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User's Guide

HP 70120A

Universal Counter

HEWLETT PACKARD

HP Part No. 70120-90007
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DANGER **The *DANGER* sign denotes an imminent hazard to people. It warns the reader of a procedure which, if not correctly performed or adhered to, could result in injury or loss of life. Do not proceed beyond a *DANGER* sign until the indicated conditions are fully understood and met.**

General Safety Considerations

WARNING

- **The instructions in this document are for use by qualified personnel only. To avoid electrical shock, do not perform any servicing unless you are qualified to do so.**
- **The opening of covers or removal of parts is likely to expose dangerous voltages. Disconnect the instrument from all voltage sources while it is being opened.**
- **The power cord is connected to internal capacitors that may remain live for five seconds after disconnecting the plug from its power supply.**
- **This is a Safety Class 1 Product (provided with a protective earthing ground incorporated in the power cord). The mains plug shall only be inserted in a socket outlet provided with a protective earth contact. Any interruption of the protective conductor inside or outside of the instrument is likely to make the instrument dangerous. Intentional interruption is prohibited.**
- **For continued protection against fire hazard, replace fuse only with same type and ratings, (type nA/nV). The use of other fuses or materials is prohibited.**

WARNING

- **Before this instrument is switched on, make sure it has been properly grounded through the protective conductor of the ac power cable to a socket outlet provided with protective earth contact.**

  Any interruption of the protective (grounding) conductor, inside or outside the instrument, or disconnection of the protective earth terminal can result in personal injury.
- **Before this instrument is switched on, make sure its primary power circuitry has been adapted to the voltage of the ac power source.**

  Failure to set the ac power input to the correct voltage could cause damage to the instrument when the ac power cable is plugged in.

In This Book

This book describes all of the procedures necessary to use and program the HP 70120A universal counter in an HP 70000 Series modular spectrum analyzer system.

Chapter 1 provides an overview of the HP 70120A universal counter, a simplified block diagram, and a hands-on tour of some basic functions. Also present are two simplified SCPI measurement program examples with measurement results and information about options, service, and support.

Chapter 2 describes basic front panel operating procedures for the HP 70120A universal counter.

Chapter 3 is divided into two principal sections. The first section provides examples showing how to use the HP 70120A universal counter. The examples give you some familiarity with Standardized Commands for Programmable Instruments (SCPI) and with all of the counter measurement functions.

The second section introduces the primary command language of the HP 70120A universal counter, which is SCPI (similar to Test and Measurement Systems Language).

Chapter 4 contains the specifications and characteristics for the HP 70120A universal counter.

Chapter 5 shows menu maps that graphically represent all top-level softkeys and their associated lower-level softkeys.

This chapter lists all menu maps in the order they appear from top to bottom on the left side of the display. With each menu map, a short description of each of the lower-level softkeys is provided.

Chapter 6 contains the error messages for the HP 70120A universal counter.

Chapter 7 provides a quick reference guide of Standard Commands for Programmable Instruments (SCPI) and a quick reference guide of *IEEE Std 488.2-1987* Common Commands applicable to the HP 70120A universal counter.

Chapter 8 describes the Standard Commands for Programmable Instruments (SCPI commands) and *IEEE Std 488.2-1987* common commands applicable to the HP 70120A universal counter.

Chapter 9 briefly explains the counter's front and rear panel features.

Chapter 10 describes an internal microprocessor in the HP 70120A universal counter that executes a program from erasable programmable read only memory.

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Getting Started

This chapter provides an overview of the HP 70120A universal counter, a simplified block diagram, and a hands-on tour of some basic functions. Also present are two simplified SCPI measurement program examples with measurement results and information about options, service, and support.

Universal Counter Overview

The HP 70120A universal counter is fully programmable with three measurement inputs:

- Input 1
- Input 2
- Input 3

The counter uses Standardized Commands for Programmable Instruments (SCPI) to program commands and measurement responses. Measurement features and capabilities are presented first, followed by a simplified block diagram description of the counter.

Measurement Features

The measurement features of the HP 70120A universal counter include its functions, input signal conditioning, and auxiliary measurement capabilities.

Measurement Capabilities

HP 70120A universal counter measurement capabilities are:

Frequency	Frequency ranges are as follows:	
	Input 1	1 mHz to 200 MHz
	Input 2	1 mHz to 100 MHz
	Input 3	90 MHz to 2.5 GHz when using Input 3
Period	Period measurements are as follows:	
	Input 1	from 5 ns to 1000 s on Input 1
	Input 2	from 10 ns to 1000 s on Input 2
	Input 3	up to the specified frequency for Input 3
Totalize	provides totalize measurements of up to $10^{12} - 1$ on Input 1.	
Pulse Width	Provides pulse width measurements from 5 ns to 1 ms on Input 1 and Input 2.	

Time Interval	Provides time interval measurements from 1 ns to 1000 s between Input 1 and Input 2.
Ratio	Provides frequency ratio measurements via Input 1, Input 2, and Input 3.
Rise/Fall Time	Provides rise and fall time measurements from 15 ns to 1 ms on Input 1.
AC/DC/MIN/MAX	Provides voltage measurements of Input 1 or Input 2 signals.

Input Signal Conditioning

HP 70120A universal counter input signal conditioning includes:

Coupling:	ac or dc
Input Impedance:	50Ω or 1 MΩ (500 kΩ in common mode)
Input Switching:	common or separate Input 1 and Input 2
Trigger Level:	automatic or user-programmed
Trigger Slope:	positive or negative

Additional Measurement Capabilities

Additional measurement capabilities include:

External Arming	is provided via front panel BNC or rear panel SMB connectors.
External Arming Slope and Level	provides three programmable trigger levels that can be selected (nominally TTL, ECL, and GND) along with positive or negative slope.
Internal Timebase Output	provides the counter's internal 10 MHz timebase to the rear panel Int/Ext Reference 10 MHz SMB for auxiliary use.
External Timebase Input	allows the counter to use an external timebase as the frequency reference via the rear panel Int/Ext Reference 10 MHz SMB.
100 Measurement Gate Averaging	provides an additional digit of measurement resolution for all functions except totalize.

Simplified Block Diagram Description

Figure 1-1 is a simplified block diagram of the HP 70120A universal counter. The counter consists of four standard functional blocks: Input 1, Input 2, and Input 3, external arming, counter, and measurement control.

Some examples of SCPI commands/options that control various parts of the counter's circuits appear above and below the block diagram and can control the associated circuit elements.

Signals routed into the Input 1 and Input 2 block are conditioned, switched (for common/separate Input 1), and triggered before transfer to the Counter block. The counter block uses Hewlett-Packard's *Reciprocal Counting Technique* to generate time and event data which is passed to the measurement control block. For details of the *Reciprocal Counting Technique*, refer to *HP Application Note 200: Fundamentals of the Electronic Counters*. The external arming block allows measurement synchronization via one of two selectable external arming signal inputs: front panel BNC and rear panel SMB.

The measurement control block uses the time and event information to generate measurement results. This block also determines when and how SCPI response messages are passed through the HP-IB or MSIB Interface. SCPI/common commands and any housekeeping tasks are also handled by this block.

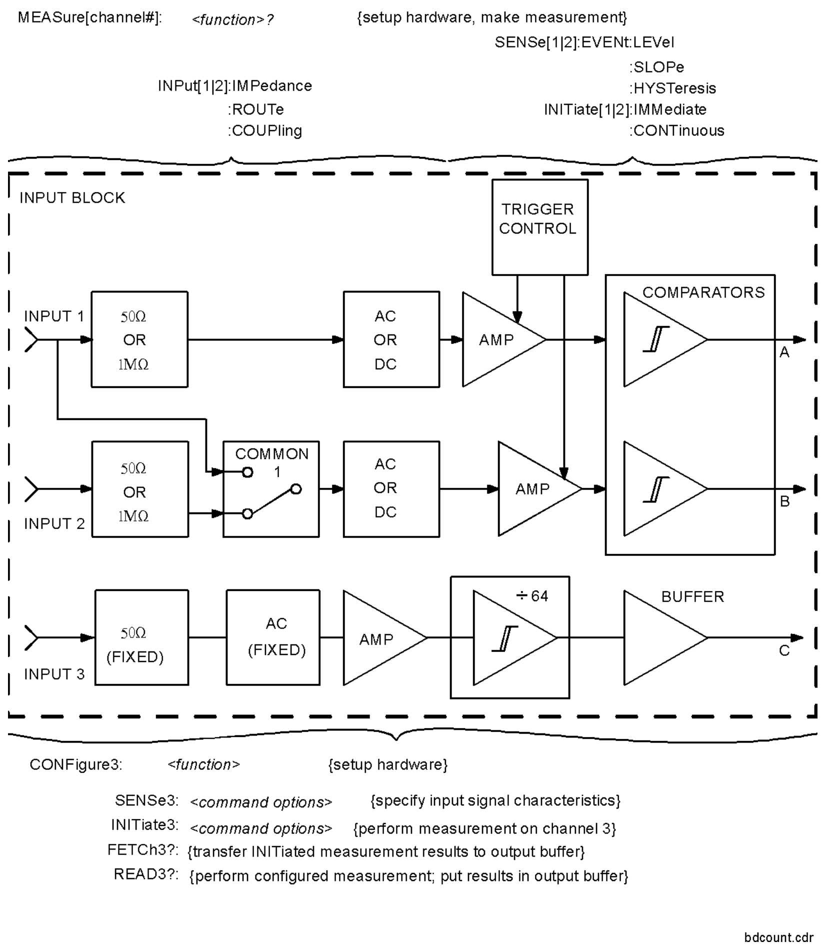


Figure 1-1. Simplified Block Diagram of Universal Counter

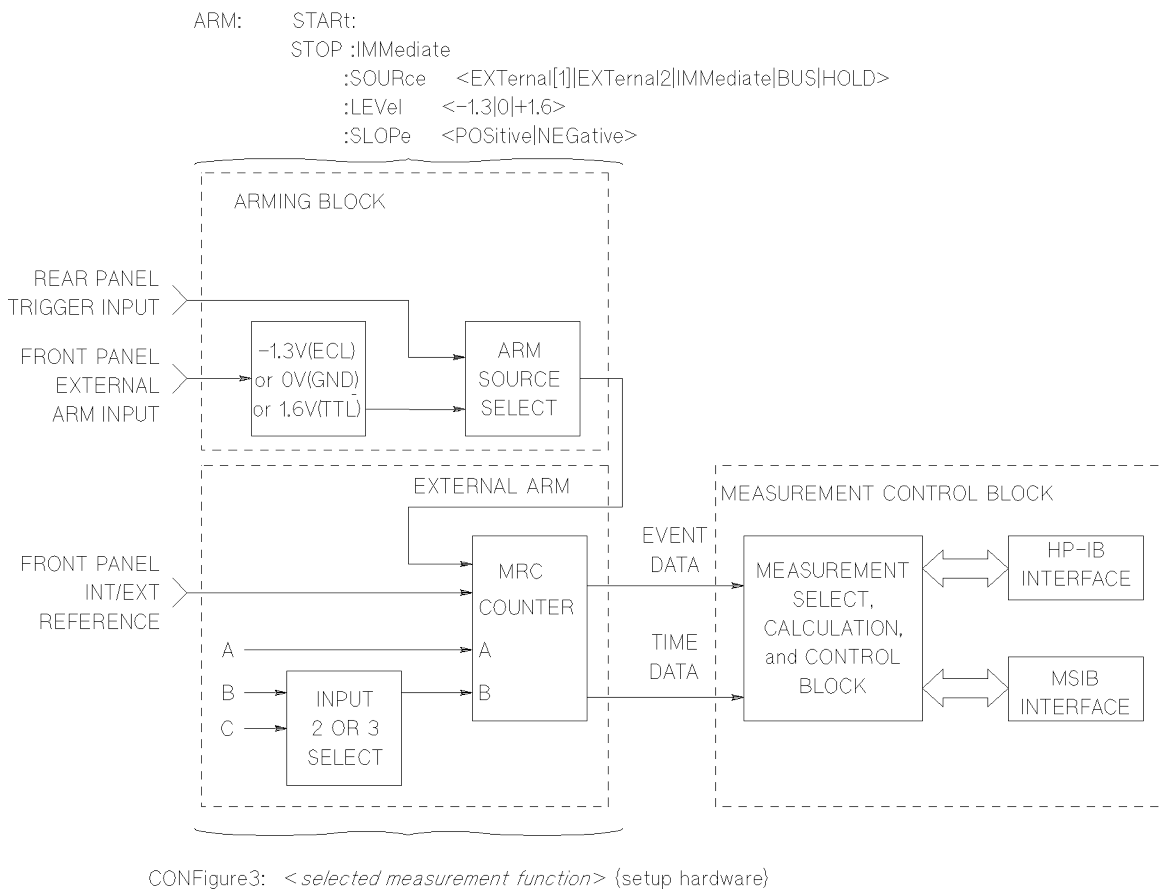


Figure 1-2. Simplified Block Diagram of Universal Counter (Continued)

Making Basic Measurements

After you have powered up the counter and successfully passed self-test, you are ready to make a measurement. Use the information and procedures in this section to quickly make two basic counter measurements: frequency and time interval. You'll be shown two simple SCPI program examples along with how to retrieve and interpret the measurement results.

Maximum Input Voltage

The maximum allowable input voltage for all front panel inputs should not exceed 5 volts rms.

CAUTION Input voltages in excess of 5 volts rms may cause permanent front-end hardware damage.

Making a Frequency Measurement

Before you begin, make sure you have two signal sources available through two separate cables with standard BNC male connectors. For this demonstration we will use:

- two signal generators capable of supplying 1 kHz and 1 MHz
- an HP 9000 Series 200/300 controller instrument controller with HP BASIC
- an HP-IB select code of 7, primary address of 06

Follow these steps to make simple frequency measurements on Input 1 and Input 2.

1. Enter the frequency measurement program listed in the example below.
2. Set the first signal source for a 1 kHz square wave at 1 V peak-to-peak and the second source for a 1 MHz sinewave at 500 mV rms.
3. Connect the first signal source to the counter's Input 1 front panel connector.
4. Connect the second signal source to the counter's Input 2 front panel connector.
5. Run the program.
6. Assess the measurement results shown on the controller display. Refer to the section *Interpreting Frequency Measurement Results* that follows for frequency measurements if you don't understand the SCPI message response that appears on the instrument controller's display.

Frequency Measurement Program Example

`10 ASSIGN @70120A TO 706`	*Assigns @70120A to address 706.*
`20 OUTPUT @70120A;"*RST"`	*Resets the counter to its default power up state.*
`30 OUTPUT @70120A;"MEAS1:FREQ? 1E3,.01"`	*Configures Input 1 for frequency measurement, sets the target frequency to 1 kHz, resolution of at least 0.01 Hz, performs the measurement, then transfers the measurement results to the output buffer.*
`40 ENTER @70120A;FREQ1`	*Transfers the Input 1 measurement from the output buffer on the counter to the input of the instrument controller.*

`50 PRINT FREQ1`	*Displays the measurement on the instrument controller's display.*
`60 OUTPUT @70120A;"MEAS2:FREQ? 1E6, 1"`	*Configures Input 2 for frequency measurement, sets the target frequency to 1 MHz, resolution of 1 Hz, performs the measurement, then transfers the measurement results to the output buffer.*
`70 ENTER @70120A;FREQ2`	*Transfers the Input 2 measurement from the output buffer on the counter to the input of the instrument controller.*
`80 PRINT FREQ2`	*Displays the measurement on the instrument controller display.*
`90 END`	*Terminates program and measurement.*

Interpreting Frequency Measurement Results

If you are having difficulty understanding the measurement results output shown on the instrument controller display, read this explanation.

All measurement results will appear in scientific notation (when more than 9 digits result) with as many digits to the right of the decimal point as needed for the requested resolution. For the frequency measurement example program you would see the display with the following formats:

```
1000.000 00
9.999999 E5
```

Note The actual displayed value may not be exactly "10 MHz" depending upon factors such as timebase accuracy, input signal accuracy, cable length, or specified resolution.

Making a Time Interval Measurement

Before you begin, make sure you have one signal source available through two separate cables (use a "T" connector) with standard BNC male connectors. For this demonstration we will use:

- a signal generator capable of generating 5 kHz,
- an HP 9000 Series 200/300 controller instrument controller with HP BASIC,
- an HP-IB select code of 7, primary address of 06.

Follow these steps to make a simple time interval measurement between Input 1 and Input 2.

1. Enter the time interval measurement program listed in the example below.
2. Set the signal source for a 5 kHz square wave at 1 V peak-to-peak.
3. Connect a "T" BNC connector on the source output and attach a BNC cable to each side of it.
4. Connect one cable to the counter's Input 1 front panel connector.
5. Connect the second cable to the counter's Input 2 front panel connector
6. Run the program.

7. Assess the measurement results shown on the controller display. Refer to the section *Interpreting Time Interval Measurement Results* that follows for time interval measurements if you don't understand the SCPI message response that appears on the instrument controller's display.

Time Interval Measurement Program Example

`10 ASSIGN @70120A TO 706`	*Assigns @70120A to address 706.*
`20 OUTPUT @70120A;"*RST"`	*Resets the counter to its default power up state.*
`30 OUTPUT @70120A;"SENS2:EVEN:SLOP NEG"`	*Selects Input 2 event slope to negative edge. Input 1 event slope is defaulted to positive edge.*
`40 OUTPUT @70120A;"MEAS1:TINT?"`	*Configures Input 1 and 2 for time interval measurement, measures the time interval between the previously programmed edges of Input 1 and Input 2, then transfers the measurement results to the output buffer.*
`50 ENTER @70120A;TINT1`	*Transfers the measurement from the output buffer on the counter to the input of the instrument controller.*
`60 PRINT TINT1`	*Displays the measurement on the instrument controller's display.*
`70 END`	*Terminates program.*

Interpreting Time Interval Measurement Results

If you are having difficulty understanding the measurement results output as shown on the instrument controller display, read this explanation. All measurement results will appear in scientific notation (when more than 9 digits result) with as many digits to the right of the decimal point needed for the requested resolution. For the time interval measurement example program you would see the display with the following format:

```
100E-06
```

Note The actual displayed value may not be exactly "100 μs" depending upon factors such as timebase accuracy, input signal accuracy, cable length, or specified resolution.

2

Front Panel Measurement Tasks

This chapter describes basic front panel operating procedures for the HP 70120A universal counter.

Notation Conventions Used in this Manual

The display presents seven top-level softkeys on the left side of the display that appear when (MENU) is pressed. Pressing one of the top-level softkeys on the left, displays softkeys on the right side of the display. Each softkey that is displayed on the right either performs a universal counter function directly or accesses another menu of related softkeys. The name of the function appears on the display next to the activating softkey.

This manual uses the following conventions:

(KEY)	A key name that looks like this represents a key that is physically located on the instrument and is commonly referred to as a front panel key.
`softkey`	Text that looks like this (with all lowercase letters) represents a softkey that accesses another menu of related softkeys.
`SOFTKEY`	Text that looks like this (with all uppercase letters) represents a softkey that executes its function.
`Display Text`	Text that looks like this represents messages that appear on a display.

Front-Panel Controls

Front-panel controls are summarized in Figure 2-1. Functions are organized into three groups which are accessed with three front panel keys:

- The (MENU) key accesses all universal counter functions.
- The (DISPLAY) key accesses all display functions.
- The (USER) key accesses a set of universal counter functions, custom-made or factory-preset, which facilitate universal counter measurements.

In addition, universal counters installed in an HP 70004A color display have an instrument keypad that executes commonly used universal counter functions.

If the universal counter is being controlled by a computer, press the (LCL) (or (LOCAL)) key to regain front panel control.

Front Panel Functions Through the Display

Functions are activated by pressing the keys around the perimeter of the display screen or on the instrument keypad. The functions are organized in levels, called softkey menus. The (MENU), (USER), and (DISPLAY) keys access the top-level menus of softkeys. Lower-level softkeys are accessed by pressing softkeys having lower-case labels. Press `MORE` to access additional softkeys. Press previous-menu and return keys, `prev menu` or (◀), to view the previously displayed level of softkeys. The (◀) key can be used to recall the last ten softkey entries. Some of the softkeys display information that exceeds the space on the display. To view additional "pages" of information, press `MORE`.

Some softkeys switch between two states, such as internal or external (INT/EXT), automatic or manual (AutoMan), and on or off (On Off). An underscore on the softkey label indicates which softkeys and operating states are selected.

Active Function and Data Entry

Once a key is pressed, its function becomes active, meaning its value can be changed. The active function readout on the left side of the screen displays the active function. In addition, the key for the active function is highlighted in inverse video or underscored. (The label of immediately executed functions is highlighted momentarily.)

Use the numeric keypad, knob, and (▲) or (▼) step keys to change the value of the active function. If the function requires an entry for units, such as hertz or volts, unit softkeys appear after a number is entered with the numeric keypad or knob. Press the desired units softkey to complete the data entry.

Press (HOLD) to blank the active function readout, and disable the knob, numeric keypad, and step keys until the next key is pressed.

Front-Panel Controls

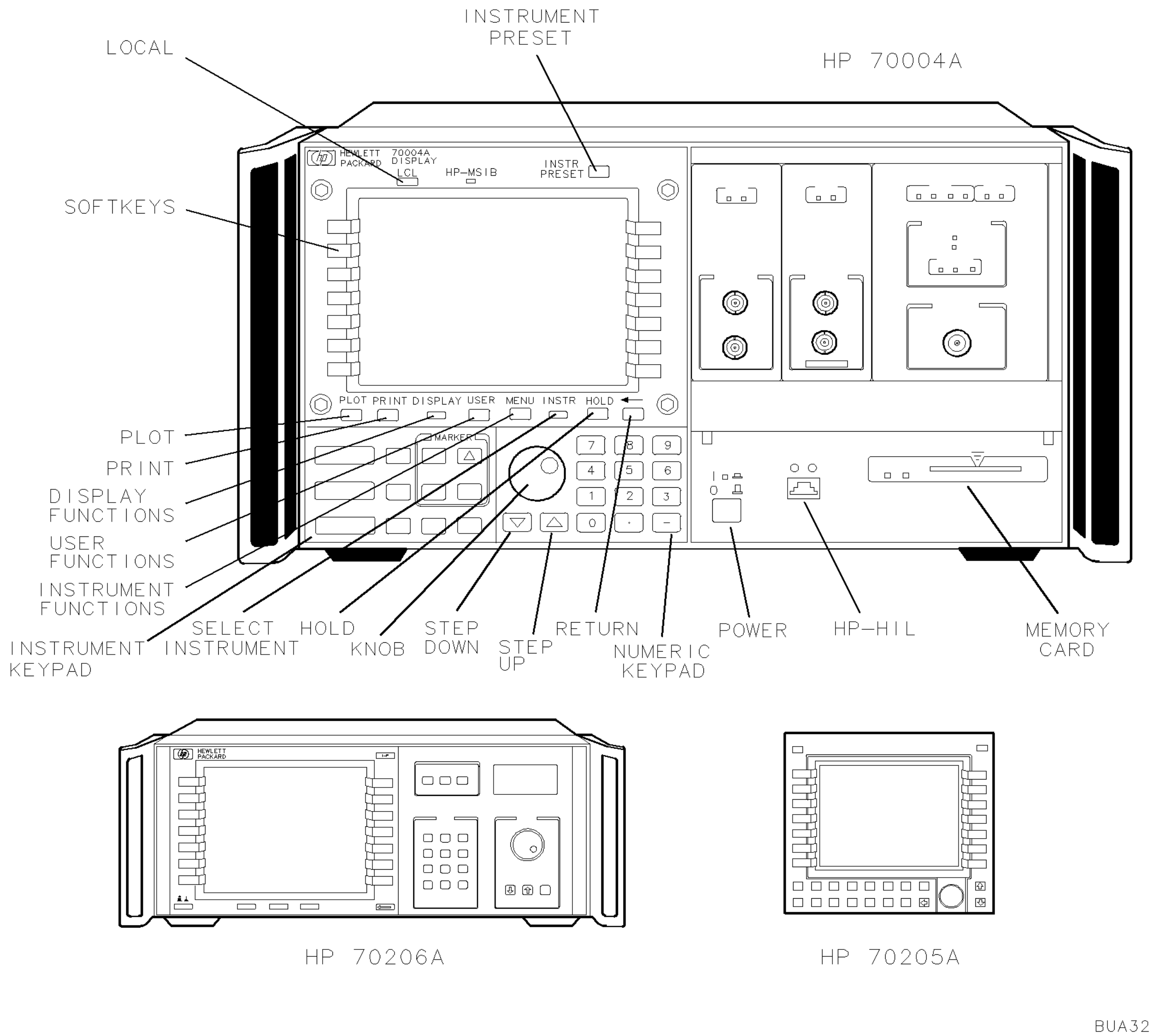


Figure 2-1. Front-Panel Controls

Instrument preset (INSTR PRESET) changes all instrument settings to their preset settings.

Local (LCL) reinstates front panel operation if the instrument has been under remote control. (This key is called (LOCAL) on some models.)

Softkeys execute instrument or display functions, depending on whether (DISPLAY), (MENU), or (USER) was selected. The softkeys are located around the perimeter of the display screen.

Plot (PLOT) plots the universal counter display if a plotter is connected to the display HP-IB port.

Print (PRINT) prints the universal counter display on a graphics printer if one is connected to the display HP-IB port.

Display functions (DISPLAY) accesses all display functions. (This key is called (DSP) on some models.)

User functions (USER) accesses functions that facilitate custom measurement procedures. (This key is called (USR) on some models.)

Instrument functions (MENU) accesses all universal counter functions. If other instruments, such as a digitizer, are added as a separate instrument, (MENU) accesses the functions of each instrument, depending on the selection made by (INSTR) (or NEXT INSTR). (MENU) does not access the display functions. (This key is called (MNU) on some models.)

Instrument keypad executes commonly used universal counter functions and duplicates operation of corresponding (MENU) softkeys.

Select instrument selects instrument that is controlled by the front panel keys. For example, if a system contains a voltmeter and an universal counter, each press of (INSTR) activates the instruments individually. If (INSTR) is not on your instrument, press (DISPLAY), NEXT INSTR. Each press of NEXT INSTR selects another instrument.

Hold (HOLD) blanks the active-function readout and disables the front panel knob, numeric keypad, and step keys until another function softkey is pressed.

Knob provides data entry, moves the marker, or moves the cursor through the character set.

Step down (▼) decreases the value of the active function or moves the cursor in the data line.

Step up (▲) increases the value of the active function or moves the cursor in the data line.

Return (◀) views previously displayed softkeys or moves the cursor to the beginning of the data line.

Numeric keypad provides data entry.

Power controls the line power to the universal counter.

HP-HIL The Hewlett-Packard Human-Interface-Link (HP-HIL) keyboard can be connected to the HP-HIL connector at the front panel of the HP 70004A color display. Many front panel functions can be initiated at the keyboard instead of by the front panel keys.

Memory card provides storage space and accesses routines and instrument personalities. These are called down-loadable programs (DLPs).

3

Remote Programming Tasks

This chapter is divided into two principal sections.

- "Using the Universal Counter"
- "Understanding the Universal Counter"

Using the Universal Counter

This section provides examples showing how to use the HP 70120A universal counter. The examples give you some familiarity with Standardized Commands for Programmable Instruments (SCPI) and with all of the counter measurement functions. Refer to "Understanding the Universal Counter" for more information.

This section contains the following sections:

- Programming Overview
- Initialization State
- Measurement Task Tutorials

Programming Overview

The primary command language of the HP 70120A universal counter is SCPI (similar to Test and Measurement Systems Language). SCPI commands are sent from an instrument controller over HP-IB or HP-MSIB.

A typical controller example is the HP 9000 Series 200/300 controller computer.

Controller Languages

The controller language determines the syntax used to send SCPI commands. Table 3-1 lists some basic SCPI commands used in this chapter. The language only affects how to send commands (instrument addressing), not the actual SCPI command string. A popular BASIC programming language that you can use with the HP 70120A universal counter is:

- HP BASIC used in an HP 9000 Series 200/300 controller Instrument Controller.

Table 3-1. Selected SCPI Counter Commands

Command	Description
*RST	Sets the hardware and firmware to a known state.
CONF[1|2|3]:<function>	Configures the Counter to the selected selected measurement function but does not initiate the measurement.
INIT[1|2|3]	Initiates the selected measurement and transfers the reading to counter module memory. Used with CONFigure or SENSe.
FETC[1|2|3]?	Transfers the most recent measurement on the configured input from the counter module memory to the output buffer. Used with INIT.
MEAS[1|2|3]:<function?>	Configures the Counter to the selected measurement function, initiates the measurement, and transfers the reading to the output buffer.
SENS[1|2|3]:<function>	Used to change selected measurement default parameters, such as event level, slope, and so forth
INP[1|2]:<function>	Used to change the input conditioning default parameters on Input 1 and Input 2 (for example coupling,, and so forth).
[1|2|3] = input numbers	

Series 200/300 HP BASIC

Use the OUTPUT statement to send commands to the counter and the ENTER statement to read data from the counter. The destination specified in the OUTPUT statement is the instrument HP-IB address. The HP-IB address identifies the different instruments in the mainframe.

This address is a combination of an interface select code, primary address, and secondary address.

Included in the OUTPUT statement is the counter's program string. This program string sends the appropriate SCPI commands to the counter such as:

```
OUTPUT 706; "MEAS1:FREQ?"
```

The portion of the string enclosed in quotes is the SCPI command information. Complete examples of OUTPUT and ENTER statements can be found in any of the example measurement programs that appear later in this chapter. These examples show how to use the ASSIGN statement so you'll only have to enter the HP-IB address once (this makes future address changes easy).

Initialization State

The initialization state is the configuration that the counter acquires on power up or at reset. Table 3-2 summarizes this initialization state. The default expected value and resolution for the CONFigure and MEASure subsystems is the same as for the SENSe subsystem. The power up states are the same for both inputs unless specified otherwise.

Table 3-2. Initialization State of the HP 70120A universal counter

Subsystem	Command/Parameter	State
INPut	COUPling	dc
	IMPedance	1 MΩ
	ROUTe	SEParate
ARM	STARt:LEVel	1.6 V (TTL)
	STARt:SLOPe	POSitive
	STARt:SOURce	IMMediate
	STOP:LEVel	1.6 V (TTL)
	STOP:SLOPe	POSitive
	STOP:SOURce	IMMediate
SENSe	APERture	100 ms
	Auto Trigger State	OFF
	DELay:STATe	OFF
	DELay:TIMe	100 ms
	EVENt:LEVel (trigger level)	0 volts
	EVENt:SLOPe	POSitive
	FUNCtion	FREQuency
	EVENt:HYSTeresis	100 mV p-p
	Input Input	Input 1
	CH1 Prescaling	OFF
	RANGe:AUTO	OFF
	RELative (trigger level)	50%
	ROSCillator:SOURce	INTernal
	TOTalize:GATe:POLarity	NORMAL
	TOTalize:GATe:STATe	OFF
OUTPut	ROSCillator:STATe	OFF

Changing Default Parameters

You can change the initialization state defaults by using the SCPI MEASure, CONFigure, and SENSe keyword commands. Refer to "Understanding the Universal Counter" and Chapter 8 for details of how to use these commands along with minimum and maximum parameter values.

Measurement Task Tutorials

This section gives examples of each measurement function the counter can perform. Input signal conditioning for each example is itemized. All example programs use an HP 9000 Series 200/300 controller with HP BASIC. The program code appears on the left of the page with comments on the right. The address for the counter uses an HP-IB select code of 7, and a counter address of 06.

Maximum Input Power

The maximum allowable input voltage for all front panel inputs should not exceed 5 volts rms.

CAUTION Input voltages in excess of 5 volts rms may cause permanent front-end hardware damage.

The remaining pages provide lessons for these HP 70120A universal counter measurement functions:

- Frequency
- Period
- Time Interval
- Pulse Width
- Ratio
- Totalize
- Rise/Fall Time
- Voltage

Frequency Measurement

The following is a summary of the FREQuency function:

- Frequency can be measured on Input 1, Input 2, or Input 3.
- Measurement range is dc to 200/100 MHz for Input 1 and Input 2 respectively and as specified on Input 3. For frequencies under 1 kHz, auto-trigger mode for the counter should be turned off. See Chapter 8, SENSe:EVENt:LEVel[:ABSOlute]:AUTO for details. Also refer to Chapter 4.
- See Chapter 8, STATus subsystem, for information on overflow indication.

Example: Making a Frequency Measurement. This example uses the counter to measure two different signal sources and exercises the frequency measurement capability of Input 1 and Input 2.

Note Before making any signal connections, you should enter the example program to ensure that it is syntactically correct (error free) on your instrument controller.

- The Input 2 is a 28 MHz sine wave.
- The Input 1 is a 50 kHz sine wave.
- The signals to Input 1 and Input 2 are expected to have an amplitude of ±1.5 V.

Input Signal Conditioning. The input signal conditioning for this measurement example is as follows:

- **Event Level:** The default event level (input trigger level) of 0 V can be used since all input signals are symmetrical about 0 V.
- **Event Slope:** Changing event slope (input trigger slope) has no effect on frequency measurements.
- **Coupling:** Dc coupling is used.
- **Impedance:** Input impedance is set to 50Ω.

Frequency Measurement Program Example.

`10 ASSIGN @70120A TO 706`	*Assigns @70120A to address 706.*
`20 OUTPUT @70120A;"*RST"`	*Resets the counter to its default state.*
`30 OUTPUT @70120A;"INP1:IMP 50;COUP DC"`	*Sets Input 1 impedance to 50 Ω and coupling to dc.*
`40 OUTPUT @70120A;"INP2:IMP 50;COUP DC"`	*Sets Input 2 impedance to 50 Ω and coupling to dc.*
`50 OUTPUT @70120A;"MEAS1:FREQ?"`	*Configures Input 1 for frequency measurement, performs the measurement, and transfers results to the output buffer.*
`60 ENTER @70120A;FREQ1`	*Transfers Input 1 measurement from output buffer to the input buffer of controller.*
`70 PRINT FREQ1`	*Displays measurement on the controller.*
`80 OUTPUT @70120A;"MEAS2:FREQ?"`	*Configures Input 2 for frequency measurement, performs the measurement, and transfers results to output buffer.*
`90 ENTER @70120A;FREQ2`	*Transfers the Input 2 measurement from the output buffer to the input buffer of the controller.*
`100 PRINT FREQ2`	*Displays measurement on the controller.*
`110 END`	*Terminates program.*

Comments. Measurement Time: Dependent on both the signal input frequency and the resolution specified. Refer to “Understanding the Universal Counter” for more information.

Related SCPI Commands: ABORt, CONFigure, FETCh?, INITiate, READ?, and SENSe. See Chapter 8 for more details.

Period Measurement

The following summarizes the PERiod function:

- Average Period can be measured on Input 1, Input 2, or Input 3.
- Measurement range is 5 ns to 15,000 s for Input 1 and 10 ns to 15,000 s for Input 2.
- See Chapter 8, STATus subsystem, for information on overflow indication.

Example: Making a Period Measurement. This example uses the counter to measure the period of an input signal. The input trigger levels may be set anywhere between ±10.2 volts in 2.5 mv increments on Input 1 and Input 2. The trigger level range for Input 3 is fixed at 0 volts.

Note Before making any signal connections, you should enter the example program to ensure that it is syntactically correct (error free) on your instrument controller.

- Input to Input 1 is expected to be a 10 MHz TTL compatible clock pulse.

Input Signal Conditioning. The input signal conditioning for this measurement example is as follows:

Event Level: Event level (input trigger level) is set to +1.2 V for a typical TTL signal (+0.2 to +3.5 V).

Event Slope: Not used here.

Coupling: The default dc coupling is used.

Impedance: Input impedance is 1 MΩ.

Period Measurement Program Example.

`10 ASSIGN @70120A TO 706`	*Assigns @70120A to address 706.*
`20 OUTPUT @70120A;"*RST"`	*Resets the counter to its default state.*
`30 OUTPUT @70120A;"INP1:COUP DC;IMP 1E6"`	*Sets CH 1 input coupling to dc and input impedance to 1 MΩ.*
`40 OUTPUT @70120A;"SENS1:EVEN:LEV 1.2 V"`	*Sets the event (trigger level) level for Input 1 to +1.2 V. (The "V" suffix in "EVEN:LEV 1.2 V" is optional.*
`50 OUTPUT @70120A;"MEAS1:PER? 1E-7,1E-9"`	*Configures Input 1 for period measurement, sets the expected period to 0.1 μs at a resolution of 1 ns, performs the actual measurement, then transfers the measurement results to the output buffer.*
`60 ENTER @70120A;PER1`	*Transfers the Input 1 measurement from the output buffer to the input buffer of the instrument controller.*
`70 PRINT PER1`	*Displays measurement on the instrument controller.*
`80 END`	*Terminates program.*

Comments. Measurement Time: Time needed to complete the measurement is dependent on both the signal input frequency and the resolution specified, and could take a maximum of 1000 s to complete. Refer to "Understanding the Universal Counter".

Related SCPI Commands: Commands associated with period measurements but not discussed in this example are: ABORt, CONFigure, FETCh?, INITiate, READ?, and SENSe.

Time Interval Measurement

The following is a summary of the TINTerval function:

- Time interval between any two events can be measured from Input 1 to 2.
- Time intervals can be selected to start and/or stop on rising or falling edge.
- Measurement range is 1 ns to 15,000 s in a single shot measurement or 1500 s using 100 Measurement Gate Averaging.

- Maximum selectable resolution is 100 ps. If the requested resolution is less than 1 ns, 100 Measurement Gate Averaging is turned on.
- See Chapter 8, STATus subsystem, for more information on overflow indication.

Example: Making a Time Interval Measurement. This example uses the counter to measure the time interval between the edges of two pulses.

Note Before making any signal connections, you should enter the example program to ensure that it is syntactically correct (error free) on your instrument controller.

- The example requires you to input the 10 MHz, TTL-compatible signal into both Input 1 and Input 2.

Input Signal Conditioning. The input signal conditioning for this measurement example is as follows:

Event Level: Event level (input trigger level) is set to +1.2 V.

Event Slope: Event slope is set to NEGative for Input 1 (measurement starts from falling edge of signal input to Input 1). Input 2 event slope is set to POSitive (measurement ends on the rising edge of the signal input to Input 2).

Coupling: Dc coupling is used.

Impedance: Input impedance is set to 1 MΩ.

Time Interval Measurement Program Example.

`10 ASSIGN @70120A TO 706`	*Assigns the counter to address 706.*
`20 OUTPUT @70120A;"*RST"`	*Resets counter to its default state.*
`30 OUTPUT @70120A;"SENS1:EVEN:SLOP NEG"`	*Selects Input 1 event slope to negative edge.*
`40 OUTPUT @70120A;"SENS2:EVEN:SLOP POS"`	*Selects Input 2 event slope to positive edge.*
`50 OUTPUT @70120A;"SENS1:EVEN:LEV 1.2"`	*Sets Input 1 event level to +1.2 V.*
`60 OUTPUT @70120A;"SENS2:EVEN:LEV 1.2"`	*Sets Input 2 event level to +1.2 V.*
`70 OUTPUT @70120A;"INP2:COUP DC;IMP 1E6"`	*Sets coupling to dc and input impedance for Input 2 to 1 MΩ.*
`80 OUTPUT @70120A;"INP1:COUP DC;IMP 1E6"`	*Sets coupling to dc and input impedance for Input 1 to 1 MΩ.*
`90 OUTPUT @70120A;"MEAS1:TINT?"`	*Configures Input 1 and 2 for time interval measurement (CH 1 as the start event), performs the actual measurement, then transfers the measurement results to the output buffer.*
`100 ENTER @70120A;TINT1`	*Transfers the measurement from the output buffer to the input buffer of the instrument controller.*
`110 PRINT TINT1`	*Displays measurement on the instrument controller.*

```
120 END                                    Terminates program.
```

Note The MEASure command in the above example does not specify a resolution. Therefore, the 1 ns default resolution is used which requires only one measurement. When a resolution less than 1 ns is requested, then 100 Measurement Gate Averaging mode is automatically turned on. Refer to the *Measurement Resolution* section of "Understanding the Universal Counter".

Comments. Measurement Time: Time Interval measurement continues until the second edge is detected.

Related SCPI Commands: Commands associated with time interval measurements but not discussed in this example are: ABORt, CONFigure, FETCh?, INITiate, READ?, and SENSe.

Pulse Width Measurement

The following summarizes the pulse width function:

- Pulse width can be measured on Input 1 or 2.
- Positive and negative pulse widths can be measured. Positive pulse width is measured from rising to falling edge, and negative pulse width is measured from falling to rising edge.
- Default event level is halfway (50%) between +Ve (maximum) and −Ve (minimum) peaks of the signal. (See SENSe:EVENt:LEVel:RELative in Chapter 8 for more details.)
- Measurement range is 5 ns to 1 ms.
- Maximum selectable resolution is 100 ps, which automatically turns 100 Measurement Gate Averaging on.
- See Chapter 8, STATus subsystem, for information on overflow indication.

Example: Making a Pulse Width Measurement. This example can use either input of the counter to measure pulse width.

Note Before making any signal connections, you should enter the example program to ensure that it is syntactically correct (error free) on your instrument controller.

- To accurately measure pulse width, the counter automatically sets the trigger level mid-way (50% in default value) between +Ve and −Ve peaks of the input signal.
- This example measures a negative-going pulse; we'll use the SCPI "NWID?" command for actual pulse measurement.
- The input signal should be 2 volts peak-to-peak at 100 kHz.

