighted). It is most useful in Time A → B measurements, where it can be used to null out systematic errors (such as unequal cable lengths and channel mismatches); however, it is available in all measurement functions.

The averages setting may be changed without losing the Null stored measurement. If the instrument is subtracting two numbers of differing resolution, the result of such a subtraction has the resolution of the lesser resolution number. This is the number that the counter automatically uses to determine how many digits to display.

Pressing the button again will re-null the result.

To exit the Null mode, press any function button (including that of the function already chosen).

Events B During A

The EVENTS B DUR A function is basically the same as WIDTH A; except, instead of clock edges, the counter counts the selected number of positive-going or negative-going events (± SLOPE, CHANNEL B) occurring during a selected positive or negative pulse width occurring on Channel A (± SLOPE, CHANNEL A). Therefore, the internal time base is not counted for this function. See Fig. 2-7 for a measurement example. The Channel B events are averaged over the selected number (AVGS) of Channel A pulse widths.

Time Manual

The TIME MANUAL function measures and displays the time interval (to the closest one-hundredth of a second) between the first and second depressions of the MEASUREMENT START/STOP pushbutton. The time count can be reset to zero and restarted by pressing and then releasing the RESET pushbutton. The AVGS switch has no affect in the Time Manual mode. When first entering this function, the measurement is in the STOPped mode, as indicated by the lighted START/STOP button.

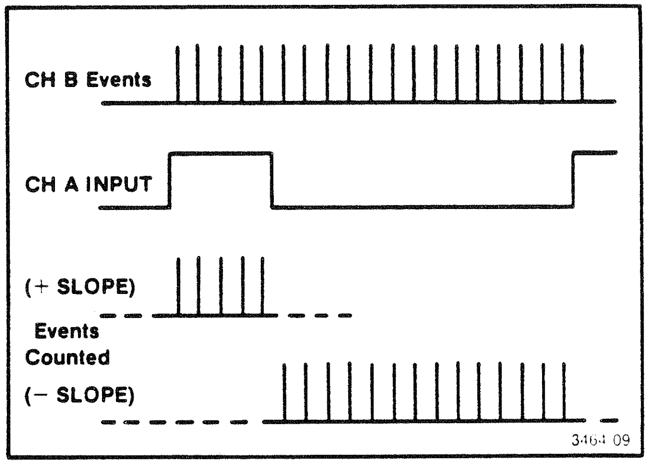

Fig. 2-7. Measurement example, EVENTS B DURING A.

Totalize A

The Total A function is basically the same as TIME MANUAL except that instead of counting the internal time base pulses, the counter counts the total number of Channel A events occurring between two successive depressions of the MEASUREMENT START/STOP pushbutton. The AVGS switch is active in this mode. With the AVGS exponent set to 0 or AUTO (−1), whole numbers are displayed. For other settings, AVGS operates as a power-of-ten scaling indicator (allowing totalizing to the full fourteen digits of the internal count chain). For example, with a 1 MHz input signal and the AVGS switch set to 10^6, the least significant digit displayed would represent 10^6 counts and would increment at one count per second (10^6 Hz/10^6 = 1 Hz). This scaling factor may be changed (Refer to Text) after a measurement is over, effectively moving the display. This allows the user to view all thirteen digits of the count chain.

Totalize A+B

The TOTAL A+B function is as described for TOTAL A with the exception that the counter counts the total number of Channel A events plus the total number of Channel B events. The B count does not begin until after the first valid A count.

Totalize A−B

The TOTAL A−B function is similar to the TOTAL A+B function with the exception that the counter counts the total number of Channel A events minus the total number of Channel B events. The B count does not begin until after the first valid A count.

Risetime A and Falltime A

The RISE/FALL A function allows the operator to automatically measure the 10% to 90% risetime (or falltime) of the counter's specified input signal appearing on Channel A. See Fig. 2-8a. Select the SLOPE (+ = risetime; − = falltime) before pressing the RISE/FALL A button. The input signal size is automatically measured and the 10% and 90% levels are automatically calculated and set. These levels are available over the GPIB bus.

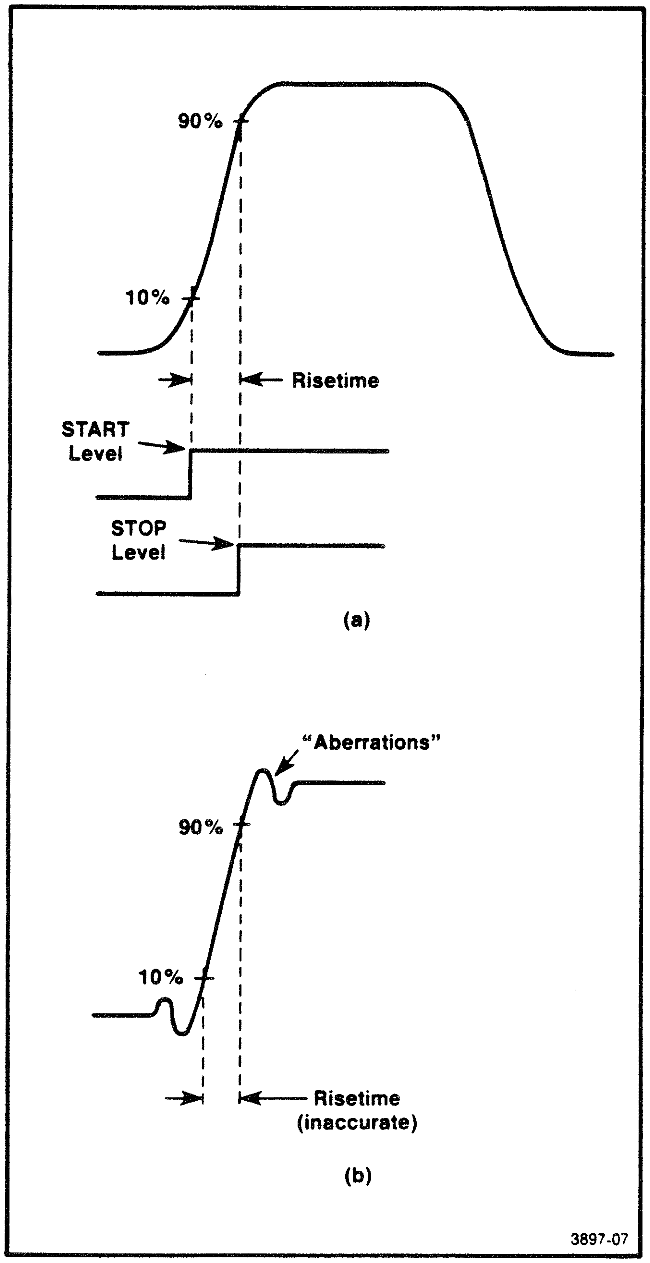

Fig. 2-8. Measurement example for risetime.

Internally, the A input is routed to both the A Channel and B Channel. The A Channel input conditioning is automatically duplicated (and indicated by the front panel lighted buttons) on the B Channel when the RISE/FALL A button is pressed. Although risetime measurements are simple to make, some operator problems can develop (even when using the automatic level setting capability of the counter). The signal being measured must satisfy the instrument requirements as detailed in the Specification section of this manual. The input signal amplitude must be greater than 1.4 V (50 Ω) or 700 mV (1 MΩ), have a risetime not less than 4 nsec (5 nsec for 1 MΩ), and not exceed 10% aberrations.

The DC 5010 uses a true peak detector circuit and detects the highest signal peak, even if the peak is an aberration (see Fig. 2-8b). If this aberration is too severe (greater than 10%), the instrument will not measure the correct risetime. Before pressing the RISE/FALL A button, the front panel FILTER (20 MHz) button can sometimes be selected to limit the internal risetime (less than 18 nsec) of the input signal to reduce these aberrations. Effective use of the filter will depend on the signal width and aberrations. Press the RISE/FALL A button. After the signal peak is measured and the 10% to 90% levels are set, the filter would be removed so the DC 5010 may display the actual unlimited risetime (without filter).

The counter front panel pushbuttons remain active after pressing the RISE/FALL A button, to enable the operator to modify signal input conditioning and trigger levels. The modified conditioning and levels must satisfy the instrument requirements as detailed in the Specification section of this manual.

For example, if the AUTO button is pressed (while in RISE/FALL A) the Channel A and Channel B levels will move from the 10% and 90% points to the 50% point. In the DC 5010 if the 20% and 80% risetime points are desired, MIN and MAX values (see the Programming notes in this section) are available over the GPIB bus. These values can be used to calculate these 20% and 80% risetime points and program them into the Channel A and Channel B.

Other specific signal levels such as TTL High or TTL Low can be programmed by the operator; however, consideration must be given for the termination setting. In the 50 Ω termination, the displayed trigger level is one-half the true trigger level due to the internal power splitter (not evident to the instrument). In the 1 MΩ termination the instrument does not take into account any attached probes (see Rise/Fall specification for level information with the use of probes).

Probe Compensation

The DC 5010 has been specifically designed to be compatible with standard probes when in 1 MΩ termination; however, the operator must still be sure that the probe is properly compensated.

In the DC 5010, a probe compensation (PROBE COMP) function is built into the counter. It allows the user to compensate the probe in place and without the use of an external oscilloscope.

A square-wave signal of approximately 1 kHz and an amplitude of approximately 5 V is provided at the front panel PROBE COMP tip jack.

Connect the probe tip to the PROBE COMP tip jack before entering the PROBE COMP mode.