Input Signal Conditioning. The input signal conditioning for this measurement example is as follows:

Event Level: Event level is automatically determined by the counter.

Event Slope: Automatically defined by the pulse width function.

Coupling: Dc coupling is used.

Impedance: Input impedance is programmed to 1 MΩ.

Pulse Width Measurement Program Example.

`10 ASSIGN @70120A TO 706`	*Assigns @70120A to address 706.*
`20 OUTPUT @70120A;"*RST"`	*Resets the counter to its default state.*
`30 OUTPUT @70120A;"INP1:COUP DC;IMP MAX"`	*Sets Input 1 impedance to 1 MΩ and coupling to dc.*
`40 OUTPUT @70120A;"MEAS1:NWID?"`	*Configures Input 1 for negative pulse width measurement and automatically determines the event (trigger) level. Performs the actual measurement, then transfers the measurement results to the output buffer.*
`50 ENTER @70120A; NWID1`	*Transfers the Input 1 measurement from the output buffer to the input buffer of the instrument controller.*
`60 PRINT NWID1`	*Displays measurement on the instrument controller.*
`70 END`	*Terminates program.*

Note The MEASure command in the above example does not specify a resolution. Therefore, the 1 ns default resolution is used which requires only one measurement. When a resolution less than 1 ns is requested, then 100 Measurement Gate Averaging mode is automatically turned on. Refer to the *Measurement Resolution* section of "Understanding the Universal Counter".

Comments. Measurement Time: Positive and Negative pulse width measurements will continue until the second edge is detected.

Related SCPI Commands: Commands associated with pulse width measurements but not discussed in this example are: ABORt, CONFigure, INITiate, SENSe, FETCh?, and READ?.

Ratio Measurement

The following summarizes the ratio function:

- Ratio is measured on Input 1 in relation to Input 2, or on Input 2 in relation to Input 1, or on Input 3 in relation to Input 1. The input specified in the command is the numerator of the ratio, for example MEAS1:FREQ:RAT? results in the ratio of frequencies of Input 1 to Input 2 (CH1/CH2).
- Minimum ratio value is 10^{-11}; maximum ratio value is 10^{11}.
- The gate time over which the ratio is counted may be specified.

Example: Making a Ratio Measurement. This example uses the counter to measure the ratio of two different frequencies.

Note Before making any signal connections, you should enter the example program to ensure that it is syntactically correct (error free) on your instrument controller.

- The program shown measures the frequency ratio of TTL signals.
- The resulting measurement could assess the input/output pulse ratio of a TTL-compatible divider or multiplier. (The higher input frequency is typically connected to the input in the numerator.)
- The input multiplier/divider signal (10 MHz) is routed to Input 1 with the output signal (5 MHz) routed to Input 2.

Input Signal Conditioning. The input signal conditioning for this measurement example is as follows:

Event Level: Since the two signals are TTL, the event level is set to +1.2 V.

Event slope: Event slope does not affect ratio measurements.

Coupling: dc coupling is used because of a TTL level.

Impedance: Input impedance is set to 1 MΩ.

Ratio Measurement Program Example.

`10 ASSIGN @70120A TO 706`	*Assigns @70120A to address 706.*
`20 OUTPUT @70120A;"*RST"`	*Resets the counter to its default state.*
`30 OUTPUT @70120A;"INP2:COUP DC;IMP 1E6"`	*Sets Input 2 coupling to dc and input impedance to 1 MΩ.*
`40 OUTPUT @70120A;"INP1:COUP DC;IMP 1E6"`	*Sets Input 1 coupling to dc and input impedance to 1 MΩ.*
`50 OUTPUT @70120A;"SENS1:EVEN:LEV 1.2"`	*Sets Input 1 event level to +1.2 V.*
`60 OUTPUT @70120A;"SENS2:EVEN:LEV 1.2"`	*Sets Input 2 event level to +1.2 V.*
`70 OUTPUT @70120A;"MEAS1:FREQ:RAT?"`	*Configures Input 1 and 2 for ratio measurement with CH 1 as numerator, performs the actual measurement, then transfers the measurement results to the output buffer. You can obtain the inverse ratio of the measurement obtained in the example above (Input 2 as the numerator) by changing the MEAS command to MEAS2:FREQ:RAT?.*
`80 ENTER @70120A;RAT1`	*Transfers the ratio measurement from the output buffer to the input buffer of the instrument controller.*
`90 PRINT RAT1`	*Displays measurement on the instrument controller.*
`100 END`	*Terminates program.*

Comments. Measurement Time: Time needed to complete the measurement is dependent on both the signal input frequency and the resolution specified. Refer to "Understanding the Universal Counter".

Related SCPI Commands: Commands associated with ratio measurements but not discussed in this example are: ABORt, CONFigure, FETCh?, INITiate, READ?, and SENSe.

Totalize Measurement

The following is a summary of the TOTalize function:

- Will totalize events on Input 1 or 2. Measurement range is 0 to $10^{12} - 1$.
- Reading the ongoing count does not stop the totalize function or reset the counter allowing for measurement on-the-fly.

Example: Making a Totalize Measurement. In this example, the counter measures a running total of events input via Input 1.

- The program shown measures the cumulative events of TTL signals. A FETCh? query returns the most recent measurement result to the instrument controller.
- In the example, this measurement is forced to ABORt. The measurement will also complete when a new function is programmed. For other ways of terminating TOTalize, refer to "Understanding the Universal Counter".

Note Before making any signal connections, you should enter the example program to ensure that it is syntactically correct (error free) on your instrument controller.

Input Signal Conditioning. The input signal conditioning for this measurement example is as follows:

Event Level: Input levels are TTL. Event level is set to +1.2 V so the input signal will transition through the event level and trigger a count.

Event Slope: Changing event slope has no effect on totalize measurements.

Coupling: dc coupling is used.

Impedance: 1 MΩ input impedance is used.

Totalize Measurement Program Example.

```
10 ASSIGN @70120A TO 706                    Assigns @70120A to address 706.
20 OUTPUT @70120A;"*RST"                    Resets the counter to its default
                                            state.
30 OUTPUT @70120A;"SENS1:EVEN:LEV 1.2"      Sets event level for Input 1 to
                                            +1.2 V.
40 OUTPUT @70120A;"INP1:COUP DC;IMP 1E6"    Enables dc coupling for Input 1
                                            and sets impedance to 1 MΩ.
50 OUTPUT @70120A;"CONF1:TOT"               Configures Input 1 for totalize measurement.
60 OUTPUT @70120A;"INIT1"                   Starts Input 1 counting.
70 FOR I=1 TO 100                           Define count: take 100 measurements.
```

`80 OUTPUT @70120A;"FETC1?"`	*Transfers Input 1 count to the output buffer. Counting continues after transfer.*
`90 ENTER @70120A;TOT1`	*Transfers the measurement from the output buffer to the input buffer of the computer.*
`100 PRINT I,"CH-1 COUNT = ",TOT1," "`	*Displays count on the instrument controller.*
`110 NEXT I`	*Loop back to 70.*
`120 OUTPUT @70120A;"ABORt"`	*ABORt the measurement. The final value is lost. (See "Understanding the Universal Counter" for measurement Start/Stop details.)*
`130 END`	*Terminates program.*

Comments. Related SCPI Commands: Commands associated with the totalize function but not discussed in this example are: ABORt, INPut, SENSe, ARM.

Rise/Fall Time Measurement

The following summarizes the RTIMe (or FTIMe) function:

- Rise/Fall Time can be measured via Input 1 only.
- Input 2 cannot be used when Input 1 is measuring rise/fall time because the counter inputs are routed in COMMon mode. You can have input signals connected to all inputs.
- All settings for Input 1 become active for Input 2.
- Measurement range is 15 ns to 15,000 s (1500 s with 100 Measurement Gate Averaging). When making an RTIMe or FTIMe measurement with auto trigger turned on, the measurement range is 15 ns to 1 ms. See Chapter 8 under SENSe:EVENt:LEVel[:ABSOlute]:AUTO for details.
- See Chapter 8, STATus subsystem, for information on overflow indication.

Example: Making a Rise Time Measurement. This example uses the counter to measure the rise time of an input signal.

Note Before making any signal connections, you should enter the example program to ensure that it is syntactically correct (error free) on your instrument controller.

- The input to Input 1 is expected to be a 1 MHz sinusoidal signal.

Input Signal Conditioning. The input signal conditioning for this measurement example is as follows:

Event Level: Using the MEAS command causes the counter to turn auto trigger on. Input 1 event level is programmed at 10% (90%) and Input 2 event level is programmed at 90% (10%) for risetime (falltime)

Event Slope: Event slope is set to positive by default (for both inputs).

Coupling: ac coupling is used.

Impedance: Input impedance is 50Ω.

Rise Time Measurement Program Example.

```
10 ASSIGN @70120A TO 706
```
Assigns @70120A to address 706.
```
20 OUTPUT @70120A;"*RST"
```
Resets the counter to its default state.
```
30 OUTPUT @70120A;"INP1:COUP AC;IMP 50"
```
Sets ch 1 input coupling to ac and input impedance to 50Ω.
```
40 OUTPUT @70120A;"MEAS1:RTIM? DEF, DEF, 1E-6,1E-9"
```
Configures Input 1 for rise time measurement, selects default values for trigger levels (10%, 90%), and sets the expected risetime with a resolution of 1E−9 s. Performs the actual measurement, then transfers the measurement results to the output buffer.
```
50 ENTER @70120A;RTIM1
```
Transfers the Input 1 measurement from the output buffer to the input buffer of the instrument controller.
```
60 PRINT RTIM1
```
Displays measurement on the instrument controller.
```
70 END
```
Terminates program.

Comments. **Measurement Time:** Time needed to to complete the measurement is dependent on both the signal input rise/fall time and the resolution specified. Refer to "Understanding the Universal Counter".

Related SCPI Commands: Commands associated with rise/fall time measurements but not discussed in this example are: ABORt, CONFigure, FETCh?, INITiate, READ?, SENSe, and ARM. The command :FALL:TIMe is identical in function to FTIMe and the command :RISE:TIMe is identical in function to RTIMe.

Voltage Measurement

The following summarizes the voltage measurement functions:

- Voltage measurements can be made on Input 1 and Input 2.
- ac: If the input signal is sinusoidal, then the ac command measures the rms value of the input signal.
- dc: Measures the offset voltage present on the input signal.
- MIN/MAX: The MINimum command reports/measures the −Ve peak of the input signal, and the MAXimum command reports/measures the +Ve peak of the input signal.
- Minimum and Maximum voltage measurements are made with auto trigger on (cannot be disabled).

Example: Making a Voltage Measurement. This example uses the counter to measure all voltage parameters of the input signal.

Note Before making any signal connections, you should enter the example program to ensure that it is syntactically correct (error free) on your instrument controller.

- The input signal to Input 1 is expected to be ±0.5 volts (1 V p-p).

Input Signal Conditioning. **Event Level:** Automatically configured to auto trigger on

Event Slope: Not used

Coupling: dc coupling default

Impedance: 50Ω

Voltage Measurement Program Example.

`10 ASSIGN @70120A TO 706`	*Assigns 70120A to address 706.*
`20 OUTPUT @70120A;"*RST"`	*Resets the counter to its default state.*
`30 OUTPUT @70120A;"MEAS:MIN?"`	*Reports the −Ve peak of the input ac signal with "implied" Input 1.*
`40 ENTER @70120A;V1`	*Transfers the Input 1 MINimum voltage measurement from the output buffer to the input buffer of the instrument controller.*
`50 PRINT V1`	*Displays the MINimum measurement on the instrument controller.*
`60 OUTPUT @70120A;"MEAS1:MAX?"`	*Reports the +Ve peak of the input ac signal.*
`70 ENTER @70120A;V2`	*Transfers the Input 1 MAXimum voltage measurement from the output buffer to the input buffer of the instrument controller.*
`80 PRINT V2`	*Displays the MAXimum measurement on the instrument controller.*
`90 OUTPUT @70120A;"MEAS1:AC?"`	*Reports the ac rms voltage of the input signal.*
`100 ENTER @1420A;V3`	*Transfers the Input 1 ac voltage measurement from the output buffer to the input buffer of the instrument controller.*
`110 PRINT V3`	*Displays the ac voltage measurement on the instrument controller.*
`120 OUTPUT @70120A;"MEAS1:DC?"`	*Reports the dc offset voltage present with the input signal.*
`130 ENTER @70120A;V4`	*Transfers the Input 1 dc voltage measurement from the output buffer to the input buffer of the instrument controller.*
`140 PRINT V4`	*Displays the dc voltage measurement on the instrument controller.*
`150 END`	*Terminates program.*

Comments. **Related SCPI Commands:** Commands associated with all voltage measurement functions but not discussed in this example are ABORt, SENSe, ARM, CONFigure, READ?, INITiate, and FETCh?

Understanding the Universal Counter

This section provides a comprehensive description of the operating characteristics of the HP 70120A universal counter. All measurement functions are explored with detailed procedures that include SCPI message examples and results interpretation. In addition, input triggering, sensitivity, and hysteresis are explained for various measurement situations.

The experienced operator who is familiar with Hewlett-Packard SCPI instrument technology can refer directly to Chapter 8 for complete HP 70120A universal counter programming details. This chapter contains the following sections:

- Counter Configuration and the Measurement Procedure
- Making Measurements With SCPI
- Measurement Functions
- Input Signal Conditioning
- Arming The Counter
- Measurement Resolution
- Output Formats

Counter Configuration and the Measurement Procedure

Counter configuration is discussed first followed by a brief summary of measurement procedure recommendations and counter parameters you will need to consider when writing SCPI program messages.

Configuration

The HP 70120A universal counter makes a measurement when configured (set up) by the parameters sent from your SCPI program message. Various input and measurement command parameters can take on different values. Table 3-2 shows the commands you can program along with their default values. The values shown define the counter's power up/reset configuration. Three SCPI commands let you "look at" or "measure" a signal of interest. They are MEASure, CONFigure, and SENSe. The MEASure command is the simplest to use and typically involves the least programming. The SENSe command has more programming "options" as part of its subsystem that allow it to "search" for very specific signals with greater speed. A MEASure or CONFigure command (discussed in the next section) automatically sets the parameter configuration based on the function specified in the command. Not all parameters listed in Table 3-2 are set by the MEASure or CONFigure command. The configured parameters determine the measurement process for a specific counter function. The process controls events that occur in the counter's hardware from the moment an input signal is detected at the front end until measurement results are stored in the counter's output buffer or sent back to the controller. The remaining sections of this chapter present the HP 70120A universal counter set-up and operation in a sequence similar to the way you would use this instrument if front panel switches and controls were present (see Figure 3-1).

Exact details of SCPI commands, options, and parameters are contained in Chapter 8, *HP 70120A universal counter Command Reference*. (The actual order of set-up and measurement events within the counter is a function of the SCPI command tree structure/syntax and the counter's firmware.)

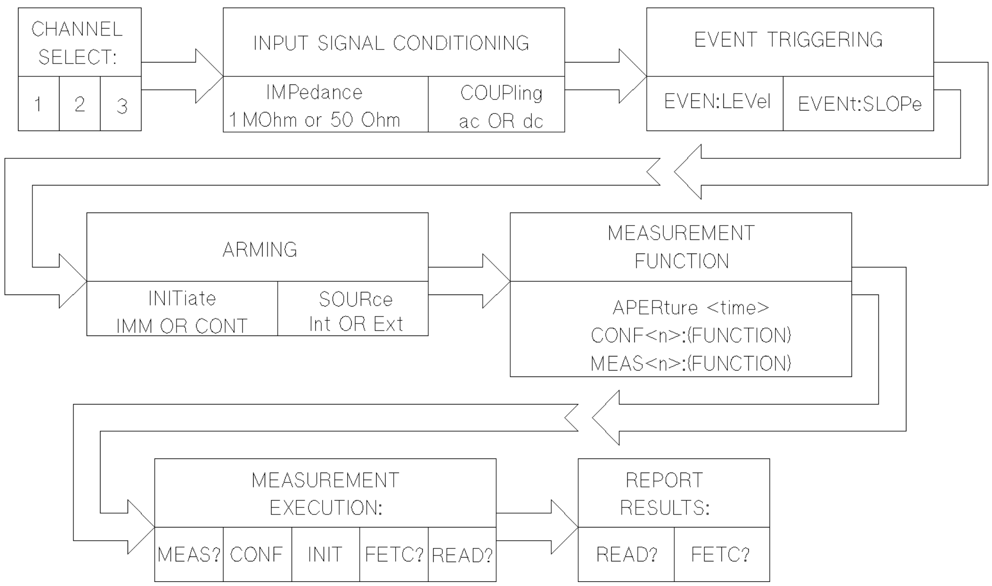


Figure 3-1. Overall SCPI Measurement Flow

Measurement Procedure

Your counter measurements may be more successful if you follow these simple guidelines:

1. *Assess the kind of signal you want to measure:* its amplitude, frequency; is it periodic? This information lets you set the input signal conditioning, trigger level, and which inputs to use. You may also consider how complex your measurement is and what SCPI command subsystem is appropriate for it (MEASure, CONFigure, or SENSe).
2. *Determine the type of measurement you need to make:* FREQuency, PERiod, TOTalize, PWIDth (positive pulse), NWIDth (negative pulse), TINTerval (time interval), RATio, RTIMe/FTIMe (rise/fall time), or AC/DC/MINimum/MAXimum (voltage). (Input 3 is limited to frequency, period, or ratio measurements). Refer to the *Measurement Functions* section of this chapter for more detailed information.
3. *Set the input signal conditioning parameters for Input 1 and Input 2:* (Input 3 characteristics are fixed). Refer to the *Input Signal Conditioning* section of this chapter for more detailed information.
4. *Set the appropriate trigger level and sensitivity* (HYSTeresis) *if necessary* (to ensure that baseline noise doesn't initiate a measurement). You can put the counter into AUTO triggering mode with SENS:EVEN:LEV:AUTO ON. Refer to the *Input Signal Conditioning* section of this chapter for more detailed information.
5. *Set the counter arming if applicable* (ensure that the ARM command parameters match the arm input signal source and level). Refer to the *Arming The Counter* section of this chapter for more detailed information.
6. *Set the measurement resolution if desired.* Refer to the *Measurement Resolution* section of this chapter for more detailed information.
7. *Make the measurement with the MEASure, CONFigure, or SENSe commands:* (explained in the next section). (When using CONFigure or SENSe, you'll also need to use READ? or INIT/FETCh? as explained in the CONFigure and SENSe sections.)

8. *Assess the results of your measurement.* Refer to the *Output Formats* section of this chapter for more detailed information.

Making Measurements with SCPI

You can customize measurements for your needs by using SCPI's three different measurement command "levels" to select and perform a measurement. The HP 70120A universal counter is fully compatible with SCPI Rev. 1991.0.

The resulting command capability gives you these performance advantages:

- You gain greater programming flexibility,
- You can use the complete feature set of the HP 70120A universal counter,
- You can trade measurement speed/versatility for automatic parameter configuration convenience and vice-versa.
- You can also trade functional instrument compatibility for complete control of the counter's hardware.

For example, the MEASure, CONFigure, and SENSe commands can be used to make a frequency measurement. The MEASure or CONFigure command automatically selects the aperture (gate time) required to obtain a desired resolution. The SENSe command lets you customize your measurements if the MEASure and CONFigure default values are not appropriate for your needs. When customized, this way, your measurements gain precision and can execute faster by using the READ?, INIT, and FETCh? commands (see Figure 3-2).

Although an extra command is required for CONFigure, the counter's actual set up changes little when using either MEASure or CONFigure. These two commands set measurement function along with aperture time or expected value. The determination results from the programmed (or default) expected value and resolution. The MEASure and CONFigure commands are signal-oriented. When using these commands, the counter automatically sets required measurement parameters to make the measurement as rapidly as possible. The SENSe:FUNCtion commands are hardware-oriented. When used, the counter's ability to automatically set necessary measurement parameters and techniques is disabled. Measurements are performed using the techniques you specify, and all necessary parameters are under your control, for example: The MEASure, CONFigure, and SENSe:FUNCtion commands can each set up a FREQuency measurement. The MEASure or CONFigure command automatically selects the aperture time (gate time) required to obtain nine digits of resolution, but the SENSe:FUNCtion command requires you to choose a specific APERture time. Figure 3-2 illustrates how the MEASure, CONFigure, and SENSe:FUNCtion commands differ in how they are used with READ?, INITiate, and FETCh? commands, and how they ALL perform the same measurement and get the data to the output buffer.

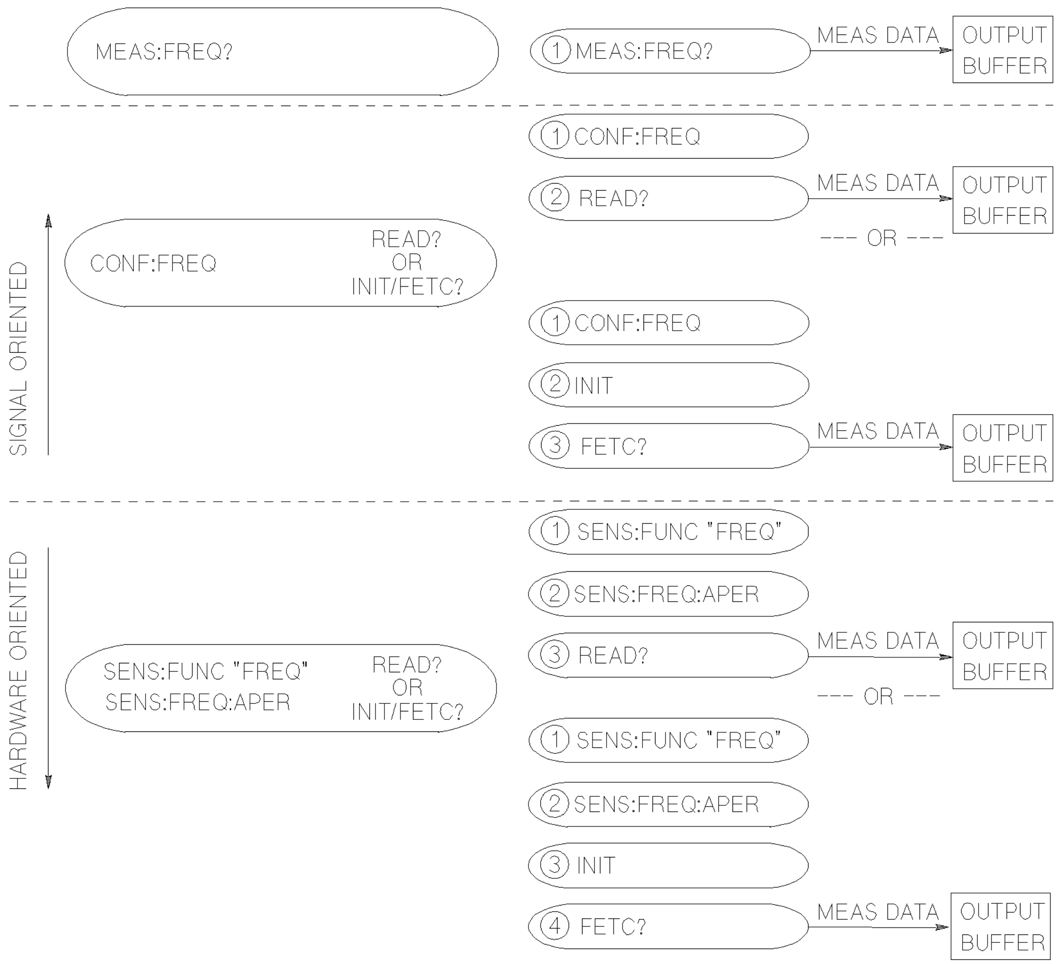


Figure 3-2. SCPI Measurement Capability

MEASure, CONFigure, and SENSe Commands

All HP 70120A universal counter measurement functions can be performed using the MEASure command except for TOTalize. All measurements can be configured with the CONFigure and SENSe commands, but at least one additional command must then be used to initiate the measurement.

Using MEASure. Use MEASure to take a measurement automatically after the configuration (primarily input signal conditioning) is set. No additional command is needed to initiate the measurement or store the results. (Exact details of SCPI commands, options, and parameters are contained in Chapter 8.) You can select and perform a measurement with this command string:

```
MEAS:<function>?
```

where <function> is one of the following:

FREQ for frequency measurements
PER for period measurements
PWID (or) NWID for ±pulse width measurements
TINT for time interval measurements
RTIM (or) FTIM for rise/fall time measurements

FREQ:RAT for ratio measurements
MIN/MAX/AC/DC for voltage measurements

For example, executing MEASure as:

```
MEAS2:FREQ? 1E7, 10
```

makes a measurement on Input 2 setting the function to frequency, the target frequency to 10 MHz, and the resolution to 10 Hz. The remaining commands are as shown in Table 3-2 or as you have set them prior to the MEASure command.

The resulting measurement data is stored in the output buffer of the counter. An ENTER statement can be used to transfer this information to the controller.

Using CONFigure. Use CONFigure when you need to specify a measurement function prior to the READ? or INIT/FETC? commands. You will also need to use CONFigure for TOTalize measurements. (Exact details of SCPI commands, options, and parameters are contained in Chapter 8.) CONFigure only sets up the configuration, and does not perform the measurement. You can select a measurement function on Input 1 with this command string:

```
CONF1:<function>
```

where <function> is one of the following:

FREQ for frequency measurements
PER for period measurements
TOT for totalize measurements
PWID (or) NWID for ±pulse width measurements
TINT for time interval measurements
RTIM (or) FTIM for rise/fall time measurements
FREQ:RAT for ratio measurements
MIN/MAX/AC/DC for voltage measurements

Once the selected measurement is configured and any additional parameters are added, the measurement is performed using a READ? or INITiate command.

Using SENSe. Use the SENSe command when you need to configure not only the measurement function but also special characteristics of the input signal. Aperture time for FREQuency, PERiod, or RATio and gate options for the TOTalize function may also be set up. (Exact details of SCPI commands, options, and parameters are contained in Chapter 8.) You can specify these additional parameters as follows:

- For frequency, period, and ratio measurements, allows you to set aperture time and expected value.
- For time-interval measurements, allows you to set and enable a delay time.
- For totalize measurements, allows you to set up GATE characteristics.
- For the EVENt parameter, allows you to specify input trigger characteristics.
- For all measurements, lets you set 100 Measurement Gate Averaging mode.

SENSe only sets up the configuration, and does not perform the measurement. You can select a measurement function for Input 1 with this command string:

```
SENS1:FUNCtion <function>
```

where <function> is one of the following:

FREQ for frequency measurements along with APERture time
PER for period measurements along with APERture time
TOT for totalize measurements along with GATE:<options>
PWID (or) NWID for ±pulse width measurements
TINT for time interval measurements
RTIM (or) FTIM for rise/fall time measurements
FREQ:RAT for ratio measurements along with APERture time
MIN/MAX/AC/DC for voltage measurements

Once the selected measurement is configured and any additional parameters are added, the measurement is performed using a READ? or INITiate command.

INITiate, READ?, and FETCh? Commands

After you have configured a measurement with CONFigure or SENSe use READ? or INITiate/FETCh? to perform the actual measurement.

Using READ?. READ? performs a configured measurment and transfers the result to the counter's output buffer. READ? should not be used on totalize or gated totalize measurements. If a READ? is attemped on an unconfigured input, an error will be generated. You can perform and read a configured measurement with this command string:

```
READn?
```

where `n` = the input number (1, 2, or 3).

An HP BASIC ENTER statement can be used to transfer this data to the controller.

Using INITiate. INITiate performs the configured measurement immediately for one measurement cycle or continuously if specified. The measurement results are not available in the counter's output buffer after INITiate has executed. The INITiate command must be used with CONFigure or SENSe followed by FETCh? for totalize or gated totalize measurements. You can perform the configured measurement with this command string:

```
INITn
```

where `n` = the input number (1, 2, or 3).

After a measurement has been INITiated, you'll need to use the FETCh? command to transfer the measurement data to the counter's output buffer. An HP BASIC ENTER statement can be used to transfer this data to the controller.

Using FETCh?. FETCh? loads the results of the most recent measurement into the counter's output buffer. You must precede this command with some SCPI measurement configuration program string and the INITiate command in order to get data with the FETCh? command. You can perform this command with the following command string:

```
FETCn?
```

where `n` = the input number (1, 2, or 3).

An HP BASIC ENTER statement can be used to transfer this data to the controller.

Measurement Functions

The following paragraphs describe how the counter performs in each of the seven measurement modes:

- Frequency
- Period
- Pulse Width
- Ratio
- Rise/Fall Time
- Time Interval
- Totalize
- Voltage

For each measurement mode of the counter, the range, available inputs, and operation are described. Figure 3-3 shows the SCPI program task flow common to all measurement levels and functions. (Exact details of SCPI commands, options, and parameters are contained in Chapter 8.)

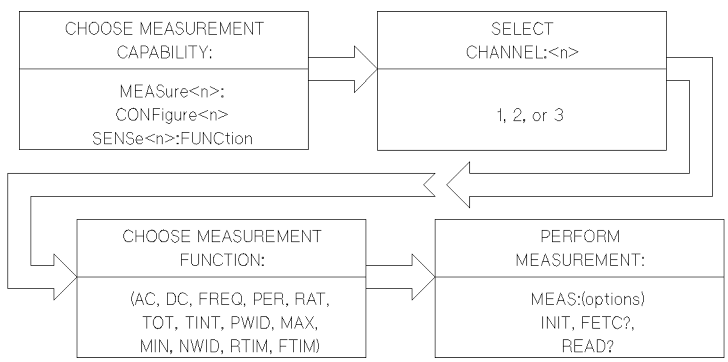


Figure 3-3. SCPI Measurement Configuration Flow

Frequency/Period Measurements

The frequency/period measurement function is specified as FREQ/PER respectively. All three counter inputs can measure frequency or period.

Measurement Definition and Range. The HP 70120A universal counter makes frequency measurements on repetitive input signals between the frequency limits shown below. Input signals are received through Input 1, Input 2, or Input 3. The frequency range for each input is:

- Input 1: 0.001 Hz to 200 MHz
- Input 2: 0.001 Hz to 100 MHz
- Input 3: 90 MHz to 2500 MHz

Procedure. You can make frequency (or period) measurements by simply connecting a signal to one of the inputs and executing a syntactically correct SCPI frequency measurement program message. Refer to the Frequency/Period Measurement program example in “Using the Universal Counter” for a typical example of a SCPI frequency/period measurement programming sequence.

Input Signal Conditioning. Input signal conditioning is setup by using one or more of the SENSe, and INPut commands. For low amplitude signals on Input 1 and Input 2, the sensitivity may be changed by using the LEVel and HYSTeresis subsystems of the SENSe:EVENt command.

Input 1 and Input 2 Trigger Level. You can adjust the optimum trigger level for Input 1 and Input 2 frequency measurements by use of the SENSe command and parameters/options. Trigger level range is ±10.2 V in 2.5 mV steps. The trigger slope is selectable for either POSitive or NEGative.

Event triggering is indicated by the flashing LED next to each input input connector. An optimum trigger point is usually on that part of the waveform where voltage change is most rapid. This trigger point will define the trigger level. (Refer to the trigger level discussion for more details about trigger level and hysteresis.) The SENS:EVENt:LEVel parameter query gives you the currently programmed trigger level.

Input 3 Trigger Level. The trigger level for Input 3 is fixed at 0 V nominal.

Gate (APERture) Time. The gate time (APERture) range is 1 ms to 99.999 s (in 1 ms increments) and may be determined by using the SENS:FREQ:APER? query. Frequency/Period is averaged over the gate time. When expected value and resolution are provided, the counter automatically determines the optimum gate time. If the programmed gate time is shorter than the input signal period, the actual gate time is increased to the signal period.

Pulse Width Measurements

The pulse width measurement function is specified as PWIDth or NWIDth. Only Input 1 and Input 2 can measure pulse width.

Measurement Definition and Range. The HP 70120A universal counter makes pulse width measurements on repetitive input pulse signals between 5 ns and 1 ms as shown in Figure 3-4. Input signals are received through Input 1 or Input 2. Autotrigger is automatically enabled for pulse width measurements unless specifically disabled. The default pulse width trigger level is 50% of the peak input signal amplitude.

Pulse width measurements are not dependent on gate time. Greater resolution can be obtained by selecting 100 Measurement Gate Averaging mode via the SCPI "SENSe:AVERage ON" program message string.

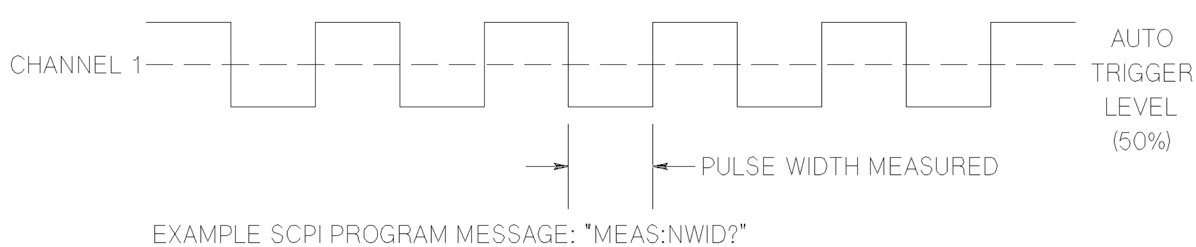


Figure 3-4. Pulse Width Measurement

Procedure. You can make pulse width measurements by simply connecting a signal to one of the inputs and executing a syntactically correct SCPI pulse width measurement program message. Refer to the pulse width measurement program examples in "Using the Universal Counter" for typical examples of SCPI pulse measurement programming sequence.

Input Signal Conditioning. Input signal conditioning is set up by using one or more of the SENSe and INPut commands. For low amplitude signals on Input 1 and Input 2, the sensitivity may be changed by using the LEVel and HYSTeresis subsystems of the SENSe:EVENt command.

Ratio Measurements

The ratio measurement function is specified as SENS:FREQ:RAT. Three input input combinations are permitted for RATio measurements:

- Input 1 with respect to Input 2,
- Input 2 with respect to Input 1,
- Input 3 with respect to Input 1.

Measurement Definition. The ratio measurement function provides measurement of the ratio between two frequencies. Both Input 1 and Input 2 have 35 mV rms sensitivity up to 100 MHz. Although the HP 70120A universal counter can measure and report ratios of less than 1, the higher frequency must be connected to the input listed in the numerator to meet the specifications.

Procedure. You can make a frequency ratio measurement by first routing signals simultaneously to Input 1 and Input 2. Then, execute the FREQ:RATio measurement function within a syntactically correct SCPI program message that includes the appropriate input signal conditioning.

Gate Time. The SENS:FREQ:APERture time determines the resolution by selecting the number of cycles of the Input 2 signal over which the ratio is measured. Increasing aperture time or increasing the signal frequency at Input 1 results in greater resolution of the measurement.

Rise/Fall Time Measurements

The rise-time or fall-time measurement function is specified as RTIMe or FTIMe. Only Input 1 can measure rise or fall time. The input signal must be repetitive.

Measurement Definition and Range. The rise-time or fall-time measurement function automatically configures the counter to perform either rise-time or fall-time measurements, via the Input 1 connector, as shown in Figure 3-5. Rise-time or fall-time measurements can be made from 15 ns to 15,000 s (1500 s with 100 Measurement Gate Averaging). The COMMon and auto-trigger modes are automatically selected. In this way the counter automatically locates the 10% and 90% points of the input signal, and sets the trigger levels accordingly.

Signal routing in COMMon mode cannot be disabled when the HP 70120A universal counter is making rise-time or fall-time measurements. The automatic level sensing can be disabled by specifically programming trigger levels as parameters. Actual gate time is controlled by the rise/fall time interval. Greater resolution can be obtained by using 100 Measurement Gate Averaging mode via the SENSe subsystem.

Procedure. You can make a rise-time or fall-time measurement by first connecting a signal to Input 1. Then execute either the RTIMe or FTIMe measurement function within a syntactically correct SCPI program message that includes appropriate input signal conditioning. Input 2 is configured to match Input 1 signal conditions.

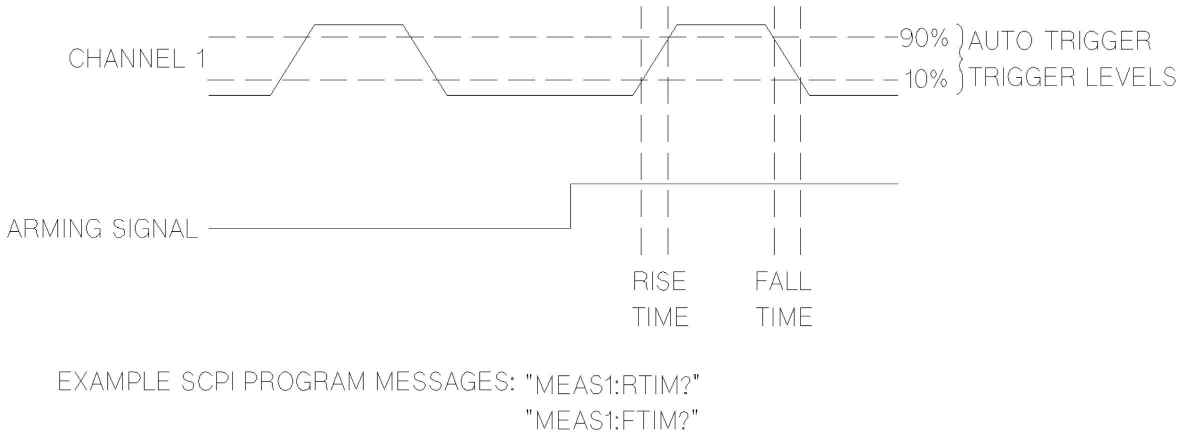


Figure 3-5. Rise/Fall Time Measurements

Time Interval Measurements

The time interval measurement function is specified as TINTerval. Only Input 1 and Input 2 can measure time interval.

Measurement Definition and Range. The HP 70120A universal counter can make single-shot and average time interval measurements programmed over a range of 1 ns to 15,000 s (1500 s with 100 Measurement Gate Averaging). The minimum START/STOP pulse width is 5 ns.

The time-interval function of the HP 70120A universal counter measures the length of time between a START signal at Input 1 and a STOP signal at Input 2, as shown in Figure 3-6. The START and STOP signals may be derived from separate signal sources, or they can originate from the same source. Trigger levels and slopes can be varied independently for each input using the SENSe command as follows:

```
SENS1:EVEN:SLOP POS
SENS2:EVEN:SLOP POS
```

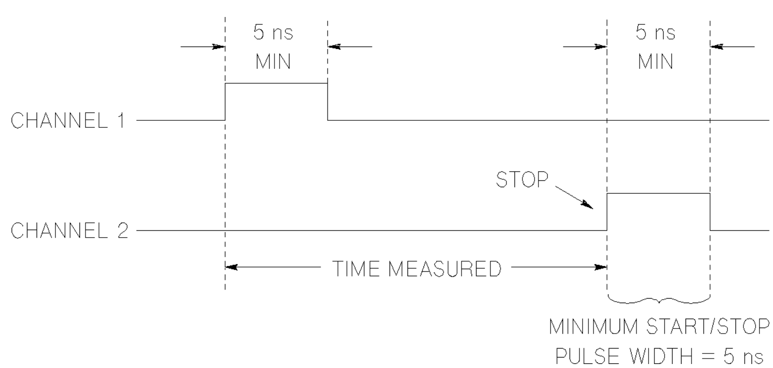


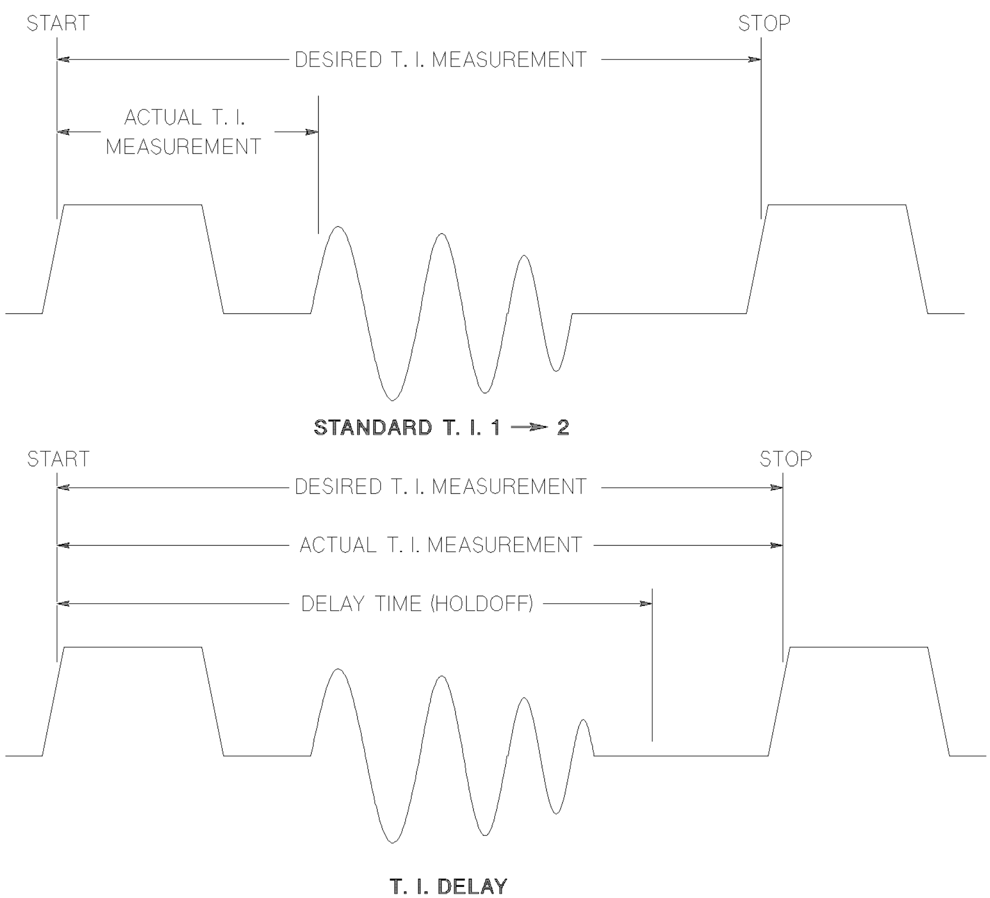
Figure 3-6. Time Interval Measurement

Procedure. You can make time-interval measurements between two events when both the start and stop events are derived from the same input signal. Simply connect the signal to Input 1 and use the "INPut:ROUTe COMMon" SCPI message string to select the common Input 1 mode.