The counter should display a zero for the most significant digit (far left) and a zero for the least significant digit (far right). The far left digit is for a probe connected to CHANNEL A and the far right digit for a probe connected to CHANNEL B. No decimal points or annunciators should be illuminated.

With the probe connected and the square-wave signal applied, perform the following steps.

1. Slowly rotate the probe adjustment in either direction until the display changes to a continuous 1 reading for the channel being compensated.

2. Slowly reverse the rotation of the probe adjustment until the display *just goes back to a 0.* At this point, the probe will be compensated. A 1 indicates that the probe is over compensated; a 0 indicates under compensation. Final adjustment should be made in the direction where the 1 just changes to a 0.

NOTE

If a display goes to a 1 and remains in that condition for one or more complete revolutions of the probe adjustment, press the RESET pushbutton to clear the condition. This can occur if the connection to the square-wave source became open during the adjustment procedure.

Test Function

A 000 display in the three MSD's for the TEST function is an indication that the microprocessor has checked itself. The test also checks the internal serial data path, the integrity of the internal counter chain (accumulators), and, as a by-product, the operation of the digital-to-analog converter (trigger levels) and input amplifier circuits.

The random-access memory space (RAM) is not checked during this front panel self-test; the RAM is checked only at power-up.

NOTE

If the CHANNEL A or CHANNEL B inputs are connected, the peaks of the input signals must be within the triggering level range of the counter for the test function to operate properly. If a failure occurs, first disconnect any CHANNEL A or CHANNEL B inputs and repeat the test. A connection to the arming input may also cause improper operation.

The gate light will flash once each time a full test cycle has been completed. If a failure is ever noted, the error code of that failure will be displayed in the three extreme left digits of the seven-segment display and the cycling will halt. The DC 5010 will stay in test mode until another function is selected.

Arming (ARM Input)

Arming provides a means by which single events or sets of events can be selected for measurement within a complex analog or digital signal. Figure 2-9 shows three different examples of arming.

The ARM input requires TTL signal levels. With no signal attached the ARM input is normally pulled high and is thus continuously armed. When the ARM input is pulled low, the counter is prevented from starting a measurement. Arming may be used in all measurement functions with the exception of TIME MANUAL, PROBE COMP, and TEST. In these three functions the ARM signal must be high.

When the arming signal changes to a high state, the first subsequent Channel A event will start the measurement process. When the arming signal changes to a low state, the next Channel A event will stop the measurement process. Therefore, the counter can be controlled as to when, in time, a measurement will be made (even in complex waveforms).

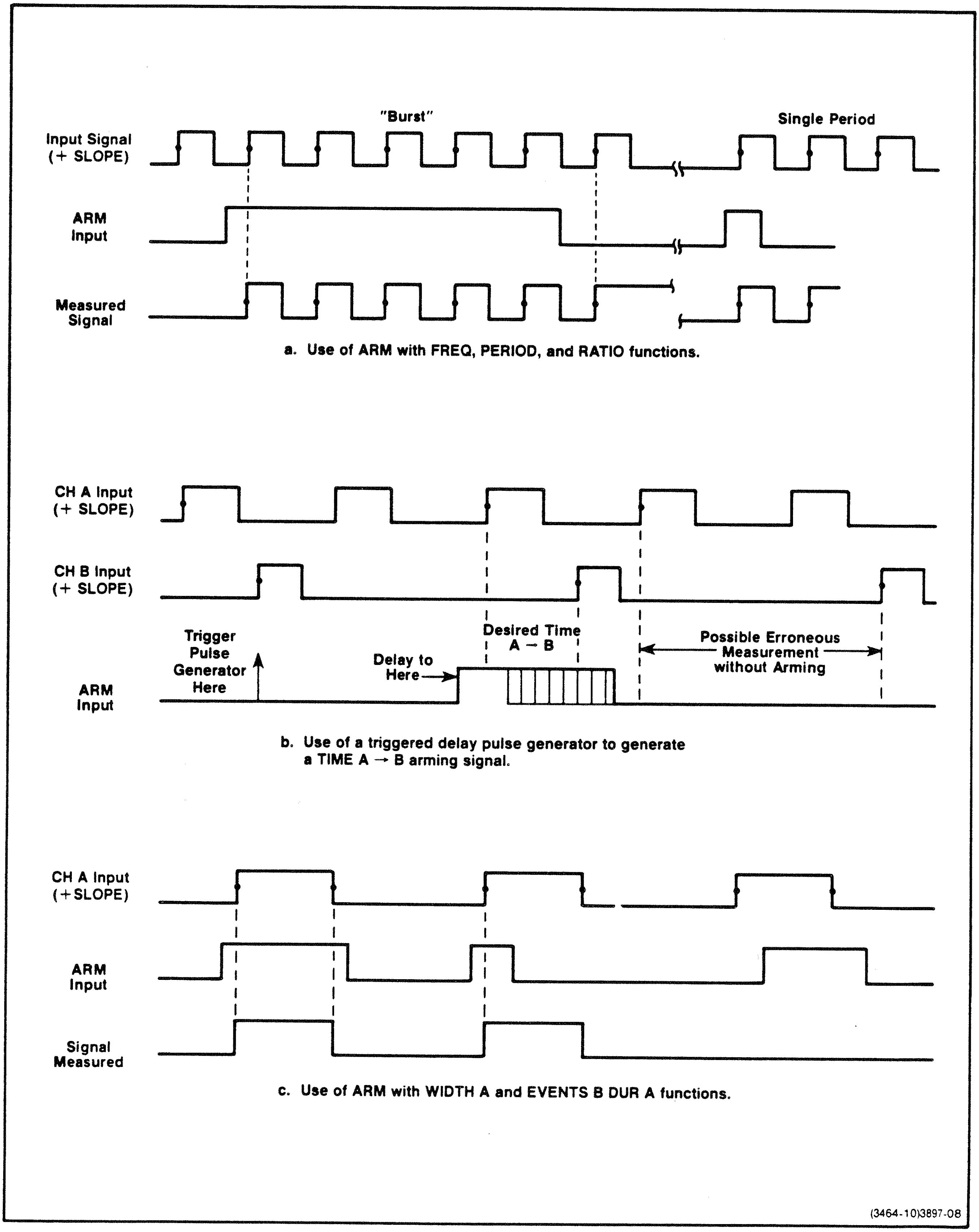

Fig. 2-9. Examples of arming.

These armed measurements can then be averaged much like time interval averaging. The counter determines the number of digits to display (best possible resolution) based on the number of Channel A events averaged. Typically, each total measurement of Frequency, Period, and Ratio contains a 1 count error and the counter displays the number of digits that can be justified given this error. When using arming in the Frequency Period, or Ratio modes (non-time interval modes), each act of arming and disarming can introduce 1 count errors. The counter does not take this into account, however, and displays the number of digits based only on the total number of events per overall measurement, independent of the number of times the instrument was armed and disarmed.

The actual resolution for a period measurement using arming will be less than that displayed. It can be found using the following relationship:

$$\text{Resolution} = \frac{T_c}{N} \; \frac{\sqrt{N T_p}}{T_B}$$

T_c = clock period

T_p = input period (CH A)

T_B = time from starting A event to stopping A event

N = number of averages, i.e., 10^6 or 10^9, etc.

PROGRAMMING

Introduction

This section of the manual provides information for programming the DC 5010 by remote control via the IEEE-488 General Purpose Interface Bus (GPIB). The following information assumes the reader is knowledgeable in GPIB communication and has some exposure to programming controllers. Communication via the GPIB is specified and described in the IEEE Standard 488-1978, "Standard Digital Interface for Programmable Instrumentation"[1] All GPIB references in this manual refer to the IEEE-488 GPIB. TM 5000 instruments are designed to communicate with any GPIB-compatible controller that sends and receives ASCII messages (commands) over the GPIB. These commands program the instrument or request information from the instrument.

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

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

Instrument commands are presented in three formats:

- A front panel illustration—showing command relationships to front panel operation (see Fig. 2-10).
- 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 Installation and Removal earlier in this section for information on installing the instrument in the power module. Also, review the Front Panel Operation portions of this section to become familiar with front panel and internally selectable instrument functions. The GPIB primary address for this instrument may be internally changed by qualified service personnel. The DC 5010 is shipped with the address set to decimal 20. The message terminator may also be internally selected by qualified service personnel. Message terminators are discussed in Messages and Communication Protocol (in this section). TM 5000 instruments are shipped with this terminator set to EOI ONLY. Refer qualified service personnel to the Maintenance section of this manual for locations and setting information. Pressing the INST ID button causes the instrument to display its selected GPIB primary address; the far right decimal point lights if the selected message terminator is LF/EOI.

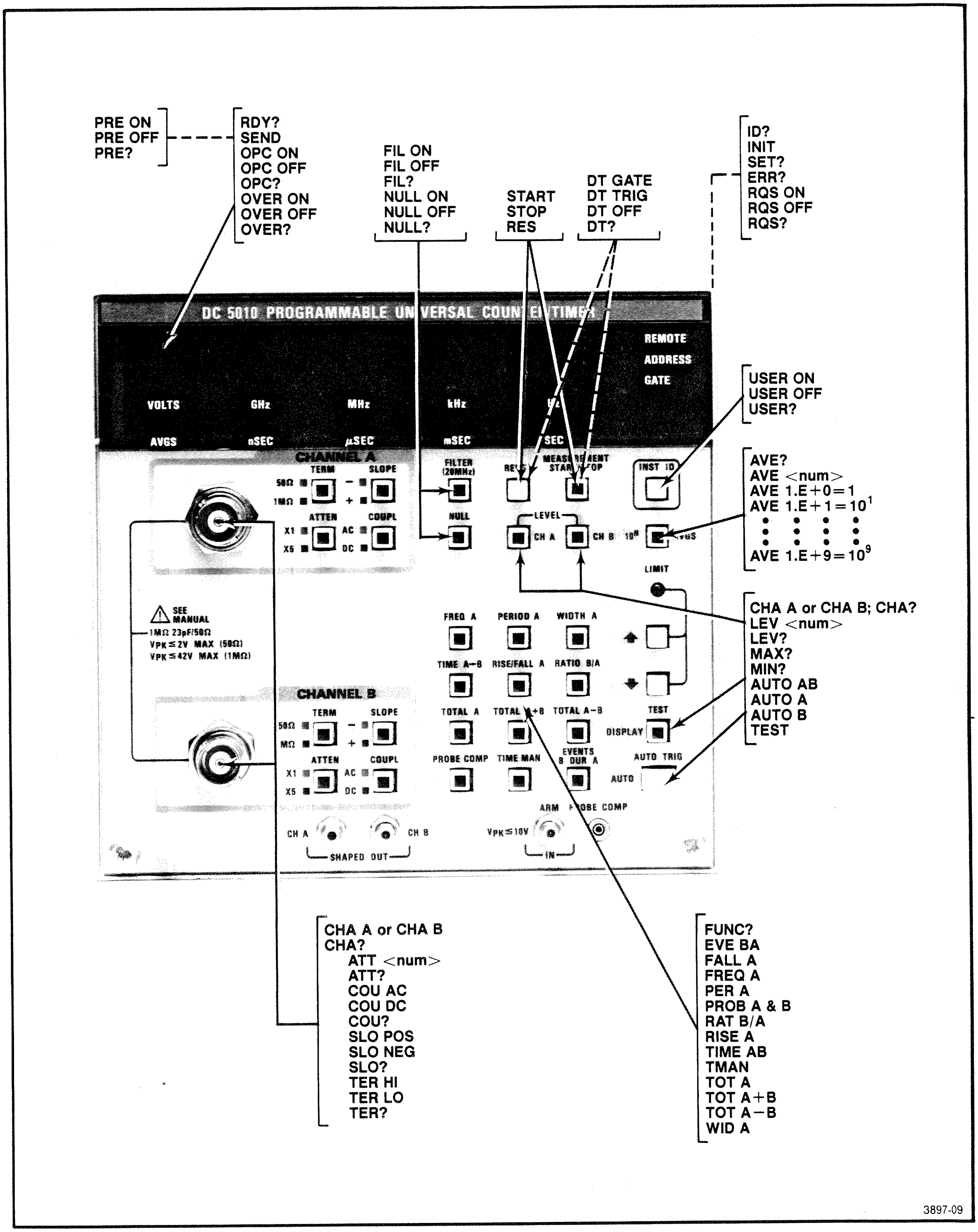

Fig. 2-10. Quick command list.

COMMANDS

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

Setting commands—control instrument settings.

Query-output commands—ask for data.

Operational commands—cause a particular action.

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

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

CAUTION

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

FUNCTIONAL COMMAND LIST

INSTRUMENT COMMANDS

Function Commands

EVE BA	– Counts Channel B during Channel A pulse width
FALL A	– Measures the falltime of the signal on Channel A
FREQ A	– Measures frequency of input signal on Channel A
FUNC?	– Query returns current instrument function
PER A	– Measures period of Channel A signal
PROB A&B	– Enables probe compensation
RAT B/A	– Measures ratio of B events to A events
RISE A	– Measures the risetime of the signal on Channel A
TEST	– Tests ROM, I/O, accumulator
TIME AB	– Measures time from A event to B event
TMAN	– Manual timing function (stop watch)
TOT A	– Totalizes Channel A events
TOT A+B	– Measures the total number of events on Channel A plus the total of events on Channel B
TOT A–B	– Measures the total number of events on Channel A minus the total number of events on Channel B
WID A	– Measures pulse width of Channel A signal

Measurement Control

AVE or AVGS	– Sets number of measurements averaged (in decades only), or auto averaging
AVE? or AVGS?	– Query returns AVE <num>; (–1 for AUTO Averages)
NULL ON	– Subtracts present measurement results from all succeeding measurements
NULL OFF	– Resets Null value
NULL ?	– Query returns NULL ON or NULL OFF
RDY?	– Query returns RDY 1 for new data ready or RDY 0 for new data not ready
RES	– Resets counters, restarts current measurement
START	– Starts TMANual, STOPped, or TOTalize measurement
STOP	– Stops any measurement except TEST or PROBECOMP

INPUT/OUTPUT CONTROL

ATT 1 or 5	– ×1 or ×5 Attenuation
ATT?	– Query returns ATT <num>
AUTO A	– Sets trigger level to signal midpoint (CH A)
AUTO B	– Sets trigger level to signal midpoint (CH B)
AUTO A&B	– Sets trigger level to signal midpoint (Both channels)
CHA A or B	– Selects channel for succeeding input settings
CHA?	– Query returns CHA A or CHA B
COU AC or DC	– Sets input coupling mode
COU?	– Query returns COU AC or COU DC
FIL ON	– Limits the channel A and B bandwidth to approximately 20 MHz
FILL OF	– Turns off filter
FIL ?	– Query returns FIL ON at FIL OFF
LEV	– Sets selected channel trigger level Num range = +2.000 to −2.000 (×1) or +10.000 to −10.000 (×5)
LEV?	– Query returns trigger level setting of selected channel
MAX?	– Query returns last AUTOtrig maximum peak voltage
MIN?	– Query returns last AUTOtrig minimum peak voltage
PRE ON	– Enables prescaler and internal scaling
PRE OFF	– Disables prescaler and internal scaling
PRE?	– Query returns PRE ON or PRE OFF
SEND	– Obtains and formats new measurement results
SLO POS	– Triggers on positive slope
SLO NEG	– Triggers on negative slope
SLO?	– Query returns SLO NEG or SLO POS
TER HI	– Sets channel input to termination 1 megohm, 23 pF
TER LO	– Sets channel input termination to 50 Ω
TER?	– Query returns TER HI or TER LO

SYSTEM COMMANDS

DT GATE	– <GET> controls Start and Stop
DT TRIG	– <GET> performs RESET
DT OFF	– Disables Device Trigger
DT?	– Query returns DT TRIG, DT OFF, or DT GATE
ERR?	– Returns error code for most recent event reported by serial poll when RQS is ON; with RQS OFF it returns the highest priority status
ID?	– Query returns instrument type and firmware versions
INIT	– Initializes instrument to power-on settings
SET?	– Query returns current instrument settings
TEST	– Tests ROM, I/O, accumulator

STATUS COMMANDS

OPC ON	– Enables assertion of SRQ on OPERATION COMPLETE
OPC OFF	– Disables SRQ on OPERATION COMPLETE
OPC?	—Query returns OPC ON or OPC OFF
OVER ON	—Enables asserting of SRQ on counter overflow
OVER OFF	—Disables SRQ on counter overflow
OVER?	—Query returns OVER ON or OVER OFF
RQS ON	—Enables SRQ assertion
RQS OFF	—Disables SRQ assertion and clears SRQ
RQS?	—Query returns RQS ON or RQS OFF
USER ON	—Enables asserting of SRQ when INST ID button is pushed
USER OFF	—Disables asserting of SRQ when INST ID is pushed
USER?	—Query returns USER ON or USER OFF

DETAILED COMMAND LIST

ATTENUATION

Type:

Setting or Query

Setting Syntax:

ATT <number>

Examples:

ATT .999999
ATT 5.00001
ATTENUATION 1

Query Syntax:

ATT?

Query Response:

ATT 1;
ATT 5;

Discussion:

The ATTENUATION command sets the input signal attenuation for the selected channel to ×1 (no attenuation) or ×5. The argument is rounded to an integer and if it is not a 1 or a 5 an execution error (ERR 205) is issued indicating the argument is out of range.

The power-on initial setting is ATT 1.

For information on selecting channels see discussion of the CHANNEL command.

AUTOTRIG

Type:

Operational

Syntax:

AUTO A
B
A&B (argument is optional)

Examples:

AUTO
AUTO A
AUTOTRIG A&B

Discussion:

The AUTOTRIG command causes the DC 5010 to automatically set the trigger levels for channels to the approximate midpoints of the input signals. The maximum and minimum peak values for both channels are saved and may be read out using the MAX? and MIN? queries. The AUTOTRIG command accepts the following valid arguments:

A — Automatically sets trigger level for Channel A only. Saves minimum and maximum peak values for both channels.

B — Automatically sets trigger level for Channel B only. Saves minimum and maximum peak values for both channels.

A&B — Automatically sets trigger levels for both channels. Also saves minimum and maximum peak values for both channels.

If no argument is specified, AUTO A&B is assumed.

When an AUTOTRIG is performed, previously set trigger levels for affected channels are replaced by the new values. These new values may not be at the midpoints if the input signals are outside the range of the instrument. Previously measured minimum and maximum peak values for both channels are always replaced.

The time required for the AUTOTRIG operation to complete is dependent on both Channel A and Channel B amplitudes and frequencies. Worst case time is approximately 2.5 seconds.

The following command sequence causes an AUTO TRIGGER to be performed and the resulting trigger levels to be output when the AUTOTRIG completes:

AUTO;CH A;LEV?;CH B;LEV?