If you want to make time-interval measurements between two events on separate input signals, connect the signal with the start event to Input 1 and the signal with the stop event to Input 2. The appropriate input signal conditioning may then be selected. Ensure that the counter is not in COMMon mode.

Slope Selection. The SLOPe parameter (POS or NEG) determines whether the trigger point for the START or STOP signal will be on the rising or falling edge. Auto trigger may be used for a repetitive input signal.

Time Interval Delay Measurements. The time interval delay measurement function is similar to time interval measurement function, but with the following additional control. The SENSe:TINTerval:DELay:TIMe <time value> and SENSe:TINTerval:DELay:STATe ON command strings used prior to TINTerval, insert a variable delay between the START (Input 1) event and the enabling of the STOP (Input 2) event, as shown in Figure 3-7. Potential STOP events are ignored during the specified delay. The counter completes the measurement on the next STOP event after the delay time has expired.



EXAMPLE SCPI PROGRAM MESSAGES: "SENS1:TINT:DEL:TIM 1MS"
SENS1:TINT:DEL:STAT ON"

Figure 3-7. Time Interval Delay Measurement

Totalize Measurements

The totalize measurement function is specified as TOT.

Measurement Definition and Range. The HP 70120A universal counter totalizes events up to a count of $10^{12} - 1$. Input signals are received through Input 1 or Input 2.

Totalize measures the number of counts (events) received through Input 1. The count is accumulated from input cycle to input cycle and can be reported by using consecutive FETCh? queries. The totalize function can be halted by using the STOP sequence of the ARM command. Totalize is independent of the APERture time setting. External arming may also be used to control the START and STOP of the totalize measurement.

You can also program the counter to give you the number of counts it received on one input during a single count on the other input. This operation is called "TOTalizing-by-GATE" mode. Refer to Chapter 8 for more details.

Procedure. You can make totalize measurements by simply connecting a signal to one of the inputs and executing a syntactically correct SCPI measurement program message. Refer to the Totalize Measurement program example in "Using the Universal Counter" for a typical example of a SCPI totalize measurement programming sequence.

Input Signal Conditioning. The appropriate input selection (Input 1 or Input 2), GATE state (ON/OFF) and input signal conditioning (input impedance/coupling) are set up by using one or more of the MEASure, SENSe, and INPut commands. For low amplitude signals on Input 1 and Input 2, the sensitivity may be changed by using the LEVel subsystem of the ARM or SENSe commands.

Voltage Measurements

The voltage measurement function is specified as AC/DC/MINimum/MAXimum. Only Input 1 and Input 2 can measure voltage.

Measurement Definition and Range. The HP 70120A universal counter measures input signal ac peak-to-peak voltage from 0.2 V to 10.2 V. A dc offset, if present, can be measured from −10.2 V to +10.2 V. The maximum frequency is 20 MHz.

Procedure. You can make voltage measurements by simply connecting a signal to Input 1 or Input 2 and executing a syntactically correct SCPI measurement program message. Refer to the voltage measurement program example in "Using the Universal Counter" for a typical example of an SCPI voltage measurement programming sequence.

Input Signal Conditioning. The event level is automatically set with auto trigger on.

Input Signal Conditioning

Input 1 and Input 2 of the HP 70120A universal counter include several programmable input signal conditioning controls. Input 3 has a fixed set of input signal conditioning values. The major elements of the circuitry for each input are the amplifier and input trigger blocks.

The input trigger converts the analog output of the input amplifier to a pulse train, compatible with the counter's Multiple Register Counter (MRC) block. The data accumulated by the MRC is used by the counter's internal microprocessor (measurement control block) to compute and format measurement results. The input characteristics described in the following paragraphs are:

- Range

- Sensitivity
- ac-dc Coupling
- Trigger Level
- Trigger Slope
- Input Impedance
- Damage Level
- Separate/Common Input

Specifications for the input characteristics of the HP 70120A universal counter are given in Chapter 4. Figure 3-8 depicts the SCPI process of signal conditioning that occurs at the front end of inputs 1 and 2. (Exact details of SCPI commands, options, and parameters are contained in Chapter 8.) Refer to Figure 1-1 for a simplified block diagram of the HP 70120A universal counter front-end.

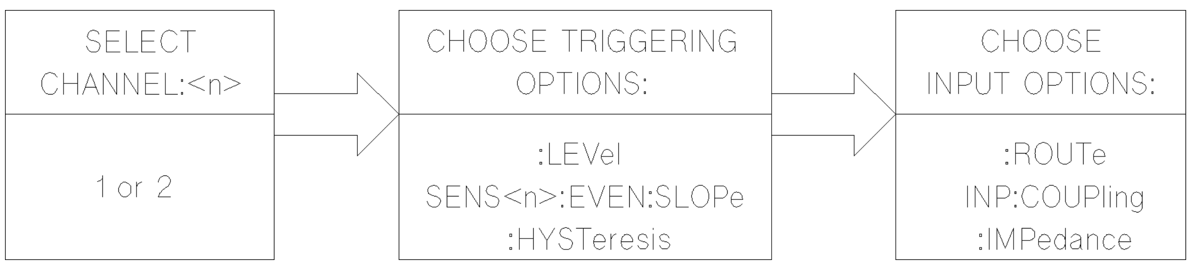


Figure 3-8. SCPI Signal Conditioning Flow

Input Range

Range defines the frequency range over which the input amplifier sensitivity is specified. The range varies with the selected coupling and input impedance. Although the specifications for Input 1 and Input 2 state that the input amplifiers have a range from dc to as high as 200 MHz, the range may vary for different operating modes.

SIGNAL OPERATING RANGE: Signal operating range defines the maximum positive and negative voltages within which the peak-to-peak signal can reliably operate. If the signal peaks extend beyond the specified signal operating range, as shown Figure 3-9 (bottom), one or more operating modes may give incorrect results; for example, frequency miscounting or time interval inaccuracies.

DYNAMIC RANGE: Dynamic range is the maximum allowable peak-to-peak signal range, specified with the trigger level set at midpoint of the input signal and centered within trigger level range. The instrument's dynamic range is limited by the input amplifier's linear range of operation. If the input signal exceeds this range, as shown in Figure 3-9 (top), the input amplifier may saturate, causing transitions of the input to be missed.

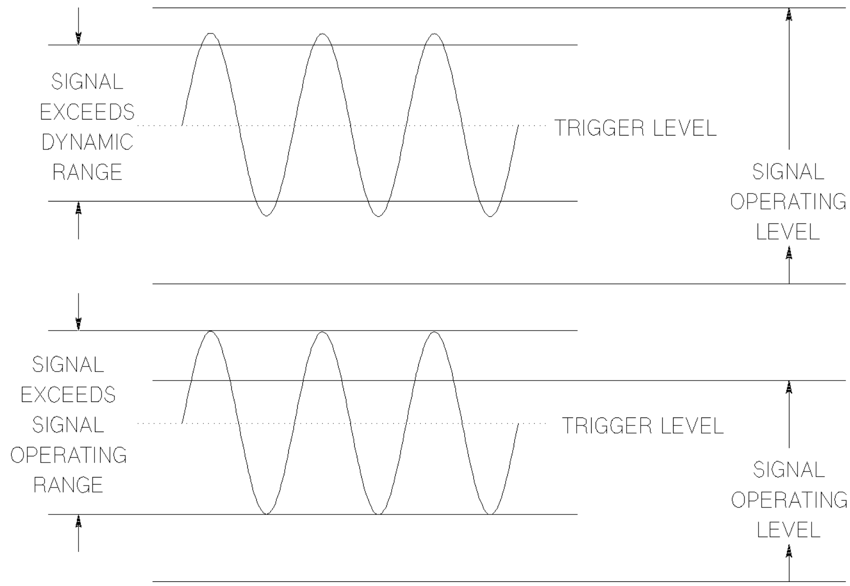


Figure 3-9. Invalid Input Signal Conditions

The dynamic range puts a further restriction on the allowable signal peaks as specified by the signal operating range. For optimum performance, the signal peaks must stay within the signal operating range specification, and the peak- to-peak value must stay within the maximum dynamic range specification, as shown in Figure 3-10.

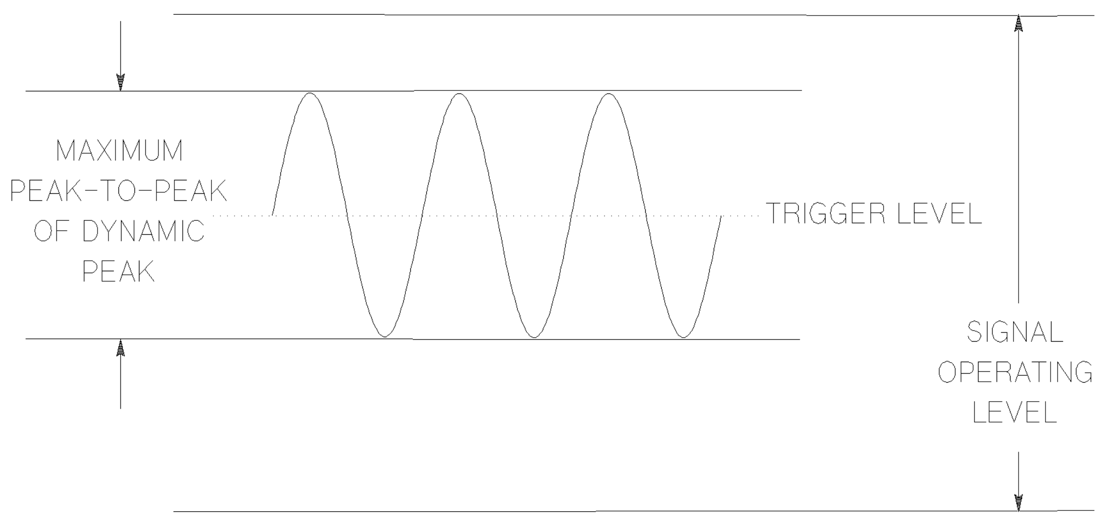


Figure 3-10. Valid Input Signal Conditions

Input Sensitivity

Sensitivity is the lowest amplitude signal at a particular frequency that the counter can measure. The input trigger level must be set at a value equal to the midpoint of the input signal. The input waveform must cross both upper and lower hysteresis levels to generate a count, as shown in Figure 3-11.

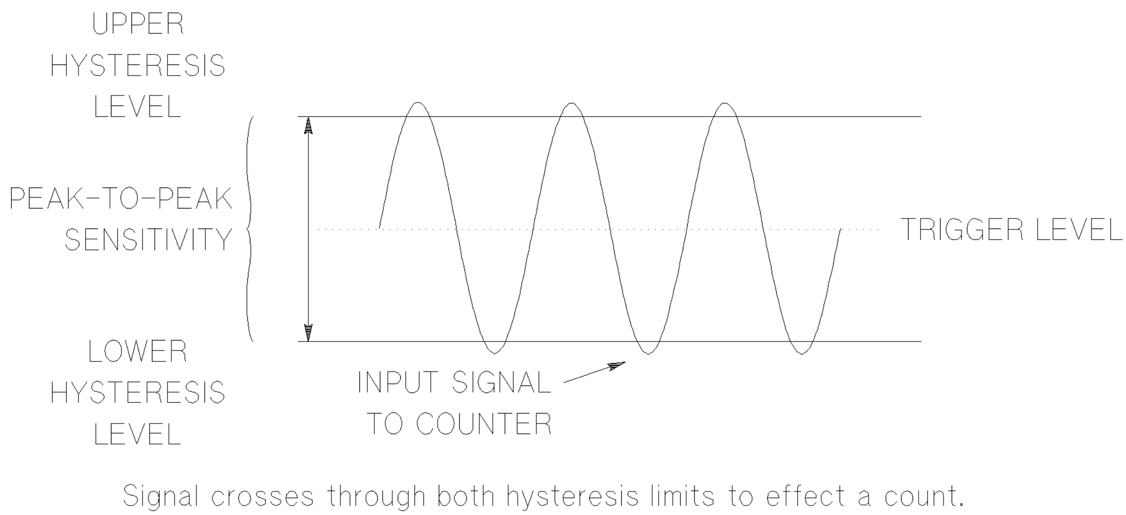


Figure 3-11. Acceptable Peak-to-Peak Amplitude

If the signal peaks do not cross both hysteresis limits, the input signal will not generate a count. For example, if the peak-to-peak amplitude is insufficient, or the trigger level is set above or below the midpoint of the input signal, as shown in Figure 3-12 and Figure 3-13, the counter can not make a measurement.

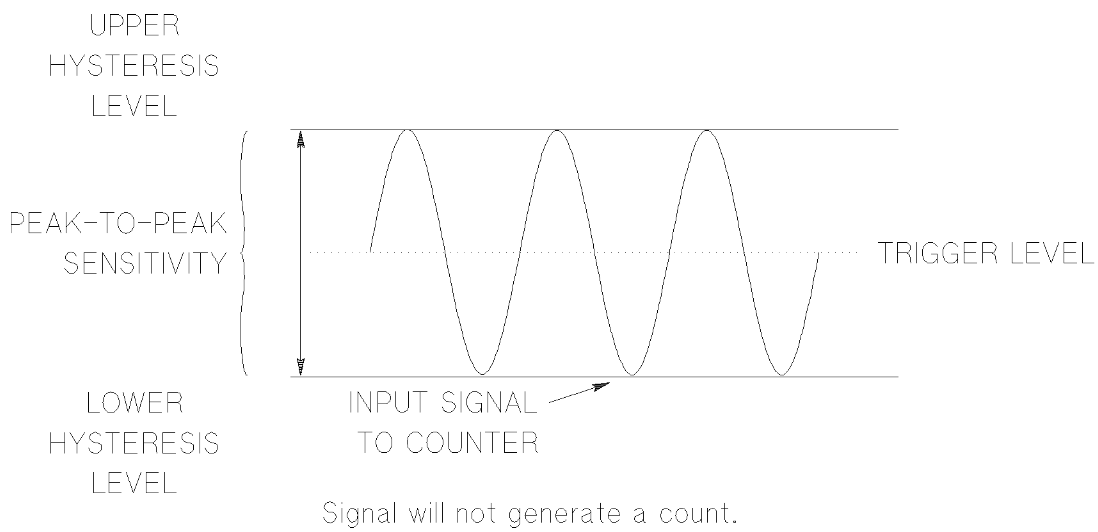


Figure 3-12. Insufficient Peak-to-Peak Amplitude

You can adjust the HYSTeresis (sensitivity) of the counter by sending the following SCPI program message to the HP 70120A universal counter:

```
SENS<n>:EVEN:HYST <MIN|MAX|DEF>
```

Where `n` is the selected Input 1 or 2.

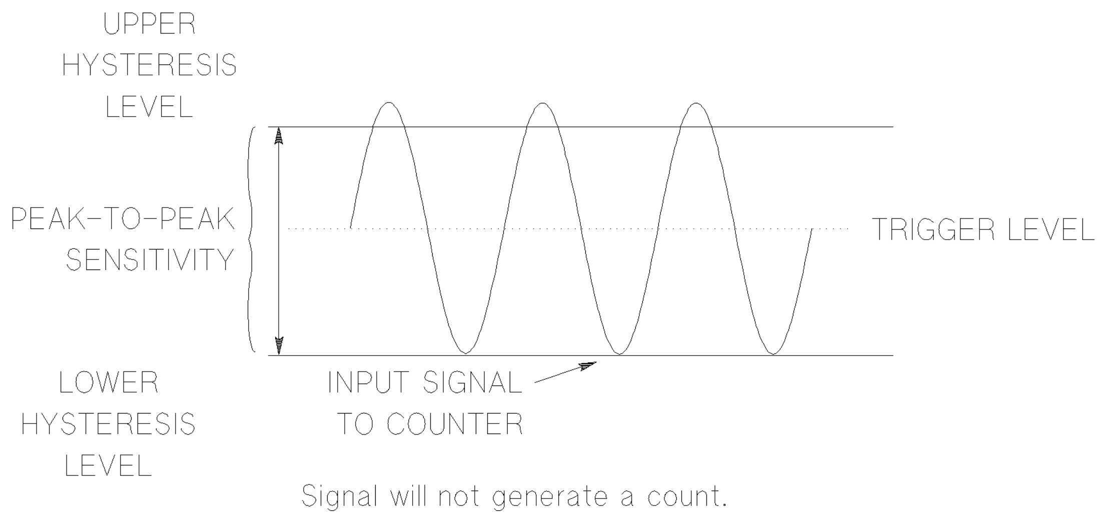


Figure 3-13. Trigger Level Set Below Midpoint of Input Signal

The sensitivity specification is given in terms of volts rms for applications that involve measuring a sine-wave signal. You should be aware that a different waveform with the same rms voltage may not trigger a count. Since the counter input does not respond to the rms value of the waveform but only to the peak-to-peak value, the sensitivity specification is also given for volts peak-to-peak with a minimum pulse width.

Note At minimum sensitivity, the hysteresis window is increased requiring a larger peak-to-peak voltage to generate a count, as shown in Figure 3-14. Optimum sensitivity depends on measurement application and other factors such as noise or interfering signals.

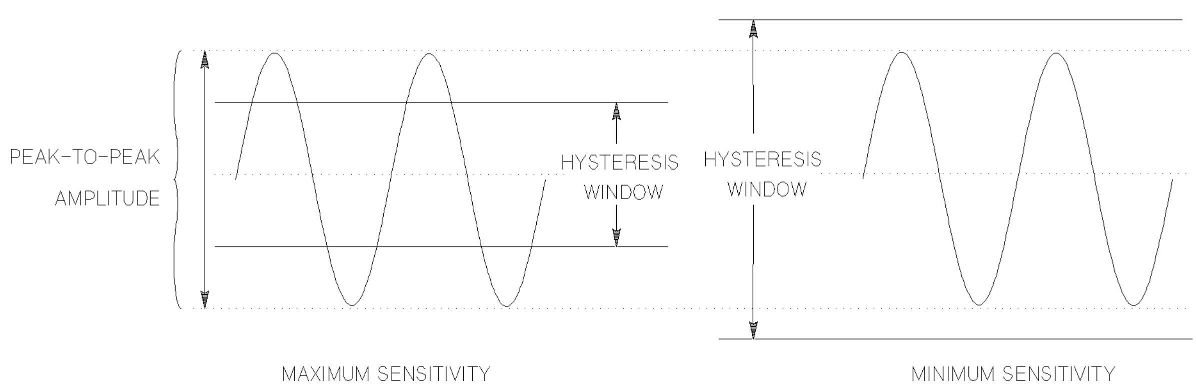


Figure 3-14. Hysteresis Window and Input Sensitivity

Input Coupling

Selectable ac or dc coupling is provided for Input 1 and Input 2. ac coupling must be used for signals with dc content exceeding the hysteresis limit of the input trigger. Figure 3-15 demonstrates the hysteresis limits and the use of ac coupling.

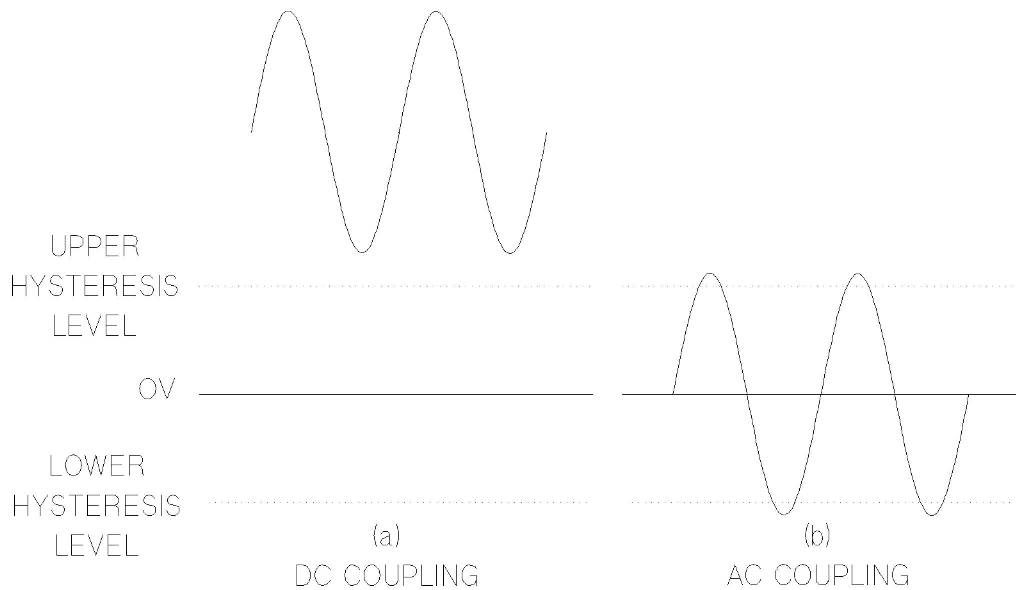


Figure 3-15. ac/dc Coupling

Note An input signal with dc content (as shown in a) would not be counted unless ac coupling (as shown in b), was used to remove the dc offset, or the appropriate trigger level was used.

Trigger Level

Trigger level is the voltage at the center of the hysteresis window. The actual trigger points are typically at the upper hysteresis level (POS slope) and at the lower hysteresis level (NEG slope), as shown in Figure 3-16.

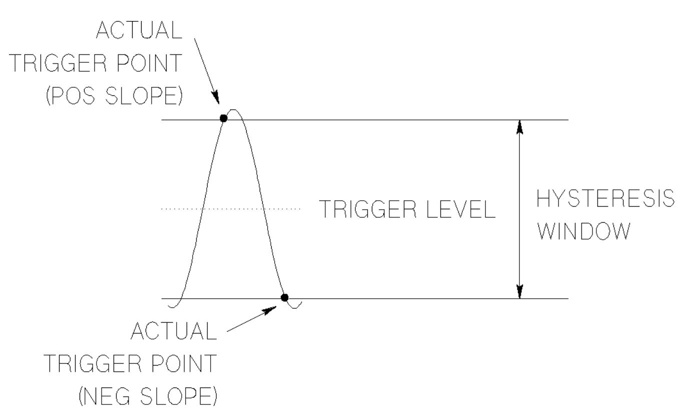


Figure 3-16. Trigger Level and Actual Trigger Point

The trigger levels are adjustable over the dynamic range of the counter when the SENS:EVENt:LEVel:AUTO command is OFF (auto trigger off) and a specific LEVel is entered. This ensures that any signal of sufficient amplitude and within the dynamic range can be counted.

Event triggering on the input signal is indicated by the flashing front panel Trigger LEDs.

When SENS:EVENt:LEVel:AUTO is on (auto trigger on), trigger levels are controlled by the amplitude of the input signal and automatically set in accordance with the measurement application. With auto trigger on, the input event trigger LEDs may flash randomly during the measurement.

For example, you can change the trigger level or select auto trigger for Input 2 by using the LEVel option of the SENSe:EVENt commands within the SCPI configuration program message as follows:

`SENS2:EVEN:LEV (nnn)` *To select a specific level.*

or

`SENS2:EVEN:LEV:AUTO ON` *For auto trigger.*

One use of programming the trigger level is to shift the hysteresis levels above or below ground. This lets you count positive or negative pulse trains, respectively, as indicated in Figure 3-17.

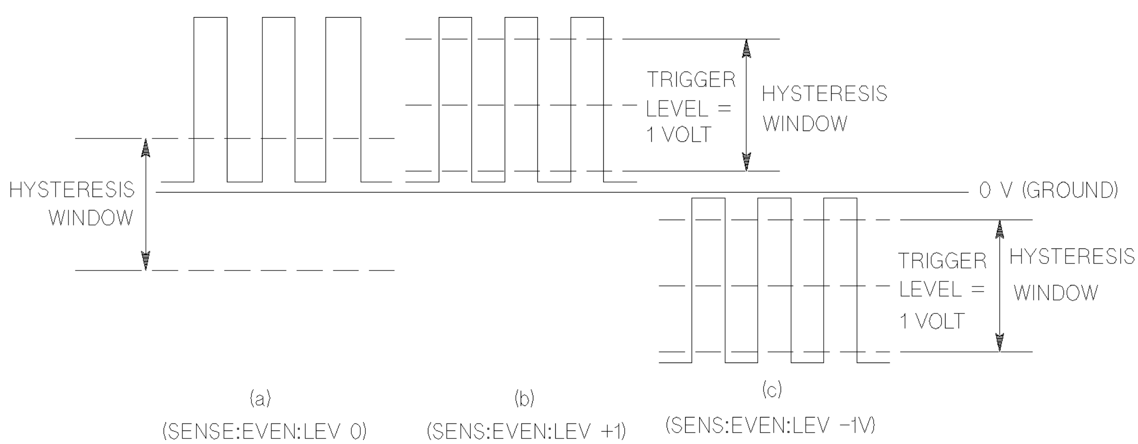


Figure 3-17. Hysteresis Window and Trigger Level

In Figure 3-17, the signal (a) will not be counted. Programming the trigger level to shift the hysteresis levels above ground (b), or below ground (c), enables a count.

Trigger Slope

The SENS:EVENt:SLOPe command string determines which edge of the input signal triggers the count. With the POSitive slope selected, a signal going from one voltage level to a more positive level, regardless of polarity, will generate a trigger pulse at the upper hysteresis limit. With the NEGative slope selected, the negative going edge of the signal will generate a trigger pulse at the lower hysteresis limit.

Trigger points for positive and negative slopes are shown in Figure 3-18.

You can change the trigger slope of the HP 70120A universal counter by using the POSitive or NEGative parameters of the SENSe:EVENt:SLOPe commands within the SCPI configuration program message sent prior to initiating a measurement as follows:

`SENS:EVENt:SLOPe POSitive` *For a positive slope.*

or

`SENS:EVENt:SLOPe NEGative` *For a negative slope.*

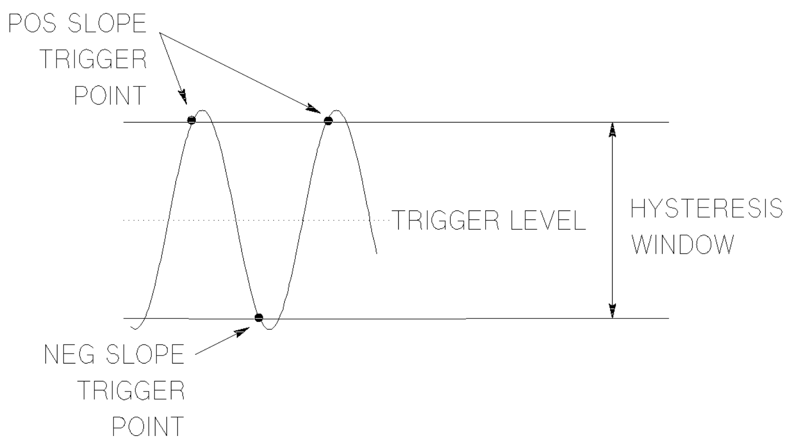


Figure 3-18. Positive and Negative Trigger Points

Input Impedance

Each input has a selectable impedance of 1 MΩ or 50 Ω. With 1 MΩ impedance, the input is shunted by < 45 pf. At the higher frequencies, the 50 Ω nominal input impedance is usually preferred, since the inherent shunt capacitance of high impedance inputs rapidly reduces input impedance.

For the lower frequencies, the 1 MΩ input impedance may be selected. The input impedance becomes 500 kΩ (shunted by 30 pf maximum) in the 1 MΩ position when signal routing is in COMMon mode. In the 50 Ω position, the impedance remains 50 Ω.

You can change the input impedance of the HP 70120A universal counter by using the IMPedance subsystem of the INPut command and specifying the desired input impedance in ohms within the SCPI configuration program message sent prior to initiating a measurement as follows:

`INP:IMP 50` *For a 50 Ω input impedance.*

or

`INP:IMP 1E6` *For a 1 MΩ input impedance.*

Damage Level

Damage level is the maximum input voltage the counter can withstand without danger of permanent input hardware failure. The damage level value varies with input impedance, coupling selection, and input waveform. For a sine wave, the maximum input signal must never exceed 5 volts rms. For accurate measurements, the input signals must stay within the dynamic range and the signal operating range of the counter.

Separate/Common Input

Input 1 and Input 2 may be coupled together to allow maximum versatility. The INPut:ROUTe command controls the selection of separate or common input. All specifications are the same for separate or common operation, except sensitivity and impedance.

When the INP:ROUTe command parameter is SEParate, Input 1 and Input 2 function independently of each other for all measurements.

When the INP:ROUTe parameter is programmed to COMMon, the Input 2 connector is disconnected and the Input 1 and Input 2 input amplifiers are connected together at Input 1. The Input 1 coupling and impedance condition the input signal to both Input 1 and Input 2 amplifiers. However, both inputs can continue to be programmed independently for trigger levels and slopes. Rise-time and fall-time functions cause the input routing to be set in COMMon mode.

The input impedance becomes 500 kΩ (shunted by 90 pf maximum) when 1 MΩ impedance is active and the Common input is enabled. When 50 Ω impedance is active, the impedance remains 50 Ω for COMMon or SEParate programmed input states. The signal operating range, dynamic range and damage level remain unchanged. You can change the configuration of HP 70120A universal counter inputs by using the ROUTe subsystem of the INPut command within the SCPI configuration program message sent prior to initiating a measurement as follows:

`INPut:ROUTe COMMon` *For common Input 1 and 2 operation.*

or

`INPut:ROUTe SEParate` *For separate Input 1 and 2 operation.*

The rise-time or fall-time measurement functions automatically set up the appropriate routing.

Time Interval Between Pulses

Common inputs, when used with the time interval function and certain configurations of the arming slop and level, can cause the counter to be unable to make a measurement. For example, suppose the desired measurement is the interval between two pulses as shown here.

Figure 3-19.

The counter may be configured as follows:

`:INP:ROUT COMM`	*Input signal appears internally on both inputs.*
`:CONF:TINT`	*The counter is configured for a time interval measurement.*
`:SENS1:EVEN:SLOP POS` `:SENS2:EVEN:SLOP POS`	*The positive slope is selected for both inputs.*
`:SENS1:EVEN:LEV 1.0` `:SENS2:EVEN:LEV 1.0`	*The event level is the same for both inputs.*

Instead of measuring the desired time interval as shown in Figure 3-19, the counter will see the start and stop signals at the same time and will not make the measurement. The resulting situation is shown in Figure 3-20 below.

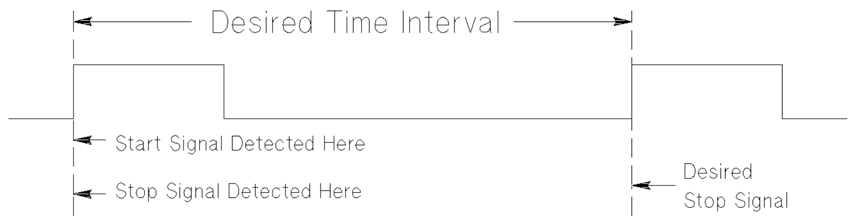


Figure 3-20.

This situation can be avoided by turning on the counter's delay mechanism and setting a small delay time so that the counter will wait until the delay time has expired before looking for a stop signal. The following two commands could be used in addition to those mentioned above:

`:SENS:TINT:DEL:STAT ON`	*Turn on the counter's delay mechanism.*
`:SENS:TINT:DEL:TIME 1 ms`	*Do not look for the stop arm until 1 ms has expired.*

This will result in the measurement occuring as shown here.

Arming the Counter Universal

This section describes the procedures (commands and, if necessary, signal connections) used to take advantage of the counter's arming system. It also explains how to abort a measurement by returning the counter to the Idle state before a measurement has completed, or before an arming sequence has completed. Arming provides a means of synchronizing measurements with external signals, internal sources, or other qualifiers such as the Group Execute Trigger (GET).

The SCPI arming selection flow is shown in Figure 3-21. (Exact details of SCPI commands, options, and parameters are contained in Chapter 8.)

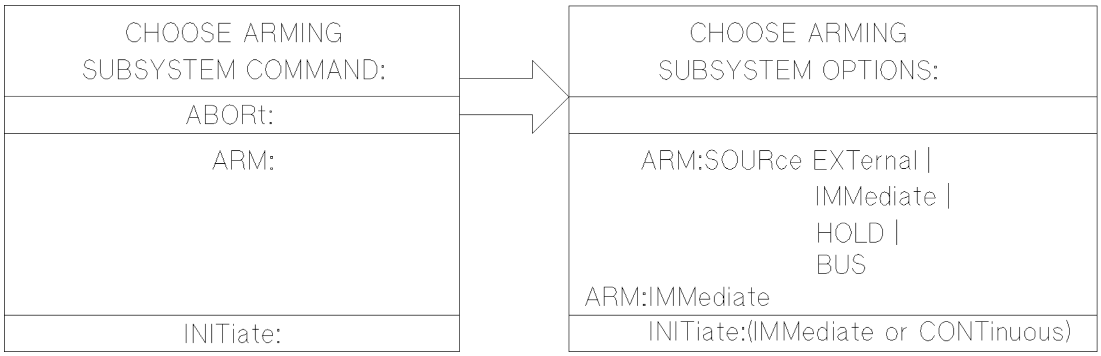


Figure 3-21. SCPI Arming Selection Flow

The HP 70120A universal counter may be armed (made ready to start or stop a measurement) via the ARM subsystem by arming sources internal or external to the counter. The counter's ARM subsystem operates in one of two states as shown in Figure 3-22

- Idle state - Configuration of the counter and its arming system occurs while in the Idle state.
- Wait-for-arm state - When the START arm condition is satisfied, the measurement starts as soon as the input signal event crosses the trigger threshold. The next signal event that occurs after the STOP arm condition is satisfied, ends the measurement. This pair of signal events marks the measurement duration.

If INIT:CONT is on, release from the idle state is immediate. If the measurement does not complete (for example totalize), the measurement must be terminated (aborted or reconfigured) before the counter returns to the Idle state.

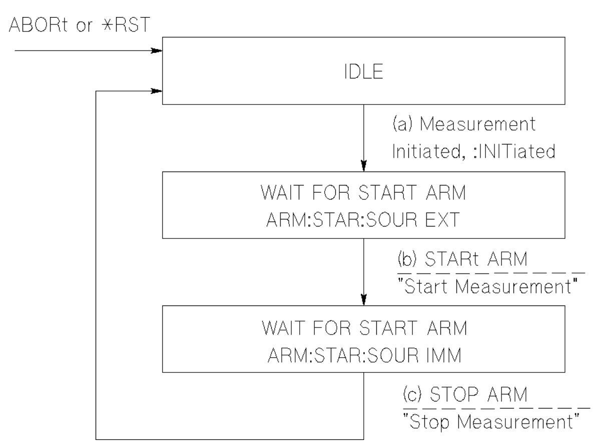


Figure 3-22. Counter Arming System

Internal Arming

Immediate source arming is used for measurements that do not require synchronization with an external signal. All internal arm states are controlled by the arming system commands and the *RST command. The *RST command always puts the counter's arming system in the Idle state. ABORt resets the arming system and places it in the Idle state. Details of these commands can be found in the *Command Reference*.

Immediate, Hold, and Bus. The ARM[:IMMediate] command provides a one-time override for recognition of the arming event (Start or Stop). This command initiates an event and has no *RST condition and cannot be queried.

HOLD suspends arming and hence measurement triggering. Once set, the counter can only resume measurement with the ARM[:IMMediate] command. If you want the counter to hold-off measurements upon execution of your measurement program messages, the arming system must be in the HOLD arming state. You can place the STOP arming system in the HOLD state by executing the following command string:

```
ARM:STOP:SOUR HOLD
```

BUS suspends arming and measurement triggering until the Group Execute Trigger (GET) command is received. A *TRG satisfies this condition.

External Arming

The HP 70120A universal counter may also be armed (made ready to start or stop a measurement) by applying an external arming signal. This signal can be supplied to the counter via the front panel BNC Arm input connector or the rear panel SMB trigger input connector.

The external ARM inputs lets you choose the point, on a waveform, at which the start and/or stop of a measurement occurs. Figure 3-23 illustrates using external arming to measure frequency at various points along a modulated signal.

The external arm levels may be programmed for 1.6 V (TTL), −1.3 V (ECL), or 0 V (GND). Details of these commands can be found in Chapter 8.

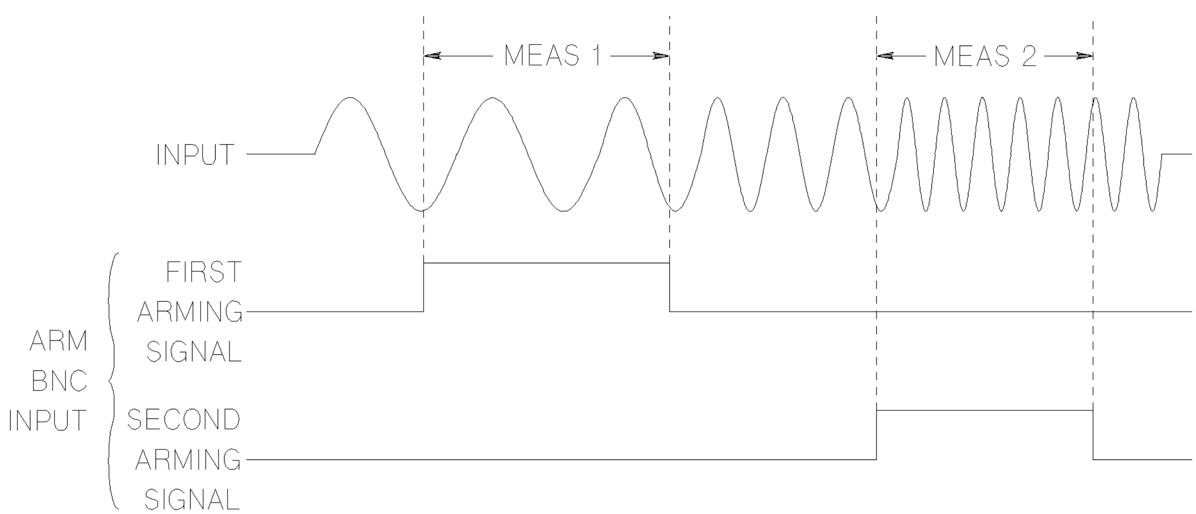


Figure 3-23. Use of External Arming to Measure Frequency

Front Panel Arm Input Connection. You can use external arming via the front panel BNC Arm input connector to make measurements that must coincide with a unique signal event outside the counter. You can use external arming via the front panel BNC Arm input connector with the following command string:

```
ARM:(STOP or STARt):SOUR EXTernal
```

The front panel external Arm Input signal that you have connected to the counter must be within the following Arm input specifications:

Frequency Range	0-20 MHz
Input Impedance	1 MΩ (40 pF shunt)
Input Sensitivity	500 mV peak-to-peak
Input Coupling	dc
Slope	positive or negative selectable
Trigger level	Selectable: 0 V, 1.6 V, and −1.3V (Nominally: GND, TTL, and ECL)
Damage Level	0 to 3.5 kHz: 50 V (dc + peak ac) > 25 kHz: 5 V rms

Note You can change the input arming slope and level characteristics by using the LEVel and SLOPe options of the ARM command. Refer to the *HP 70120A universal counter Command Reference*.

Rear Panel Trigger Input Connection. You can trigger the counter from an external trigger source by using the rear panel SMB trigger input connector. Use the following command to accomplish this.

```
ARM(:STOP|:STARt):SOUR EXT2
```

The rear panel external trigger signal must be TTL compatible.

Measurement Resolution

Resolution is the smallest change in a measurement that can be discerned. The more resolution you desire, the longer the gate time needed to sample the input signal. There are two ways to specify resolution. You can set it directly with the SENSe command by changing the gate time via APERture, or you can program a particular resolution as a parameter to the MEASure, CONFigure, or SENSe commands.

The gate time actually determines the resolution of the measurement. You can set it by changing the aperture time with the APERture command of the SENSe subsystem. The gate time range is 1 ms to 99.999 s in 1 ms increments. The maximum resolution is nine digits, per second of gate time. Thus, 1 ms of gate time will display six digits of resolution.

On power up, the HP 70120A universal counter initializes to the FREQ function on Input 1 with the gate time set at 100 ms and auto trigger off. Figure 3-24 shows the resolution selection process. (Exact details of SCPI commands, options, and parameters are contained in the *HP 70120A universal counter Command Reference*.)