AVERAGES

Type:

Setting or Query

Setting Syntax:

AVE <number>
or
AVGS <number>

Examples:

AVE −1
AVGS 1.E+2
AVERAGES 100

Query Syntax:

AVE? or AVGS?

Query Response:

AVE −1;
AVE 1.E+4;

Discussion:

The AVERAGES command sets the minimum number of events to be counted on Channel A before calculating measurement results. Valid <number> arguments are:

<number> $\leqslant 0$ – Sets DC 5010 to "auto-averages" mode. In "auto-averages", the instrument accumulates counts for ≈.3 seconds.

When in "auto-averages" query returns AVE −1.

<number> = 1, 1.E+1, 1.E+2, 1.E+3, 1.E+4, 1.E+5, 1.E+6, 1.E+7, 1.E+8, 1.E+9.

The argument <number> is first rounded to the nearest power of ten. If the resulting value is not one of the above valid values, the averages setting is left unchanged and an execution error (ERR 205) is issued.

The AVERAGES setting is also used to scale the displayed results for TOTALIZE measurements. Results output to the IEEE-488 bus, however are not scaled.

The power-on initial settings is AVE −1.

CHANNEL (CHANNEL SELECT)

Type:

Setting or Query

Setting Syntax:

CHA A
B

Examples:

CHANNEL A
CHA B

Query Syntax:

CHA?

Query Response:

CHA A;
CHA B;

Discussion:

The CHANNEL command selects the channel that the subsequent input setting commands affect. The input settings commands are SLOPE, SOURCE, ATTENUATION, COUPLING, and LEVEL. Valid arguments are:

A — Channel A is affected by input setting commands.

B — Channel B is affected by input setting commands.
The power-on initial setting is CHA A.

COUPLING

Type:

Setting or Query

Setting Syntax:

COU AC
DC

Examples:

COUPL AC
COU DC

Query Syntax:

COU?

Query Response:

COU AC;
COU DC;

Discussion:

The COUPLING command sets the input signal coupling for the selected channel. Valid arguments are:

AC — Select ac coupling for input signal.

DC — Select dc coupling for input signal.

When switching from DC Coupling to AC Coupling or when the dc level of an input signal changes and the signal is ac coupled, the following settling times are required:

×1 probe connected — 1.0 seconds
×5 probe connected — 2.5 seconds
×10 probe connected — 5.0 seconds

The above times specify the time until the Coupling capacitor is charged to within 1% of its final value and assumes the source has a very low impedance.

The power-on initial setting is COU DC.

For information on selecting channels see discussion of the CHANNEL command.

DT (DEVICE TRIGGER)

Type:

Setting or Query

Setting Syntax:

DT GATE
TRIG
OFF

Examples:

DT GATE
DT TRIG
DT OFF

Query Syntax:

DT?

Query Response:

DT GATE
DT TRIG
DT OFF

Discussion:

The DT command controls the instrument's response to the GROUP EXECUTE TRIGGER <GET> interface message. The valid arguments are:

GATE — In this Device Trigger mode, <GET> controls the STARTing and STOPping of the measurement. If measurement is STOPped, <GET> will START measurement. When STARTed, <GET> will STOP the measurement.

TRIG — In this Device Trigger mode, <GET> causes a measurement RESET to be performed. If the measurement is already STARTed, this causes it to be reset and restarted. If the measurement is currently STOPped, this causes a single measurement to be initiated.

OFF — In this mode a <GET> causes instrument to issue an execution error (ERR 206).

The power on initial setting is DT OFF.

ERROR

Type:

Query

Syntax:

ERR?
ERROR?

Response:

ERR <number>;

Discussion:

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

If RQS is ON, the ERROR query returns an event code <number> describing why the RQS bit was set in the last Status Byte reported by the instrument. The event code is then reset to 0.

If RQS is OFF, the ERROR query returns an event code <number> describing the highest priority condition currently pending in the instrument. This event code is then cleared and another ERROR query will return the event code for the next highest priority condition pending.

EVENTS (EVENTS B DURING A)

Type:

Operational

Syntax:

EVE BA (argument is optional)

Examples:

EVENTS BA
EVE

Discussion:

The EVENTS command sets up the DC 5010 to measure the total number of events occurring on Channel B during the pulse width of the input signal on Channel A.

FALLTIME

Type:

Operational

Syntax:

FALL A (argument is optional)

Examples:

FALL
FALLTIME A

Discussion:

The FALLTIME command sets up the instrument to measure the falltime of the input signal on Channel A. CHANNEL A SLOPE is automatically set to – and the CHANNEL B ATTEN, COUPL, SLOPE, and TERM settings are updated to match those of CHANNEL A. The CHANNEL A input signal is internally routed through both Channels A and B input circuits and then the 90% and 10% trigger level points are determined and set.

The Falltime function uses the autotrigger operation to determine the 10% and 90% points. Therefore, the trigger levels and the minimum and maximum peak values are affected by Falltime measurements.

FILTER

Type:

Setting

Syntax:

FIL ON
OFF

Examples:

FIL ON
FILTER OFF

Query Syntax:

FIL?

QUERY Response:

FIL ON:
FIL OFF:

Discussion:

The FILTER command controls the setting of the high frequency noise filter. Valid arguments are:

ON — Sets high frequency noise filter to limit bandwidth of both channels to 20 MHz.

OFF — Resets high frequency noise filter to allow full 350 MHz bandwidth.

The power-on initial setting is FIL OFF

@

FREQUENCY

Type:

Operational

Syntax:

FREQ A (argument is optional)

Examples:

FREQUENCY A
FREQ

Discussion:

The FREQUENCY command sets up the DC 5010 to measure the frequency of the input signal on Channel A.

This is the power-on function setting.

FUNCTION

Type:

Query

Syntax:

FUNC?
FUNCTION?

Response:

EVE BA;
FALL A;
FREQ A;
PER A;
RAT B/A;
TIME AB;
TMAN;
TOT A;
TOT A+B;
TOT A−B;
WID A;
PROB A&B;
RISE A;
TEST;

Discussion:

The FUNCTION query returns one of the responses shown above. The response indicates the measurement function currently selected.

IDENTIFY

Type:

Query

Syntax:

ID?
IDENTIFY?

Response:

ID TEK/DC5010,V79.1,Fx.y;

Discussion:

The IDENTIFY query returns the above response where:

TEK/DC 5010	— Identifies the instrument type.
V79.1	— Identifies the version of Tektronix Codes and Format Standard to which the instrument conforms.
Fx.y	— Identifies the firmware version of the instrument, where x.y is a decimal number.

INITIALIZE

Type:

Operational

Syntax:

INIT
INITIALIZE

Discussion:

The INIT command performs a power-on initialization of the instrument's settings. The power-on settings for the DC 5010 are:

FREQ A
AVE −1
FIL OFF
NULL OFF
SLO POS (Channels A&B)
ATT 1 (Channels A&B)
COU DC (Channels A&B)
TERM HI (Channels A&B)
CHA A
OPC OFF
OVER OFF
PRE OFF
DT OFF
USER OFF
RQS ON

In addition, an autotrigger is performed to set the trigger levels. With the maximum and minimum peak values of autotrigger performed, the maximum execution time for the INIT function is 2.5 seconds.

The INIT command does not generate a power-on SRQ nor does it put the instrument in LOCAL mode as a normal power-on does.

LEVEL (TRIGGER LEVEL)

Type:

Setting or Query

Setting Syntax:

LEVEL <number>

Examples:

LEVEL −1.025
LEV 0.005
LEV 7.5

Query Syntax:

LEV?

Query Response:

LEV −1.025;
LEV 0.000;

Discussion:

The LEVEL command sets the trigger level of the previously selected channel to the value specified. The value is expressed in volts and has a range of −2.000 to 2.000 when in ×1 attenuation and −10.000 to 10.000 when in ×5 attenuation. The resolution is 0.004 for ×1 attenuation and 0.020 for ×5 attenuation.

The value is rounded to the nearest step and if this is not within the range of the DC 5010 the trigger level is left unchanged and an execution error (ERR 205) is issued.

For information on selecting Channels, see discussion of the CHANNEL command.

MAXIMUM

Type:

Query

Syntax:

MAX?
MAXIMUM?

Response:

MAX <number>;

Discussion:

The MAX? query returns a value indicating the maximum input signal voltage for the selected channel measured during the last autotrigger cycle. If the signal has changed and/or the input signal conditioning has changed since the last autotrigger, another AUTOTRIG is required to obtain the new MAX values.

An autotrigger cycle occurs for each AUTOTRIG, PROBECOMP, RISE, or FALL operation. The maximum execution time for each operation is 2.5 sec, (1.5 sec, typical).

MINIMUM

Type:

Query

Syntax:

MIN?

Response:

MIN <number>

Discussion:

The MINIMUM? query returns a value indicating the minimum input signal voltage for the selected channel measured during the last autotrigger cycle. If the signal has changed and/or the signal conditioning has changed since the last autotrigger, another AUTOTRIG is required to obtain the new MIN values.

An autotrigger cycle occurs for each AUTOTRIG, PROBECOMP, RISE, or FALL operation. The maximum execution time for each operation is 2.5 sec, (1.5 sec, typical).

NULL

Type:

Operational

Syntax:

NULL ON
NULL OFF

Examples:

NULL ON
NULL OFF

QUERY Syntax:

NULL?