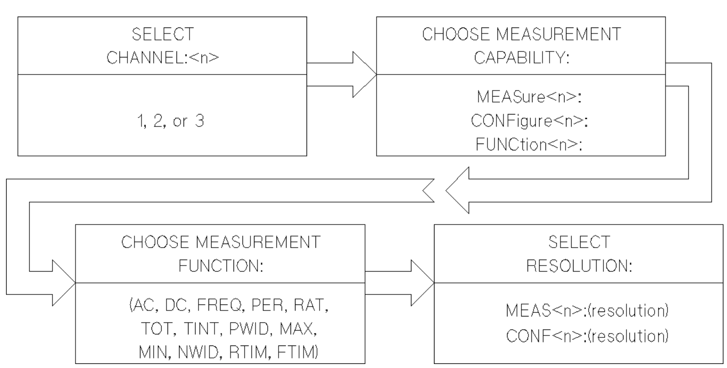


Figure 3-24. SCPI Resolution Selection Flow

Setting the Aperture Time

Aperture time (gate time) can be specified by using the APERTure command of the SENSe subsystem for FREQuency, PERiod, and RATio measurements only. Setting the aperture time selects a specific resolution. Aperture time can be set from 1 ms to 99.999 s in steps of 1 ms.

Use the following command string to specify a desired aperture time:

```
SENS :FREQ:APER n
```

Where `n` is the aperture time in seconds.

Note By specifying the resolution in a MEASure or CONFigure command, the counter automatically selects the aperture time required to obtain that resolution. Explicitly selecting an aperture time after a CONFigure command will override the automatic selection of the aperture time.

Note The more resolution you ask for, the longer the aperture time required to obtain that resolution. Asking for more resolution than your needs require will decrease measurement speed.

Resolution and Gate Time Calculations

The number of digits of resolution is a direct function of gate time. The absolute resolution in Hertz (for frequency) is a function of both the measurement gate time and signal frequency. Table 3-3 provides a listing of available digits of resolution, corresponding gate times, and effective resolution in Hertz for 1 MHz, 10 MHz, and 100 MHz.

Table 3-3. Resolution and Gate Time

Digits of Resolution	Gate Time	Resolution in Hertz 100 MHz	10 MHz	1 MHz
9	1 s	0.1	0.01	0.001
8	100 ms	1.0	0.1	0.01
7	10 ms	10	1	0.1
6	1 ms	100	10	1
*5	1 ms	100	10	1
*4	1 ms	100	10	1
*3	1 ms	100	10	1

* The counter gives more resolution than required because the minimum gate time is 1 ms.

An additional digit of resolution is available via 100 Measurement Gate Averaging mode. When enabled, this mode accumulates 100 gated measurements, computes the average, and displays the results. It can be used with all functions except TOTalize, ac, dc, MINimum, and MAXimum.

Output Formats

The HP 70120A universal counter measurement results are output to the controller in scientific notation as shown in Figure 3-25. The output data contains 16 characters arranged in the following format:

One digit
Decimal point
Nine digits
E ±sign
Two exponent digits
Carriage return
Line feed

Figure 3-25. Numeric Output Format

Measurement Data Field

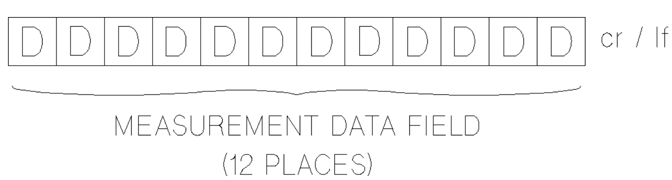
The data field consists of a 12-character string as shown in Figure 3-25.

Exponent

The exponent will always be two digits preceded by a ± sign.

Totalize Output

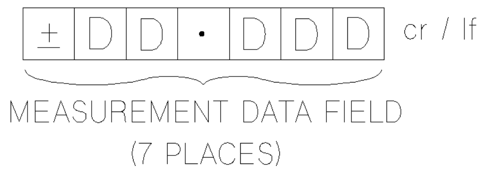
For TOTalize, output format differs from above as follows:



The digits are right justified, that is, if the returned results do not fill all twelve places, the spaces are inserted.

MIN/MAX/AC/DC

The measurement data field for MINimum, MAXimum, ac, and dc differs from the above as follows:


± D D . D D D
cr / lf
MEASUREMENT DATA FIELD
(7 PLACES)

4

Specifications and Characteristics

This chapter contains the specifications and characteristics for the HP 70120A universal counter.

These are the performance standards, or limits against which the instrument may be tested including typical characteristics as additional information for the user. (Only specifications are warranted.)

Table 4-1. Specifications and Characteristics

OPERATING MODE SPECIFICATIONS	
Frequency 1,2,3	
Range 1[***]	.001 Hz to 100 MHz (200 MHz with ÷ 2 prescaler)
Range 2[***]	.001 Hz to 100 MHz
Range 3	90 MHz to 2400 MHz (with ÷ 64 prescaler)
LSD[*]	(4 ns / Gate Time) × FREQ
Resolution[†]	$\pm\text{LSD} \pm \frac{(1\text{ ns rms} + 1.4 \times \text{Trigger Error}) \times \text{FREQ}}{\text{Gate Time}}$ [‡]
Accuracy	± Resolution ± Time Base Error[§]
Period 1,2,3	
Range 1,2	10 ns to 15,000 s (5 ns to 15,000 s on Input 1)
Range 3	11 ns to 420 ps
LSD[*]	(4 ns / Gate Time) × PER
Resolution[†]	$\pm\text{LSD} \pm \frac{(1\text{ ns rms} + 1.4 \times \text{Trigger Error}) \times \text{PER}}{\text{Gate Time}}$ [‡]
Accuracy	± Resolution ± Time Base Error[§]
Time Interval, 1 to 2	
Range	1 ns to 15,000 s (single-shot), 150 s (100 gate average)
LSD[*]	1 ns (100 ps using 100 gate average)
Resolution	± LSD ± Start Trigger Error[‡] ± Stop Trigger Error[‡] ± 1 ns rms[**]
Accuracy	± Resolution ± Time Base Error[§] ± Trigger Level Timing Error[††] ± Trigger Level Setting Error[‡‡] ± 2ns[§§]

[*] See definition 1.
[†] See Figure 4-1.
[‡] See definition 3.
[§] See definition 2.
[**] 100 ps using 100 gate average.
[††] See definition 4.
[‡‡] See definition 5.
[§§] Systematic error due to differential channel delay. Can be eliminated with optimized measurement technique (offsets, cable length, etc.).
[***] Frequency range is dependant on auto-trigger state. See Auto Trigger under Input Specifications for restrictions.

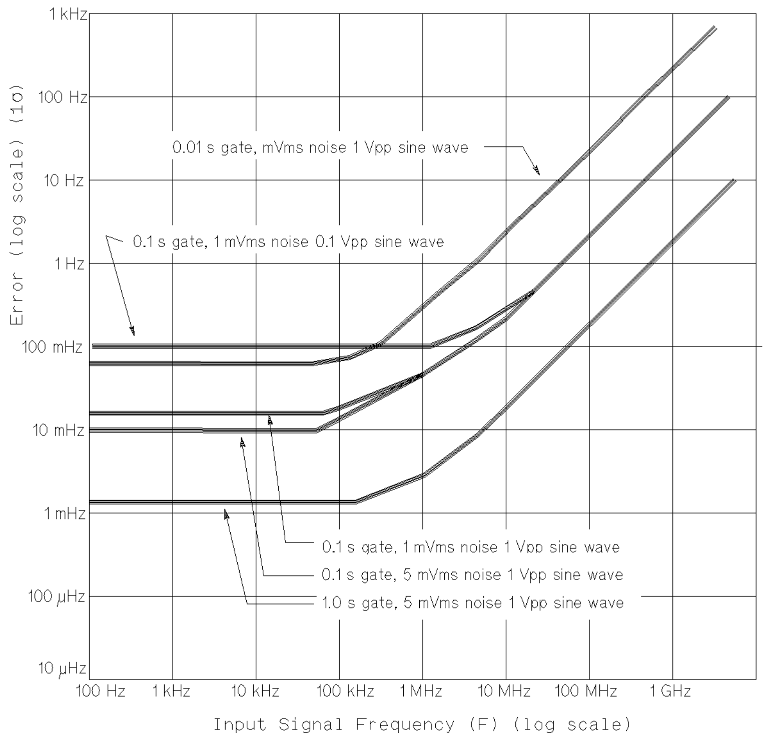


Figure 4-1. Frequency Resolution Error

Noise on the input signal and internal uncertainties affects Frequency and Period measurements. For Period, invert the period (P) of the input signal ($F = \frac{1}{P}$), and find frequency error (ΔF). Period error $(\Delta P) = (\frac{\Delta F}{F}) \times P$.

OPERATING MODE SPECIFICATIONS (continued)	
Time Interval Delay, 1 to 2*	
Delay Range	1 ms to 99.999 s (1 ms steps)
Delay Accuracy	$\pm$ 100 μs $\pm$ 0.05% $\times$ Delay Time
Frequency Ratio 1/2, 2/1, 3/1	
Input Range 1, 2	.001 Hz to 100 MHz (200 MHz on input 1 if ÷ 2 prescaler is selected)
Input Range 3	90 MHz to 2400 MHz
LSD†	$\frac{4 \times \text{RATIO}}{\text{Numerator Input FREQ} \times \text{GateTime}}$
Resolution‡	$\pm\text{LSD} \pm \frac{\text{Denominator Input Trigger Error}}{\text{Gate Time}} \times \text{RATIO}$‡
Accuracy	Same as resolution

* Used with TI, 1 to 2, a selectable delay can be inserted between START (Input 1 trigger) and STOP (Input 2 trigger). Electrical inputs during delay are ignored. Specifications are the same as TI, 1 to 2.
† See definition 1.
‡ See definition 3.

OPERATING MODE SPECIFICATIONS (continued)	
Totalize 1, 1 by 2, 2 by 1	
Range	0 to 1 × 10^{12} −1 events
LSD[*]	1 count of input signal
Resolution	± 1 count
Accuracy	± 1 count
Maximum Frequency	20 MHz
Rise/Fall Time 1	
Range	×1: 15 ns to 15,000 s (150 s with 100 gate average)
	×10: 50 ns to 15,000 s (150 s with 100 gate average)
LSD[*]	1 ns (100 ps using 100 gate average)
Resolution	± LSD ± Start Trigger Error[†] ± Stop Trigger Error[†] ± 1 ns rms[‡]
Accuracy	± Resolution ± Time Base Error[§] ± Trigger Level Timing Error[**] ± Trigger Level Setting Error[††] ± 2 ns[‡‡]
Levels	10%/90% MAX (20%/80% MAX in ×10 mode)
With Automatic Triggering	
Range	15 ns to 1 ms
Minimum Amplitude	500 mV p-p
Frequency Range	1 kHz to 20 MHz
Pulse Width 1, 2	
Polarity	Positive or Negative
Range	5 ns to 1 ms
LSD[*]	1 ns (100 ps using 100 gate average)
Resolution	± LSD ± Start Trigger Error[†] ± Stop Trigger Error[†] ± 1 ns rms[‡]
Accuracy	± Resolution ± Time Base Error[§] ± Trigger Level Timing Error[**] ± Trigger Level Setting Error[††]
With Automatic Triggering	
Minimum Amplitude	200 mV p-p (70 mV rms sine wave)
Frequency Range	1 kHz to 20 MHz
Voltages 1,2	
Measurements	MIN, MAX, DC, AC[§§]
Frequency Range	dc, 1 kHz to 20 MHz
Dynamic Range	
dc signals	± 10.2 V (± 30V in ×10 mode)
ac signals	200 mV p-p to 10.2 V p-p

[*] See definition 1.
[†] See definition 3.
[‡] 100 ps using 100 gate average.
[§] See definition 2.
[**] See definition 4.
[††] See definition 5.
[‡‡] Systematic error due to differential channel delay. Can be eliminated with optimized measurement technique (offsets, cable length, etc.).
[§§] AC voltage reading gives RMS value assuming a sine wave input.

OPERATING MODE SPECIFICATIONS (continued)		
Voltages 1,2 (continued)		
Resolution		
Min, Max, AC/DC	30 mV	
Accuracy		
Min, Max, DC, AC	AC ± 50 mV ± 5% of p-p voltage (± 20% in ×10 mode)	
INPUT SPECIFICATIONS		
Input 1 Range		
dc coupled	0 to 100 MHz (200 MHz with ÷ 2 prescaler)	
ac coupled	100 Hz to 100 MHz (200 MHz with ÷ 2 prescaler)	
Input 2 Range		
dc coupled	0 to 100 MHz	
ac coupled	100 Hz to 100 MHz	
Input 3 Range		
ac coupled	90 MHz to 2400 MHz	
Sensitivity 1,2 (MAX)	35 mV rms sine wave; 100 mV p-p at a minimum pulse width of 5 ns.	
Sensitivity 3	−30 dBm at 100 MHz	−10 dBm at 2400 MHz
1 MΩ 1,2		
Dynamic Range (ac)	10 V p-p	(100 V p-p in ×10 mode)
Signal Operating Range (dc)	± 10 Volts	(± 100 V in ×10 mode)
50 Ω 1,2,3		
Dynamic Range (ac)	10 V p-p	
Signal Operating Range (dc)	± 10 Volts	
AC + DC	not to exceed 10 Vrms (5 Vrms input 3)	
Trigger Level Range 1,2	±10.2 V with step	
Trigger Level Range 3	fixed at 0 V	
Trigger Level Accuracy 1,2	±30 mV ± 1% of trigger level* (± 20% in ×10 mode)	
Auto Trigger†		
Frequency Range	1 kHz to 20 MHz	
Minimum Amplitude	70 mV rms sine wave, 200 mV p-p	
External Arming		
Input	Front-panel BNC	
Minimum Start to Stop Time	50 ns	
Sensitivity	500 mV p-p	
Signal Operating Range	− 5 V dc to +5 V dc	
Dynamic Range	500 mV to 5 V p-p	

* Same as Autotrigger Level Accuracy

† Can be selected to determine trigger levels for all measurements except totalize and Input 3 measurements.

TCXO TIME BASE SPECIFICATIONS	
Frequency	10 MHz
Stability	
Aging Rate	$<$ 1 ppm/year
Temperature	$<$ 5 ppm, 0 – 55°
INPUT CHARACTERISTICS	
Hysteresis 1,2 (@1 MHz)	
Adjustable to: (typical)	
MIN	30 mVp-p (300 mVp-p in ×10 mode)
MAX	100 mVp-p (1.0 Vp-p in ×10 mode)
DEF	60 mVp-p (600 Vp-p in ×10 mode)
Coupling 1,2	ac, dc
Trigger Slope 1,2	Independent selection of + or − slope
Impedance 1,2	1 MΩ shunted by $<$ 45 pf or 50 Ω*
Impedance 3	50 Ω (ac coupled)
Damage Level 1,2 (AC + DC)	
50 Ω	10 Vrms
1 MΩ	
≤ 20 kHz	± 100 V peak
> 20 kHz	10 Vrms
Damage Level 3	5 Vrms ac (± 30 V dc)
Common Input Routing†	
Input 1 Range	Limited to 100 MHz
Impedance	500 kΩ shunted by $<$ 90 pF or 50 Ω*
External Arm‡	
Range	0 to 20 MHz
Trigger Levels	0 V (GND), 1.5 V (TTL), − 1.3 V (ECL)
Slope	Independent Selection of START and STOP ARM slopes, +, −, or OFF.
Impedance	dc coupled. 1 MΩ shunted by $<$ 45 pF*
Damage Level	
≤ 20 kHz	85 Vrms
> 20 kHz	10 Vrms
External Trigger	TTL level input

* Resistance values are measured at dc and capacitance at 1 MHz.

† All specifications are the same as separate operation except for those shown.

‡ Front panel ARM input can be used to determine Start and/or Stop point of a measurement. External Arm can be used with all measurements.

TIME BASE CHARACTERISTICS		
Standard Time Base	Uses Internal TCXO as default	
External Reference Input	Rear panel SMB accepts 10 MHz, 500 mV to 5 V rms into 1 kΩ shunted by < 30 pF	
External Reference Output	The TCXO Time Base signal can be routed out the rear panel SMB	
Signal	10 MHz, Square wave into 50 Ω, amplitude 320 mVp-p	
GATE TIME CHARACTERISTICS		
Range	1 ms to 99.999 seconds in 1 ms increments. (100 ms default)	
Resolution	1 ms	
Accuracy	$\pm$ 100 μs $\pm$ (0.05% $\times$ Gate Time) + up to one period of input signal	
100 Gate Average	100 gates accumulated and average is returned. This adds an additional digit of resolution. It can be used with all functions except Totalize.	
Gate Output	Level is TTL low while gate is open during all measurements except Totalize.	
MEASUREMENT THROUGHPUT CHARACTERISTICS*		
Short Speeds		
Free-run	Up to 60 measurements/second	
Switching	Up to 40 measurements / second	
Comprehensive Single Reading Times		
Frequency/Period	100 Hz signal, .1 Hz resolution (3 digits)	60 ms
	100 Hz signal, .0001 Hz resolution (6 digits)	60 ms
	10 MHz signal, 10 kHz resolution (3 digits)	24 ms
	10 MHz signal, 10 Hz resolution (6 digits)	25 ms
Totalize	10 MHz signal, Time to read total (FETC?)	9 ms
Ratio	100 kHz signal, .0001 resolution (4 digits)	426 ms
	10 MHz signal, .0001 resolution (4 digits)	31 ms
Time Interval	10 ms signal, 10 ns resolution (6 digits)	40 ms
	100 μs signal, 100 ns resolution (3 digits)	21 ms
	100 μs signal, 1 ns resolution (5 digits)	173 ms
Automatic Pulse Width	5 ms signal, 5 ns resolution (6 digits)	290 ms
	50 μs signal, 50 ns resolution (3 digits)	280 ms
Automatic Rise/Fall Time	1 ms per., 6 Vp-p, 1 μs rt/ft, 1 ns res (3 digits)	284 ms
Voltage	1 MHz, 6 Vp-p, .06 V resolution (2 digits)	438 ms

* See "Definitions".

GENERAL CHARACTERISTICS	
Memory	Ten measurement set-ups, including trigger levels, may be stored in memory and subsequently recalled. Set-ups are lost when power is removed from the instrument.
Programming Language	SCPI 1991.0
Operating Temperature	0 to 55°C
Power Requirements	27 VAC 40 kHz; < 25 watts average
Size	One slot module
Weight	< 2.5 kg
Auto-Trigger	Auto-trigger can be used to automatically set trigger levels at 50% point (10%, 90% for Rise/Fall Time) of the input signal. The standard auto-trigger will evaluate the input signal, set the trigger level, measure and repeat. Single-measurement auto-trigger will evaluate the input signal only once, and then measure repeatedly, speeding up the process. Trigger levels can be specified in Volts or percentage of signal height. Percentage trigger levels will activate the auto-trigger to evaluate the signal amplitude.

Definitions

1. **LSD**

   Unit value of Least Significant Digit. Calculations should be rounded to the nearest decade (i.e., 5 Hz becomes 10 Hz and 4 ns becomes 1 ns).

2. **Time Base Error**

   Maximum fractional frequency change in the time base frequency due to all errors (aging, temperature, line voltage) multiplied by the measurement result.

3. **Trigger Error** (See Figure 4-2.)

   $$TE = \frac{\sqrt{(ei)^2+(en)^2}}{\text{Input Slew Rate at Trigger Point}}$$

   ei = Effective rms noise of counter's input channel (1.5 mV typical)

   en = rms noise of input signal for input bandwidth

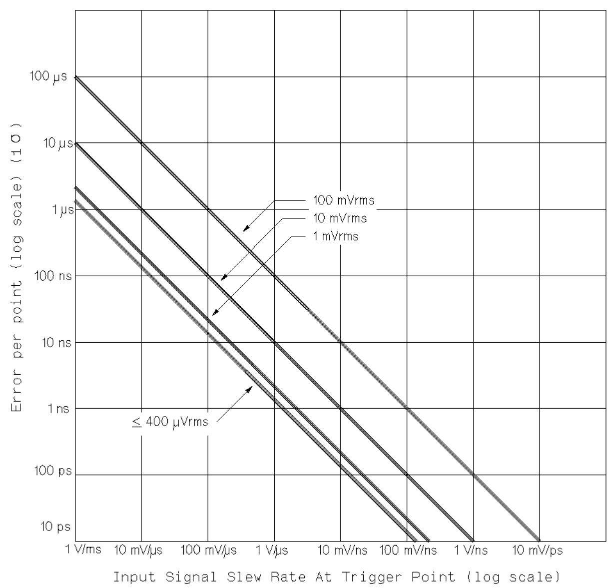


Figure 4-2. Input Noise Trigger Error

Noise on the input signal affects both the Start and Stop points of all time interval measurements.

4. **Trigger Level Timing Error** (See Figure 4-3.)

Larger of:

a. 0.5 × hysteresis band/input slew rate at start trigger point. (See list item 5.)

b. 0.5 × hysteresis band/input slew rate at stop trigger point. (See list item 5.)

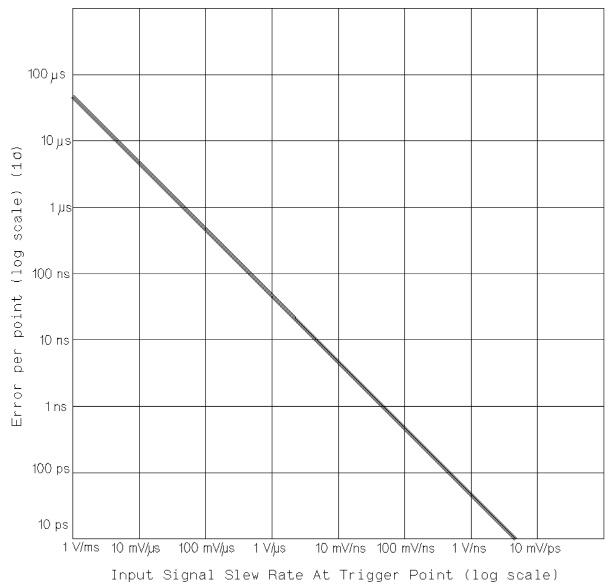


Figure 4-3. Trigger Level Timing Error

Affects the Start and Stop points of all time interval measurements. Total error is the larger of the two trigger point errors. (For sine waves, Slew rate at midpoint = 2 × π × frequency × amplitude, where amplitude is 1.2 of the peak-to-peak voltage.)

5. **Trigger Level Setting Error** (See Figure 4-4.)

Normal mode:

$\pm\frac{30mV \pm 1\% \text{ of trigger level setting (TI only)}}{\text{Input slew Rate at Start Trigger Point}}$

$\pm\frac{30mV \pm 1\% \text{ of trigger level setting (TI only)}}{\text{Input Slew Rate at Stop Trigger Point}}$

$\times$ 10 mode:

$\pm\frac{300mV \pm 20\% \text{ of trigger level setting (TI only)}}{\text{Input slew Rate at Start Trigger Point}}$

$\pm\frac{300mV \pm 20\% \text{ of trigger level setting (TI only)}}{\text{Input Slew Rate at Stop Trigger Point}}$

(See definition 6.)

Note that rise/fall times use 10% and 90% points of signal for trigger points, unless programmed differently.

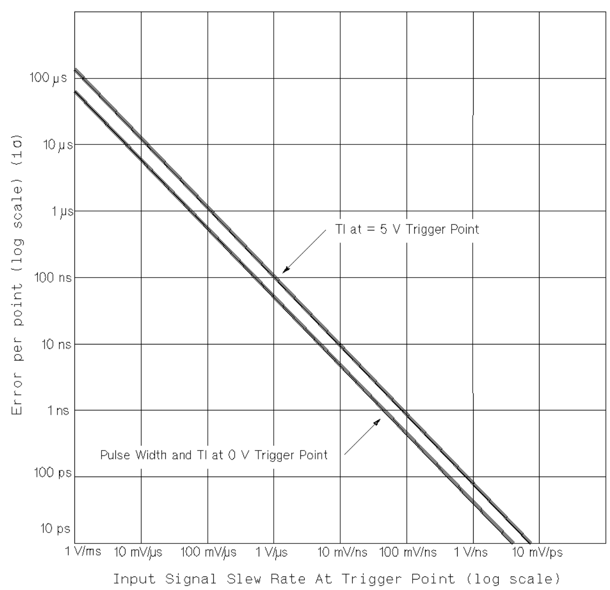


Figure 4-4. Trigger Level Setting Error

Affects both the Start and Stop points of all time interval measurements.

6. **Trigger Point and Hysteresis**

Auto trigger disabled: trigger point = trigger level reading

Auto trigger enabled: For all measurements except Rise/Fall Time,

trigger points = $\frac{\text{Max peak} + \text{Min peak}}{2}$

For Rise/Fall Time,

10% trigger point = .1 × max peak + .9 × min peak

90% trigger point = .9 × max peak + .1 × min peak

Min/Max voltage function is used to measure peaks.

For X% trigger point = $(\frac{X}{100}) \times$ Max peak $+ (1 - \frac{X}{100}) \times$ Min peak

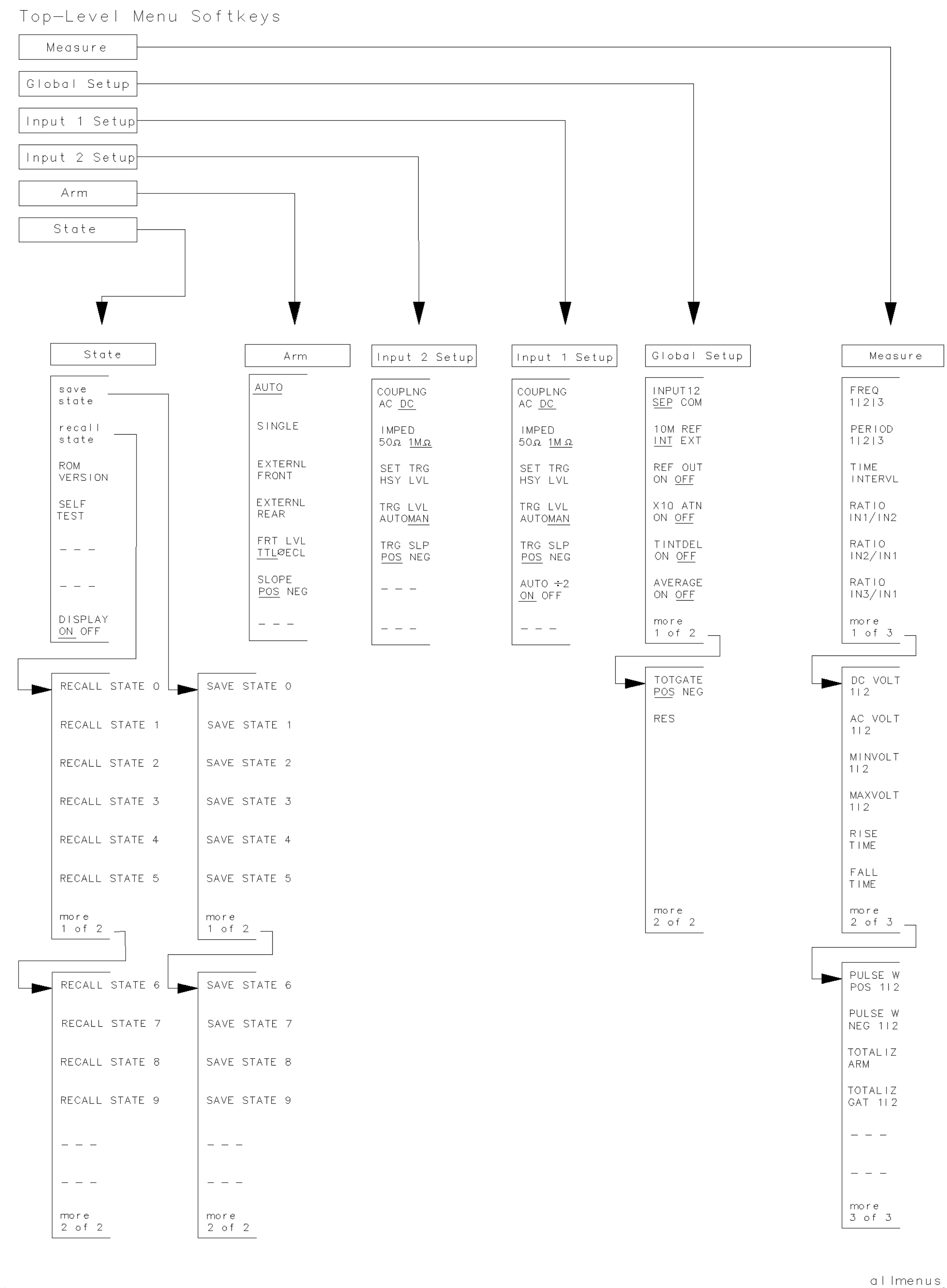
Measurement Throughput Definitions	
Short Speeds	Quick indicator of maximum counter speeds.
Setup	Embedded controller
Signal	> 1 MHz; signal does not limit speed of measurement.
Gate	1 ms; measurement << counter processing time.
Triggering	Manual
Free Run	Indicates speed of measuring and outputting results.Important if many measurements are made from one setup.
Algorithm	Setup Frequency Measurement, then do multiple reads.
Switching	Indicates speed of setup, measurement and output. Important if measurement mode or parameters are changed frequently.
Algorithm	Setup Frequency Measurement, then make one read;
	Setup Time Interval Measurement, then make one read;
	Setup Period Measurement, then make one read;
	Repeat.
Setups	
Frequency setup	Input 1 AC, Neg Slope, 50 Ω, Trig Level 0.2 V.
Time Interval setup	COMMON, Input 2 Pos Slope, 50 Ω, Trig Level 0.2 V.
Period setup	Input 1 DC, Pos Slope, 1 MΩ, Trig Level −.35 V
Comprehensive Single Reading Times	Single Reading Times indicate the times needed for command transfer, instrument setup, measurement, and result transfer.
Hardware Setup	HP 9000 Series 300 computer (320)
Software Setup	HPBASIC Version 5

5

Menu Maps and Softkey Descriptions

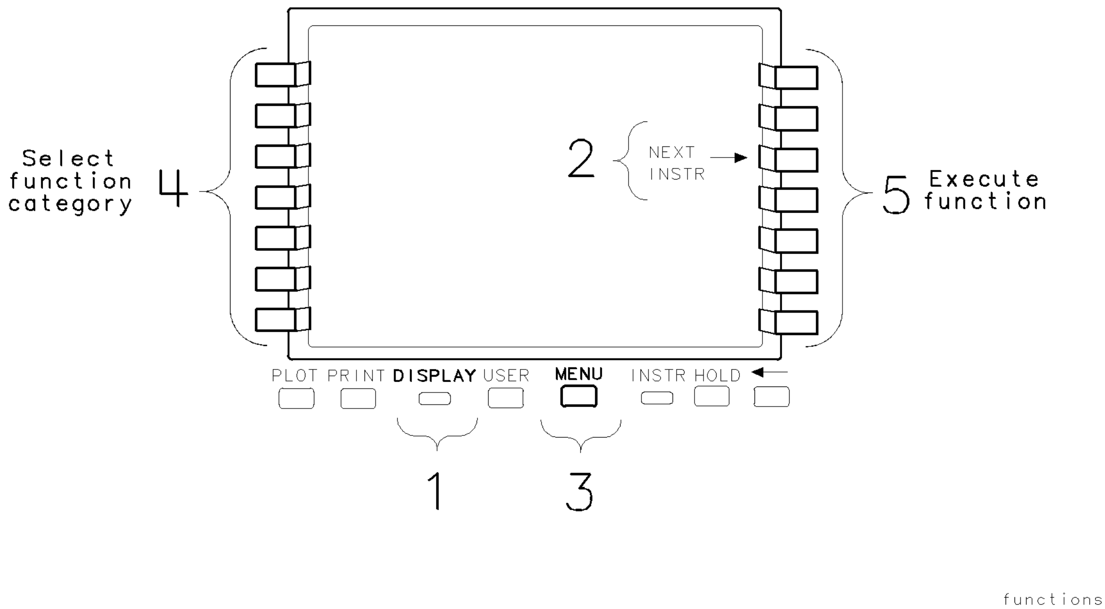
This chapter lists all menu maps in the order they appear from top to bottom on the left side of the display. With each menu map, a short description of each of the lower-level softkeys is provided. Menu maps graphically represent all top-level softkeys and their associated lower-level softkeys.

The softkey menu illustrations in this chapter are arranged in the same sequence as the softkeys on the left side of the display, reading from the top softkey to the bottom softkey.



Overall Menu Map

How to Access Functions



To Access Universal Counter Functions:

1. Press the (DISPLAY) key.
2. Press the (NEXT INSTR) key to select the HP 70120A universal counter.
3. Press the (MENU) key.

   This gives you access to all universal counter functions.

4. Select a function category.

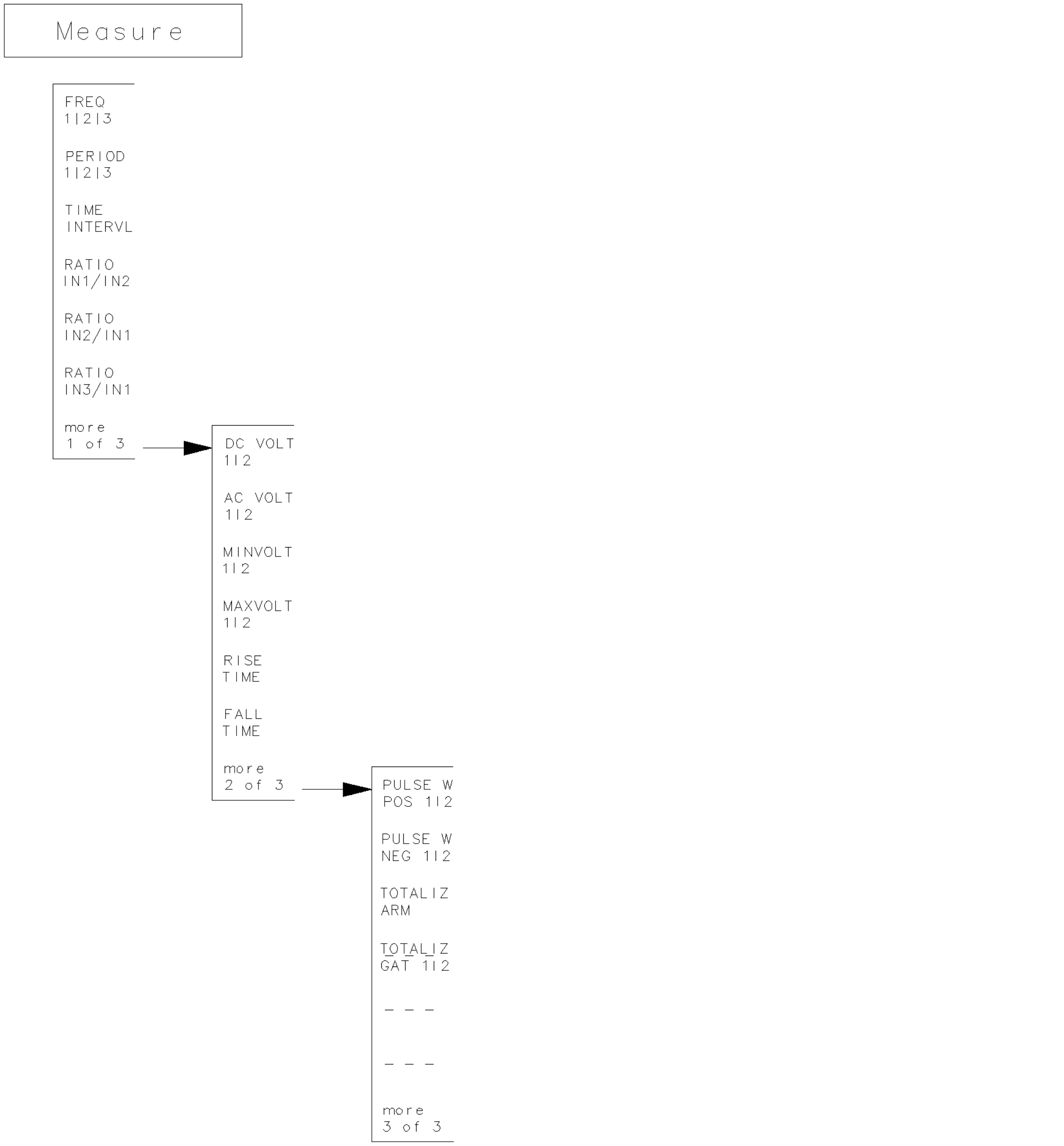
   The functions are divided into six categories which are accessed with six keys at the left side of the display screen. The underscore indicates which group of functions is selected.

5. Select the function that you want to execute.

   The functions on the menu softkeys are displayed as separate menu pages. Press the `more` softkeys to access additional menu pages.

The softkey menu illustrations in this chapter are arranged in the same sequence as the softkeys on the left side of the display, reading from the top softkey to the bottom softkey.

Measure Menu and Softkey Descriptions



Measure Menu Map

FREQ 1|2|3

The FREQ 1|2|3 key selects the Frequency mode of operation for signals received through Input 1, Input 2, or Input 3.

The Frequency mode allows measurements on frequencies from 1 mHz to 200 MHz when using Input 1, frequencies from 1 mHz to 100 MHz when using Input 2, and frequencies from 90 MHz to 2.5 GHz when using Input 3.

On power-up, the counter assumes the FREQ 1 function with the GATE TIME set at 100 milliseconds, automatic trigger ON (AUTO TRIG), and automatic attenuation (X10 ATN OFF). Any periodic signal connected to Input 1 at this time will self-arm the counter and measurements will begin immediately (provided the signal is within input specifications, and within the restrictions set by the signal conditioning controls). The displayed resolution is controlled by the GATE TIME setting.

(For further information, refer to "[:VOLTage]:FREQuency" in Chapter 8 under CONFigure.)

PERIOD 1|2|3

The PERIOD 1|2|3 key selects the Period mode of operation for signals received through Input 1, Input 2, or Input 3. The Period mode allows period measurements from 10 nanoseconds to 1,000 seconds. The counter automatically averages period measurements whenever the GATE TIME setting is greater than the period of the signal being measured. The number of periods averaged is determined by the GATE TIME setting and the period of the input signal.

(For further information, refer to "[:VOLTage]:PERiod" in Chapter 8 under CONFigure.)

TIME INTERVL

The TIME INTERVL key selects the Time Interval mode of operation, measuring elapsed time between a start signal on Input 1 and a stop signal on Input 2. Independent SLOPE and TRIGGER LEVEL/SENS controls for the start and stop signals allow variable triggering on either positive or negative going slopes. Time interval measurements may be made over a range of −1 nanosecond to 1000 seconds. The minimum start/stop pulse width is 5 nanoseconds. Gate time is controlled by the measured time interval.

(For further information, refer to "[:VOLTage]:TINTerval" in Chapter 8 under CONFigure.)

RATIO IN1/IN2

The RATIO IN1/IN2 key selects the Ratio mode of operation, measuring the ratio of the signal frequency at Input 1 to the signal frequency at Input 2. Since the counter can display ratios of less than 1, the higher frequency can be applied to either input channel. However, it is recommended that the higher frequency be applied to Input 1 for measurements and displays greater than 1.

The GATE TIME setting determines the resolution by selecting the number of cycles of the Input 2 signal over which the ratio is measured. Increasing the gate time or increasing the signal frequency at Input 1 results in greater resolution of the measurement.

(For further information, refer to "[:VOLTage]:FREQuency:RATio" in Chapter 8 under CONFigure.)

RATIO IN2/IN1

The RATIO IN2/IN1 key selects the Ratio mode of operation, measuring the ratio of the signal frequency at Input 2 to the signal frequency at Input 1. Since the counter can display ratios of less than 1, the higher frequency can be applied to either input channel. However, it is recommended that the higher frequency be applied to Input 2 for measurements and displays greater than 1.

The GATE TIME setting determines the resolution by selecting the number of cycles of the Input 1 signal over which the ratio is measured. Increasing the gate time or increasing the signal frequency at Input 2 results in greater resolution of the measurement.

(For further information, refer to "[:VOLTage]:FREQuency:RATio" in Chapter 8 under CONFigure.)

RATIO IN3/IN1

The RATIO IN3/IN1 key selects the Ratio mode of operation, measuring the ratio of the signal frequency at Input 3 to the signal frequency at Input 1. Since the counter can display ratios of less than 1, the higher frequency can be applied to either input channel. However, it is recommended that the higher frequency be applied to Input 3 for measurements and displays greater than 1.

The GATE TIME setting determines the resolution by selecting the number of cycles of the Input 1 signal over which the ratio is measured. Increasing the gate time or increasing the signal frequency at Input 3 results in greater resolution of the measurement.

(For further information, refer to "[:VOLTage]:FREQuency:RATio" in Chapter 8 under CONFigure.)

DC VOLT 1|2

The DC VOLT 1|2 key configures the counter to measure the dc component of the input ac signal through either Input 1 or Input 2. This function assumes symmetrical signals because the dc value is calculated as a center point between positive and negative peak values of the signal.

(For further information, refer to "[:VOLTage]:DC" in Chapter 8 under CONFigure.)

AC VOLT 1|2

The AC VOLT 1|2 key configures the counter to measure the rms ac voltage component of the input ac sinusoidal signal through either Input 1 or Input 2.