Query Response:

NULL ON;
NULL OFF;

Discussion:

The NULL command controls the storing of measurement results to be subtracted from all subsequent measurements. Valid arguments are:

ON — Store current measurement result and subtract it from all following measurements.

OFF — Reset stored Null value.

The Null value is reset each time the NULL OFF command is executed and each time a FUNCTION COMMAND IS EXECUTED. For Time interval measurement (TIME, WIDTH, RISE, FALL) the Null value is reset to 5.2 nsec to provide compensation for propagation delay time between Channels A and B input circuitry. For all other measurements, the Null value is reset to 0.

The power-on initial setting is NULL OFF.

OPC (OPERATION COMPLETE)

Type:

Setting or Query

Setting Syntax:

OPC ON
OFF

Examples:

OPC ON
OPC OFF

Query Syntax:

OPC?

Query Response:

OPC ON;
OPC OFF;

Discussion:

The OPC command controls the asserting of SRQ when a measurement is completed. This command allows a controller to start a measurement, and then process some other task while waiting for an SRQ to inform it that measurement data is ready.

When OPC is ON and a measurement completes, SRQ is asserted and remains asserted until the status is read via a serial poll or until cleared by RQS OFF or a Device Clear. Operation Complete is indicated by a Status Byte of 66 or 82 and an ERROR query response of ERR 402.

For more Status Byte and ERROR information, see "Error and Status Reporting".

The Power on initial setting is OPC OFF.

OVERFLOW

Type:

Setting or Query

Setting Syntax:

OVER ON
OFF

Examples:

OVER ON
OVERFLOW OFF

Query Syntax:

OVER?

Query Response:

OVER ON;
OVER OFF;

Discussion:

The OVERFLOW command controls the asserting of SRQ when the internal counting capacity of the DC 5010 is exceeded. This command allows the controller to detect and to respond to overflow conditions.

When making measurements, the DC 5010 uses two internal 43-bit counters, one for Channel A and one for Channel B.

For EVENTS, FREQUENCY, PERIOD, RATIO, TIME, or WIDTH measurements, OVERFLOW usually indicates that one of the input channels is not set up properly.

For TMANUAL and TOTALIZE measurements, OVERFLOW can easily be used by the controller to extend the range of the measurement. When making TMANUAL measurements, an OVERFLOW indicates that the Channel B counter has counted 2^{43} internal time base pulses ($\approx$87960.9 seconds). When making TOTALIZE measurements, an OVERFLOW indicates that the Channel A counter has counted 2^{43} ($\approx 8.8 \times 10^{12}$) on the Channel A input. For both TMANUAL and TOTALIZE, the measurement result is reset and the measurement continues after an overflow is detected.

PROBECOMP and TEST measurements do not generate overflow conditions.

When OVERFLOW is ON and the instrument's internal capacity is exceeded, SRQ is asserted and remains asserted until the status is read via a serial poll or until cleared by RQS OFF or a Device Clear. Channel A overflow is indicated by a Status Byte of 193 or 209 and an ERROR query response of ERR 711. Channel B overflow is indicated by a Status Byte of 194 or 210 and an ERROR query response of ERR 712.

The power-on initial state is OVER OFF.

PERIOD

Type:

Operational

Syntax:

PER A (argument is optional)

Example:

PERIOD A
PER

Discussion:

The PERIOD command sets up the DC 5010 to measure the period of the input signal on Channel A.

PRESCALE

Type:

Setting or Query

Setting Syntax:

PRE ON
OFF

Examples:

PRESCALE ON
PRE OFF

Query Syntax:

PRE?

Query Response:

PRE ON;
PRE OFF;

Discussion:

The PRESCALE command multiplies the Channel A count by 16 before calculating FREQUENCY, PERIOD, RATIO, and TOTALIZE. This command should be used when a divide by 16 prescaler is attached to Channel A, otherwise erroneous measurements will result. Valid arguments are:

ON — The Channel A input is multiplied by 16 before calculating results.

OFF — The Channel A input is not scaled before the results are calculated.

When the PRESCALE command is used and a compatible prescaler is not connected to the DC 5010 an execution warning (ERR 604) is issued.

The power-on initial setting is PRE OFF.

PROBECOMP (PROBE COMPENSATION)

Type:

Operational

Syntax:

PROBE A&B (argument is optional)

Examples:

PROBECOMP A&B
PROB

Discussion:

The PROBE COMP command sets up the DC 5010 to provide information which can be used to help compensate probes.

This function generates 2-digit results. The most significant digit is the result for Channel A and the least significant digit is the result for Channel B.

The PROBECOMP function uses the autotrigger operation in the compensation process. Therefore, trigger levels and MIN and MAX values will be affected by PROBECOMP measurements.

The autotrigger, used by PROBECOMP, is a fast version of auto, with f_{min} approximately 100 Hz and maximum execution time approximately 0.25 second. This fast auto may be used to quickly update MIN and MAX values for signals greater than 100 Hz.

For more information see description of Probe Compensation in this manual.

RATIO

Type:

Operational

Syntax:

RAT B/A

Examples:

RATIO B/A
RAT

Discussion:

The RATIO command sets up the DC 5010 to measure the ratio of events on Channel B to the events on Channel A.

RDY (DATA READY)

Type:

Query

Syntax:

RDY?

Response:

RDY 0;
RDY 1;

Discussion:

The RDY query returns "data ready" status. If the value returned is 0, measurement data is not currently available. If the value returned is 1, measurement data is available.

When measurement data is not available and the DC 5010 is "talked" by the controller, the instrument responds in one of two ways. If "talked" after receiving the SEND command and data is not ready, the DC 5010 waits for data to become ready and then sends it. If "talked" and the instrument has not received the SEND command and data is not ready, the DC 5010 responds by sending FF_{16} (all data lines asserted).

Data becomes ready when a measurement is completed. It remains ready until the data is read out of the instrument or until an instrument setting, except averages, is changed. Data Ready is also cleared by a RESET.

RESET

Type:

Operational

Syntax:

RES
RESET

Discussion:

The RESET command resets the instrument's count chains and initiates a new measurement. For EVENTS, FALL, FREQUENCY, PERIOD, RATIO, RISE, TIME, OR WIDTH measurements, a single result is determined if the measurement had been "STOPped" before the RESET. For PROBECOMP measurement, RESET clears current compensation status and restarts compensation process. For TMAN and TOTALIZE measurements, counts are reset to zero and a new measurement is restarted if not "Stopped" before the RESET. For TEST measurement, RESET clears any existing error result and restarts TEST process.

RISETIME

Type:

Operational

Syntax:

RISE A (argument is optional)

Examples:

RISETIME A
RISE

Discussion:

The RISETIME command sets up the instrument to measure the risetime of the input signal on Channel A. CHANNEL A SLOPE is automatically set to + and the CHANNEL B ATTEN, COUPL, SLOPE, and TERM settings are updated to match those of CHANNEL A. The CHANNEL A input signal is internally routed through both Channels A and B input circuits, and then the 10% and 90% trigger level points are determined and set.

The Risetime function used the autotrigger operation to determine the 10% and 90% points. Therefore, the trigger levels and the minimum and maximum peak values are affected by Risetime measurements.

RQS (REQUEST FOR SERVICE)

Type:

Setting or Query

Setting Syntax:

RQS ON
OFF

Examples:

RQS ON
RQS OFF

Query Syntax:

RQS?

Query Response:

RQS ON;
RQS OFF;

Discussion:

The RQS command is a global control for assertion of SRQ by the DC 5010. When RQS is OFF the DC 5010 will not assert SRQ under any circumstance. When RQS is ON the DC 5010 is allowed to assert SRQ under appropriate circumstances; i.e., errors, operation complete, etc.

The ERROR? query can be used while RQS is OFF to see if any SRQ type conditions have occurred.

SRQ will be asserted for any previously unreported SRQ event when RQS is turned ON after being OFF.

The power-on initial setting is "RQS ON".

SEND

Type:

Output

Syntax:

SEND

Output Examples:

45.13755019E+6;	(Frequency)
3.0018E-6;	(Period)
01;	(Probecomp)
395;	(Test)
1977249.;	(Totalize)

Discussion:

The SEND command formats available data for output. Data is available when a completed measurement result has not previously been output. If no data is available the SEND command causes the DC 5010 to wait for the current measurement to complete and then formats the result.

SETTINGS

Type:

Query

Syntax:

SET?
SETTINGS?

Response:

<function>;CHA A;ATT <num>;COU xx;SLO xx; TERM xx;LEV <num>;CHA B;ATT <num>;COU xx; SLO xx;TERM xx;LEV <num>;AVE <num>;OPC xx; OVER xx;PRE xx;FIL xx;NULL xx;DT xx; USER xx; RQS xx;

Example Response:

FREQ A;CHA A;ATT 1;COU DC;SLO POS;TERM HI;
LEV 1.500;CHA B;ATT 5;COU AC;SLO NEG;TERM LO;
LEV −5.000;AVE −1;OPC OFF;OVER ON;PRE OFF;
FIL OFF;NULL OFF:DT OFF;USER OFF;RQS ON;

Discussion:

The SETTINGS query returns the current settings of the instrument.

The SETTINGS query response may then be used at a later time to reset the instrument back to those settings.

SLOPE

Type:

Setting or Query

Setting Syntax:

SLO NEG
POS

Examples:

SLO POSITIVE
SLOPE POS
SLOPE NEGATIVE
SLO NEG

Query Syntax:

SLO?

Query Response:

SLO POS;
SLO NEG;

Discussion:

The SLOPE command sets the input trigger for the selected channel to the specified slope. The valid arguments are:

NEG — Input will trigger on negative going edge.
POS — Input will trigger on positive going edge.

The power-on initial setting is SLO POS.

For information on selecting channels see discussion of the CHANNEL command.

START

Type:

Operational

Syntax:

START

Discussion:

The START command starts a TMANUAL or TOTALIZE A, TOTALIZE A+B, TOTALIZE A−B, measurement. For EVENTS, FALL, FREQUENCY, PERIOD, RATIO, RISE, TIME, or WIDTH measurements, START restarts measurement if STOPped.

STOP

Type:

Operational

Syntax:

STOP

Discussion:

The STOP command stops all measurements except TEST and PROBECOMP. The STOP command is ignored when TEST or PROBECOMP measurements are being made.

When FALL, FREQUENCY, PERIOD, RATIO, RISE, TIME, WIDTH, or EVENTS measurements are STOPped, the measurement in process is aborted.

When TMANUAL or TOTALIZE measurements are STOPped, the current result is retained and the measurement can be restarted from the point where stopped.

TERMINATION

Type:

Setting

Syntax:

TER HI
TER LO

Examples:

TER HI
TERM LOW
TERMINATION HIGH

Query Syntax:

TER?

Query Response:

TER HI;
TER LO

Discussion:

The TERMINATION command sets the input termination for the selected channel to the specified setting. Valid arguments are:

HI — Set input termination to 1 MΩ, 23 pF
LO — Set input termination to 50 Ω

When the Termination setting is LO (50 Ω) and an overly large input signal (greater than 2 volts at ×1 attenuation) is detected, the instrument automatically switches the Termination from LO to HI.

If the Termination is automatically switched from LO to Hi, SRQ is asserted and remains asserted until the status is read via a serial poll or until cleared by RQS OFF or device clear. Channel A "50 Ω protect" is indicated by a Status Byte of 102 or 118 and an ERROR query response of 602. Channel B "50 Ω protect" is indicated by a Status Byte of 102 or 118 and an ERROR query response of 603.

The power-on initial setting is TERM HI.

For information on selecting channels, see the discussion of the CHANNEL command.

TEST

Type:

Operational

Syntax:

TEST

Discussion:

The TEST command sets up the instrument to perform repetitive self tests. The tests performed are the ROM tests, Serial I/O Hardware Test, and the Counter Hardware Integrity Test.

The tests performed by the TEST command are the same as those tests performed during the power-on self test sequence, with the exception of the instrument RAM tests. The RAM tests are only performed during power-on.

If a failure is detected by any of the tests, the test sequence is halted. The sequence is restarted when the instrument executes another TEST command or a RESET command.

The results of each TEST sequence are made available to be output by the instrument. A result of 0 indicates that no failures were detected. If a failure is detected, the value generated for output is the same as the error code that is displayed for power-on self test failures.

See section on "Error and Status Reporting".

TIME (TIME A TO B)

Type:

Operational

Syntax:

TIME AB (argument is optional)

Examples:

TIME
TIME AB

Discussion:

The TIME command sets up the DC 5010 to measure the time interval from the first occurrence of an event on Channel A to the occurrence of the first succeeding event on Channel B.

TMANUAL (TIME MANUAL)

Type:

Operational

Syntax:

TMAN
TMANUAL

Discussion:

The TMANUAL command sets up the DC 5010 to measure time in a "stop watch" type operation. Measurement is started by the "START" command and is halted by the "STOP" command. If in "DT GATE" mode, TMANUAL operation is started and stopped alternately using the Group Execute Trigger <GET> interface message.

See discussions of START, STOP, and DT commands.

See discussion of <GET> in Sending IEEE Interface Control Messages in this section.

TOTALIZE

Type:

Operational

Syntax:

TOT A (argument is optional)
A+B
A−B

Examples:

TOTALIZE A+B
TOT A−B
TOT A

Discussion:

This command sets up the DC 5010 to measure and calculate the total number of events on the specified channel or channels. The measurement is started by the "START" command and stopped by the "STOP" command. If in "DT GATE" mode, TOTALIZE operation is started and stopped alternately using the Group Execute Trigger <GET> interface message.

In the A+B and A−B modes, the DC 5010 will only count B events after the first valid A event.

If no argument is specified, TOT A is assumed.

See discussions of START, STOP, and DT commands.

See discussion of <GET> in sending in IEEE Interface Control Messages in this section.

USEREQ (USER REQUEST)

Type:

Setting or Query

Setting Syntax:

USER ON
OFF

Examples:

USER ON
USEREQ OFF

Query Syntax:

USER?

Query Response:

USER ON;
USER OFF;

Discussion:

The USEREQ command controls the asserting of SRQ when the front panel INST ID button is pushed. This provides a communication capability between the instrument and a controller that can be initiated from the front panel of the instrument.

When USER is ON and the INST ID button is pushed, SRQ is asserted and remains asserted until the status is read via a serial poll or until cleared by RQS OFF or a Device Clear. The User Request is indicated by a Status Byte of 67 or 83 and an ERROR query response of ERR 403.

The power-on initial setting is USER OFF.

WIDTH

Type:

Operational

Syntax:

WID A (argument is optional)

Examples:

WIDTH A
WID

Discussion:

This command sets up the DC 5010 to measure the pulse width of the input signal on Channel A. The slope setting of Channel A determines whether positive going pulse width or negative-going pulse width is measured.

MESSAGES AND COMMUNICATION PROTOCOL

Command Separator

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

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

Message Terminator

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

Formatting A Message

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

The instruments expect all commands to be encoded in ASCII; however, they accept both upper and lower case ASCII characters. All data output is in upper case (see Fig. 2-11).

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.

$RQS_{SP}ON$

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

Example 1: $RQS_{SP}ON;$

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

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

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

USER?
USERE?
USEREQ?
USEREQUEST?

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

2,3

$2_{SP}3$

$2,_{SP}3$

NOTE

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

Number Formats

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

- Signed or unsigned integers (including +0 and −0). Unsigned integers are interpreted as positive. Examples: +1, 2, −1, −10
- Signed or unsigned decimal numbers. Unsigned decimal numbers are interpreted to be positive. Examples: −3.2, +5.0, 1.2
- Floating point numbers expressed in scientific notation. Examples: +1.0E-2, 1.0E-2, 0.01E+0

ASCII & IEEE 488 (GPIB) CODE CHART

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

ADDRESSED COMMANDS

UNIVERSAL COMMANDS

LISTEN ADDRESSES

TALK ADDRESSES

SECONDARY ADDRESSES OR COMMANDS

KEY TO CHART

octal — 25 PPU — GPIB code

NAK — ASCII character

hex — 15 (21) — decimal

3888-24

Fig. 2-11. ASCII and IEEE 488 (GPIB) code chart.

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

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

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

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

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

Multiple Messages

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

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

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

One other situation may cause the instrument to delete output. The execution of a long message might cause both the Input and Output buffers to become full. When this occurs, the instrument cannot finish executing the message because it is waiting for the controller to read the data it has generated; but the controller cannot read the data because it is waiting to finish sending its message. Because the instrument's Input buffer is full and it is holding off the rest of the controllers message with NRFD, the system is hung up with the controller and instrument waiting for each other. When the instrument detects this condition, it generates an error, 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 which specifies what it should output. In this case, acquisition instruments (counters and digital multimeters) return a measurement if one is ready. If no measurement is ready, they return a single byte message with all bits equal to 1 (with message terminator); other TM 5000 instruments will return only this message.

Instrument Response to IEEE-488 Interface Messages

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

UNL—Unlisten
UNT—Untalk

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

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

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

IFC—Interface Clear

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

DCL—Device Clear

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

SDC—Selected Device Clear

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

GET—Group Execute Trigger

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

SPE—Serial Poll Enable
SPD—Serial Poll Disable

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

MLA—My Listen Address
MTA—My Talk Address

The primary listen and talk addresses are established by the instruments GPIB address (internally set). The current setting of the GPIB address is displayed on the front panel when the INST ID button is pressed.

LLO—Local Lockout

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

REN—Remote Enable

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

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

GTL—Go To Local

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

Remote-Local Operation

The preceding discussion of interface messages describes the state transitions caused by GTL and REN. Most front panel controls cause a transition from REMS to LOCS by asserting a message called return-to-local (*rtl*). This transition may occur during message execution; but in contrast to GTL and REN transitions, a transition initiated by *rtl* does affect message execution. In this case, the instrument generates an error if there are any unexecuted setting or operational commands. Front panel controls that only change the display (like ID) do not affect the remote-local states—only front panel controls that change settings assert *rtl*. *Rtl* is unasserted after processing the front panel control change.

Local State (LOCS)

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

Local With Lockout State (LWLS)

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

Remote With Lockout State (RWLS)

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

Remote State (REMS)

In this state, the instrument executes all instrument commands. Changing a front panel control, except trigger level controls, generates an *rtl* and causes the instrument to return to local (LOCS).

STATUS AND ERROR REPORTING

Through the Service Request function (defined in the IEEE-488 Standard), the instrument may alert the controller that it needs service. This service request is also a means of indicating that an event (a change in status or an error) has occurred. To service a request the controller performs a Serial Poll; in response the instrument returns a Status Byte (STB) which indicates whether it was requesting service or not. The STB can also provide a limited amount of information about the request. The format of the information encoded in the STB is given in Table 2-2. When data bit 8 is set, the STB conveys Device Status information which is indicated by bits 1 through 4.