(For further information, refer to "[:VOLTage]:AC" in Chapter 8 under CONFigure.)

MINVOLT 1|2

The MINVOLT 1|2 key configures the counter to read the minimum value (−Ve) of the input signal ac voltage through either Input 1 or Input 2.

(For further information, refer to "[:VOLTage]:MINimum" in Chapter 8 under CONFigure.)

MAXVOLT 1|2

The MAXVOLT 1|2 key configures the counter to read the maximum value (+Ve) of the input signal ac voltage through either Input 1 or Input 2.

(For further information, refer to "[:VOLTage]:MAXimum" in Chapter 8 under CONFigure.)

RISE TIME

The RISE TIME key configures the counter to measure the rise time of the input signal. By selecting this key, the user is prompted to input the lower/upper % of full scale points to be measured. If the lower/upper reference levels are not specified, the default levels are set to 10% and 90% of peak values.

The RISE TIME key must be pressed once to select this function, once to accept the lower limit, and once to select the upper limit.

(For further information, refer to "[:VOLTage]:RTIMe|RISE:TIME" in Chapter 8 under CONFigure and Table 8-4 for Average Mode Status.)

FALL TIME

The FALL TIME key configures the counter to measure the fall time of the input signal. By selecting this key, the user is prompted to input the lower/upper % of full scale points to be measured. If the lower/upper reference levels are not specified, the default levels are set to 10% and 90% of peak values.

The FALL TIME key must be pressed once to select this function, once to accept the lower limit, and once to select the upper limit.

(For further information, refer to "[:VOLTage]:FTIMe|FALL:TIME" in Chapter 8 under CONFigure and Table 8-4 for Average Mode status.)

PULSE W POS 1|2

The PULSE W POS 1|2 key configures the counter for the positive pulse width measurement function on Input 1 or Input 2. Positive pulse width is measured as the time between the rising edge and the next falling edge of the input signal.

If the reference level is not specified, the default level is set to 50% of the peak-to-peak voltage. The reference level can be changed by selecting MAN with the the TRG LVL AUTOMAN key.

(For further information, refer to "[:VOLTage]:PWIDth" in Chapter 8 under CONFigure.)

PULSE W NEG 1|2

The PULSE W NEG 1|2 key configures the counter for the negative pulse width measurement function on Input 1 or Input 2. Negative pulse width is measured as the time between the falling edge and the next rising edge of the input signal.

If the reference level is not specified, the default level is set to 50% of the peak-to-peak voltage. The reference level can be changed by selecting MAN with the the TRG LVL AUTOMAN key.

(For further information, refer to "[:VOLTage]:NWIDth" in Chapter 8 under CONFigure.)

TOTALIZ ARM

The TOTALIZ ARM key selects the Totalize mode of operation, and starts a continuous count and display of the number of events received through Input 1. The count is accumulated from input cycle to input cycle. The Totalize mode is manually gated from the front panel, and is independent of the gate time setting.

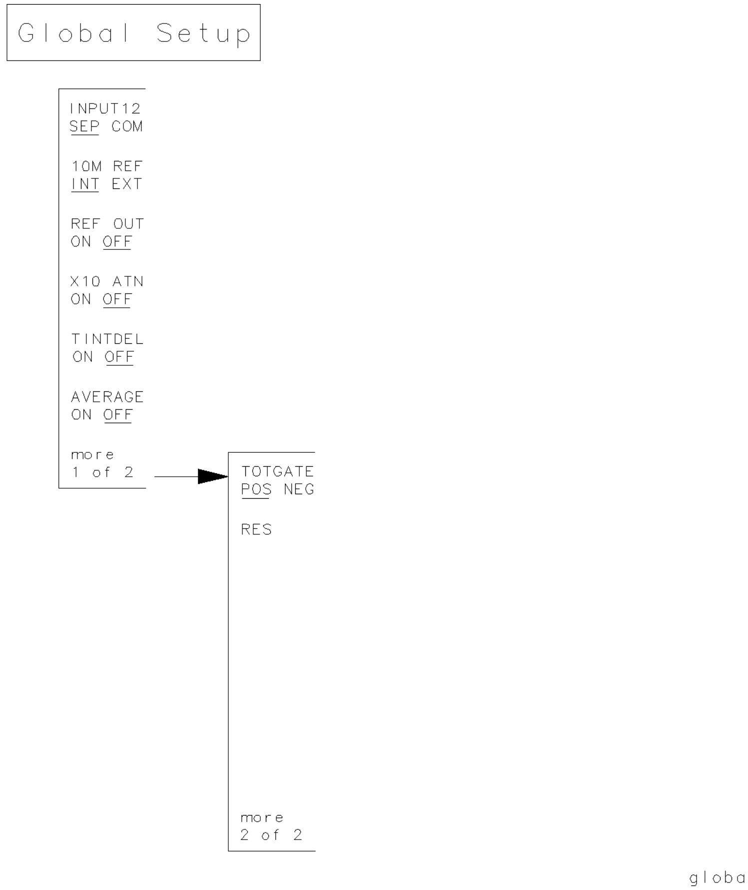
(For further information, refer to "[:VOLTage]:TOTalize" in Chapter 8 under CONFigure.)

TOTALIZ GATE 1|2

The TOTALIZ GATE 1|2 key selects the gated Totalize mode of operation through Input 1 or Input 2. This causes the counter to accumulate events on the selected input while the other input is active.

(For further information, refer to ":TOTalize:GATE:STATe" in Chapter 8 under SENSe.)

Global Setup Menu and Softkey Descriptions



Global Menu Map

INPUT 1|2 SEP COM

The INPUT 1|2 SEP COM key routes Input 1 signals to both Input 1 and Input 2 input circuits (sets both inputs to common) when COM (common) is selected. The Input 2 connector is not active when when in this mode.

When SEP (separate) is selected, both Input 1 and Input 2 can be used independently; this is default state.

(For further information, refer to ":ROUTe" in Chapter 8 under INPut.)

10M REF INT EXT

The 10M REF INT EXT key controls selection of the reference oscillator source used as the counter's timebase.

When INT (internal) is selected, the counter uses an internal precision oscillator.

When EXT (external) is selected, the counter uses an external timebase signal supplied through the rear panel Int/Ext Reference SMB connector, and sets the REF OUT ON OFF function to OFF.

(For further information, refer to ":ROSCillator:SOURce" in Chapter 8 under SENSe.)

REF OUT ON OFF

The REF OUT ON OFF key specifies whether or not the internal timebase is routed to the rear panel Int/Ext Reference SMB.

When ON is selected, the rear panel Int/Ext Reference SMB's output is enabled.

When OFF is selected, the rear panel Int/Ext Reference SMB's output is disabled. This is affected when EXT is selected by the 10M REF INT EXT key.

(For further information, refer to "OUTPut:ROSCillator:STATe" in Chapter 8 under OUTPut.)

X10 ATN ON OFF

The X10 ATN ON OFF key selects the attenuation of signals at the corresponding input (1, 2, or 3). The ON position attenuates the input signal by a factor of 10; the OFF position connects the input signal directly to the input amplifiers.

When AUTO TRIG is on, attenuation is automatically controlled by the input voltage and cannot be changed manually.

(For further information, refer to ":ATTenuation" in Chapter 8 under INPut.)

TINTDEL ON OFF

The TINTDEL ON OFF key controls whether time-interval measurement is made with or without a delay time. This selection affects only time interval measurements.

(For further information, refer to ":TINTerval:DELay" in Chapter 8 under SENSe and the *Time Interval Measurements* section in "Understanding the Universal Counter" in Chapter 3.)

AVERAGE ON OFF

The AVERAGE ON OFF key controls whether 100 Gate Averaging mode is used or not.

When ON is selected, the counter enters 100 Gate Averaging mode. This measurement mode provides 100 ps resolution for time-interval measurements.

When OFF is selected, the counter is set to single-shot measurement mode. If the resolution parameter of CONFigure/MEASure is less than 1 ns, 100 Gate Averaging mode is automatically turned on.

(For further information, refer to ":AVERage[:STATe]" in Chapter 8 under SENSe.)

TOTGATE POS NEG

The TOTGATE POS NEG key sets the polarity of the GATE signal for gated TOTalize measurements.

When POS (positive) is selected, the events are accumulated when the GATE source is high (NORMal).

When NEG (negative) is selected, the events are accumulated when the GATE source is low (INVerted).

(For further information, refer to ":TOTalize:GATE:POLarity" in Chapter 8 under SENSe.)

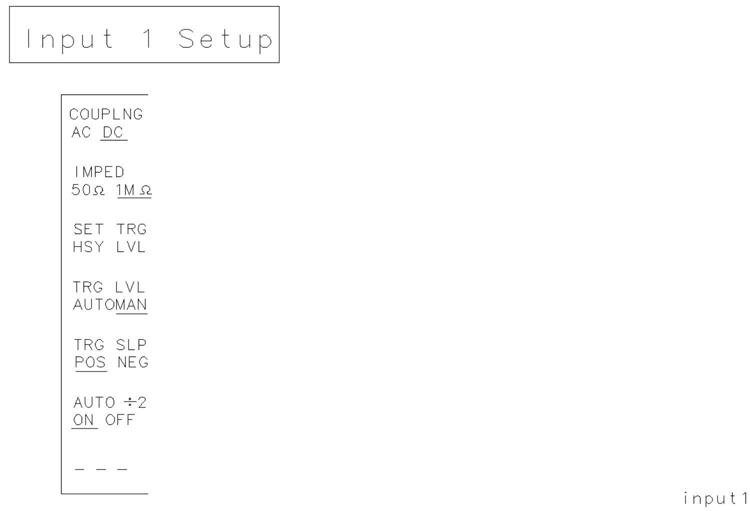
RES

The RES key allows you to change the resolution through the numeric keypad on the front panel of the display.

The number of digits of resolution is a direct function of gate time. The absolute resolution is a function of both the measurement gate time and signal frequency.

(For further information, refer to "[:VOLTage]:FREQuency" in Chapter 8 under CONFigure and *Measurement Resolution* under "Understanding the Universal Counter" in Chapter 3.)

Input 1 Setup Menu and Softkey Descriptions



Input 1 Setup Menu Map

COUPLING AC DC

The COUPLING AC DC key selects the input coupling for Input 1 or Input 2. Input coupling can be selected as ac or dc. (The ac parameter is used to remove any dc component from the input signal.)

Input 3's coupling is ac only.

(For further information, refer to ":COUPling" in Chapter 8 under INPut.)

IMPED 50Ω 1MΩ

The IMPED 50Ω 1MΩ key selects the input impedance for Input 1 or Input 2. Input impedance can be selected as 50 Ω or 1 MΩ.

Input 3's input impedance is fixed at 50 Ω.

(For further information, refer to ":IMPedance" in Chapter 8 under INPut.)

SET TRG HSY LVL

The SET TRG HSY LVL key specifies the sensitivity of the counter. If the input signal peaks do not extend beyond both hysteresis limits, then the input signal does not generate a count. If the input signal has a significant noise content, then the hysteresis must be increased to prevent the counter from counting false events.

(For further information, refer to ":EVENt:HYSTeresis" in Chapter 8 under SENSe.)

TRG LVL AUTOMAN

The TRG LVL AUTOMAN key selects the mode of triggering to be AUTO (automatic) or MAN (manual).

When AUTO is selected, the trigger point may be set as a percentage between the negative and positive detected peaks; this is accomplished with the remote command EVENt:LEVel:RELative. The level is calculated as a percentage of the peak-to-peak voltage, added to the negative −Ve peak value. The actual level determination does not occur unless a measurement is initiated.

When MAN is selected, the trigger point may be set as a voltage through the numeric keypad on the front panel of the display.

(For further information, refer to ":EVENt:LEVel:RELative" in Chapter 8 under SENSe and ":EVENt:LEVel[:ABSolute]" in Chapter 8 under SENSe.)

TRG SLP POS NEG

The TRG SLP POS NEG key specifies either the POSitive (rising) or NEGative (falling) edge of the input signal to be used in the measurement.

(For further information, refer to ":EVENt:SLOPe" in Chapter 8 under SENSe.)

AUTO ÷2 ON OFF

The AUTO ÷2 ON OFF key specifies whether or not the counter will automatically determine the frequency range.

When ON is selected, automatic prescaling (divide by 2) is enabled on Input 1. This only affects input signal frequencies that are greater than 100 MHz.

When OFF is selected, automatic prescaling (divide by 2) is disabled.

This key can be used only for frequency, period, and ratio measurements, and has no effect on Input 2 or Input 3.

(For further information, refer to ":FREQuency:RANGe:AUTO" in Chapter 8 under SENSe.)

Input 2 Setup Menu and Softkey Descriptions

Input 2 Setup Menu Map

COUPLING AC DC

The COUPLING AC DC key selects the input coupling for Input 1 or Input 2. Input coupling can be selected as ac or dc. (The ac parameter is used to remove any dc component from the input signal.)

Input 3's coupling is ac only.

(For further information, refer to ":COUPling" in Chapter 8 under INPut.)

IMPED 50Ω 1MΩ

The IMPED 50Ω 1MΩ key selects the input impedance for Input 1 or Input 2. Input impedance can be selected as 50 Ω or 1 MΩ.

Input 3's input impedance is fixed at 50 Ω.

(For further information, refer to ":IMPedance" in Chapter 8 under INPut.)

SET TRG HSY LVL

The SET TRG HSY LVL key specifies the sensitivity of the counter. If the input signal peaks do not extend beyond both hysteresis limits, then the input signal does not generate a count. If the input signal has a significant noise content, then the hysteresis must be increased to prevent the counter from counting false events.

(For further information, refer to ":EVENt:HYSTeresis" in Chapter 8 under SENSe.)

TRG LVL AUTOMAN

The TRG LVL AUTOMAN key selects the mode of triggering to be AUTO (automatic) or MAN (manual).

When AUTO is selected, the trigger point may be set as a percentage between the negative and positive detected peaks; this is accomplished with the remote command EVENt:LEVel:RELative. The level is calculated as a percentage of the peak-to-peak voltage, added to the negative −Ve peak value. The actual level determination does not occur unless a measurement is initiated.

When MAN is selected, the trigger point may be set as a voltage through the numeric keypad on the front panel of the display.

(For further information, refer to ":EVENt:LEVel:RELative" in Chapter 8 under SENSe and ":EVENt:LEVel[:ABSolute]" in Chapter 8 under SENSe.)

TRG SLP POS NEG

The TRG SLP POS NEG key specifies either the POSitive (rising) or NEGative (falling) edge of the input signal to be used in the measurement.

(For further information, refer to ":EVENt:SLOPe" in Chapter 8 under SENSe.)

Arm Menu and Softkey Descriptions

Arm Menu Map

AUTO

The AUTO key selects internal auto triggering.

(For further information, refer to ":EVENt:LEVel[:ABSolute]:AUTO" in Chapter 8 under SENSe.)

SINGLE

The SINGLE key selects internal auto triggering for one single measurement. (The counter behaves in the same manner that it would if AUTO is selected, but for only one measurement.)

(For further information, refer to ":EVENt:LEVel[:ABSolute]:AUTO" in Chapter 8 under SENSe.)

EXTERNL FRONT

The EXTERNL FRONT key selects selects external triggering. It uses the front panel external trigger input.

EXTERNL REAR

The EXTERNL REAR key selects selects external triggering. It uses the rear panel external trigger input.

The rear panel port only accepts TTL levels.

FRT LVL TTLϕECL

The FRT LVL TTLϕECL key configures the ARM subsystem to qualify the selected amplitude of a source signal arriving at the front panel ARM connector signal that generates a measurement.

The Arm Input is used to provide a synchronizing signal to the counter that can start and/or stop the measurement process. Input impedance is 1 MΩ with dc coupling. The Arm Input frequency range is dc to 20 MHz. Input trigger level is programmable between TTL, ϕ, or ECL.

TTL	When TTL is selected, +1.001 to +5 results as +1.6 volts for TTL.
ϕ	When ϕ is selected, -1 to $+1$ results as 0 volts for GND.

ECL — When ECL is selected, −5 to −.999 results as nominal −1.3 volts for ECL.

(For further information, refer to "[:LAYer[1]]:LEVel" in Chapter 8 under ARM.)

SLOPE POS NEG

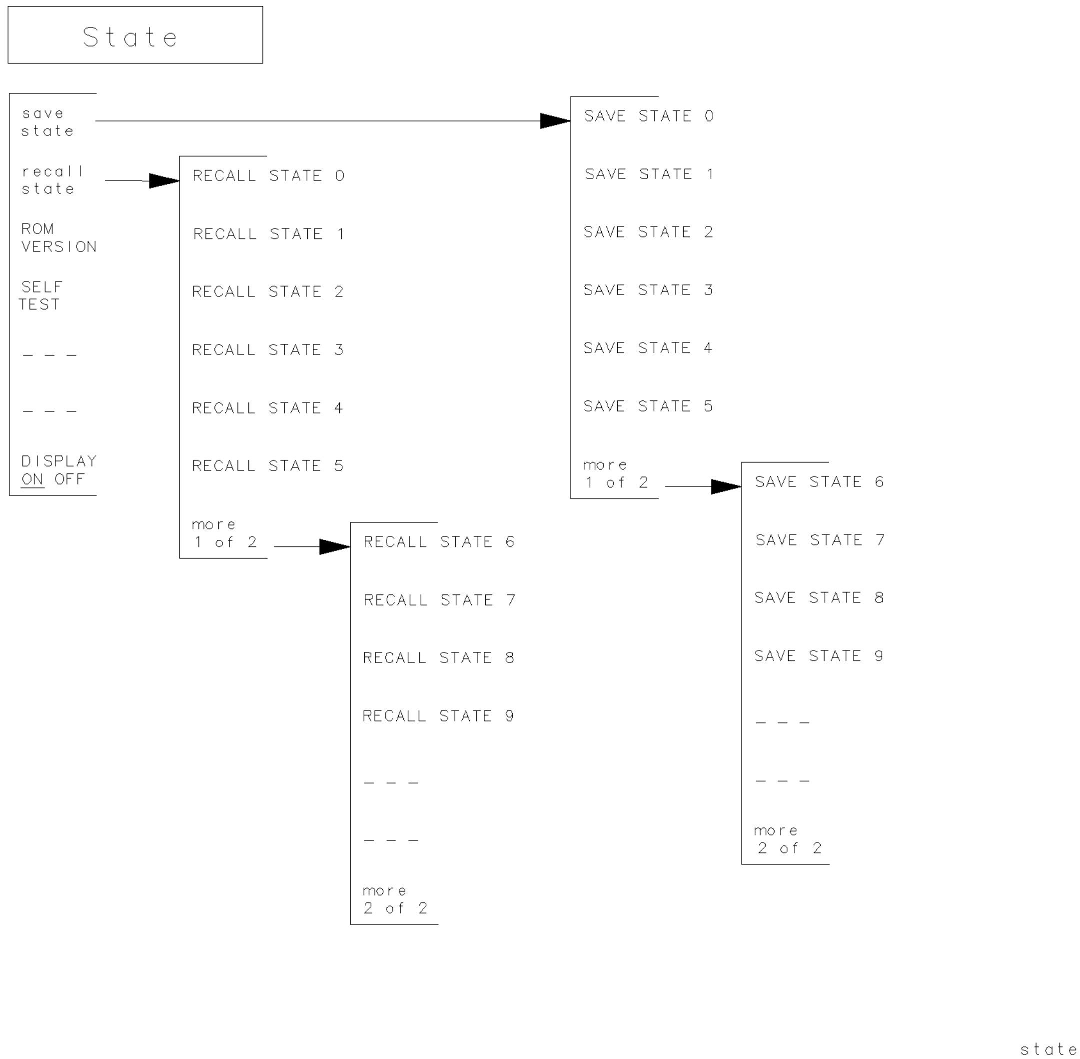
The SLOPE POS NEG key configures the trigger subsystem to select the slope of a selected source (FRT or REAR) that generates a measurement.

When POS (positive) is selected, the event occurs on the rising edge of the signal.

When NEG (negative) is selected, the event occurs on the falling edge of the signal.

(For further information, refer to "[:LAYer[1]]:SLOPe" in Chapter 8 under ARM.)

State Menu and Softkey Descriptions



State Menu Map

RECALL STATE The RECALL STATE key allows you to recall previously saved states. You can recall up to 10 saved states that were saved using the SAVE STATE key.

SAVE STATE The SAVE STATE key allows you to save the current instrument state in a state-register file. You can save up to 10 states and recall each of them using the RECALL STATE key.

ROM VERSION The ROM VERSION key returns the current revision and datecode. As software is updated, or new commands added, the response to this query may change to reflect the latest version.

(For further information, refer to ":VERsion?" in Chapter 8 under SYSTem.)

State Menu and Softkey Descriptions

SELF TEST — The SELF TEST key starts a self test routine on the HP 70120A universal counter.

DISPLAY ON OFF — The DISPLAY ON OFF key turns the display information on or off.

6

Universal Counter Error Messages

This chapter contains the error messages for the HP 70120A universal counter.

Error Messages for the HP 70120A universal counter

Code	Message	Cause
−100	Command error	
−101	Invalid character	Unrecognized character in specified parameter
−102	Syntax error	Command missing space/comma between parameters
−103	Invalid separator	Command parameter separated by space not comma
−104	Data type error	Wrong data type specified in parameter
−105	GET not allowed	Group Execute Trigger was received
−108	Parameter not allowed	Parameter specified in parameterless command
−109	Missing parameter	Parameter missing in entered command
−112	Program mnemonic too long	Header contains more than 12 characters
−113	Undefined header	Command header incorrectly specified
−114	Header suffix out of range	Nonheader character encountered by parser
−121	Invalid character in number	Entered character for numeric data is incorrect
−123	Numeric overflow	Exponent larger than 32000
−124	Too many digits	More than 256 digits specified
−128	Numeric data not allowed	Number specified for parameter not letter
−131	Invalid suffix	Parameter suffix incorrectly specified (for example 50 M instead of 50 MHz)
−138	Suffix not allowed	Parameter suffix specified when not allowed
−141	Invalid character data	Parameter type specified not allowed (for example "MEAS:FREQ HIGH" instead of "MEAS:FREQ MAX"
−144	Character data too long	Character data element has more than 12 characters
−148	Character data not allowed	Entered character data not recognized by counter
−150	String data error	Entered string data contained a non−specific error
−151	Invalid string data	Entered string data syntax invalid
−158	String data not allowed	String data encountered but not allowed
−160	Block data error	Entered block data contained a non−specific error
−161	Invalid block data	Entered block data syntax invalid
−168	Block data not allowed	Block data encountered but not allowed
−170	Expression error	Entered expression contained a non−specific error
−171	Invalid expression	Entered block data syntax invalid
−178	Expression data not allowed	Expression data encountered but not allowed
−180	Macro error	Entered macro command or parameter contained a non−specific error

Error Messages for the HP 70120A universal counter (continued)

−181	Invalid outside macro definition	Macro parameter placeholder encountered outside a macro definition
−183	Invalid inside macro definition	Program message sent with *DMC is syntactically invalid
−200	Execution error	Requested measurement is not available
−201	Invalid while in local	Command not executeable while device in local
−203	Measurement timeout	Measurement execution exceeded maximum time
−204	Channel not configured for measurement	Appropriate channel was not set up for the requested measurement
−205	Arming configuration conflict	External arm source inconsistent for start and stop within the same program message
−206	Measurement has not been initiated	Executed FETCh? without initiating measurement for new configuration
−207	Invalid totalize	Totalize on channel 2 (totalize on 1 or totalize 2 by 1)
−208	Value out of range	Calculated parameter outside allowed range
−209	Data clipped to limit	Entered parameter(s) outside of range − data truncated at limit
−212	ARM ignored	ARM:IMMediate set without being INITialized
−213	INIT ignored	Another measurement already in progress
−215	Arm deadlock	Attempted FETCh? while arming was in HOLD or BUS mode
−221	Setting conflict	A valid command but not supported for the specified channel
−222	Data out of range	Specified parameter value too large/small
−223	Too much data	Excess data for memory/device−specific process requirements
−224	Illegal parameter value	Specified numeric value not allowed
−230	Data corrupt or stale	New measurement started but not completed since last access
−231	Data questionable	Measurement accuracy is suspect
−240	Hardware error	Execution error due to hardware fault
−241	Hardware missing	Option 010 or 030 not installed
−270	Macro error	Non−specific execution related macro error
−271	Macro syntax error	Illegal macro syntax entered

Error Messages for the HP 70120A universal counter (continued)

−272	Macro execution error	Macro execution error due to macro definition error
−273	Illegal macro label	Entered macro label not accepted by device
−274	Macro parameter error	Macro definition contains improperly used macro parameter
−276	Macro recursion error	Device found macro recursive
−277	Macro redefinition not allowed	Macro label already defined
−310	System error	Non−specific system error has occurred
−331	Selftest failed; ROM checksum failure	Specified hardware failed
−332	Selftest failed; RAM failure	Specified hardware failed
−334	Selftest failed; Front end failure	Specified hardware failed
−335	Selftest failed; Calibration memory failure	Specified hardware failed
−336	Selftest failed; MRC failure	Specified hardware failed
−337	Selftest failed; MRC Interpolator failure	Specified hardware failed
−338	Selftest failed; Interpolator delay failure	Specified hardware failed
−339	Selftest failed; Internal timebase failure	Specified hardware failed
−350	Too many errors	The error queue is full; more than 30 errors have occurred
−400	Query error	
−410	Query interrupted	Data not read from output buffer before another command was executed
−420	Query unterminated	Command generating data unable to complete due to configuration error
−430	Query deadlocked	Command cannot complete output due to controller request for input
−440	Query unterminted after indefinite response	Query received after a query requesting an indefinite response
1501	External reference missing	External clock signal missing

7

Remote Programming Commands Quick Reference

This chapter provides a quick reference guide of Standard Commands for Programmable Instruments (SCPI) and a quick reference guide of *IEEE Std 488.2-1987* Common Commands applicable to the HP 70110A digital multimeter.

This chapter contains the following sections:

- SCPI Commands Quick Reference
- *IEEE Std 488.2-1987* Common Commands Quick Reference

SCPI Commands Quick Reference

Table 7-1 lists the SCPI commands implemented for the HP 70120A universal counter.

The SCPI commands used in the counter are in conformance with the SCPI Standard 1991.0. The counter's SCPI commands consist of the following:

- Applicable Common commands as defined in *IEEE Std 488.2-1987*.
- Subsystem commands as defined (and listed) in the SCPI Standard. (These are the commands contained in Table 7-1 as Std.)
- Subsystem commands designed for the counter in conformance with SCPI standards but currently not listed in the SCPI standard. (These are the commands contained in Table 7-1 as New and may or may not be incorporated in future versions of SCPI.)

Table 7-1. SCPI Command Summary

<table>
<tr><th>Keyword/Syntax</th><th>Parameter Form</th><th>Input Number</th><th>SCPI Status</th></tr>
<tr><td>ABORt[1|2|3]</td><td></td><td>1,2,3</td><td>Std</td></tr>
<tr><td>ARM</td><td></td><td></td><td>Std</td></tr>
<tr><td>[:SEQuence[1]|:STARt]|</td><td></td><td></td><td>Std</td></tr>
<tr><td>:SEQuence2|:STOP</td><td></td><td></td><td>Std</td></tr>
<tr><td>[:LAYer[1]]</td><td></td><td></td><td>Std</td></tr>
<tr><td>[:IMMediate]</td><td></td><td></td><td>Std</td></tr>
<tr><td>:LEVel</td><td><<i>level</i>> |MIN|MAX|DEF</td><td></td><td>Std</td></tr>
<tr><td>:LEVel?</td><td>[<MIN|MAX|DEF>]</td><td></td><td>Std</td></tr>
<tr><td>:SLOPe</td><td>POS|NEG</td><td></td><td>Std</td></tr>
<tr><td>:SLOPe?</td><td></td><td></td><td>Std</td></tr>
<tr><td>:SOURce</td><td>EXT[1]|EXT2|IMM|BUS|HOLD</td><td></td><td>Std</td></tr>
<tr><td>:SOURce?</td><td></td><td></td><td>Std</td></tr>
<tr><td>CONFigure[1|2|3]</td><td></td><td></td><td>Std</td></tr>
<tr><td>[:VOLTage]</td><td></td><td></td><td>Std</td></tr>
<tr><td>:AC</td><td>[<<i>expected value</i>> [,<<i>resolution</i>>]]</td><td>1,2</td><td>Std</td></tr>
<tr><td>:DC</td><td>[<<i>expected value</i>> [,<<i>resolution</i>>]]</td><td>1,2</td><td>Std</td></tr>
<tr><td>:FREQuency</td><td>[<<i>expected value</i>> [,<<i>resolution</i>>]]</td><td>1,2,3</td><td>Std</td></tr>
<tr><td>:RATio</td><td>[<<i>expected value</i>> [,<<i>resolution</i>>]]</td><td>1,2,3</td><td>New</td></tr>
<tr><td>:FTIMe|:FALL:TIME</td><td>[<<i>lower reference</i>> [,<<i>upper reference</i>>
[,<<i>expected value</i>> [,<<i>resolution</i>>]]]]</td><td>1</td><td>Std</td></tr>
<tr><td>:MAXimum</td><td>[<<i>expected value</i>> [,<<i>resolution</i>>]]</td><td>1,2</td><td>Std</td></tr>
<tr><td>:MINimum</td><td>[<<i>expected value</i>> [,<<i>resolution</i>>]]</td><td>1,2</td><td>Std</td></tr>
<tr><td>:NWIDth</td><td>[<<i>reference</i>> [,<<i>expected value</i>>
[,<<i>resolution</i>>]]]</td><td>1,2</td><td>Std</td></tr>
<tr><td>:PERiod</td><td>[<<i>expected value</i>> [,<<i>resolution</i>>]]</td><td>1,2,3</td><td>Std</td></tr>
<tr><td>:PWIDth</td><td>[<<i>reference</i>> [,<<i>expected value</i>>
[,<<i>resolution</i>>]]]</td><td>1,2</td><td>Std</td></tr>
<tr><td>:RTIMe|:RISE:TIME</td><td>[<<i>lower reference</i>> [,<<i>upper reference</i>>
[,<<i>expected value</i>> [,<<i>resolution</i>>]]]]</td><td>1</td><td>Std</td></tr>
<tr><td>:TINTerval</td><td>[<<i>expected value</i>> [,<<i>resolution</i>>]]</td><td>1</td><td>New</td></tr>
<tr><td>:TOTalize</td><td>[<<i>expected value</i>> [,<<i>resolution</i>>]]</td><td>1</td><td>New</td></tr>
<tr><td>CONFigure[1|2|3]?</td><td></td><td></td><td>Std</td></tr>
</table>

Table 7-1. SCPI Command Summary (continued)

Keyword/Syntax	Parameter Form	Input Number	SCPI Status
DIAGnostics			Std
:BOOT			New
:SOURce	<INST|LOAD>		New
:SOURce?			New
:ASSembly			New
[:ALL]?			
:A1?			New
:A2?			New
:BLOCk			New
[:ALL]?			New
:CALMem?			New
:COUNtchain			New
[:ALL]?			New
:DINTerpolat?			New
:FEND?			New
:INTerpolat?			New
:MRC?			New
:TIMebase?			New
:RAM?			New
:ROM?			New
:CALibrate			New
:FULLscale?	<CH1|CH2|BOTH>		New
:OFFSet?	<CH1|CH2|BOTH>		New
:DACS1|:DACS2			New
:FULLscale			New
:SET	<*fullscale value*>		New
:HYSTeresis			New
:SET	<*hysteresis value*>		New
:OFFSet			New
:SET	<*offset value*>		New
:TRIGger			New
:RAMP	<0|OFF|1|ON>		New
:SET	<*trigger level*>		New
:READ			New
:INT?	<STS|SPS|STL|SPL|STARt|STOP|CAL|ALL>		New
:MRC?	<EREG|TREG|ALL>		New
:UFAil[?]	<OFF|0|ON|1> (N/A for Query)		New
FETCh[1|2|3]			Std
[:<function>]?		1,2,3	

Table 7-1. SCPI Command Summary (continued)

<table>
<tr><th>Keyword/Syntax</th><th>Parameter Form</th><th>Input Number</th><th>SCPI Status</th></tr>
<tr><td>INITiate[1|2|3]</td><td></td><td></td><td>Std</td></tr>
<tr><td>[:IMMediate]</td><td></td><td></td><td>Std</td></tr>
<tr><td>:CONTinuous</td><td><OFF|0|ON|1></td><td></td><td>Std</td></tr>
<tr><td>:CONTinuous?</td><td></td><td></td><td>Std</td></tr>
<tr><td>INPut[1|2]</td><td></td><td></td><td>Std</td></tr>
<tr><td>:ATTenuation</td><td><1|10></td><td>1,2</td><td>Std</td></tr>
<tr><td>:ATTenuation?</td><td>[<1|10>]</td><td>1,2</td><td>Std</td></tr>
<tr><td>:COUPling</td><td><AC|DC></td><td>1,2</td><td>Std</td></tr>
<tr><td>:COUPling?</td><td></td><td>1,2</td><td>Std</td></tr>
<tr><td>:IMPedance</td><td><expected value> |MIN|MAX|DEF</td><td>1,2</td><td>Std</td></tr>
<tr><td>:IMPedance?</td><td>[<MIN|MAX|DEF>]</td><td>1,2</td><td>Std</td></tr>
<tr><td>:ROUTe</td><td><COMM|SEP></td><td>1</td><td>New</td></tr>
<tr><td>:ROUTe?</td><td></td><td>1,2</td><td>New</td></tr>
<tr><td>MEASure[1|2|3]</td><td></td><td></td><td>Std</td></tr>
<tr><td>[:VOLTage]</td><td></td><td></td><td>Std</td></tr>
<tr><td>:AC?</td><td>[<expected value> [,<resolution>]]</td><td>1,2</td><td>Std</td></tr>
<tr><td>:DC?</td><td>[<expected value> [,<resolution>]]</td><td>1,2</td><td>Std</td></tr>
<tr><td>:FREQuency?</td><td>[<expected value> [,<resolution>]]</td><td>1,2,3</td><td>Std</td></tr>
<tr><td>:RATio?</td><td>[<expected value> [,<resolution>]]</td><td>1,2,3</td><td>New</td></tr>
<tr><td>:FTIMe?|:FALL:TIME?</td><td>[<lower reference> [,<upper reference>
[,<expected value> ,[<resolution>]]]]</td><td>1</td><td>Std</td></tr>
<tr><td>:MAXimum?</td><td>[<expected value> [,<resolution>]]</td><td>1,2</td><td>Std</td></tr>
<tr><td>:MINimum?</td><td>[<expected value> [,<resolution>]]</td><td>1,2</td><td>Std</td></tr>
<tr><td>:NWIDth?</td><td>[<reference> [,<expected value>
[,<resolution>]]]</td><td>1,2</td><td>Std</td></tr>
<tr><td>:PERiod?</td><td>[<expected value> [,<resolution>]]</td><td>1,2,3</td><td>Std</td></tr>
<tr><td>:PWIDth?</td><td>[<reference> [,<expected value>
[,<resolution>]]]</td><td>1,2</td><td>Std</td></tr>
<tr><td>:RTIMe?|:RISE:TIME?</td><td>[<lower reference> [,<upper reference>
[,<expected value> [,<resolution>]]]]</td><td>1</td><td>Std</td></tr>
<tr><td>:TINTerval?</td><td>[<expected value> [,<resolution>]]</td><td>1</td><td>New</td></tr>
<tr><td>OUTPut</td><td></td><td></td><td>Std</td></tr>
<tr><td>:ROSCillator</td><td></td><td>Int/Ext</td><td>Std</td></tr>
<tr><td>[:STATe]</td><td><OFF|0|ON|1></td><td>Reference</td><td>Std</td></tr>
<tr><td>[:STATe]?</td><td></td><td></td><td>Std</td></tr>
<tr><td>READ[1|2|3]</td><td></td><td></td><td>Std</td></tr>
<tr><td>[:<function>]?</td><td></td><td>1,2,3</td><td></td></tr>
</table>

Table 7-1. SCPI Command Summary (continued)

Keyword/Syntax	Parameter Form	Input Number	SCPI Status
[SENSe[1|2|3]]			Std
:AVERage		1,2	New
[:STATe]	<OFF|0|ON|1>		New
[:STATe]?			New
:COUNt?			New
:EVENt		1,2	New
:LEVel			New
[:ABSolute]	<*level*> |MIN|MAX|DEF		New
[:ABSolute]?	[<MIN|MAX|DEF>]		New
:AUTO	<OFF|0|ON|1|ONCE>		New
:AUTO?			New
:RELative	<*expected value*> |MIN|MAX|DEF		New
:RELative?	[<MIN|MAX|DEF>]		New
:SLOPe	<pOS|NEG>		New
:SLOPe?			New
:HYSTeresis	<MIN|MAX|DEF>		New
:HYSTeresis?			New
:FREQuency			Std
:APERture	<*expected value*> |MIN|MAX|DEF	1,2,3	Std
:APERture?	[<MIN|MAX|DEF>]	1,2,3	Std
:RANGe		1	Std
[:UPPer]	<*range*> |MIN|MAX|DEF		Std
[:UPPer]?	[<MIN|MAX|DEF>]		Std
:AUTO	<OFF|0|ON|1>		Std
:AUTO?			Std
:FUNCtion	"[VOLTage:]AC"	1,2	Std
	"[VOLTage:]DC"	1,2	Std
	"[VOLTage:]FREQuency"	1,2,3	Std
	"[VOLTage:]FREQuency:RATio"	1,2,3	New
	"[VOLTage:]FTIMe"	1	New
	"[VOLTage:]FALL:TIME"	1	New
	"[VOLTage:]MAXimum"	1,2	New
	"[VOLTage:]MINimum"	1,2	New
	"[VOLTage:]NWIDth"	1,2	New
	"[VOLTage:]PERiod"	1,2,3	Std
	"[VOLTage:]PWIDth"	1,2	New
	"[VOLTage:]RTIMe"	1	New
	"[VOLTage:]RISE:TIME"	1	New
	"[VOLTage:]TINTerval"	1,2	Std
	"[VOLTage:]TOTalize"	1,2	Std

Table 7-1. SCPI Command Summary (continued)

Keyword/Syntax	Parameter Form	Input Number	SCPI Status
:FUNCtion?		1,2,3	Std
:PERiod			New
:APERture	<*expected value*> |MIN|MAX|DEF	1,2,3	New
:APERture?	[<MIN|MAX|DEF>]	1,2,3	New
:RATio			New
:APERture	<*expected value*> |MIN|MAX|DEF	1,2,3	New
:APERture?	[<MIN|MAX|DEF>]	1,2,3	New
:ROSCillator			Std
:SOURce	<INT|EXT>	Int/Ext	Std
:SOURce?		Reference	Std
:TINTerval			New
:DELay			New
[:STATe]	<OFF|0|ON|1>		New
[:STATe]?			New
:TIME	<*time*> |MIN|MAX|DEF		New
:TIME?	[<MIN|MAX|DEF>]		New
:TOTalize			New
:GATE			New
[:STATe]	<OFF|0|ON|1>		New
[:STATe]?			New
:POLarity	<NORM|INV>		New
:POLarity?			New
:SOURce?			New
STATus			Std
:OPERation			Std
:CONDition?			Std
:ENABle	<*mask*>		Std
:ENABle?			Std
[:EVENt]?			Std
:QUEStionable			Std
:CONDition?			Std
:ENABle	<*mask*>		Std
:ENABle?			Std
[:EVENt]?			Std
:PRESet			Std
SYSTem			Std
:ERRor?			Std
:PIMacro	<*string*>		New
:VERSion?			Std

IEEE Std 488.2-1987 Common Commands Quick Reference

Table 7-2 lists the *IEEE Std 488.2-1987* Common commands implemented for the HP 70120A universal counter.

Table 7-2. Common Command Summary

Command	Description
*CLS	Clears the Status Byte Register, Standard Event Status Register, and error queue.
*DMC	Assigns a sequence of program elements to a Macro label.
*EMC	Enables/disables the execution of macros.
*EMC?	Returns the current enable/disable status of a macro.
*ESE	Enable events in Standard Event Status Register to be reported.
*ESE?	Returns the sum of all enabled bits in the Standard Event Status Register.
*ESR?	Returns the sum of all set bits in the Standard Event Status Register.
*GMC?	Returns the current definition of a macro.
*IDN?	Returns identification string.
*LMC?	Returns the labels of all currently defined macros.
*OPC	Sets bit 0 in the Standard Event Status Register after all pending operations complete.
*OPC?	Returns ASCII "1" after all pending operations complete.
*PMC	Purges all currently defined macros.
*RCL	Recalls configuration previously stored via the *SAV command.
*RST	Resets the counter to a known power up/reset status.
*SAV	Saves the current counter module configuration.
*SRE	Enable Status Register bits to assert SRQ.
*SRE?	Returns sum of enabled Status Byte register bits.
*STB?	Returns sum of all bits set in Status Byte Register.
*TRG	Triggers the counter.
*TST?	Executes the counter's internal self-test.
*WAI	Causes the counter to wait until all previous commands or queries complete.

8

Remote Programming Commands Reference

This chapter describes the Standard Commands for Programmable Instruments (SCPI commands) and *IEEE Std 488.2-1987* common commands applicable to the HP 70120A universal counter. This chapter is organized into two sections summarized below.