Table 2-2
DEFINITION OF STATUS BYTE BITS

- Bit 8: If 0, STB indicates event class; If 1, STB indicates device status
- Bit 7: 1 if requesting service
- Bit 6: 1 indicates an abnormal event
- Bit 5: 1 if message processor is busy
- Bits 4, 3, 2, 1: Define events

Status Byte (Example)	DATA BITS 8	7	6	5	4	3	2	1	DECIMAL Not Busy	Busy
Power On	0	1	0	X	0	0	0	1	65	81
Channel A overflow	1	1	0	0	0	0	0	1	193	209
Channel B overflow	1	1	0	0	0	0	1	0	194	210

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

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

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

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

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

EXECUTION WARNING The instrument is operating but the user should be aware of potential problems.

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

DEVICE STATUS Device dependent events.

The instrument can provide additional information about many of the events, particularly the errors reported in the Status Byte. After determining that the instrument requested service (by examining the STB) the controller may request the additional information by sending an error query (ERR?). In response, the instrument returns a code which defines the event. These codes are described in Table 2-3.

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

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

Table 2-3
BUS ERROR CODES AND SERIAL POLL RESPONSE

Description	Error Query Response	Serial Poll[a] (Decimal)
Command Errors		
Command header error	101	97
Header delimiter error	102	97
Command argument error	103	97
Argument delimiter error	104	97
Nonnumeric argument (numeric expected)	105	97
Missing argument	106	97
Invalid message unit delimiter	107	97
Execution Errors		
Command not executable in Local	201	98
Settings lost due to "rtl"	202	98
I/O buffers full, output dumped	203	98
Argument out of range	205	98
Group execute trigger ignored	206	98
Internal Errors		
Interrupt fault	301	99
System error	302	99
System Events		
Power on[b]	401	65
Operation Complete	402	66
User request	403	67
Device Warnings		
Channel A 50 Ω protect	602	102
Channel B 50 Ω protect	603	102
No prescaler	604	102
Device Dependent Events		
Channel A overflow	711	193
Channel B overflow	712	194
No Errors or Events	0	0
Data not ready	0	128
Data ready	0	132

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

[b]See Table 2-2 for example.

RQS OFF inhibits all SRQ's (except power-on event) so in this mode the ERR? query allows the controller to find out about events without first performing a Serial Poll. With RQS OFF, the controller may send the ERR? query at any time and the instrument returns an event waiting to be reported (see Table 2-4). The controller can clear all events by sending the error query until a zero (0) code is returned, or clear all events except power-on through the DCL interface message.

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

Table 2-4
FRONT PANEL DISPLAY ERROR CODES

Serial I/O Fault	313
Channel A	
Counter Integrity	320-324, 329
Channel B	
Counter Integrity	330-334, 339
System RAM Error U1410	340
System RAM Error U1610	341
System RAM Error U1311	342
ROM placement error U1610	361
ROM placement error U1102	374
ROM placement error U1201	375
ROM checksum error U1410	380
ROM checksum error U1610	381
ROM checksum error U1102	394
ROM checksum error U1201	395

SENDING INTERFACE CONTROL MESSAGES

Bus communications are performed through use of the controller input and output statements. ASCII commands are transmitted using the PRINT statements. The DC 5010 is factory set to address 20.

PRINT @ 20:"SET?;"

ASCII replies are received by the controller using input statements.

INPUT @ 20:A$

Bus interface control messages are sent as low level commands through the use of WBYTE controller commands. For the following commands A = 32 plus the instrument address and B = 64 plus the instrument address.

Listen	WBYTE @ A:
Unlisten	WBYTE @ 63:
Talk	WBYTE @ B:
Untalk	WBYTE @ 95:
Unlisten-untalk	WBYTE @ 63, 95:
Device clear (DCL)	WBYTE @ 20:
Selective device clear (SDC)	WBYTE @ A, 4:
Go to local (GTL)	WBYTE @ A, 1:
Remote with lockout	WBYTE @ A, 17, 63:
Local lockout of instruments	WBYTE @ 17:
Group execute trigger (GET)	WBYTE @ A, 8:

These commands are for the TEKTRONIX 4050-Series controllers and representative for other controllers.

A programming guide for Tektronix controllers, such as the 4052 Graphic Computing System, is available. This guide contains programming instructions, tips, and example programs for use with this instrument. Ask your Tektronix Sales Engineer for a copy or order the GPIB Programming Guide, Tektronix Part No. 070-3985-00.

POWER ON SETTINGS

At power-on the instrument's settings are initialized as indicated in Table 2-5.

In addition, an autotrigger is performed to set the trigger levels and to set the maximum and minimum peak values.

Table 2-5
POWER ON SETTINGS

Header	Argument
FREQ	A
AVG −1	AUTO
SLO (CHA & B)	POS
ATT (CHA A & B)	X1
COU (CHA A & B)	DC
TER (CHA A & B)	HI
FIL	OFF
PRE	OFF
CHA	A
OPC	OFF
OVER	OFF
DT	OFF
USER	OFF
RQS	ON

EXAMPLE PROGRAMS

TALKER LISTENER PROGRAMS

These 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 4050-Series Controllers

```
100 REM DC5010 TALKER/LISTENER PROGRAM
110 REM DC5010 PRIMARY ADDRESS = 20
120 INIT
130 ON SRQ THEN 260
140 DIM A$(200)
150 PRINT "ENTER MESSAGE(S): ";
160 INPUT C$
170 PRINT @20:C$
180 REM CHECK FOR QUERIES
190 IF POS(C$,"?",1)<>0 THEN 220
200 REM CHECK FOR 'SEND'
210 IF POS(C$,"SEND",1)=0 THEN 150
220 REM INPUT FROM DEVICE
230 INPUT @20:A$
240 PRINT A$
250 GO TO 150
260 REM SERIAL POLL ROUTINE
270 POLL X,Y;20
280 PRINT "STATUS BYTE: ";Y
290 RETURN
```

Talker Listener Program For 4040-Series Controllers

```
100 Rem DC5010 TALKER/LISTENER PROGRAM
110 Rem      PRIMARY ADDRESS = 20
120 Init all
130 On srq then gosub srqhdl
140 Enable srq
150 Dim respons$ to 200
160 Input prompt "ENTER MESSAGE(S): ":message$
170 Print #20:message$
180 Rem CHECK FOR QUERIES
190 If pos(message$,"?",1) then goto 260
200 Rem CHECK FOR 'SEND' COMMAND
210 If pos(message$,"SEND",1) then goto 260
220 Rem CHECK FOR 'TEST' COMMAND
230 If pos(message$,"TEST",1) then goto 260
240 Goto 160
250 Rem INPUT FROM DEVICE
260 Input #20:respons$
270 Print "RESPONSE: ";respons$
280 Goto 160
290 Rem SERIAL POLL ROUTINE
300 Srqhdl: poll stb,pri
310 Print "STATUS BYTE: ";stb
320 Resume
330 End
```

PROGRAMMING HINTS

The purpose of this section of the manual is to show how to program the DC 5010 to perform some basic measurement functions and how to take advantage of some of its special programming features.

The following examples are given in 4050-Series BASIC. The implementation details vary from controller to controller.

Changing Input Channel Settings

Before a meaningful measurement can be made, the input signal conditioning settings must be set properly. The following example first sets up the Channel A input signal conditioning. Next the trigger levels are automatically set to their midpoints using the AUTO command and the AVE −1 command sets up the instrument to make measurements at a rate of approximately 3 per second. Finally, the DC 5010 is instructed to make frequency measurements.

```
100 PRINT @20:"CHA A;SLO POS;TERM HI;"
110 PRINT @20:"COU DC;ATT 1;AUTO;"
120 PRINT @20:"AVE -1;FREQ;SEND;"
130 INPUT @20:R
140 PRINT "THE FREQUENCY IS ";R
150 END
```

Although the above example shows all the Channel A input settings being programmed to the desired states, only those settings not already at the desired states need to be programmed.

Making Time Interval Measurement

The following example sets up the instrument to measure the time interval between two TTL level signals connected to the Channel A and Channel B inputs using ×5 probes.

```
200 PRINT @20:"CHA A;SLO POS;TERM HI;"
210 PRINT @20:"ATT 1;COU DC;LEV 0.275;"
220 PRINT @20:"CHA B;SLO POS;TERM HI;"
230 PRINT @20:"ATT 1 COU DC;LEV 0.275;"
240 PRINT @20:"AVE 1;TIME;SEND;"
250 INPUT @20:T
260 PRINT "TIME A TO B IS ";T
270 END
```

Again, only those input channel settings not already at the desired states would have to be programmed.