- "Command Types"
- "*IEEE Std 488.2-1987* Common Commands"

Command Types

Commands are separated into two types: *IEEE Std 488.2-1987* Common Commands and SCPI Commands. The SCPI commands control instrument measurement/command functions unique to the HP 70120A universal counter. The *IEEE Std 488.2-1987* Common commands control and manage communications protocol/information interchange between the counter and the instrument controller.

Common Command Format

The *IEEE Std 488.2-1987* standard defines the Common commands that perform functions like reset, self-test, status byte query, and so forth. Common commands are four or five characters in length, always begin with the asterisk character (*), and may include one or more parameters. The command keyword is separated from the first parameter by a space character. Some examples of Common commands are shown below:

```
*RST   *ESR 32   *STB?
```

SCPI Command Format

The SCPI commands perform functions like counter setup, making measurements, and querying instrument states or retrieving data. A subsystem command structure is a hierarchical structure that usually consists of a top level (or root) command, one or more lower level commands, and their parameters. The following example shows part of a typical subsystem:

```
INPut[1|2]
    :IMPedance <expected value> |MIN|MAX|DEF
    :IMPedance? [<MIN|MAX|DEF>]
```

INPut is the root command with :IMPedance and :IMPedance? the second level commands with parameters.

Command Separator

A colon (:) always separates one command from the next lower level command as shown below:

```
INPut[1|2]:IMPedance?
```

Abbreviated Commands

The command syntax shows most commands as a mixture of upper and lower case letters. The upper case letters indicate the abbreviated spelling for the command. For shorter program lines, send the abbreviated form. For better program readability, you may send the entire command. The instrument will accept either the abbreviated form or the entire command.

For example, if the command syntax shows MEASure, then MEAS and MEASURE are both acceptable forms. Other forms of MEASure, such as MEASU or MEASUR will generate an error. You may use upper or lower case letters. Therefore, MEASURE, measure, and MeAsUrE are all acceptable.

Implied Input

Some commands contain input numbers in square brackets, for example [1|2|3]. The brackets indicate that the same programming sequence can be used for all three inputs, one of which must be specified. If an input number is not specified, it will default to Input 1.

Implied Commands

Implied commands are those which appear in square brackets ([ ]) in the command syntax. (Note that the brackets are not part of the command and are not sent to the instrument.) Suppose you send a second level command but do not send the preceding implied command. In this case, the instrument assumes you intend to use the implied command and it responds as if you had sent it. Examine the portion of the [SENSe:] subsystem shown below:

```
[SENSe]
   :EVENt
   :SLOPe <POSitive|NEGative>
   :SLOPe?
   :LEVel <number|MINimum|MAX|DEF>
   :LEVel?
```

The root command [SENSe:] is an implied command. To set the instrument's trigger level to +1.5, you can send either of the following command statements:

```
SENS:EVEN:LEV 1.5 or EVEN:LEV 1.5
```

If a command is an implied form but can also accept input numbers, the implied form pertains to Input 1 only. To switch inputs, you must use the input number in the command string, for example, "SENS2:EVEN:LEV 1.5".

Parameter Types

Table 8-1 contains explanations and examples of parameter types you might see later in this chapter. Parameter types may be numeric, boolean, or discrete.

Table 8-1. Parameter Types

Type	Explanations and Examples
Numeric:	Accepts all commonly used decimal representations of numbers including optional signs,decimal points,, and scientific notation: 123, 123E2, −123, −1.23E2, .123, 1.23E-2, 1.23000E-01. Special cases include MIN, MAX, and DEF. MIN selects minimum value available, MAX selects maximum value available, and DEF selects the default or reset value. Queries on MIN, MAX, or DEF result in an associated numeric value. All decimal types also accept MIN, MAX, or DEF, and can be queried with them to produce a numeric value (except with MEASure or CONFigure, or Status Enable registers).
Boolean:	Represents a single binary condition that is either true or false: 1 or ON, 0 or OFF (Query response returns only 1 or 0.)
Discrete:	Selects from a finite number of values. These parameters use mnemonics to represent each valid setting. An example is the ARM:SOURce<source> command where source can be BUS, HOLD, IMMediate, EXTernal, or EXTernal2.

Optional Parameters

Parameters shown within square brackets ([ ]) are optional parameters. (Note that the brackets are not part of the parameter and are not sent to the instrument.) If you do not specify a value for an optional parameter, the instrument chooses an appropriate value.

For example, sending the MEAS:NWID? [ref [,expected value [,resolution]]] command without any parameter as "MEAS:NWID?" causes the counter to choose the value of "ref" as 50%, with the "expected value" and "resolution" being automatically determined.

Query Parameters

All selectable numeric parameters can be queried to return the minimum, maximum, or default values they are capable of being set to by sending a MIN, MAX, or DEF optional parameter after the "?". For example, consider the EVENt:LEVel? [<MIN|MAX|DEF>] command.

If you send the command without specifying a parameter, the present EVENt:LEVel value is returned. If you send the MIN parameter, the command returns the minimum level available. If you send the MAX parameter, the command returns the maximum level available. Be sure to place a space between the command and the parameter.

Linking Commands

To link *IEEE Std 488.2-1987* Common Commands with SCPI Commands, use a semicolon between the commands. For example:

```
*RST;CONF2:PER
```

Multiple SCPI commands with corresponding parameters can also be sent at the same time. Here, the first command is always referenced to the root node. Subsequent commands, separated by “;”, are referenced to the same level as the previous command if no “:” is present immediately after the command separator. For example, sending:

```
EVEN:LEV 1;SLOP POS
```

is equivalent to sending:

```
EVEN:LEV 1
EVEN:SLOP POS
```

The “:” must be present to distinguish another root level command. For example:

```
EVEN:LEV 1;:ARM:SOUR EXT
```

is equivalent to sending:

```
EVEN:LEV 1
ARM:SOUR EXT
```

If the “:” in front of ARM is omitted, the counter assumes that you have sent “EVEN:ARM:SOUR EXT” and will generate an error.

IEEE Std 488.2-1987 Common Commands

This section describes the *IEEE Std 488.2-1987* Common commands and queries for the HP 70120A universal counter. Descriptive information about function and operation are included for each command. For complete details of the common commands refer to *IEEE Std 488.2-1987*.

*CLS (Clear Status)

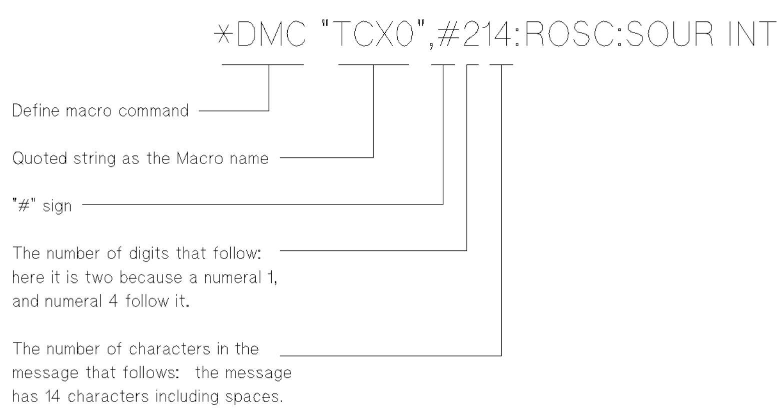
The Clear Status command clears status data structures, the Request-for-OPC flag, and forces the counter into the Operation Complete Command Idle State and the Operation Complete Query Idle State. The status data structures include all Event registers and all Queues, except the Output Queue.

*DMC (Define Macro)

The Define Macro command lets you assign a sequence of program elements to a macro label. The sequence is executed when the label is received as a command or query program header. This macro helps minimize backplane command traffic. The detailed description is described in the *IEEE Std 488.2-1987* - 1987 standard. You can define a macro by sending the *DMC command, followed by a string designating the label. Following the label, you must send an <Arbitrary Block Program Data> element defining the macro. For example:

```
*DMC "TCXO",#214:ROSC:SOUR INT
```

defines a macro with the name "TCXO" that selects the internal timebase as the counter's timebase. The components of a macro command statement are composed of the following syntactic elements:



Macro definitions also allow you to pass parameters with the macro. Placeholders for parameters appear as a dollar sign (ASCII $, 36 decimal) followed by a single digit in the range 1 to 9 (49-57 decimal). For example:

```
*DMC "EXT_ARM",#243ARM:SOUR EXT;:ARM:STOP:SOUR
EXT;:ARM:LEV $1
```

defines a macro with one parameter. Sending the command

```
"EXT_ARM −1.3"
```

would be equivalent to sending these three commands to the counter:

```
ARM:SOUR EXT
ARM:STOP:SOUR EXT
ARM:LEV −1.3
```

The macro label may be either a command or a query. The label cannot be the same as a common command or common query. It may be the same as a counter dependent command. When a macro label is the same as a counter dependent command, the counter will execute the macro rather than the counter command if macros are enabled.

*EMC (Enable Macro)

This command enables and disables the expansion of macros by a counter. However, it does not affect the macro definitions. An example of the use of this command is to turn off macros in order to use a counter dependent command which has the same name as a macro. Sending this command followed by 0 will disable all macros. Sending an integer other than 0 in the range −32768 to 32767 will enable macros. If the number does not round to an integer within this range −200, "Execution Error", will be reported.

For example, sending

```
*EMC 0
```

will disable macros. Sending

```
*EMC −12
```

will enable macros.

*EMC? (Enable Macro Query)

The Enable Macro Query allows the user to determine whether or not macros are enabled on the counter. The counter will return a value of 1 (ASCll 49 decimal) when macros are enabled. It will return a value of 0 (ASCll 48 decimal) when macros are disabled.

*ESE (Standard Event Status Enable)

The Standard Event Status Enable Command sets the Standard Event Status Enable Register bits. The data is defined as <Decimal Numeric Program Data>. The counter rounds this number to an integer. Expressing this number in base 2 (binary) represents values of the individual bits of the Standard Event Status Enable Register. For example to set bit 5 (Command Error) and bit 2 (Query Error) the command

```
*ESE 36
```

would be sent to the counter. The number sent to the counter must be in the range 0 to 255 or an error, −222, "Data out of range", occurs. (Refer to STATus command description for more information about the Standard Event Status Register.)

*ESE? (Standard Event Status Enable Query)

This command reads the contents of the Standard Event Status Enable Register (SESER). In response to this query the counter sends the contents of the SESER in integer format. It will be in the range 0 to 255.

*ESR? (Event Status Register Query)

The Event Status Register Query command reads the contents of the Standard Event Status Register. Reading this register clears it. It returns an integer, which, when converted to a binary number represents the contents of the individual bits of the register. This number will be in the range 0 to 255 decimal.

*GMC? (Get Macro Contents Query)

The Get Macro Contents Query allows you to obtain the current definition of a macro from the counter. Simply send the *GMC? query followed by the label string of the macro. The counter responds with a <Definite Length Arbitrary Block Response Data> element which contains the macro definition. For example, sending

```
*GMC? "TCXO"
```

to a counter will tell it to send the macro definition for the macro "TCXO" defined earlier. An attempt to retrieve the contents of an undefined macro returns a zero length block and reports an error, −270, "Macro error".

*IDN? (Identification Query)

The Identification Query causes the counter to send its "identity" over the bus as an <Arbitrary ASCll Response Data> element. The response string for the HP 70120A universal counter will appear as follows:

```
HEWLETT-PACKARD,70120A,XXXXXXXXXX,910628
```

The entire length of the response is 72 characters or less. The third field (represented by ten X's) will contain the module's serial number. The last field of the response (REV A.01.00) is the firmware revision date code.

*LMC? (Learn Macro Query)

The Learn Macro Query instructs the counter to respond with the labels of all the currently defined macros. The counter will respond with strings separated by commas. lf no macros are defined the counter will return a null string of two consecutive double quote (" ") marks. The response is the same whether or not macros are enabled or disabled.

*OPC (Operation Complete)

The Operation Complete command tells the counter to set bit 0 in the Standard Event Status Register when it completes all pending operations.

*OPC? (Operation Complete Query)

The Operation Complete Query tells the counter to place an ASCll '1' (decimal 49) in the counter's output queue when it completes all pending operations.

*PMC (Purge Macros)

The Purge Macros Command causes the counter to delete all macros in memory that were defined by the *DMC command. All macro sequences and labels are removed from memory. You can purge single macros by using the SYST:PIM command of the SYSTem subsystem.

*RCL (Recall)

The Recall command restores the state of a counter from a copy previously stored in local memory through the *SAV command. The counter has I/O storage areas, so the command includes a numeric parameter to indicate which storage area to use. These numbers will begin at zero and end at nine.

*RST (Reset)

This command resets the counter. The reset command:

1. Sets the counter-dependent functions to a known state, independent of its current state. (Refer to Table 3-2.)
2. Disables macros.
3. Aborts all pending operations.
4. Forces the counter to forget about any previously received Operation Complete commands.

The reset command does *not* affect:

1. The Output Queue.
2. The Error Queue.
3. The Service Request Enable Register.
4. The Standard Event Status Enable Register.
5. The power up flag.
6. Macros (except to disable them).
7. Calibration data.
8. The Protected User Data (for example Save/Recall states).

*SAV (Save)

The Save Command stores the present state of the counter in local memory. The counter has ten locations in which to store this data. Therefore, the command is followed by a numeric parameter designating the storage area to use. These numbers begin at zero and end at nine. The instrument states are stored until power is removed from the counter.

*SRE (Service Request Enable)

The Service Request Enable command sets the Service Request Enable Register. This register determines what bits in the Status Byte will cause a service request from the counter. The data sent with the command is a <Decimal Numeric Program Data>. The counter rounds this number to an integer. Expressing this number in base 2 (binary) would then represent the values of the individual bits of the Service Request Enable Register.

For example, to set bit 4 (Message Available) the command

```
*SRE 16
```

would be sent. The counter would then cause a service request when data is ready.

*SRE? (Service Request Enable Query)

The Service Request Enable Query command reads the contents of the Service Request Enable Register. The counter returns the data as an <NR1> (integer), in the range 0 to 63 or 128 to 191, since bit 6 (the RQS bit) cannot be set.

*STB? (Status Byte Query)

The Status Byte Query command reads the status byte with the Master Summary Status (MSS) bit. The counter responds with an integer in the range 0 to 255. These bits represent the contents of the status byte. Bit 6 represents MSS rather than RQS (Request Service). (Refer to STATus command for more information about the Status Byte Register.)

*TRG (Trigger)

The Trigger command causes the counter to immediately start/stop a measurement if the corresponding ARM source is previously programmed to "BUS". When "BUS" is selected as a source, the word-serial command <GET> or *TRG will satisfy the arming condition. The measurement must be INITiated prior to sending *TRG (refer to the INITiate command).

*TST? (Self-Test Query)

The *TST? *IEEE Std 488.2-1987* self-test query causes the counter to perform the following self-test routines:

ROM
SRAM
Calibration Memory
Front End
Timebase
MRC Measurement
MRC Interpolator

MRC Interpolator Delay

If the test passes, the number "0" will be returned.

If any test fails, a positive number representing the weighted sum of the failed tests will be returned. The weights for the tests are as follows:

Test	Test Weight
ROM	128
SRAM	64
Calibration Memory	32
Front End	16
Timebase	8
MRC Measurement	4
MRC Interpolator	2
MRC Interpolator Delay	1

At the conclusion of the test cycle, the previous state of the counter will be restored.

*WAI (Wait)

The Wait to Continue command makes the counter wait until all the previous commands or queries complete. It thus forces the sequential execution of commands. The counter then continues executing commands that follow the *WAI command.

SCPI Command Reference

This section describes the Standard Commands for Programmable Instruments (SCPI commands) for the HP 70120A universal counter. The listings are alphabetical by SCPI root command.

ABORt

The **ABORt** command terminates a measurement and places the counter into the idle state.

Subsystem Syntax: `ABORt[1|2|3]`

Parameters: Only one input number can be specified in the command. The input number defaults to Input 1 if a input number is not specified.

Comments:

- If the continuous mode is active, the counter aborts the current measurement and resumes making measurements.
- Implied ABORt: In general, it is not necessary to abort a measurement using the ABORt command. Selecting a new function or initiating a new measurement will perform an implied abort.
- If the counter is waiting to respond to a query, a word-serial "Clear" must be sent to exit the query.

Example:

`CONF2:PER`	*Input 2 function is period.*
`ARM:SOUR HOLD`	*Suspend the START ARM condition.*
`INIT2`	*Input 2 go to wait-for-arm state.*
`ABOR2`	*Input 2 go to idle state.*

ARM

The purpose of the **ARM** command is to qualify a single event to start or stop a measurement. The ARM subsystem of the HP 70120A universal counter provides:

- A selectable arming source,
- A selectable arming slope,
- A selectable arming trigger level for an external arming signal,
- A one-time software override of the arm event detection layer.

Subsystem Syntax

```
ARM
   [:SEQuence[1]|:STARt]
      [:LAYer[1]]
         [:IMMediate]
         :LEVel    <level> |MIN|MAX|DEF
         :LEVel?    [<MIN|MAX|DEF>]
         :SLOPe    POS|NEG
         :SLOPe?
         :SOURce    EXT[1]|EXT2|IMM|BUS|HOLD
         :SOURce?
   :SEQuence2|:STOP
      [:LAYer[1]]
         [:IMMediate]
         :LEVel    <level> |MIN|MAX|DEF
         :LEVel?    [<MIN|MAX|DEF>]
         :SLOPe    POS|NEG
         :SLOPe?
         :SOURce    EXT[1]|EXT2|IMM|BUS|HOLD
         :SOURce?
```

[:SEQuence[1]|:STARt]

:STARt]| **ARM[:SEQuence[1]|:STARt]** determines how "Start-Arm" (to start measurement) is programmed based on the command options and parameters in the command levels following STARt.

:SEQuence2|:STOP

:STOP| **ARM(:SEQuence2|:STOP)** determines how “Stop-Arm” (to stop measurement) is programmed based on the command options and parameters in the command levels following STOP.

[:LAYer[1]]

[**:LAYer**[1]] provides entry into future arming and event detection schemes.

[:LAYer[1]] [:IMMediate]

If [**:IMMediate**] is associated with ARM:STARt, the counter is armed to start measurement immediately, ignoring the arming source for the current measurement. If [:IMMediate] is associated with ARM:STOP, then the counter is armed immediately to stop measurement ignoring the arming source for the current measurement.

Comments

- All previously programmed values for :SOURce, :LEVel, and :SLOPe remain in effect after the single-shot exit from the arming subsystem initiated by [:IMMediate]
- ARM commands configure the arming subsystem but do not arm the counter. The INITiate command enables the arming subsystem.
- If an ARM:IMMediate command is sent prior to INITiating a measurement, error −212, "Arm ignored", is returned.

Example

`CONF1:FREQ`	*Function is frequency on Input 1.*
`ARM:STAR:SOUR EXT` `ARM:STAR:SLOP POS`	*Start measurement armed with rising edge of external arming source.*
`ARM:STOP:SOUR EXT` `ARM:STOP:SLOP NEG`	*Stop measurement armed with falling edge of external arming source.*
`INIT`	*Initiate a measurement.*
`ARM:STAR:IMMediate`	*For one measurement only, start arm is immediate. Counter doesn't wait for rising edge of the external Arm signal, but does wait for the falling edge.*
`FETC?`	*place measurement in the output buffer.*
`INIT`	*Initiate a measurement that will not start until the counter receives the rising edge of an external arming source.*

[:LAYer[1]]:LEVel

[:LAYer[1]]:LEVel <*level*> configures the ARM subsystem to qualify the selected amplitude of a source signal arriving at the front panel ARM connector signal that generates a measurement. Parameter entry is −1.3, +1.6, or 0 volts.

Parameters

Parameter Name	Parameter Type	Range of Values	Default Value
level	numerical	−5 to −.999 results as nominal −1.3 V for ECL −1 to +1 results as 0V for GND +1.001 to +5 results as nominal 1.6V for TTL	1.6
	discrete	MIN|MAX|DEF	0 volts GND

Comments

- LEVel is functional only when arming is EXTernal via the front panel BNC connector.
- Even though values between −5 and +5 volts are accepted, the counter will program only three nominal values suitable for TTL, ECL, or ac-coupled signals.
- For EXT2 input, this value is ignored as the counter automatically defaults to the TTL level (nominally 1.6 volts).
- MIN value: −1.3 volts ECL
- MAX value: +1.6 volts TTL
- ***RST Condition:** 1.6 volts.

Example

`ARM:STAR:LEVel 0` *Trigger level for external arm signal is set to 0 volts.*

[:LAYer[1]]:LEVel?

[:LAYer[1]]:LEVel? [<*trigger level*>] returns the discrete value currently assigned to the trigger subsystem LEVel command. The quoted string is sent to the output buffer.

Parameters

Parameter Name	Parameter Type	Range of Values	Default Value
trigger level	discrete	MAX|MIN|DEF	

Example

`ARM:LEVel?`	*Query counter to return trigger level setting.*
`"ENTER" statement`	*Enter value into controller.*

[:LAYer[1]]:SLOPe

[:LAYer[1]]:SLOPe <*slope*> configures the trigger subsystem to select the slope of a selected source (EXT1 or EXT2) that generates a measurement. SLOPe qualifies whether the event occurs on the rising edge or falling edge of the signal.

Parameters

Parameter Name	Parameter Type	Range of Values	Default Value
slope	discrete	POSitive|NEGative	POS

Comments

- Useful for EXTernal arm source.
- ***RST Condition:** POS

Example

`ARM:STOP:SLOPe POS` *Specify the SLOPe command of the ARM subsystem.*

[:LAYer[1]]:SLOPe?

[**:LAYer**[1]]**:SLOPe?** returns the discrete value currently assigned to the trigger subsystem SLOPe command. The quoted string is sent to the output buffer. An example of the use of this query is shown below:

`ARM:SLOPe?`	*Query counter to return trigger slope setting.*
`"ENTER" statement`	*Enter value into controller.*

[:LAYer[1]]:SOURce

[:LAYer[1]]:SOURce <*source*> configures the trigger subsystem to respond to the specified source. The following sources are available:

- BUS: *TRG or <GET> (Group Execute Trigger) command is sent over the MSIB bus. The counter must be initiated to recognize the *TRG or <GET> command.
- EXTernal[1]:The front panel ARM input connector is selected as the source.
- EXTernal2: The rear panel trigger input connector is selected as the source.
- IMMediate: The arming system is always true.
- HOLD: Suspend arming. Once in HOLD mode, the counter can only be armed by the "ARM:IMMediate" command.

Parameters

Parameter Name	Parameter Type	Range of Values	Default Value
source	discrete	EXT[1]|EXT2|IMM|HOLD|BUS	IMM

Comments

- If EXTernal[1] is selected as the first Start/Stop source, then another source cannot be selected as the second Start/Stop source. If such a mixed-source combination is programmed, the counter will generate error −205, "Arming configuration conflict", upon initiation.
- ARM[:IMMediate] causes an arming cycle to occur immediately provided the Trigger subsystem has been initiated by the INITiate command. This command ignores the current arming source.
- Because ARM:IMMediate is an event, it has no query condition.
- ***RST Condition:** ARM:SOUR IMM

Example

s *Example One*

`CONF1:PER`	*Function is period on Input 1.*
`ARM:STAR:SOUR EXT`	*Arming Start/Stop source*
`ARM:STOP:SOUR EXT`	*is the specified external arm.*
`ARM:STAR:SLOP NEG`	*Arming Start specified as negative edge.*
`ARM:STOP:SLOP POS`	*Arming Stop specified as positive edge.*
`READ?`	*place counter in wait-for-arm state. Measurement is made when the external arm goes low.*

Example Two

`CONF1:FREQ`	*Function is frequency on Input 1.*
`ARM:STARt:SOURce`	*Arming START source is the BUS when *TRG is sent.*

INIT	*Initiate a measurement. The counter waits for *TRG*
*TRG	*Satisfy arming subsystem, take a measurement.*
FETCh?	*Transfer the data to the output queue.*

[:LAYer[1]]:SOURce?

[**:LAYer**[1]]**:SOURce?** returns EXT1, EXT2, IMM, BUS, or HOLD indicating the current arming source. The quoted string is sent to the output buffer. An example of the use of this query is shown below:

`ARM:STOP:SOUR HOLD`	*Arming source for Stop arming is suspended.*
`ARM:STOP:SOUR?`	*Query counter to return arm source setting.*
`"ENTER" statement`	*Enter value into controller.*

CONFigure

The CONFigure command subsystem sets up the counter to perform a specified measurement but does not perform the actual measurement. Use the INITiate and FETCh? or READ? command to initiate and read the measurement.

Subsystem Syntax

```
CONFigure[1|2|3]
   [:VOLTage]
      :AC [<expected value>[,<resolution>]]*
      :DC [<expected value>[,<resolution>]]*
      :FREQuency [<expected value>[,<resolution>]]
      :RATio [<expected value>[,<resolution>]]
      :FTIMe|:FALL:TIME [<lower reference>[,<upper reference>
      [,<expected value>[,<resolution>]]]]
      :MAXimum [<expected value>[,<resolution>]]*
      :MINimum [<expected value>[,<resolution>]]*
      :NWIDth [<reference>[,<expected value>
      [,<resolution>]]]
      :PERiod [<expected value>[,<resolution>]]
      :PWIDth [<reference>[,<expected value>
      [,<resolution>]]]
      :RTIMe|:RISE:TIME [<lower reference>[,<upper reference>
      [,<expected value>[,<resolution>]]]]
      :TINTerval [<expected value>[,<resolution>]]
      :TOTalize <expected value>[,<resolution>]]*

* Expected value and resolution parameters are accepted
but ignored for ac, dc, MINimum, MAXimum, and TOTalize measurements.
```

Comments

- Manually entered expected value: If the optional expected value and resolution are specified, the state of the counter will be changed to obtain the requested resolution.

Note Table 8-2 shows what effect the expected value and resolution (or their absence) have on gate time and the prescaler. In some cases, the prescaler will be placed in auto mode. This requires the counter to take a preliminary measurement to determine if the prescaler should be turned on or off. If the counter is externally start armed, two arming pulses are required (one to set the prescaler, the other to take the measurement).

- Specifying optional parameters: The optional parameters can be defaulted from right-to-left. For example, if a value for resolution is to be entered, the expected value must be specified. If the parameter is explicitly omitted, the best possible value is chosen.
- [:VOLTage] is an implied node and may be omitted from the program message.

- Auto Acquire:

  If the optional parameters expected value and resolution are not entered, the gate time is set by the counter.

- Auto Trigger:

  Making measurements with auto trigger greatly reduces throughput as compared to measurement speed when trigger levels are programmed manually. During auto triggered frequency measurements, the counter determines the positive and negative voltage peaks of the input signal.

  It then programs the trigger level according to the current [SENSe:]EVENt:LEVel:RELative parameter value.

  During auto triggered rise/fall time measurements, input 1 is programmed for 10% (90%) value and Input 2 is programmed for 90% (10%) value. Rise/fall time measurements use both input amplifiers (common Input 1). A signal arriving at the Input 2 connector is not counted.

Note Auto-triggering should not be used when measuring signals below 1 kHz.

- CONFigure and MEASure versus [SENSe:] Most measurements can be performed using one of these three subsystems, and each has advantages and disadvantages over the other. The basic difference between the commands is as follows: The CONFigure command can be used for all measurements except “gated totalize” and “time-interval delay” measurements. The CONFigure command only configures a input for a specific function, and does not perform the measurement. Use of additional commands (READ?, or INIT/FETC?) to perform the measurement and read the results is necessary. Further customization of the counter set-up is provided, through the use of optional parameters. The MEASure command can be used for all measurements except TOTalize. The MEASure command configures a input for a specific function, performs the measurement, and returns the result to the output buffer. Further customization of the counter set-up is provided, through the use of optional parameters. The MEASure command is instrument independent and can be used in other instruments to perform similar functions. This command should be used when the portability of instrument syntax is important. CONFigure/READ? is less compatible if the counter re-configuration occurs between the CONFigure and READ? operations. The [SENSe:] subsystem can be used for all measurements. The [SENSe:]FUNCtion command only configures a input for a specific function and does not perform the measurement. The state of the counter is not otherwise affected. Use of additional commands (READ?, or INIT/FETC?) to perform the measurement and store the results is required. The [SENSe:] commands should be used when direct control over the measurement is important.

[:VOLTage]:AC

CONFigure[**1**|**2**][**:VOLTage**]**:AC** [<*expected value*>[,<*resolution*>]] configures the counter to measure the rms ac voltage component of the input ac sinusoidal signal. This command does not initiate the measurement process.

Parameters There are no parameters for the ac function. However, *expected value* and *resolution* are accepted by the command but ignored.

Comments

- Input Selection: is valid for Input 1 and Input 2 only.
- Type of Signal Measured: Signals must be sinusoidal for the ac voltage function.
- This function configures the counter for auto-triggered measurements on the selected input.

[:VOLTage]:DC

CONFigure[1|2][:VOLTage]:DC [<*expected value*>[,<*resolution*>]] configures the counter to measure the dc component of the input ac signal. This function assumes symmetrical signals because the dc value is calculated as a center point between positive and negative peak values of the signal. This command does not initiate the measurement process.

Parameters

There are no parameters for the dc function. However, *expected value* and *resolution* are accepted by the command but ignored.

Comments

- Input Selection: Valid for Input 1 and Input 2 only.
- Type of Signal Measured: Signals must be periodic and symmetrical for the dc voltage function.
- This function configures the counter for auto-triggered measurements on the selected input.

[:VOLTage]:FREQuency

CONFigure[1|2|3][:VOLTage]:FREQuency [<*expected value*>[,<*resolution*>]] configures the counter for the frequency measurement function. This command does not initiate the measurement process.

Refer to the *Measurement Resolution* section of "Understanding the Universal Counter" in Chapter 3 for more information regarding numeric entry. Refer to Table 8-2 for instrument settings when using the command with parameters.

Parameters

Parameter Name	Parameter Type	Range of Values	Default Value
expected value	numeric	.001 to 200E6 Hz (ch 1)	N/A
		.001 to 100E6 Hz (ch 2)	
		90E6 to 2500E6 (ch 3)	
	discrete	DEF|MIN|MAX|AUTO	
resolution	numeric	1E−9 to 1E5	9 digits
	discrete	DEF|MIN|MAX	

Comments

- Input Selection: Valid for Input 1, Input 2, and Input 3, but only one input is selected at a time.
- Signals must be periodic for the frequency function as the counter measures average frequency over the gate time.
- *expected value* can be entered as a number in Hz from 0.001 Hz to 200/100 MHz for Input 1 and Input 2 respectively. For Input 3, *expected value* can be entered as a number in Hz from 90 MHz to 2.5 GHz. Selecting a value greater than 100 MHz, enables prescaling (divide by 2) on Input 1.
- *resolution* is entered as a number from 1E-9 Hz to 100 kHz. Entries up to 1E8 for Input 1 and Input 2 and 1E9 for Input 3 will be accepted. Resolution is automatically set for 9 digits of resolution by not entering a value for the optional *resolution* parameter. If *resolution* is entered, *expected value* must also be entered.
- If no parameters are entered, the counter goes into auto-ranging mode using a gate time of 400 ms.
- If the entered parameters are out of range, then the counter returns error −209, "Data clipped to limit".

Table 8-2.
Gate Time as a Function of Frequency Resolution and Expected Value

	Expected Value *					
Resolution	**min**	**max**	**def**	**auto**	**no param**	**num**
min	1 ms, off	1 ms, on	1 ms, off	100 ms, auto	N/A	If FREQ $\geq$ 100 MHz, then 800 ms, ON If FREQ < 100 MHz, then 400 ms, OFF
max	800 ms, off	800 ms, on	400 ms, off	1 s, auto	N/A	
def	100 ms, off	100 ms, on	100 ms, off	100 ms, auto	N/A	
no param	400 ms, off	400 ms, on	400 ms, off	400 ms, auto	400 ms, auto	
num	1 s, off	case B, on	case A, off	1 s, auto	N/A	Gate time = (4 ns/RES)xFreq.
Case A	4 s	400 ms	40 ms	4 ms	4 ms	
Case B	800 ms	800 ms	800 ms	80 ms	8 ms	
Resolution (R)	0<R<0.05	0.05<R<0.5	0.5<R<5	5<R<50	50<R	
* Each cell entry = gate time, prescaler on/off/auto. N/A = Not applicable						

Example	`CONF1:FREQ 1E6,0.1`	*Input 1; Function: Frequency; expected value: 1 MHz; resolution: 0.1 Hz, Prescaler - off, gate time = 40 ms from formula.*
	`READ?`	*Take a reading.*

[:VOLTage]:FREQuency:RATio

CONFigure[1|2|3][:VOLTage]:FREQuency:RATio [<*expected value*>[,<*resolution*>]] configures the counter for the ratio measurement function. A ratio measurement requires two inputs of input with the specified input as the numerator of the ratio. This command does not initiate the measurement process.

Refer to the *Measurement Resolution* section of "Understanding the Universal Counter" in Chapter 3 for more information regarding numeric entry. Refer to Table 8-3 for instrument settings when using the command with parameters.

Parameters

Parameter Name	Parameter Type	Range of Values	Default Value
expected	numeric discrete	10 E11 to 10 E-11 MIN|MAX|DEF	1
resolution	numeric discrete	4 E-12 to 4000 MIN|MAX|DEF	4 E-7

Comments

- Select only one input at a time. Input 1, Input 2, or Input 3 may be used for ratio measurements and the input selected is the numerator of the ratio. For example, if Input 1 is specified (CONF1:FREQ:RAT), the result will be the ratio of Input 1/Input 2. If Input 2 is specified (CONF2:FREQ:RAT), the result will be the ratio of Input 2/Input 1. If Input 3 is specified (CONF3:FREQ:RAT), the result will be the ratio of Input 3/Input 1.
- Signals must be periodic for the ratio function.
- *expected value* is entered as a number from 10 E-11 to 10 E11. The counter will automatically acquire the input signal when the *expected value* parameter is not specified.
- *resolution* is entered as a number from 4E−12 to 4000. Nine digits of resolution is automatically set if *resolution* is not specified in the command. Table 8-3 shows the relationship between *resolution* and *expected value*.
- Specifications are valid when a ratio is greater than 1.
- The default frequency range for both Input 1 and Input 2 is 100 MHz. The frequency range on Input 1 can be extended to 200 MHz by enabling Input 1 prescaling via the [SENSe:]FREQuency:RANGe[:UPPer] command.

Table 8-3.
Gate Time as a Function of Ratio Resolution and Expected Value

	Expected Value *				
Resolution	**min**	**max**	**def**	**num**	**no param**
min	1 s	1 s	1 s	1 s	N/A
max	1 s	1 s	1 s	1 s	N/A
def	1 s	1 s	1 s	1 s	N/A
num	1 s	1 s	1 s	(See Formula)	N/A
no param	1 s	1 s	1 s	1 s	1 s

* The actual gate time may be longer than listed depending on the period on Input 1.
Gate Time = $\frac{4 \times Ratio(\frac{freqx}{freqy})}{(freqy) \times resolution}$. N/A = not applicable.

Example

`CONF:FREQ:RAT`	*Function: Ratio (ch1/ch2).*
`READ?`	*place counter in wait-for-arm state; make measurement; put data in the output buffer.*
`"ENTER" statement`	*Enter readings into computer.*

[:VOLTage]:FTIMe|FALL:TIME

FALL:TIME| **CONFigure[1][:VOLTage]:FTIMe|CONFigure[1][:VOLTage]:FALL:TIME** [<*lower reference*>[,<*upper reference*>[,<*expected value*>[,<*resolution*>]]]] configures the counter to measure the fall time of the input signal. If the lower/upper reference levels are not specified, the default levels are set to 10% and 90% of peak values. This command does not initiate the measurement process. See also Table 8-4 for Average Mode status.

Parameters

Parameter Name	Parameter Type	Range of Values	Default Value
lower ref., upper ref.	numeric (percent) numeric (voltage) discrete	10 to 90 percent −10.2375V to +10.2375V MIN|MAX|DEF	10%-lower, 90%-upper N/A
expected value	numeric discrete	15 ns to 30 ms MIN|MAX|DEF|AUTO	100 ns 100 ns
resolution	numeric discrete	100 ps to 1 ms MIN|MAX|DEF	1 ns 1 ns

Comments

- This command is valid for Input 1 only.
- The input signal must be periodic.
- Automatically routes the Input 1 to the Input 2 amplifier (INP:ROUT COMM). All parameter settings for Input 2 are reconfigured with the parameter settings for Input 1. The COMMon input mode cannot be overridden.
- The default unit of measure for the *lower reference, upper reference* parameters is percent (PCT). However, absolute units V (volts) can also be specified. Selecting PCT (%) as units turns auto trigger mode on, while choosing V (volts) turns auto trigger off.
- The :CONF:FALL:TIME command is an alias (functional equivalent) to the :CONF:FTIM command.
- The counter's input configuration (coupling and impedance for CH2, routing for CH1, and state of auto trigger for both inputs), before execution of either the CONF:FTIM or CONF:RTIM command, is restored whenever measurement function is changed. However, the absolute trigger levels are not affected.

Example

`CONF:FTIM DEF, DEF, 100E-9, 1E-9`	*Configures Input 1 and Input 2 COMMon; Function - Fall time; selects 10% and 90% as lower and upper reference value (auto trigger on) expected value - 100 ns; resolution - 1 ns.*
`READ?`	*Take reading.*

`CONF:FTIM 0.4V, 3.5V, 1E-6, 10E-9`	*Configures lower reference to 0.4 volts and upper reference to 3.5 volts (turns auto trigger off).*
`READ?`	*Take reading.*

[:VOLTage]:MAXimum

CONFigure[**1**|**2**][**:VOLTage**]**:MAXimum** [<*expected value*>[,<*resolution*>]] configures the counter to read the maximum value (+Ve) of the input signal ac voltage. This command does not initiate the measurement process.

Parameters — There are no parameters for the MAXimum function. However, *expected value* and *resolution* are accepted by the command but ignored.

Comments

- This command is valid for Input 1 and Input 2 only.
- Type of Signal Measured: Signals must be periodic for the MAXimum value function.
- This function configures the counter for auto triggered measurements on the selected input.

[:VOLTage]:MINimum

CONFigure[**1**|**2**][**:VOLTage**]**:MINimum** [<*expected value*>[,<*resolution*>]] configures the counter to read the minimum value (−Ve) of the input signal ac voltage. This command does not initiate the measurement process.

Parameters — There are no parameters for the MINimum function. However, *expected value* and *resolution* are accepted by the command but ignored.

Comments

- This command is valid for Input 1 and Input 2 only.
- Type of Signal Measured: Signals must be periodic for the MINimum value function.
- This function configures the counter for auto triggered measurements on the selected input.

[:VOLTage]:NWIDth

CONFigure[1|2]:[:VOLTage]:NWIDth [<*reference*>[,<*expected value*>[,<*resolution*>]]] configures the counter for the negative pulse width measurement function on Input 1 or Input 2. This command does not initiate the measurement process. Negative pulse width is measured as the time between the falling edge and the next rising edge of the input signal. If the reference level is not specified, the default level is set to 50% of the peak-to-peak voltage.

Refer to the *Measurement Resolution* section of "Understanding the Universal Counter" in Chapter 3 for more information regarding numeric entry. Refer to Table 8-4 for instrument settings when using the command with parameters.

Parameters

Parameter Name	Parameter Type	Range of Values	Default Value
reference	percent (PCT)	10 to 90	50%
	voltage (V)	−10.2375V to +10.2375V	N/A
	discrete	MIN|MAX|DEF	
expected value	numeric	5 ns to 10 ms	100 ns
	discrete	MIN|MAX|DEF|AUTO	
resolution	numeric	100 ps to 100 ns	1 ns
	discrete	MIN|MAX|DEF	

Comments

- The default unit of measure for the *reference* parameter is percent (PCT). However, absolute units V (volts) can also be specified. Selecting percent (PCT) turns the auto trigger mode on while choosing V (volts) turns auto trigger off.
- Measurement range for *expected balue* is from 5 ns to 10 ms. If *expected value* is to be entered, the *reference* parameter must be specified.
- *resolution* can be entered as a number in seconds from 100 ps to 100 ns. The 100 Gate Averaging mode is turned on for resolutions less than 1 ns. The default resolution is automatically set to 1 ns by not entering values for *expected value* and *resolution*. If *resolution* is entered, *expected value* and *reference* must also be entered. Refer to Table 8-4 for more information.
- Select Input 1 or Input 2. Input 3 cannot make pulse width measurements.
- You can override the 50% default by using the SENSe[1|2]:EVENt:LEVel:RELative command or by explicitly providing a value in the command parameter.
- Negative pulse width is measured from the falling edge to the rising edge. The measurement will not complete until the second edge is detected.
- Refer to Table 8-4 for status of 100 Gate Averaging mode based on expected value versus resolution. The table is valid not only for NWIDth, but also PWIDth, FTIMe, RTIMe, TINTerval, and TINTerval DELay measurements.

Table 8-4.
Status of 100 Gate Averaging Mode Based on Expected Value vs Resolution

	Expected Value *					
Resolution**	**min**	**max**	**def**	**auto**	**no param**	**value**
min	ON	OFF	OFF	OFF	N/A	OFF
max	ON	OFF	ON	varies/w T.I. input	N/A	ON when T.I. input <0.01
def	ON	OFF	OFF	OFF	N/A	OFF
no param	ON	OFF	no change	varies/w T.I. input	varies/w T.I. input	varies/w T.I. input
value	ON	OFF	<1E-9 = ON >1E-9 = OFF	varies/w T.I. input	N/A	ON if exp. value <0.01 and resolution ≤ 1 ns

* Each cell entry = Status of 100 Gate Averaging mode for combinations of discrete measurement parameters. No change: does not change the status of the mode. N/A = Not applicable.
** Applies to NWIDth, PWIDth, FTIMe, TINTerval, and TINTerval:DELay measurements.

Example

`CONF:NWID 75,1.5E-6,500E-12`	*Input 1; Function - Negative Pulse Width with reference set at 75% auto trigger on and 100 Gate Averaging mode on.*
`READ?`	*Take reading.*
`"ENTER" statement`	*Enter value into controller.*

[:VOLTage]:PERiod

CONFigure[1|2|3][:VOLTage]:PERiod [<*expected value*>[,<*resolution*>]] configures the counter for the period average measurement function on Input 1, Input 2, or Input 3 (Input 1 is the default). This command does not initiate the measurement process.

Refer to Table 8-5 for instrument gate time/prescaler status when using the command with parameters.

Parameters

Parameter Name	Parameter Type	Range of Values	Default Value
expected value	numeric	5 ns to 15,000 s (ch 1)	
		10 ns to 15,000 s (ch 2)	
		400 ps to 11 ns (ch 3)	
	discrete	MIN|MAX|DEF	100 ns
resolution	numeric	1 E-18 to 10 E-2	
	discrete	MIN|MAX|DEF	100 ns

Comments

- Selection only one input at a time.
- Signals must be periodic for the period function as the counter measures average period over the gate time.
- The *expected value* should be within a range as specified above. Selecting a value less than 10 ns for Input 1 automatically turns prescaling on (divide by 2).
- *resolution* is entered as a number in seconds from 1 E-18 s to .001 s. Resolution is automatically set to 9 digits if *expected value* and *resolution* are not specified in the command. If *resolution* is entered, it must be preceded by an *expected value*.

Table 8-5. Gate Time as a Function of Period Resolution and Expected Value

	Expected Value *					
Resolution	**min**	**max**	**def**	**auto**	**no param**	**num**
min	1 ms, on	1 ms, off	1 ms, off	100 ms, auto	N/A	If Per. ≥ 10 ns, then 400 ms/OFF If Per. < 10 ns, then 800 ms/ON
max	100 ms, on	100 ms, off	100 ms, off	100 ms, auto	N/A	
def	800 ms, on	800 ms, off	400 ms, off	1 s, auto	N/A	
no param	400 ms, on	400 ms, off	400 ms, off	400 ms, auto	400 ms, auto	
num	case B, on	1 s, off	case A	1 s, auto	N/A	Gate time = (4 ns/RES)×Per.
Case A	4 s	400 ms	40 ms	4 ms		
Case B	8 s	800 ms	80 ms	8 ms		
Resolution (R)	R<1E-16	1E-16≤R ≤1E-15	1E-15<R ≤1E-14	1E-14<R		

* Each cell entry = gate time, prescaler on/off/auto. N/A = Not applicable.

Example

`CONF:PER 1E-3,1E-6`	*Function: Period; expected value: 1 ms; resolution: 1 μs.*
`READ?`	*Take reading.*
`"ENTER" statement.`	*Enter readings into computer.*

[:VOLTage]:PWIDth

CONFigure[1|2][:VOLTage]:PWIDth [<*reference*>[,<*expected value*>[,<*resolution*>]]] configures the counter for the positive pulse width measurement function on Input 1 or Input 2. This command does not initiate the measurement process. Positive pulse width is measured as the time between the rising edge and the next falling edge of the input signal. If the reference level is not specified, the default level is set to 50% of the peak-to-peak voltage.

Parameters

Parameter Name	Parameter Type	Range of Values	Default Value
reference	numeric (percent)	10 to 90	50%
	numeric (voltage)	−10.2375V to +10.2375V	N/A
	discrete	MIN|MAX|DEF	50%
expected value	numeric	5 ns to 10 ms	
	discrete	MIN|MAX|DEF|AUTO	DEF
resolution	numeric	100 ps to 100 ns	
	discrete	MIN|MAX|DEF	

Comments

- The default units of measure for the *reference* parameter is percent (PCT). However, absolute units V (volts) can also be specified. Selecting percent (PCT) turns the auto trigger mode on while choosing V (volts) turns auto trigger off.
- The measurement range for *expected value* is from 5 ns to 1 ms. If *expected value* is to be entered, the *reference* parameter must be specified.
- *resolution* can be entered as a number in seconds from 100 ps to 1000 s. The 100 Gate Averaging mode is turned on for resolutions less than 1 ns.
- A preliminary measurement is done to determine the best default *resolution* if the *expected value* and *resolution* are not entered. If *resolution* is entered, *expected value* and *reference* must also be entered.
- Select Input 1 or Input 2. Input 3 cannot make pulse width measurements.
- You can override the 50% default by using the SENSe[1|2]:EVENt:LEVel:RELative command or by explicitly providing a reference value in the configuration command parameter.
- Positive pulse width is measured from the rising edge to the falling edge. The measurement will not complete until the second edge is detected.
- Refer to Table 8-4 for status of 100 Gate Average mode based on expected value versus resolution. The table is valid for not only PWIDth, but also NWIDth, FTIMe, RTIMe, TINTerval, and TINTerval DELay measurements.

Example

```
CONF:PWID 75,1.5E-6,500E-12
```

Input 1; Function - Positive Pulse Width with reference set at 75% auto trigger on and 100 Gate Averaging mode on.

`READ?`	*Take reading.*
`"ENTER" statement`	*Enter value into controller.*

[:VOLTage]:RTIMe|RISE:TIME

RISE:TIME| **CONFigure[1][:VOLTage]:RTIMe|CONFigure[1][:VOLTage]:RISE:TIME** [<lower reference>[,<*upper reference*>[,<*expected value*>[,<*resolution*>]]]] configures the counter to measure the rise time of the input signal. If the lower/upper reference levels are not specified, the default levels are set to 10% and 90% of peak values. This command does not initiate the measurement process. See also Table 8-4 for Average Mode Status.

Parameters

Parameter Name	Parameter Type	Range of Values	Default Value
lower ref., upper ref.	percent voltage discrete	10 to 90 percent −10.2375V to +10.2375V MIN|MAX|DEF	10%-lower,90%-upper N/A
expected value	numeric discrete	15 ns to 30 ms MIN|MAX|DEF|AUTO	100 ns
resolution	numeric discrete	100 ps to 1 ms MIN|MAX|DEF	DEF (1 ns)

Comments

- This command is valid for Input 1 only.
- The input signal must be periodic.
- Automatically routes the Input 1 to the Input 2 amplifier (INP:ROUT COMM). All parameter settings for Input 2 are reconfigured with the parameter settings for Input 1. The COMMon input mode cannot be overridden.
- The default unit of measure for the *lower reference, upper reference* parameters is percent (PCT). However, absolute units V (volts) can also be specified. Selecting PCT (%) as units turns auto trigger mode on while choosing V (volts) turns auto trigger off.
- The CONF:RISE:TIME command is an alias (functional equivalent) to the CONF:RTIM command.
- The counter's input configuration (coupling and impedance for CH2, routing for CH1, and state of auto trigger for both inputs) before execution of either the CONF:FTIM or CONF:RTIM command is restored whenever measurement function is changed. However, the absolute trigger levels are not affected.

Example

`CONF:RTIM DEF, DEF, 1E-6, 10E-9`	*Configures Input 1 and 2 COMMon; Function - Rise time selects10% and 90% as lower and upper reference values (auto trigger on); expected value - 1 us; resolution - 10 ns.*
`READ?`	*Take reading.*

`CONF:RTIM 0.4V, 3.5V, 1E-6, 10E-9`	*Configures lower reference to 0.4 volts and upper reference to 3.5 volts (turns auto trigger off).*
`READ?`	*Take reading.*

[:VOLTage]:TINTerval

CONFigure[1][:VOLTage]:TINTerval [<*expected value*>[,<*resolution*>]] configures the counter to measure the time interval from the signal edge on Input 1 to the signal edge on Input 2. This command does not initiate the measurement process. You must send an expected value parameter for resolution to be accepted.

Parameters

Parameter Name	Parameter Type	Range of Values	Default Value
expected value	numeric discrete	1 ns to 1000 s MIN|MAX|DEF|AUTO	100 ns
resolution	numeric discrete	100 ps to 100 ns MIN|MAX|DEF	1 ns

Comments

- This command is valid only for Input 1.
- The edges of both the start and stop inputs can be selected using the SENSe[1|2]:EVENt:SLOPe command. Unless changed, the measurement will be performed using the currently selected slope.
- The measurement range for *expected value* is 1 ns to 1000 s.
- *resolution* is entered as a number from 100 ps through 100 ns. The default resolution is 1 ns if a *resolution* is not specified in the command. If a resolution better than 1 ns is specified, 100 Gate Averaging mode is automatically enabled. Refer to Table 8-4 for the status of 100 Gate Averaging mode.
- If you need to make time interval measurements with delay, then refer to the [SENSe:]TINT:DEL command description.
- Maximum input frequency range is 100 MHz for Input 1 and Input 2.

Example

`CONF:TINT`	*Function: Time Interval (CH 1 to CH 2).*
`READ?`	*Take reading.*
`"ENTER" statement`	*Enter value into controller.*

[:VOLTage]:TOTalize

CONFigure[1][**:VOLTage**]**:TOTalize** configures the counter for the totalize function but does not initiate the measurement procedure. This function allows you to count events on Input 1. Once the measurement is started, the totalize function continues counting until the input is reconfigured to another function or the ABORt or ARM:STOP:IMM command is received.

Parameters There are no parameters for the totalize function. However, *expected value* and *resolution* parameters are accepted by the command but ignored.

Comments

- The totalize measurement is started with the INITiate command. Measurement results are read using the FETCh? command which reads the current count without interrupting the measurement. The READ? command reinitializes the totalize measurement before returning results. See the explanation for the :READ? command for more details.
- The measurement range is 1 E12 events with a maximum frequency of 1 MHz.
- The Totalize measurements can be gated by an external arm signal, the EXT2 back plane trigger input, or Input 2. Refer to the [SENSe:]TOTalize subsystem for further details.

Example

`CONF:TOT`	*Sets Input 1 to the Totalize function.*
`INIT`	*Initiates measurement and starts the counting of events. . . . . Count accumulates.*
`FETC?`	*Read the count on-the-fly; store count in output buffer.*
`"ENTER" statement`	*Enter readings into controller.*
`FETC?`	*Read new value.*
`"ENTER" statement`	*Enter readings into controller.*

CONFigure?

CONFigure? returns the function with its associated parameters that the specified input was configured for with the last CONFigure or MEASure command.

Subsystem Syntax	`CONFigure[1|2|3]?`
Parameters	Select one input for the command (Input 1, Input 2, or Input 3). If a input is not specified, the command acts on Input 1 which is the default.

Comments

- Output Format: The strings returned have the following format: "<function><*parameters*>", with multiple parameters separated by ",".
- If the query is made on a input other than the one last configured, then error −204, "Input not configured for measurement" is returned.
- The values of MIN, MAX, and DEF cannot be queried.

Example

`CONF2:FREQ 1E5, 10`	*Input 2 configured for frequency of 100 kHz with 10 Hz resolution.*
`CONF2?`	*Query configuration of Input 2.*
`"ENTER" statement`	*Returns "FREQ 1E5, 10".*
`CONF2:PER`	*Input 2 configured for period measurement.*
`CONF2?`	*Query configuration of Input 2.*
`"ENTER" statement`	*Returns "PER , ".*

DIAGnostics

The DIAGnostic command subsystem provides access to both calibration and test functions via SCPI as options and parameters of the DIAGnostic root command. Most of the command options for this command node require the expertise of qualified service personnel and use of specific test equipment to ensure correct application and results. The structure and syntax of the SCPI HP 70120A universal counter diagnostic subsystem tree is as follows:

Subsystem Syntax DIAGnostics

```
:ASSembly
   [:ALL]?
   :A1?
   :A2?
:BLOCk
   [:ALL]?
   :CALMem?
   :COUNtchain
      [:ALL]?
      :DINTerpolat?
      :FEND?
      :INTerpolat?
      :MRC?
      :TIMebase?
      :RAM?
      :ROM?
:BOOT
   [:SOURce]   <LOAD|INST>
   [:SOURce]?
:CALibrate
   :FULLscale?   <CH1|CH2|BOTH>
   :OFFSet?   <CH1|CH2|BOTH>
:DACS1|:DACS2
   :FULLscale
      :SET   <fullscale value>
   :HYSTeresis
      :SET   <hysteresis value>
   :OFFSet
      :SET   <offset value>
   :TRIGger
      :RAMP   <0|OFF|1|ON>
      :SET   <trigger level>
:READ
   :INT?    <STS|STL|SPS|SPL|STARt|STOP|CAL|ALL>
   :MRC?    <EREG|TREG|ALL>
:UFAil[?]   <OFF|0|ON|1> (N/A for Query)
```

:ASSembly

DIAGnostics:ASSembly causes the counter to perform all diagnostics applicable on an assembly-level basis. The diagnostics provide a means of isolating hardware faults to either the A1 main printed-circuit assembly (PCA) or A2 processor PCA.

:ASSembly:ALL?

DIAGnostics:ASSembly:ALL? performs diagnostics on both the main PCA (A1) and the processor PCA (A2). See the A1 and A2 diagnostic descriptions for information concerning tested hardware.

:ASSembly:A1?

DIAGnostics:ASSembly:A1? performs diagnostics for the main A1 PCA. This command causes the counter to perform the following self-test routines: MRC Measurement, MRC Interpolator, MRC Interpolator Delay, Timebase, and Front End. If the test passes, the message "PASSED, A1" will be returned. If any test fails, subsequent tests will be performed and a message for the form: "FAILED, A1, <*testlist*>" will be returned where <*testlist*> consists of a list of the failed tests as follows:

Test	Testlist Entry
MRC Measurement	MRC
MRC Interpolator	INT
MRC Interpolator Delay	DINT
Timebase	TIM
Front End	FEND

If repeated failures occur for one or more of these hardware elements, then replacement of the A1 PCA is indicated.

:ASSembly:A2?

DIAGnostics:ASSembly:A2? performs diagnostics for the input amplifier A2 PCA. This command causes the counter to perform the following self-test routines: ROM, SRAM, and Calibration Memory.

If the test passes, the message "PASSED, A2" will be returned. If any test fails, subsequent tests will be performed and a message for the form: "FAILED, A1, <*testlist*>" will be returned where <*testlist*> consists of a list of the failed tests as follows:

Test	Testlist Entry
ROM	ROM
SRAM	RAM
Calibration Memory	CALM

If repeated failures occur for one or more of these hardware elements, then replacement of the A2 PCA is indicated.

:BLOCk

DIAGnostics:BLOCk causes the counter to perform all diagnostics applicable on a functional-block basis. The power up default for this command is “ALL?”. The other choices are CALMem?, COUNtchain, RAM?, and ROM?.

Successful completion of BLOCk command tests is indicated by the “PASSED” response. The only exception to this is the COUNtchain node which requires an additional query option. The choices available are: ALL?, DINTerpolat?, FEND?, INTerpolat?, MRC?, and TIMebase?.

All query options (except MRC?, INTerpolat?, and DINTerpolat?) will return only “PASSED” or “FAILED” results. The MRC?, INTerpolators?, and DINTerpolators? queries will return messages containing measurement data of their internal registers.

:BLOCk[:ALL]?

:BLOCk[:ALL]? causes the counter to perform the following self-tests:

ROM
SRAM
Calibration Memory
Front End
MRC Measurement
MRC Interpolator
MRC Interpolator Delay
Timebase

If the test passes, the message “PASSED,BLOCK” will be returned.

If any test fails, subsequent tests will be performed and a message of the form: “FAILED,BLOCK,<*testlist*>” will be returned, where <*testlist*> consists of a list of the failed tests separated by commas. The failed tests will be listed as follows:

Test	Testlist Entry
MRC Measurement	MRC
MRC Interpolator	INT
MRC Interpolator Delay	DINT
Timebase	TIM
Front End	FEND
ROM	ROM
SRAM	RAM
Calibration Memory	CALM

:BLOCk:CALMem?

:BLOCk:CALMem? causes the counter to perform the Calibration Memory self-test. If the test passes, the message “PASSED CALIBRATION MEMORY TEST” will be returned. If the test fails, the message “FAILED CALIBRATION MEMORY TEST” will be returned.

:BLOCk:COUNtchain [:ALL]?

:BLOCk:COUNtchain[:ALL]? causes the counter to perform the following self-tests:

Front End
MRC Measurement
MRC Interpolator
MRC Interpolator Delay
Timebase

If the test passes, the message "PASSED,COUN" will be returned. If any test fails, subsequent tests will be performed and a message of the form: "FAILED,COUN,<*testlist*>" will be returned, where <*testlist*> consists of a list of the failed tests separated by commas. The failed tests will be listed as follows:

Test	Testlist Entry
MRC Measurement	MRC
MRC Interpolator	INT
MRC Interpolator Delay	DINT
Timebase	TIM
Front End	FEND

:BLOCk:COUNtchain:DINTerpolat?

:BLOCk:COUNtchain:DINTerpolat? causes the counter to perform the MRC Interpolator Delay Calibration.

Upon completion, the following message will be returned: "CALIBRATION DATA: STS *Sts*, SPS *Sps*, STL *Stl*, SPL *Spl*", where

Sts is the start interpolator value for short calibration,
Sps is the stop interpolator value for short calibration,
Stl is the start interpolator value for long calibration, and
Spl is the stop interpolator value for long calibration.

:BLOCk:COUNtchain:FEND?

:BLOCk:COUNtchain:FEND? causes the counter to perform the Front End self-test. If the test passes, the message "PASSED FRONT END REGISTER TEST" will be returned. If the test fails, the following message will be returned: "FAILED FRONT END REGISTER TEST: TEST xxxx" where xxxx contains a weighted sum according to which test pattern failed, and which lines failed:

Test	Test Weight
clear all bits	1
walking ones	2
set all bits	4
walking zeroes	8
"55" pattern	16
"AA" pattern	32
50A failed	64
ACA failed	128
ATTN failed	256
50B failed	512
ACB failed	1024
CH A/2 failed	2048
COM failed	4096
CH B failed	8192

:BLOCk:COUNtchain:INTerpolat?

:BLOCk:COUNTchain:INTerpolat? causes the counter to perform the MRC Interpolator Calibration.

Upon completion, the following message will be returned: "CALIBRATION DATA: STS *Sts*, SPS *Sps*, STL *Stl*, SPL *Spl*", where

Sts is the start interpolator value for short calibration,
Sps is the stop interpolator value for short calibration,
Stl is the start interpolator value for long calibration, and
Spl is the stop interpolator value for long calibration.

:BLOCk:COUNtchain:MRC?

:BLOCk:COUNtchain:MRC? causes the counter to perform the MRC Diagnostic Measurement. The MRC E register and T register values and the measured frequency error are returned in the following format: "DIAGNOSTIC MEASUREMENT:EREG xxxxxxx, TREG xxxxxxx, FREQUENCY ERROR x.xxx"

:BLOCk:COUNtchain:TIMebase?

:BLOCk:COUNtchain:TIMebase? causes the counter to perform the Timebase self-test.

The Timebase test verifies the proper operation of the internal 10 MHz reference oscillator by performing a frequency measurement of that oscillator. The measurement result is compared to known limits, and the test fails if the result exceeds those limits. In addition, the correct level and pulse width of the internal reference oscillator is compared against known limits, and an error is generated if those limits are exceeded. Since the counter has no known good reference for this test, absolute reference frequency accuracy is not assured by this test.

If the test passes, the message "TIMEBASE TEST: INT PASSED" will be returned.

:BLOCk:RAM?

:BLOCk:RAM? causes the counter to perform the RAM self-test. If the test passes, the message "PASSED RAM TEST"will be returned. If the test fails, the following message will be returned: "FAILED RAM TEST: BITS xxxx, ADDRESS yyyy" where xxxx are the data lines which failed and yyyy are the address lines which failed.

:BLOCk:ROM?

:BLOCk:ROM? causes the counter to perform the ROM self-test. If the test passes, the message "PASSED ROM CHECKSUM TEST" will be returned. If the test fails, the message "FAILED ROM CHECKSUM TEST" will be returned.

:BOOT[:SOURce]

DIAGnostic:BOOT[**:SOURce**] <*source*> instructs the instrument to run the counter or the program loader on the next power up.

Parameters

Parameter Name	Parameter Type	Range of Values	Default Units
source	discrete	LOAD|INST	none

Example Select the program loader to be run on the next power up.

Comments

- LOAD instructs the module to run the program loader on the next power up.
- INST instructs the module to run the counter instrument on the next power up.
- The DIAGnostic:BOOT[:SOURce] <*source*> is stored in non- volatile electrically erasable memory. It is recommended to only use this command when necessary because this memory is limited to 10,000 write cycles.
- If the Program Loader configuration switch is set then the Program Loader will be run regardless of the state of the DIAGnostic:BOOT <*source*> command.
- During power up of the program loader DIAGnostic:BOOT[:SOURce] is set to INST. This setting will be used in the next power up.
- ***RST Condition:** INST

:BOOT[:SOURce]?

DIAGnostic:BOOT[**:SOURce**]**?** returns the current boot source, either LOAD or INST.

:CALibrate

DIAGnostics:CALibrate causes the counter to perform calibrations of key parameters on the input amplifiers.

:CALibrate:OFFSet?

DIAGnostics:CALibrate:OFFSet? performs offset calibration on input amplifiers CHannel1, CHannel2, or BOTH. Requires grounding the input being calibrated. Successful completion of the calibration returns “PASSED OFFSET CH1”, “PASSED OFFSET CH2”, or “PASSED OFFSET CH1, PASSED OFFSET CH2”.

:CALibrate:FULLscale?

DIAGnostics:CALibrate:FULLscale? performs fullscale calibration on input amplifiers CHannel1, CHannel2, or BOTH. Requires input of precision (+5V) dc supply voltage to the input being calibrated. Successful completion of the calibration returns “PASSED FULLSCALE CH1”, “PASSED FULLSCALE CH2”, or “PASSED FULLSCALE CH1, PASSED FULLSCALE CH2”.

:DACS1|:DACS2:FULLscale:SET

:DACS2:FULLscale:SET| **DIAGnostics:DACS1:FULLscale:SET** <*fullscale value*> sets the Input 1 Full-Scale Range DAC to the specified value. **DIAGnostics:DACS2:FULLscale:SET** <*fullscale value*> sets the Input 2 Full-Scale Range DAC to the specified value. The *fullscale value* must be a number between 0 and 63, inclusive.

:DACS1|:DACS2:HYSTeresis:SET

:DACS2:HYSTeresis:SET| **DIAGnostics:DACS1:HYSTeresis:SET** <*hysteresis value*> sets the Input 1 Hysteresis DAC to the specified value. **DIAGnostics:DACS2:HYSTeresis:SET** <*hysteresis value*> sets the Input 2 Hysteresis DAC to the specified value. The *hysteresis value* must be a number between 0 and 63, inclusive.

:DACS1|:DACS2:OFFSet:SET

:DACS2:OFFSet:SET| **DIAGnostics:DACS1:OFFSet:SET** <*offset value*> sets the Input 1 Offset DAC to the specified value. **DIAGnostics:DACS2:OFFSet:SET** <*offset value*> sets the Input 2 OFFset DAC to the specified value. The *offset value* must be a number between 0 and 63, inclusive.

:DACS1|:DACS2:TRIGger:RAMP

:DACS2:TRIGger:RAMP| When **DIAGnostics(:DACS1|:DACS2):TRIGger:RAMP** <**0**|**OFF**|**1**|**ON**> is executed with a parameter of "1" or "ON" it causes either the Input 1 or Input 2 (depending on choice of :DACS1 or :DACS2) Trigger Level DAC to output a repetitive, full-scale, triangle-shaped ramp wave. Only one input will output a ramp at a time. If the other input is generating a ramp when this command is executed with a parameter of "1" or "ON," the other input's ramp will be turned off first. When executed with a parameter of "0" or "OFF" this command causes the chosen input's Trigger Level DAC to be restored to its previous setting.

:DACS1|:DACS2:TRIGger:SET

:DACS2:TRIGger:SET| **DIAGnostics(:DACS1|:DACS2):TRIGger:SET** <*trigger level*> sets the Input 1 or Input 2 (depending on choice of :DACS1 or :DACS2) Trigger Level DAC to the specified value. The *trigger level* must be between -4095 and 4095, inclusive.

:READ:INT?

This SCPI message string returns an interpolator calibration and/or measurement value as follows:

- **STS** returns the start interpolator value for short calibration,
- **STL** returns the start interpolator value for long calibration,
- **SPS** returns the stop interpolator value for short calibration,
- **SPL** returns the stop interpolator value for long calibration,
- **STARt** returns the start interpolator value for measurement,
- **STOP** returns the stop interpolator value for measurement.
- **CAL** returns calibration values in listed order (sts, sps, stl, spl).
- **ALL** returns all the calibration values and values for measurement as follows: sts, sps, stl, spl, start, stop.

:READ:MRC?

This SCPI message string returns the value of the E register (ereg parameter), the T register (treg parameter) or both registers for the last measurement as follows:

- **EREG** returns the count in the E register, each count equivalent to one zero crossing (event) of the input signal.
- **TREG** returns the count in the T register, each count equivalent to 100 ns.
- **ALL** returns the EREG value first, followed by the TREG value.

:UFAil[?]

DIAGnostics:UFAil <OFF|0|ON|1> enables the counter to execute the next diagnostic command in a continuous loop. When turned on, the next diagnostic is executed continuously until a failure occurs. The DIAGnostics:UFAil? query returns the state of UFAil.

CAUTION This command is to be used for troubleshooting only. When Ufail is on and a diagnostic selftest command is issued, the box will not respond to any other command or query until either the test fails or power is cycled.

:FETCh?

FETCh? retrieves the measurement stored in the counter's memory by the most recent INITiate command and places it in the output buffer. This command is most commonly used in conjunction with CONFigure and SENSe.

Subsystem Syntax
```
FETCh[1|2|3]
    [:<function>]?
```

Comments

- Select only one input at a time.
- If the <function> is requested, the counter retrieves the value of the function derived from the data taken by the last measurement. If the value cannot be derived, error −230, "Data corrupt or stale", is returned. If a frequency measurement is made, then a period value may be fetched or vice-versa. If AUTO triggered measurements are made, then all voltage measurements (ac, dc, MINimum, MAXimum) can also be fetched.
- When the <function> is omitted, the last function FETChed, READ?, or measured is used.
- You must execute INITiate before sending the FETCh? command. If the INITiate command has not been executed prior to FETCh?, error −206, "Measurement has not been initiated", is returned unless the counter has been INITiated in the CONTinuous state. Refer to the INITiate command.
- If the counter configuration changes during a measurement, FETCh? will return error −230, "Data corrupt or stale".
- If a FETCh? is made on a different input than the one currently initiated, error −204, "Input not configured for measurement", is returned.
- Multiple FETCh? queries are allowed on measurement data as long as the instrument set up has not been changed.
- TOTalize Measurements: If the selected input is configured for totalize, FETCh? reads the current value from the counter and returns the result. This is the only mechanism to continue reading results for the TOTalize function.
- If the counter is in ARM:HOLD or BUS mode, an attempted FETCh? returns error −215, "ARM deadlock".

Example

`CONF:FREQ 10E6,1`	*Function is frequency of Input 1.*
`INIT`	*Makes a measurement.*
`FETC?`	*place readings in output buffer. As <function> is missing, frequency is assumed.*
`"ENTER" statement`	*Enter measurement into controller.*
`FETCh:PERiod?`	*place period reading in output buffer. Does not make a measurement.*
`"ENTER" statement`	*Enter measurement into controller.*
`FETCh:TINTerval?`	*Generates error −230, "Data corrupt or stale".*

INITiate

INITiate is used to control the initiation of the measurement cycle.

Subsystem Syntax

```
INITiate[1|2|3]
   [:IMMediate]
      :CONTinuous   <OFF|0|ON|1>
      :CONTinuous?
```

Comments

- Select only one input at a time.
- If you attempt to initiate a measurement on a input not previously configured for a measurement, the counter returns error −204, "Input not configured for measurement"
- After the measurement is initiated using INIT, the state of the Arming subsystem controls when the actual measurement occurs. For example: if ARM:SOURce is IMMediate (the default for ARM:SOUR), the measurement is performed as soon as INITiate is executed. The measurement result is stored in the counter's memory. A measurement stored in memory from a previous command is replaced by the new measurement data. (See the ARM command in this chapter for more information.)
- Use the FETCh? command to transfer a measurement result from the counter's memory to the output buffer.

[:IMMediate]

INITiate[1|2|3][:IMMediate] causes an immediate exit from the idle state, executes one measurement cycle, and returns to idle upon completion.

Comments

- INITiate[1|2|3][:IMMediate] is an event and cannot be queried as there is no state associated with it.
- If a measurement has been initiated and the instrument set up changes, then the current measurement aborts, or:
- If another INIT:IMM is received then error −213, "INIT ignored", is returned.
- If the counter is not in the idle state or if INITiate:CONTinuous is set on, an INIT:IMMediate command has no effect on the Trigger subsystem and error −213, "INIT ignored", is returned.

Example

`CONF:FREQ`	*Function is frequency.*
`ARM:SOUR EXT`	*Start arm source is external.*
`ARM:STOP:SOUR EXT`	*Stop arm source is external.*
`INIT`	*Initiate a measurement. The counter makes a measurement during the external arm.*
`FETCh?`	*Transfer measurement to output buffer.*
`.`	*Transfer old measurement*
`.`	*to output buffer.*
`FETCh?`	
`.`	*Initiate a new measurement.*
`INIT`	

:CONTinuous

INITiate[1|2|3]:CONTinuous <OFF|0|ON|1> determines whether the counter makes only one measurement or makes measurements continuously. If CONTinuous is set on, then measurements will be made as long as arming conditions defined via the ARM command are satisfied. When CONTinuous is set off, the counter finishes the current measurement and returns to the idle state.

Comments

- The state of INIT[1|2|3]:CONTinuous: on is not affected by the ABORt command, however the current measurement aborts, and the counter resumes measurement.
- Attempting to configure a different input while INIT:CONTinuous is on will generate error −200, "Execution Error". The state of the counter remains unchanged, continuing with measurement execution.
- Changing any parameters or functions associated with a configured input is permitted when "Continuous" state is on. The current measurement aborts, the requested change is made, and the counter resumes measurement.
- The MEASure? command turns the INIT:CONTinuous to off, and performs the desired measurement.
- An INIT:IMMediate command while in continuous mode causes error −213, "INIT ignored".
- ***RST Condition:** CONTinuous is off.

Example

`CONF:FREQ`	*Set up the counter to measure frequency.*
`INIT:CONT ON`	*Counter will initiate measurements continuously.*
`FETCh?`	*Transfers measurement results to output buffer.*
`"ENTER" statement`	*Enter measurement into controller.*
`FETCh?`	*Transfers new measurement results to output buffer.*
`"ENTER" statement`	*Enter measurement into controller.*

:CONTinuous?

INITiate:CONTinuous? will return "1" if the Continuous state is on and "0" if the Continuous state is off.

INPut

The INPut subsystem commands provide control of impedance, coupling, and signal routing (common Input 1) for the counter.

Subsystem Syntax

```
INPut[1|2]
   :ATTenuation    <1|10>
   :ATTenuation?   [<1|10>]
   :COUPling    <AC|DC>
   :COUPling?
   :IMPedance     <expected value> |MIN|MAX|DEF
   :IMPedance?   [<MIN|MAX|DEF>]
   :ROUTe    <COMM|SEP>
   :ROUTe?
```

:ATTenuation

INPut[1|2]:ATTenuation <*value*|*expected value*> attenuates the input signal by a factor of 10; a value of 1 connects the input signal directly to the input amplifiers.

Parameters

Parameter Name	Parameter Type	Range of Values	Default Value
value	numeric	1|10	1

Comments

- When AUTO TRIG is on, attenuation is automatically controlled by the input voltage and cannot be changed manually.

Example `INP1:ATT:10`

:ATTenuation?

INPut[1|2]:ATTenuation? returns the attenuation for Input 1 or Input 2 as either 1 or 10. An example of the use of this query is shown below:

`INP2:ATT?`	*Queries the attenuation for Input 2.*

:COUPling

INPut[1|2]:COUPling <*mode*> sets the input coupling to ac or dc. The ac parameter is used to remove any dc component from the input signal.

Parameters

Parameter Name	Parameter Type	Range of Values	Default Value
mode	discrete	AC|DC	DC

Comments ■ ***RST Condition:** INP:COUP DC

Example `INP2:COUP AC` *Sets Input 2 coupling to ac.*

:COUPling?

INPut[1|2]:COUPling? returns the coupling for Input 1 or Input 2 as either ac or dc. An example of the use of this query is shown below:

`INP2:COUP?`	*Queries the coupling for Input 2.*

:IMPedance

INPut[1|2]:IMPedance <*expected value*> sets the input impedance to 50 Ω or 1 MΩ.

Parameters

Parameter Name	Parameter Type	Range of Values	Default Value
expected value	numeric	40 to 60 and .9E6 to 1.1E6	1 MΩ
	discrete	MIN|MAX|DEF	1 MΩ

Comments

- When Input 1 COMMon mode routing is active, Input 1 impedance will drop to 500 kΩ if the 1 MΩ is selected.
- Numerical *expected value* can be specified between 40 and 60 for 50 Ω and 0.9E6 to 1.1E6 for 1 MΩ.
- MIN value: 50 Ω
- MAX value: 1 MΩ
- ***RST Condition:** INP:IMP 1E6 (1 MΩ)

Example

`INP2:IMP MIN` *Sets Input 2 impedance to 50Ω.*

:IMPedance?

INPut[1|2]:IMPedance? [<**MIN**|**MAX**|**DEF**>] returns the impedance value for Input 1 or Input 2 as a floating point number. An example of the use of this query is shown below:

`INP2:IMPedance?`	*Queries the input impedance of Input 2.*

:ROUTe

INPut[1]:ROUTe <*mode*> routes Input 1 signals to both Input 1 and Input 2 input circuits (sets both inputs to common). The INP2:ROUTe command string will generate error −221 “Settings conflict”.

Parameters

Parameter Name	Parameter Type	Range of Values	Default Value
mode	discrete	COMM|SEP	SEP

Comments

- Front-panel Input 2 connector is not active when Input 1 is routed in COMMon mode.
- Rise/fall time measurements are automatically made using ROUTe set to COMMon. Input 2 settings are the same as Input 1. When the function changes, the previous settings are reinstated.
- Input impedance will drop to 500 kΩ if 1 MΩ is selected while in COMMon mode.
- ***RST Condition:** INP:ROUTe SEParate

Example

`INP:ROUTe COMMon`	*Routes Input 1 connector to both Input 1 and 2 input circuits.*

:ROUTe?

INPut[1|2]:ROUTe? returns the status of input routing as either SEParate or COMMon. Input 2 route is always SEParate.

MEASure

The MEASure command subsystem sets up the counter to perform a specified measurement either automatically-acquired or for a manually-entered expected value, and then performs the measurement. After making the measurement, the data is stored in the output buffer.

Subsystem Syntax

```
MEASure[1|2|3]
   [:VOLTage]
      :AC?      [<expected value>[,<resolution>]]*
      :DC?      [<expected value>[,<resolution>]]*
      :FREQuency?     [<expected value>[,<resolution>]]
         :RATio?     [<expected value>[,<resolution>]]
      :FTIMe?|:FALL:TIME?     [<lower reference>[,<upper reference>
      [,<expected value>[,<resolution>]]]]
      :MAXimum?     [<expected value>[,<resolution>]]*
      :MINimum?     [<expected value>[,<resolution>]]*
      :NWIDth?     [<reference>[,<expected value>
      [,<resolution>]]]
      :PERiod?     [<expected value>[,<resolution>]]
      :PWIDth?     [<reference>[,<expected value>
      [,<resolution>]]]
      :RTIMe?|:RISE:TIME?     [<lower reference>[,<upper reference>
      [,<expected value>[,<resolution>]]]]
      :TINTerval?     [<expected value>[,<resolution>]]
```

```
*Expected value and resolution parameters are accepted
but ignored for ac, dc, MINimum, and MAXimum measurements.
```

Comments

- The MEASure command CANNOT be used to totalize counts because totalize continues counting events until the function is changed.
- If the optional parameters *expected value* and *resolution* are specified, the state of the counter will be changed to obtain the requested resolution.

Note Table 8-2 shows what effect the expected value and resolution (or their absence) have on gate time and the prescaler. In some cases, the prescaler will be placed in auto mode. This requires the counter to take a preliminary measurement to determine if the prescaler should be turned on or off. If the counter is externally start armed, two arming pulses are required (one to set the prescaler, the other to take the measurement).

- The optional parameters can be defaulted from right-to-left. For example, if a value for *resolution* is to be entered, the *expected value* must be specified. If the parameter is explicitly omitted, the best possible value is chosen.
- If you execute the MEASure command while the counter is in continuous measurement mode (INIT:CONTinuous ON), the INIT:CONTinuous state is turned off, and the counter then makes the measurement.

- [:VOLTage] is an implied node and may be omitted from the program message.
- If the optional parameters *expected value* and *resolution* are not entered, the gate time is set by the counter.
- Auto Trigger: Making measurements with auto trigger greatly reduces throughput as compared to measurement speed when trigger levels are programmed manually. During auto triggered frequency measurements, the counter determines the positive and negative voltage peaks of the input signal. It then programs the trigger according to the current [SENSe:]EVENt:LEVel:RELative parameter value. Rise/fall time measurements use both input amplifiers (common Input 1). During auto triggered rise/fall time measurements, Input 1 is programmed for 10% (90%) value and Input 2 is programmed for 90% (10%) value. A signal arriving at the Input 2 connector is not counted.

Note Auto-triggering should not be used when measuring signals below 1 kHz.

- Most measurements can be performed using one of the three subsystems CONFigure, MEASure, or [SENSe:] and each has advantages and disadvantages over the other. The basic difference between the commands is as follows:

  The CONFigure command can be used for all measurements except for gated totalize and time-interval delay measurements. The CONFigure command only configures a input for a specific function, and does not perform the measurement. Use of additional commands (READ?, or INIT/FETC?) to perform the measurement and read the results is necessary. Further customization of the counter set-up is provided, through the use of optional parameters.

  The MEASure command can be used for all measurements except TOTalize. The MEASure command configures a input for a specific function, performs the measurement, and returns the result to the output buffer. Further customization of the counter set-up is provided, through the use of optional parameters.

  The MEASure command is instrument independent and can be used in other instruments to perform similar functions. This command should be used when the portability of instrument syntax is important. CONFigure/READ? is less compatible if the counter re-configuration occurs between the CONFigure and READ? operations. The [SENSe:] subsystem can be used for all measurements. The [SENSe:]FUNCtion command only configures a input for a specific function and does not perform the measurement. The state of the counter is not otherwise affected. Use of additional commands (READ?, or INIT/FETC?) to perform the measurement and store the results is required. The [SENSe:] commands should be used when direct control over the measurement is important.
- Input 3 can perform FREQuency, FREQ:RATio, and PERiod measurements only.

MEASure Command Details

For detailed explanations of the MEASure command functions, parameters, examples, and comments, refer to the individual CONFigure command measurement function descriptions of the CONFigure subsystem. Three simple examples using the MEASure command are provided below.

All details of the MEASure command functions are identical to the CONFigure command functions except for the following:

- TOTalize measurements are NOT available under the MEASure subsystem,
- The function is written as the query form by including a question mark (?) at the end of the measurement function name: for example, "TINTerval" becomes "TINTerval?"as the MEASure function. When the MEASure function queries are used, the READ?, and INITiate/FETCh? commands are not needed.

CAUTION If you are making multiple rise/fall time measurements and are *not* changing the input signal in any fashion (amplitude, frequency). Do not use the MEASure subsystem commands. These commands will reconfigure the counter for each measurement and cause excessive wear on the front-end relays. Instead, use:

```
CONF:RTIM;
INIT;
FETC?
```

MEASure Examples

`MEAS2:FREQ? 10E6, 1`	*Measures frequency on Input 2 with an expected value of 10 MHz and resolution of 1 Hz.*
`MEAS1:RTIM? 20, 80`	*Measures rise time on Input 1 between 20% and 80% of the input signal level transition.*
`MEAS1:PER?`	*Measure period; when no parameters are given, the counter autoranges the requested measurement providing the best possible resolution. Gate time is 400 ms.*

OUTPut

The Output subsystem controls if the internal timebase reference signal is output via the rear panel Int/Ext Reference SMB connector.

Subsystem OUTPut

Syntax

```
:ROSCillator
   [:STATe]    <OFF|0|ON|1>
   [:STATe]?
```

OUTPut:ROSCillator:STATe

OUTPut:ROSCillator:STATe <OFF|0|ON|1> specifies whether or not the internal timebase is routed to the rear panel Int/Ext Reference SMB. OUTPut:ROSCillator:STATe ON enables this output. OUTPut:ROSCillator:STATe OFF disables this output.

OUTPut:ROSCillator:STATe?

The **OUTPut:ROSCillator:STATe?** query returns the current output status of the reference oscillator source selected and routed to the rear panel Int/Ext Reference SMB connector.

READ?