Making Single Measurements

Single measurements may be made using either of the two methods shown in the following examples. To make a single measurement, the instrument is first set to STOP mode. A RESET then causes a single measurement to be made and then the measurement process is again stopped. The first example shows how to make a single TIME interval measurement using STOP and RESET.

```
300 PRINT @20:"AVE 1;TIME;"
310 PRINT @20:"STOP;RESET;SEND;"
320 INPUT @20:R
330 PRINT "TIME INTERVAL IS ";R
340 END
```

The next example shows how to use Group Execute Trigger <GET> in place of the RESET, to make single measurements. To use <GET>, the instrument's Device Trigger Function must first be enabled using the DT TRIG command. Again, the instrument must be set to STOP mode before the <GET> causes a RESET and a single measurement to be made.

```
400 PRINT @20:"DT TRIG;AVE 1;TIME;"
410 PRINT @20:"STOP;"
420 FOR I=1 TO 200
430 REM  ALLOW TIME FOR COUNTER TO
440 REM  PROCESS PENDING SETTINGS
450 REM  BUFFER
460 NEXT I
470 REM  52 IS LISTEN ADDR. 20 (32+20)
480 REM  8 IS <G.E.T.> IEEE-488
490 WBYTE @52,8:
500 PRINT @20:"SEND;"
510 INPUT @20:R
520 PRINT "TIME INTERVAL IS ";R
530 END
```

Reading Results

There are two basic ways of obtaining measurement data from the DC 5010. The first method shown below uses the SEND command to request a measurement result from the instrument. If a measurement result is available, the DC 5010 will respond immediately when "talked", otherwise it will wait until a result is available before responding.

```
300 PRINT @20:"FREQ;"
310 PRINT @20:"SEND;"
320 INPUT @20:A
330 PRINT "FREQUENCY IS ";A
340 END
```

The other method that may be used to obtain measurement data involves just "talking" the DC 5010 and then reading the results. If a result is available, "talking" the instrument causes the result to be output. If a result is not available, it causes the instrument to output an FF(hex) byte instead. The following example shows how to read out data by just "talking" the instrument and checking for FF(hex).

```
200 PRINT @20:"FREQ;"
210 INPUT @20:A$
220 IF LEN(A$)=0 THEN 210
230 PRINT "FREQUENCY IS ";A
240 END
```

Both the RDY? and OPC commands can be used to determine when measurement data is available to be read out. Data ready status can be queried using the RDY? query command, as in the following example.

```
100 PRINT @20:"PER;"
110 PRINT @20:"RDY?;"
120 INPUT @20:R
130 IF R=0 THEN 110
140 INPUT @20:A
150 PRINT "PERIOD IS ";A
160 END
```

The following example shows how the OPC command allows the Service Request (SRQ) and the Status Byte response (STB) to be used to signal data ready.

```
100 REM  USING OPC INTERRUPT AND
110 REM  STATUS BYTE TO SIGNAL
120 REM  WHEN THE DATA IS READY
130 A=0
140 PRINT @20:"PER;OPC ON;"
150 ON SRQ THEN 220
160 WAIT
170 IF A=0 THEN 160
180 PRINT @20:"SEND;OPC OFF;"
190 INPUT @20:A
200 PRINT "PERIOD IS ";A
210 END
220 POLL D,S;20
230 IF S=66 OR S=82 THEN 260
240 PRINT "SRQ OCCURED, STATUS = ";S
250 GO TO 270
260 A=1
270 RETURN
```

Extending Range Using Overflow

Overflow occurs when the internal 43-bit capacity of the counter is exceeded. By detecting these occurrences of Overflow, the range of Tmanual and Totalize measurements may be extended.

The following example monitors a Totalize measurement watching for the count to reach 1.0E+14, approximately 11 times the counting capacity of the DC 5010. This is done by counting occurrences of Overflow and using this count to extend the precision of the result.

```
1 REM<EXTENDING RANGE USING>
2 REM OVERFLOW - TOTALIZE A
100 C=0
110 PRINT @20:"OVER ON;TOT;START;"
120 ON SRQ THEN 500
130 PRINT @20:"SEND;"
140 INPUT @20:A
150 R=A+C*8.796093022E+12
160 IF R<1.0E+14 THEN 130
170 PRINT "RESULT IS ";R
180 PRINT @20:"OVER OFF;"
190 END
500 POLL D,S;20
510 IF S=193 OR S=209 THEN 540
520 PRINT "SRQ OCCURED, STATUS = ";S
530 RETURN
540 C=C+1
550 RETURN
```

The next example monitors a Tmanual measurement to determine when 24 hours have elapsed. Since 24 hours is equivalent to 86,400 seconds, it exceeds the 27487.8 seconds counting capacity of the DC 5010. By counting the occurrences of Overflow, the precision can be extended to count this amount of time.

```
1 REM<EXTENDING RANGE USING>
2 REM OVERFLOW - TIME MANUAL
100 C=0
110 PRINT @20:"OVER ON;"
120 PRINT @20:"TMAN;START;"
130 ON SRQ THEN 210
140 PRINT @20:"SEND;"
150 INPUT @20:A
160 R=A+C*27487.79069
170 IF R<86400 THEN 140
180 PRINT "RESULT IS ";R
190 PRINT @20:"OVER OFF;"
200 END
210 POLL D,S;20
220 IF S=194 OR S=210 THEN 250
230 PRINT "SRQ OCCURED, STATUS = ";S
240 RETURN
250 C=C+1
260 RETURN
```

Using INST ID Button

Communication between the controller and an instrument operator can be accomplished using the INST ID button and the USER command. The following example allows a front panel operator to compensate probes and then inform the controller that the Probecomp is complete. As shown, the probes can be compensated and the INST ID button used even while the rest of the front panel controls are locked out.

```
1 REM <USING THE INST ID BUTTON>
100 PRINT "COMPENSATE PROBES - ";
110 PRINT "PUSH INST ID BUTTON ";
120 PRINT "WHEN DONE."
130 I=0
140 PRINT @20:"USER ON;PROBE;"
150 REM  GPIB "LLO" IS 17
160 WBYTE @17:
170 ON SRQ THEN 300
180 WAIT
190 IF I=0 THEN 180
200 PRINT @20:"INIT;"
210 PRINT "COMPENSATION DONE."
220 END
300 POLL D,S;20
310 IF S=67 OR S=93 THEN 340
320 PRINT "SRQ OCCURED, STATUS = ";S
330 GO TO 360
340 PRINT "INST ID BUTTON SENSED."
350 I=1
360 RETURN
```

The INST ID button can also be used to inform the controller that the instrument has been set up properly to measure the input signals. Once informed, the controller can then "learn" the current instrument settings, using the SET? query command, and save the setup for later use.

```
800 REM  LEARN SETTINGS
810 PRINT "SET UP THE INSTRUMENT - ";
820 PRINT "PUSH INST ID WHEN DONE."
830 DIM A$(215)
840 I=0
850 PRINT @20:"USER ON;"
860 ON SRQ THEN 940
870 WAIT
880 IF I=0 THEN 870
890 PRINT @20:"SET?;"
900 INPUT @20:A$
910 PRINT "STORED SETTINGS ARE: ";A$
920 PRINT @20:"USER OFF;"
930 END
940 POLL D,S;20
950 IF S=67 OR S=93 THEN 980
960 PRINT "SRQ OCCURED, STATUS = ";S
970 GO TO 990
980 I=1
990 RETURN
```

Duty Cycle Measurement

Duty Cycle measurements can easily be made using a combination of Width and Period measurements. The following example determines the Duty Cycle of the positive going pulse of the Input signal. This example assumes the trigger level is already set to the desired value.

```
400 REM  DUTY CYCLE MEASUREMENT
410 PRINT @20:"CHA A;SLO POS;"
420 PRINT @20:"WID;SEND;"
430 INPUT @20:W
440 PRINT @20:"PER;SEND;"
450 INPUT @20:P
460 D=W/P
470 PRINT "THE DUTY CYCLE IS ";D
480 END
```

Phase Measurement

A combination of Period and Time measurements can be used to make Phase measurements. The following example determines the phase difference between the Channel A and Channel B signals by first measuring the Period of one signal and then using the Time function to measure the time difference between the two signals. The phase angle is then computed using these two measurements. This example assumes that the appropriate signals are connected to input channels A and B and assumes that the trigger levels are set correctly.

```
1 REM <PHASE MEASUREMENT>
100 PRINT @20:"CHA A;SLO POS;"
110 PRINT @20:"CHA B;SLO POS;"
120 PRINT @20:"PER;SEND;"
130 INPUT @20:P
140 PRINT @20:"TIME;SEND;"
150 INPUT @20:T
160 P=T/P*360
170 PRINT "THE PHASE IS ";P
180 END
```

Slew Rate Measurements

Slew Rate measurements can be made using a combination of the RISE and MIN?; MAX? commands. The RISE command measures the risetime between the 10% and 90% points. The signal level difference between the 10% and 90% points is then calculated using the results returned for the MIN? and MAX? query commands. Using the signal level difference and risetime values, the slew rate is determined.

```
400 REM  SLEW RATE
410 PRINT @20:"RISE;SEND;"
420 INPUT @20:R
430 PRINT @20:"CHA A;MIN?;MAX?;"
440 INPUT @20:A1,A2
450 D=(A2-A1)*0.8
460 S=D/R
470 PRINT "SLEW RATE IS ";S
480 END
```

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

1 070-3985-00—GPIB Programming Guide. This manual is specifically written for applications of this instrument in IEEE-488 systems. It contains programming instructions, tips and some specific example programs.

2 070-2270-00—4051 GPIB Hardware Support Manual. This manual gives an indepth discussion of IEEE-488 bus operation, explanations of bus timing details and early bus interface circuitry.

3 070-2058-01—Programming In BASIC

4 070-2059-01—Graphic Programming In BASIC

5 062-5971-01—4050-Series Programming Aids, T1 (includes software)

062-5972-01—4050-Series Programming Aids, T2 (includes software)

6 070-2380-01—4907 File Manager Operators manual

7 070-2128-00—4924 Users manual

8 070-1940-01—4050 Series Graphic System Operators manual

9 070-2056-01—4050 Series Graphic System Reference manual

10 070-3918-00—4041 Operators manual

11 061-2546-00—4041 Programming Reference manual