The **READ?** command is used to initiate a measurement and then transfer the measurement result to the output buffer. The READ? command performs the identical function as sending the sequence ABORt, INITiate:IMMediate, FETCh?.

Subsystem Syntax

```
READ[1|2|3]
    [:<function>]?
```

Comments

- Input Selection: Specify only one input at a time. If a input is not specified, the command defaults to Input 1.
- If you enter a <function> that does not correspond to the last configured measurement function, the <function> will be ignored. The results of the most recent measurement function will be returned.
- When used with the TOTalize function, the READ? command will initialize the measurement and should be used with caution. Use the INIT and FETC? commands to obtain measurement results for this function.
- Attempting to READ? on a non-configured input will return error −204, "Input not configured for measurement".
- If INITiate:CONTinuous is set on, executing READ? will generate error −213, "INIT ignored".

Example

`CONF:FREQ:RAT`	*Function is ratio.*
`READ?`	*Take measurement; transfer data to output buffer.*
`"ENTER" statement`	*Enter readings into controller.*
`READ:FREQ?`	*Counter ignores the FREQuency? query and returns ratio.*

[SENSe]

The [SENSe] command subsystem can be used to manually configure all available measurements, and/or to enter various measurement parameters. The [SENSe] command also offers direct manual control of the counter hardware. [SENSe] enables you to change/verify the following settings:

- Trigger Level, Slope, or Hysteresis
- Measurement Function
- Aperture Time and Gate State
- Average mode selection
- Time-Interval Delay
- Frequency Range
- Timebase Selection
- Totalize Measurement Setup

Subsystem Syntax

```
[SENSe[1|2|3]]
   :AVERage
      [:STATe]    <OFF|0|ON|1>
      [:STATe?
      :COUNt?
   :EVENt
      :LEVel
         [:ABSolute]     <level> |MIN|MAX|DEF
         [:ABSolute?]    [<MIN|MAX|DEF>]
            :AUTO    <OFF|0|ON|1|ONCE>
            :AUTO?
         :RELative     <expected value> |MIN|MAX|DEF
         :RELative?    [<MIN|MAX|DEF>]
      :LEVel?
      :SLOPe    <pOS|NEG>
      :SLOPe?
      :HYSTeresis    <MIN|MAX|DEF>
      :HYSTeresis?
   :FREQuency
      :APERture    <expected value> |MIN|MAX|DEF
      :APERture?    [<MIN|MAX|DEF>]
         :RANGe
            :AUTO    <OFF|0|ON|1>
         :AUTO?
         [:UPPer]     <range> |MIN|MAX|DEF
         [:UPPer?]    [<MIN|MAX|DEF>]
   :FUNCtion
      :[VOLTage:]AC
      :[VOLTage:]DC
      :[VOLTage:]FREQuency
```

```
    :[VOLTage:]FREQuency:RATio
    :[VOLTage:]FTIMe
    :[VOLTage:]FALL:TIME
    :[VOLTage:]MAX
    :[VOLTage:]MIN
    :[VOLTage:]NWIDth
    :[VOLTage:]PERiod
    :[VOLTage:]PWIDth
    :[VOLTage:]RTIMe
    :[VOLTage:]RISE:TIME
    :[VOLTage:]TINTerval
    :[VOLTage:]TOTalize
:FUNCtion?
:PERiod
    :APERture    <expected value> |MIN|MAX|DEF>
    :APERture?    [<MIN|MAX|DEF>]
:RATio
    :APERture    <expected value> |MIN|MAX|DEF>
    :APERture?    [<MIN|MAX|DEF>]
:ROSCillator
    :SOURce    <INT|EXT>
    :SOURce?
:TINTerval
    :DELay
        [:STATe]    <OFF|0|ON|1>
        [:STATe]?
        :TIME    <time> |MIN|MAX|DEF
        :TIME?    [<MIN|MAX|DEF>]
:TOTalize
    :GATE
        [:STATe]    <OFF|0|ON|1>
        [:STATe]?
        :POLarity    <NORM|INV>
        :POLarity?
        :SOURce?
```

:AVERage[:STATe]

[SENSe[1|2]]:AVERage[:STATe] <**OFF**|**0**|**ON**|**1**> has the following functions.
AVERage[:STATe] ON causes the counter to enter 100 Gate Averaging mode. This measurement mode provides 100 ps resolution for time-interval measurements.
AVERage[:STATe] OFF causes the counter to return to single-shot measurement. If the resolution parameter of CONFigure/MEASure is less than 1 ns, the AVERage state is automatically turned on.

:AVERage[:STATe]?

[SENSe[1|2]]:AVERage[:STATe?] query returns the AVERage[:STATe] status.

:AVERage:COUNt?

The **[SENSe[1|2]]:AVERage:COUNt?** query returns 100, indicating the current number of averages is 100. There is no command to change this number.

:EVENt:LEVel[:ABSolute]

[SENSe[1|2]]:EVENt:LEVel[:ABSolute] <*level*> specifies the trigger level for Input 1 and Input 2.

Parameters

Parameter Name	Parameter Type	Range of Values	Default Value
level	numeric	−10.2375V to +10.2375V	0 volts
	discrete	MIN|MAX|DEF	0 volts

Comments

- Event level is programmable in 2.5 mV steps on Input 1 and Input 2. Each input can be programmed for a different trigger *level*. A trigger *level* entered outside the range will return error −209, "Data clipped to limit". Levels are truncated to nearest 2.5 mV.
- When the counter is in auto trigger mode, executing this command turns auto trigger off. The trigger level is set as requested.
- MIN value: −10.2375 V.
- MAX value: +10.2375 V.
- ***RST Condition:** The event level is set to 0 volts for both Input 1 and Input 2.

Example

`SENS2:EVEN:LEV 1.2` *Sets Input 2 event level to +1.2 V.*

:EVENt:LEVel[:ABSolute]?

[SENSe[1|2]]:EVENt:LEVel[:ABSolute?] [<**MIN**|**MAX**|**DEF**>] query returns the current level setting as one of these numeric values:

- The current trigger level in volts if no parameter is specified.
- The minimum trigger level available (−10.2 V) if MIN is specified.
- The maximum trigger level available (+10.2 V) if MAX is specified.
- The default trigger level (0 V) if DEF is specified.

Example	`SENS2:EVEN:LEV:ABSolute?`	*Both of these commands are the same same, querying Input 2.*
	`or`	
	`SENS2:EVEN:LEV?`	
	`"ENTER" statement`	*Enter the queried value.*

:EVENt:LEVel[:ABSolute]:AUTO

[SENSe[1|2]]:EVENt:LEVel[:ABSolute]:AUTO <OFF|0|ON|1|ONCE> has the following functions: "ON" specifies counter operation in the auto trigger mode. In this mode, the trigger point, [LEVel:ABSolute] is automatically set between the negative and positive detected peaks. The level is calculated as a percentage of the peak-to-peak voltage, added to the negative −Ve peak value. The percentage is defined in EVENt:LEVel:RELative. The actual level determination does not occur unless a measurement is initiated. If "ONCE" is selected, counter determines the level automatically for one measurement only.

:EVENt:LEVel[:ABSolute]:AUTO?

The **[SENSe[1|2]]:EVENt:LEVel[:ABSolute]:AUTO?** query returns the EVENt:LEVel[:ABSolute]:AUTO status auto trigger mode as either 1 (ON) or 0 (OFF). If "ONCE" was selected, query returns 0.

:EVENt:LEVel:RELative

[SENSe[1|2]]:EVENt:LEVel:RELative <*expected value*> specifies the peak-to-peak signal range percentage used to set the LEVel when AUTO is on.

Parameters

Parameter Name	Parameter Type	Range of Values	Default Value
expected value	numerical	10% to 90%	50%
	discrete	MIN|MAX|DEF	0 V

Comments

- Note that numeral values are in percent and discrete values are in volts.
- MAX value: +10.2375 V
- MIN value: −10.2375 V
- ***RST Condition:** 50%.

Example

`CONF:RTIM`	*Configure the counter for 10% and 90% rise time measurement.*
`SENS:EVEN:LEV:REL 20`	*Sets trigger level on Input 1 to the 20% point.*
`SENS2:EVEN:LEV:REL 80`	*Sets trigger level on Input 2 to the 80% point.*
`READ?`	*Causes the counter to make a measurement and report rise time from the 20% to 80% transition point.*

Comments

- ***RST condition:** 50%.

:EVENt:LEVel:RELative?

[SENSe[1|2]]:EVENt:LEVel:RELative? [<**MIN**|**MAX**|**DEF**>] query returns the EVENt:LEVel:RELative status as one of these numeric values:

- The current relative trigger level in percent if no parameter is specified.
- The minimum relative trigger level in percent (10%) available if MIN is specified.
- The maximum relative trigger level in percent (90%) available if MAX is specified.
- The default relative trigger level in percent (50%) if DEF is specified.

:EVENt:LEVel?

[SENSe[1|2]]:EVENt:LEVel? query returns the current level setting as a numeric value. This query is identical to :EVENt:LEVel[:ABSolute]?.

:EVENt:SLOPe

[SENSe[1|2]]:EVENt:SLOPe <*slope*> specifies either the POSitive (rising) or NEGative (falling) edge of the input signal to be used in the measurement.

Parameters

Parameter Name	Parameter Type	Range of Values	Default Value
slope	discrete	POS|NEG	POS

Comments

- ***RST condition:** The slope is POSitive for all inputs.

Example

`SENS2:EVEN:SLOP NEG` *Sets Input 2 slope to negative.*

:EVENt:SLOPe?

[SENSe[1|2]]:EVENt:SLOPe? returns one of the following responses:

- POS if slope was programmed to the rising edge.
- NEG if slope was programmed to the falling edge.

Example	`SENS2:EVEN:SLOP?`	*Query counter to return the slope of Input 2.*
	`"ENTER" statement`	*Enter value into controller.*

:EVENt:HYSTeresis

[SENSe[1|2]]:EVENt:HYSTeresis <*sensitivity*> specifies the sensitivity of the counter. If the input signal peaks do not extend beyond both hysteresis limits, then the input signal does not generate a count. If the input signal has a significant noise content, then the hysteresis must be increased to prevent the counter from counting false events.

Parameters

Parameter Name	Parameter Type	Range of Values	Default Value
sensitivity	discrete	MIN|MAX|DEF	60 mV p-p

Comments

- Selecting MAX provides the greatest noise immunity (lowest sensitivity) while selecting MIN gives the most sensitivity (least noise immunity).
- MIN value: 30 mV p-p
- MAX value: 100 mV p-p

Example

`SENS:EVEN:HYST MAX` *Sets the counter hysteresis to MAXimum.*

:EVENt:HYSTeresis?

[SENSe[1|2]]:EVENt:HYSTeresis? returns the current (MIN, MAX, or DEF) value set by EVENt:HYSTeresis.

:FREQuency:APERture

[SENSe[1|2|3]]:FREQuency:APERture <*expected value*> specifies the aperture time for a frequency measurement. APERture time is the same as measurement gate time and can be calculated from the following formula:

Resolution in Hz = (4×10^{-9}) (F/T), where F=frequency, and T=gate or APERture time.

Parameters

Parameter Name	Parameter Type	Range of Values	Default Value
expected value	numeric	1 ms to 99.999 s	100 ms
	discrete	MIN|MAX|DEF	

Comments

- Aperture time is the minimum gate time during which frequency measurements are made. The actual gate time depends on the period of the input signal. A larger aperture time is required to obtain greater resolution. Refer to CONFigure:FREQuency in this chapter for more information.
- Aperture time is programmable in 1 ms steps. If an aperture time is specified that is not an exact step, it is truncated. Specifying a value out of range causes the counter to default to the closest MINimum or MAXimum value. It Also generates error −209, "Data clipped to limit".
- MIN value: 1 ms
- MAX value: 99.999 s
- ***RST condition:** 100 ms.

Example

`FREQ:APER 100E−3` *Specifies aperture time as 100 ms.*

:FREQuency:APERture?

[SENSe[1|2|3]]:FREQuency:APERture? [<**MIN**|**MAX**|**DEF**>] returns one of the following numbers to the output buffer:

- The current aperture time in seconds if no parameter is specified.
- The minimum aperture time available if MIN is specified.
- The maximum aperture time available if MAX is specified.
- The default aperture time if DEF is specified.

Example	`SENS:FREQ:APER 256E-03`	*Aperture time is 256 mS.*
	`FREQ:APER? MAX`	*Maximum aperture time (99.999 S) is returned.*
	`FREQ:APER?`	*Returns 0.256.*

:FREQuency:RANGe

[SENSe[1|2|3]]:FREQuency:RANGe subsystem is used to specify the frequency range for Input 1.

:FREQuency:RANGe:AUTO

[SENSe[1|2|3]]:FREQuency:RANGe:AUTO <**OFF**|**0**|**ON**|**1**> specifies whether or not the counter will automatically determine the frequency range.

Comments

- This command has no effect on Input 2 or Input 3.
- Enables prescaling (divide by 2) on Input 1 when the input signal frequency is greater than 100 MHz.
- If AUTO is on, then manually selecting range turns AUTO OFF.
- This command can be used only for frequency, period, and ratio measurements.

:FREQuency:RANGe:AUTO?

The **[SENSe[1|2]]:FREQuency:RANGe:AUTO?** query returns the :FREQuency:RANGe:AUTO status as either 1 (ON) or 0 (OFF).

:FREQuency:RANGe[:UPPer]

[SENSe[1|2|3]]:FREQuency:RANGe[:UPPer] <*range*> specifies the maximum frequency that the counter will acquire as its input.

Parameters

Parameter Name	Parameter Type	Range of Values	Default Value
range	numeric	0.001 to 200 E6	100 E6 Hz
	discrete	MIN|MAX|DEF	100 E6 (Input 1 and Input 2)

Comments

- This command has no effect on Input 3.
- If the *range* $\geq$ 100 MHz for Input 1, prescaling is enabled and the UPPer value is set to 200 MHz. When prescaling is on, only frequency, period, and ratio measurements can be made. If the entered value of *range* is less than 100 MHz, prescaling is turned off and the UPPer value is set to 100E6.
- MIN value: 0.001 (Input 1 and Input 2)
- MAX value: 200E6 (Input 1) and 100E6 (Input 2)
- If range determination is currently automatic ([SENSe]:FREQ:RANG:AUTO ON), then setting the value of RANGe will disable auto ranging ([SENSe]:FREQ:RANG:AUTO OFF).

Example

`FREQ:RANG:UPP 170E6` *Turns prescaling on and sets the upper value to 200 MHz.*

:FREQuency:RANGe [:UPPer?]

[**SENSe**[**1**|**2**|**3**]]**:FREQuency:RANGe**[**:UPPer**]**?** [<**MIN**|**MAX**|**DEF**>] is used to query the value of UPPer frequency range. Querying on Input 1 returns 100 or 200 MHz while querying on Input 2 will return 100 MHz.

If the query returns 200E6, then prescaling (*divide* 2) on Input 1 is on.

:FUNCtion

You can specify the measurement function with the following command string:

```
[SENSe[1|2|3]]:FUNCtion "[VOLTage:]<function>"
```

This command is used to set up the counter to perform a specified measurement function without affecting any other measurement parameters or set up. Some measurement functions such as TOTalize by gate may require additional [SENSe] commands.

Input 3 is limited to frequency, period, and frequency ratio measurements only.

Parameters

Parameter Name	Parameter Type	Range of Values	Default Value
function	discrete	:[VOLTage:]AC	"FREQ"
		:[VOLTage:]DC	
		:[VOLTage:]FREQuency	
		:[VOLTage:]FREQuency:RATio	
		:[VOLTage:]FTIMe	
		:[VOLTage:]FALL:TIME	
		:[VOLTage:]MAXimum	
		:[VOLTage:]MINimum	
		:[VOLTage:]NWIDth	
		:[VOLTage:]PERiod	
		:[VOLTage:]PWIDth	
		:[VOLTage:]RTIMe	
		:[VOLTage:]RISE:TIME	
		:[VOLTage:]TINTerval	
		:[VOLTage:]TOTalize	

Comments

- Select only one input at a time.
- If the counter is in continuous measurement mode (INITiate:CONTinuous is set on), specifying a function on the other input generates error −204, "Input not configured" with no change made. However, the function may be changed on the configured input.
- TOTalize on Input 2 is not allowed but TOTalize on input 2 by Input 1 is permitted. Refer to the TOTalize:GATE subsystem.
- Measurement Description: See the CONFigure subsystem for a description of all available measurements.
- [VOLTage:] is an implied node and may be omitted from the program message.
- Making measurements with auto trigger greatly reduces throughput as compared to measurement speed when trigger levels are programmed manually. During auto triggered frequency measurements, the counter determines the positive and negative voltage peaks of the input signal. It then programs the trigger level according to the current

[SENSe]:EVENt:RELative parameter value. Rise/fall time measurements use both input amplifiers (common Input 1). During auto triggered rise/fall time measurements, Input 1 is programmed for 10% (90%) value and Input 2 is programmed for 90% (10%) value. A signal arriving at the Input 2 connector is not counted.

Note Auto-triggering should not be used when measuring signals below 1 kHz.

- Most measurements can be performed using one of the three subsystems CONFigure, MEASure, or [SENSe] and each has advantages and disadvantages over the other. The basic difference between the commands is as follows: The CONFigure command can be used for all measurements except gated totalize and time interval delay. The CONFigure command only configures a input for a specific function, and does not perform the measurement. Use of additional commands (READ?, or INIT/FETC?) to perform the measurement and read the results is necessary. Further customization of the counter set-up is provided, through the use of optional parameters. The MEASure command can be used for all measurements except TOTalize. The MEASure command configures a input for a specific function, performs the measurement, and returns the result to the output buffer. Further customization of the counter set-up is provided, through the use of optional parameters. The MEASure command is instrument independent and can be used in other instruments to perform similar functions. This command should be used when the portability of instrument syntax is important. CONFigure/READ? is less compatible if the counter re-configuration occurs between the CONFigure and READ? operations. The [SENSe] subsystem can be used for all measurements. The [SENSe]:FUNCtion command only configures a input for a specific function and does not perform the measurement. The state of the counter is not otherwise affected. Use of additional commands (READ?, or INIT/FETC?) to perform the measurement and store the results is required. The [SENSe] commands should be used when direct control over the measurement is important.
- Input 3 can perform FREQuency, FREQ:RATio or PERiod measurements only.

Example

`SENS2:FUNC "PWID"`	*Sets Input 2 function to positive pulse width.*
`READ2?`	*Make pulse width measurement.*
`FUNC "PWID"`	*Abbreviated command for setting "PWID" function on Input 1.*

:FUNCtion?

[SENSe[1|2|3]]:FUNCtion? returns one of the following functions listed in the [SENSe]:FUNCtion command section. Only one input may be selected for the :FUNCtion query at a time. If the query is made on a input other than the last configured input, then error −302, "Input not configured for measurement" is returned. An example of the use of this query is shown below:

Comments

- Input 3 is restricted to FREQuency, FREQ:RATio, and PERiod queries only.

Example

`FUNC "FREQ:RAT"`	*Function is ratio.*
`FUNC?`	*Query counter to return selected function.*
`"ENTER" statement`	*Enter quoted string into controller.*

:PERiod:APERture

[SENSe[1|2|3]]:PERiod:APERture <*expected value*> determines the gate time used for PERiod measurements. The gate time you program is the minimum value, the actual gate depends on the measured period.

Parameters

Parameter Name	Parameter Type	Range of Values	Default Value
expected value	numeric	1 ms to 99.999 s	100 ms
	discrete	MIN|MAX|DEF	

Comments

- MIN value: 1 ms
- MAX value: 99.999 s
- *RST Condition: 100 ms

Example

`SENS:PER:APER 0.10` *Specifies aperture time as 10 ms.*

:PERiod:APERture?

The **[SENSe[1|2|3]]:PERiod:APERture?** query returns the PERiod:APERture value.

:RATio:APERture

[SENSe[1|2|3]]:RATio:APERture programs the gate time during which ratio measurements are calculated. Refer to Table 8-4 in CONFigure:RATio for more details about APERture (gate time) and resolution.

:RATio:APERture?

The **[SENSe[1|2|3]]:RATio:APERture?** query returns the RATio:APERture value.

Note The counter does not distinguish between "apertures" for differing measurement functions or inputs. The aperture time most recently programmed is the one that is used.

:ROSCillator:SOURce

[SENSe[1|2]]:ROSCillator:SOURce <INT|EXT> controls selection of the reference oscillator source used as the counter's timebase. The SOURce parameters are INT and EXT. The parameters have the following meaning:

INTernal: The counter uses an internal precision oscillator.

EXTernal: The counter uses an external timebase signal supplied through the rear panel Int/Ext Reference SMB connector.

Comments

- A 30 minute warm-up period is recommended for the oscillator before making measurements.
- If the selected oscillator is not found, error −241, "Hardware missing" is returned.
- ***RST Condition:** The counter is locked to the internal reference oscillator.

:ROSCillator:SOURce?

The **[SENSe[1|2]]:ROSCillator:SOURce?** query returns the current source of the counter's timebase.

:TINTerval:DELay

The **[SENSe[1|2]]:TINTerval:DELay** subsystem controls whether time-interval measurement is made with or without a delay time. Refer to the *Time Interval Measurements* section in "Understanding the Universal Counter" in Chapter 3 for details of use. This subsystem affects only time interval measurements.

Subsystem Syntax

```
:TINTerval
   :DELay
      [:STATe]    <OFF|0|ON|1>
      [:STATe]?
      :TIME    <time> |MIN|MAX|DEF
      :TIME?    [<MIN|MAX|DEF>]
```

:TINTerval:DELay[:STATe]

[SENSe[1|2]]:TINTerval:DELay[:STATe] <**OFF**|**0**|**ON**|**1**> command enables/disables time-interval delay measurements. If :STATe is on, the counter will ignore all STOP:ARM events for the duration determined by the TINTerval:DELay:TIME command. If [:STATe] is off, and time interval measurement is programmed, routine time interval measurements will be made according to current ARMing subsystem status.

:TINTerval:DELay[:STATe?]

[SENSe[1|2]]:TINTerval:DELay[:STATe?] query returns the TINTerval:DELay[:STATe] status. If time interval delay measurements are enabled, the query returns 1 (ON), otherwise it will return 0 (OFF).

:TINTerval:DELay:TIME

[SENSe[1|2]]:TINTerval:DELay:TIME <*time*> command determines the delay time for time interval delay measurements.

Parameters

Parameter Name	Parameter Type	Range of Values	Default Value
time	numeric	1 ms to 99.999 s	100 ms
	discrete	MIN|MAX|DEF	100 ms

Comments

- The *time* should be programmed in 1 ms increments. If an entered *time* is not in ms increments, it will be truncated.
- MIN value: 1 ms
- MAX value: 99.999 s
- The counter ignores all STOP arm events for the requested delay time if TINTerval:DELay:STATe is on. If TINTerval:DELay:STATe is off, setting a delay time will not affect any measurement.

:TINTerval:DELay:TIME?

[SENSe[1|2]]:TINTerval:DELay:TIME? [<MIN|MAX|DEF>] query returns a delay time regardless of the TINTerval:DELay[:STATe] status (ON or OFF).

:TOTalize:GATE

The **[SENSe[1|2]]:TOTalize:GATE** subsystem is used to define a measurement gating signal for alternative measurement features of the TOTalize function. TOTalize by GATE means that the counter will accumulate events only when a specified gate signal is present. The GATE signal source will always be the other input (Input 1 or Input 2). The events accumulate for only one pulse of the gating signal.

Subsystem Syntax

```
:TOTalize
   :GATE
      [:STATe]      <OFF|0|ON|1>
      [:STATe]?
      :POLarity     <NORM|INV>
      :POLarity?
      :SOURce?
```

:TOTalize:GATE:STATe

[SENSe[1|2]]:TOTalize:GATE:STATe <*mode*> command enables/disables the TOTalize-by-GATE measurement feature. Selecting on or 1 enables the feature while choosing off or 0 disables it.

Parameters

Parameter Name	Parameter Type	Range of Values	Default Value
mode	discrete	OFF|0|ON|1	OFF

Comments

- If TOTalize:GATE:STATe is on, the counter will accumulate events on the selected input for the duration of time defined by the signal present on the other input and the TOTalize:GATE:POLarity command.

  In other words, if TOTalize:GATE:STATe is on, events on one input are accumulated for a single pulse (whose polarity is defined by the GATE:POLarity command) on the other input.

:TOTalize:GATE:STATe?

The **[SENSe[1|2]]:TOTalize:GATE:STATe?** query returns the TOTalize:GATE:STATe status: 0 if “OFF” and 1 if “ON”.

:TOTalize:GATE:POLarity

[SENSe[1|2]]:TOTalize:GATE:POLarity <*polarity*> command sets the polarity of the GATE signal for gated TOTalize measurements. The events are accumulated when the GATE source is either high (NORMal) or low (INVerted) depending on the configured polarity.

Parameters

Parameter Name	Parameter Type	Range of Values	Default Value
polarity	discrete	NORM|INV	NORMal

Comments

- *** RST condition:** NORMal

Example

This example shows how to TOTalize 2 by 1.

`SENS2:FUNC "TOT"`	*Configure Input 2 for TOTalize (Not valid unless gated by Input 1.)*
`SENS2:TOT:GATE:POL INV`	*Sets polarity of GATE signal to INVerted.*
`SENS2:TOT:GATE:STAT ON`	*Turns on gating by Input 1.*
`READ2`	*Make a measurement. Counts number of events on Input 2 for one negative pulse on Input 1.*

:TOTalize:GATE:POLarity?

[SENSe[1|2]]:TOTalize:GATE:POLarity? query returns the TOTalize:GATE:POLarity status, either NORMal or INVerted of the gating source.

:TOTalize:GATE:SOURce?

[SENSe[1|2]]:TOTalize:GATE:SOURce? query returns the source of the gating signal. If Input 2 is totalized with Input 1 as the gate, then the query returns "INT1". If Input 1 is totalized with Input 2, then the query returns "INT2".

STATus

The STATus subsystem lets you examine the status of the counter by monitoring the Operation Status Register and the Questionable Data/Signal Register. Figure 8-1 shows all of the counter's status registers.

Subsystem Syntax

```
STATus
   :OPERation
      :CONDition?
      :ENABle    <mask>
      :ENABle?
      [:EVENt]?
   :QUEStionable
      :CONDition?
      :ENABle    <mask>
      :ENABle?
      [:EVENt]?
```

The STATUS system contains four registers (and the Output Queue), two of which are under *IEEE Std 488.2-1987* control. These are the Standard Event Status Register (ESR) and the Status Byte Register (SBR). The other two are the Standard Operation Status register and Questionable Data register. Refer to the description of common commands for more details.

The two registers under the counter's control are the Standard Operation Status Register, and the Questionable Data Register. These registers may be set and queried.

Parameters

Parameter entry for both of these registers is numeric only. Numeric types may be Decimal, Hexadecimal, Octal, or Binary. The decimal numeric range is between 0 and 32767. The power up/reset default value is 0.

Bit Number to Decimal Value Conversion																
Bit Number	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Decimal Value	32768	16384	8192	4096	2048	1024	512	256	126	64	32	16	8	4	2	1

Sending a decimal value of 64 will set bit 6.

Using the Operation Status Register

The 16-bit Operation Status Register monitors counter operations currently being performed. The counter implements bit 6 only and is defined as follows:

- Bit 6: has a decimal weight of "64" when the counter is in the wait-for-arm state.

The Operation Status Register group consists of a condition (C) register, an event (EV) register, and an enable (EN) register as shown in Figure 8-1. The commands in the STATus:OPERation subsystem control and monitor these registers.

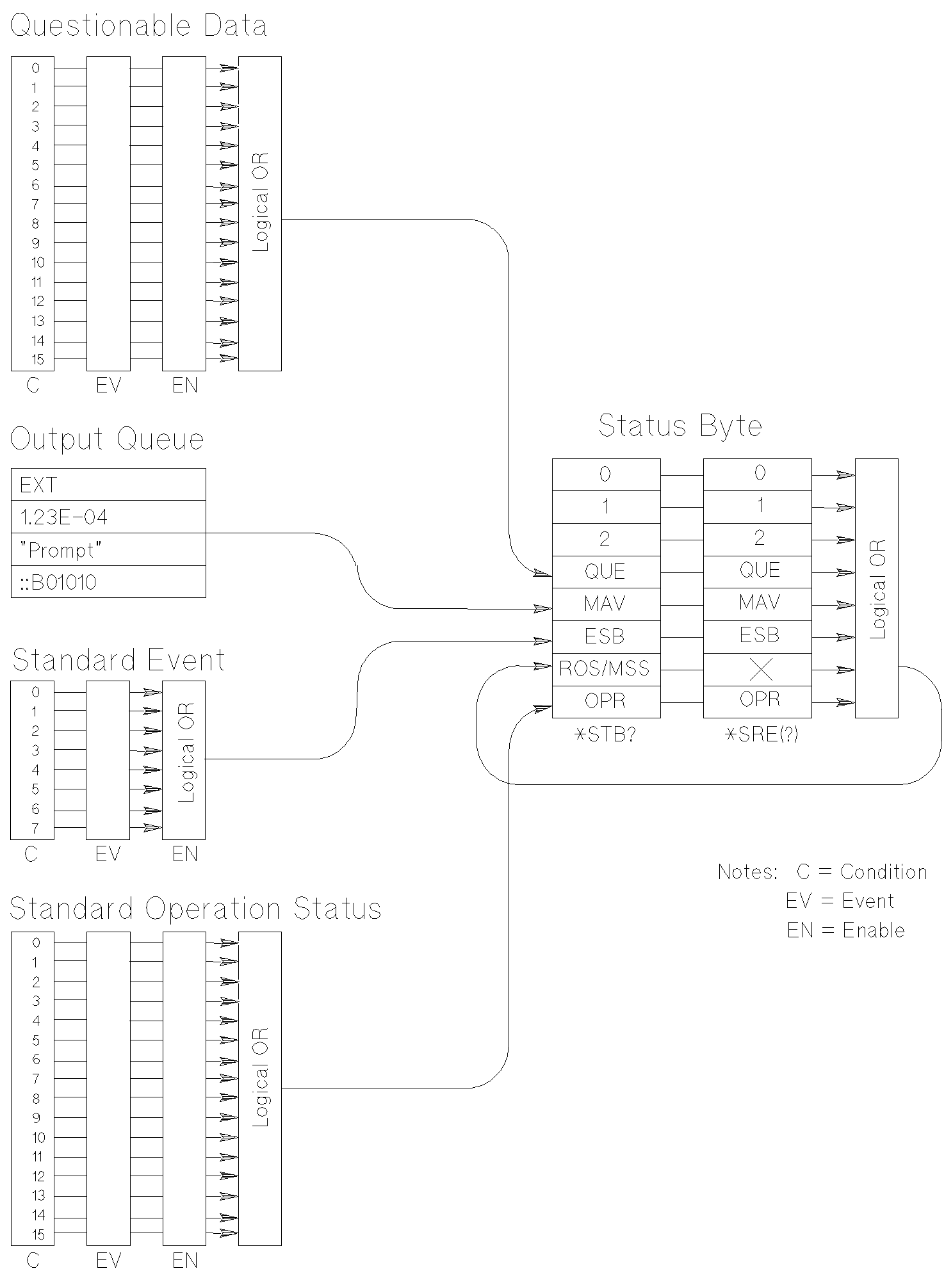


Figure 8-1. Status System Registers

Using the Questionable Data Register

The Questionable Data Register conveys information about the quality of the measurements made by the counter. The counter implements bits 0, 8, and 9 as follows:

- Bit 0: has a decimal weight of “1” when voltage measurement is questionable. This is useful in auto trigger measurements for ac, dc, MAXimum, and MINimum where one of the voltages is at the trigger limit or MIN and MAX are the same.
- Bit 8: has a decimal weight of “256” when the interpolator has overflowed. This may occur during a hardware failure or when too many external gates have been used to take average measurements. Decreasing the configured APERture time may remedy this overflow.
- Bit 9: has a decimal weight of “512” when the internal interpolator values are questionable. If this bit is set repeatedly, then a hardware problem is suspect.

The Questionable Data Register group consists of a condition register, an event register, and an enable register as shown in Figure 8-1. The commands in the STATus:QUEStionable subsystem control and monitor these registers.

The STATus:QUEStionable subsystem commands query the QUEStionable Register to indicate whether an overflow has occurred on a given input after an INIT, FETC?, READ?, or MEASure command has executed. When any of the bits are set (questionable data), bit 3 of the Status Register is set to 1 if enabled by the STAT:QUES:ENAB command.

:OPERation:CONDition?

STATus:OPERation:CONDition? returns a decimal-weighted number representing the bits set in the Operation Status Register's condition register. Reading the condition register does not destroy its contents.

Comments

- This command returns "0" (no bits set) or "64" (bit 6 set).
- The condition register does not implement latching and buffering. The register is updated in real-time whenever the counter makes a measurement.
- The CLS (clear status) command clears all status registers.

Example

`STAT:OPER:COND?`	*Read condition register.*
`ENTER statement`	*Enter value into controller.*

:OPERation:ENABle

STATus:OPERation:ENABle <*mask*> enables bits in the Operation Status Register's event register to be reported to the summary bit (setting Status Byte Register bit 7 true). The event register bits are not reported in the Status Bytes Register unless specifically enabled. Although values 0 - 32767 are accepted, setting bit 6 (decimal 64) is the only recommended operation.

Comments

- If any bits are enabled in the enable register, the corresponding bits set in the Operation Status Register's event register are reported to the Status Byte Register.
- The *CLS (clear status) command clears all status registers. The * CLS command does not affect which bits are enabled to be reflected in the Status Byte Register.

Example `STAT:OPER:ENAB 64` *Enable bit 6.*

:OPERation:ENABle?

STATus:OPERation:ENABle? returns a decimal-weighted number representing the bits set in the Operation Status Register's enable register.

Example	`STAT:OPER:ENAB?`	*Read enable register; clear register contents.*
	`ENTER statement`	*Enter value into controller.*

:OPERation[:EVENt]?

STATus:OPERation[:EVENt]? returns a decimal-weighted number representing the bits set in the Operation Status Register's event register. Reading the event register clears its contents.

Comments

- The :EVENt parameter is optional. Both of the following command statements read the event register:

  `STAT:OPER:EVEN? or STAT:OPER?`

- The event register latches conditions from the condition register. Bits in the event register are latched, and remain set until cleared by STAT:OPER:EVEN? or the * CLS (clear status) command.
- The CLS (clear status) command clears all status registers (Standard Event Status Register, Operation Status Register, Questionable Data Register).

Example

`STAT:OPER:EVEN?`	*Read event register; clear register contents.*
`ENTER statement`	*Enter value into controller.*

:QUEStionable:CONDition?

STATus:QUEStionable:CONDition? query is accepted and returns 0 as the condition register is not accessible.

:QUEStionable:ENABle

STATus:QUEStionable:ENABle <*mask*> sets the enable mask which allows true conditions in the Questionable Data/Signal EVENt Register to be reported in the summary bit (setting Status Byte Register bit 3 true).

Parameters

Parameter Name	Parameter Type	Range of Values	Default Value
mask	numeric	0 to 32767	0

Comments

- Summary Bit: If any of the bits are set in the Questionable Data/Signal ENABle Register, a transition of these EVENt register bits causes the associated summary bit to be true.

Example `STAT:QUES:ENAB 768` *Sets bits 8 and 9 true.*

:QUEStionable:ENABle?

STATus:QUEStionable:ENABle? query returns the bit value of the Questionable Data ENABle Register.

Comments

- Output Format: The command returns a decimal weighted value from 0 to 1023 indicating which bits are set true.
- Maximum Value Returned: The maximum decimal weighted value used in the counter module is 1023 (bits 1 through 9 set true).

Example

`STAT:QUES:ENAB?`	*Queries the enable register.*
`"ENTER" data`	*Enter data into the controller.*

:QUEStionable[:EVENt]?

STATus:QUEStionable:[:EVENt]? Queries the status of the Questionable Data/Signal EVENt Register.

Comments

- Information Updated: The EVENt Register latches only low to high events from the CONDition Register.
- Output Format: Returns a decimal weighted value from 0 to 32767 indicating which bits are set true.
- Reading Contents: Reading the EVENt Register by a query will clear its contents.

Example

`STAT:QUES:EVEN?`	*Queries the Questionable Event Register.*
`STAT:QUES?`	*The short version of the command.*

SYSTem

The SYSTem command subsystem returns error numbers and messages in the error queue.

Subsystem Syntax SYSTem

```
    :ERRor?
    :PIMacro    <string>
    :VERSion?
```

:ERRor?

SYSTem:ERRor? returns the error numbers and corresponding error messages in the error queue. See Appendix B in this manual for a listing of the error numbers and messages.

Comments

- When an error is generated by the counter, it stores an error number and corresponding message in the error queue.
- One error is removed from the error queue each time the SYSTem:ERRor? command is executed. The errors are cleared in a first-in, first-out order. This means that if several errors are waiting in the queue, each SYSTem:ERRor? query will return the oldest (not the most recent) error. That error is then removed from the queue.
- When the error queue is empty, subsequent SYSTem:ERRor? queries returns +0, “No error”. To clear all errors from the queue, execute the * CLS command.
- The error queue has a maximum capacity of 15 errors. If the queue overflows, the last error is replaced with −350, “Too many errors”. No further errors are accepted by the queue until space becomes available.
- **Power up condition:** The error queue is empty unless an error occurs during power up.
- ***RST Condition:** *RST does not clear the error queue.

An example of querying the error queue is shown below:

`CONF:FRQ 10E6, 1`	*Enter misspelled FREQuency function (FRQ). Front-panel Error LED turns on.*
`SYST:ERR?`	*Query the error queue.*
`"ENTER" Statement`	*Counter returns error −113, “Undefined header”.*

:PIMacro

SYSTem:PIMacro <*string*> command (Purge Individual Macro) will delete the macro described by the string name. If the string is not defined, error −270, "Macro error", will be returned. Use the *PMC command to delete all macros.

:VERsion?

SYSTem:VERSion? query returns the current SCPI version identifier (currently 1991.0). The returned version number signifies that the counter's programmable functions conform to the equivalent date of the SCPI standard. As software is updated, or new commands added, the response to this query may change to reflect the latest version.

9

Configuring and Addressing

Front and Rear Panel Terminals

This chapter briefly explains the counter's front and rear panel features.

- Connectors and Indicators

Connectors and Indicators

The HP 70120A universal counter front panel has four signal connectors and eleven LED indicators. The rear panel has three connectors: trigger, 10 MHz REF (IN/OUT), and GATE. Figure 9-1 shows the front panel connectors, indicators, and adjustment. Figure 9-2 shows the rear panel connectors.

Front Panel Signal Connectors

The front panel signal connectors are all standard BNC providing three Input inputs for signal measurement and one Arm Input for measurement synchronization. The basic characteristics of these inputs are explained following a description of input power.

Maximum Input Power

The maximum allowable input voltage for all front panel inputs should not exceed 5 volts rms.

CAUTION Input voltages in excess of 5 volts rms may cause permanent front-end hardware damage.

Input 1 and Input 2

Input 1 and Input 2 are the main measurement inputs of the counter. They can be used for all specified measurement functions from dc to 200 and 100 MHz respectively. Input impedance is selectable for either 50 Ω or 1 MΩ. Input coupling is selectable between ac and dc. The inputs can be used independently or together depending on the measurement functions and needs.

Input 3

Input 3 is the high frequency input and is used for frequency, period, or ratio measurements. Input impedance is fixed at 50 Ω and coupling is ac only.

Arm Input

The Arm Input is used to provide a synchronizing signal to the counter that can start and/or stop the measurement process. Input impedance is 1 MΩ with dc coupling. Input trigger level is programmable between 0 V (GND), 1.6 V (TTL), or −1.3 V (ECL). The Arm Input frequency range is dc to 20 MHz.

Rear Panel Signal Connectors

The rear panel signal connectors are all standard SMB. The basic characteristics of these are explained below.

10 MHz Reference (IN/OUT)

The 10 MHz Reference (IN/OUT) connector can be used to lock the counter's circuits to an external timebase input. Input level is nominally 0.2 volts p-p into a 1.1 kΩ load. Send the following SCPI program message commanding the HP 70120A universal counter to expect its timebase signal input from the rear panel Int/Ext Reference SMB connector:

```
OUTPUT @70120A;"SENS:ROSC:SOUR EXT"
```

If you want to program the counter to output its high stability timebase through the rear panel Int/Ext Reference SMB connector, send the following SCPI program message:

```
OUTPUT 706;"OUTP:ROSC:STATe ON"
```

You can turn OFF this timebase output by sending either the *RST or "OUTP:ROSC:STATe OFF" program messages to the counter.

Warm-up. If the internal TCXO timebase is selected, a thirty minute warm-up period is recommended before making any measurement.

GATE Out

The instrument's internal measurement gate signal is available to synchronize with other instruments.

TRIGGER

The trigger utilizes an external signal which can be used to synchronize multiple instruments.

Front Panel Indicators

The counter's front panel has eleven LED indicators that provide information about normal operation and errors.

HP-IB Status

There are four HP-IB status LEDs on the counter's front panel:

- The RMT LED lights if the counter is addressed by a computer. In addition, depending on the instructions received from the computer, the LSN, TLK, or SRQ indicators will also light.
- The LSN LED lights when the counter is receiving data or instructions over HP-IB.
- The TLK LED lights when the counter is sending data or instructions over HP-IB.

- The SRQ LED lights when the counter has requested computer service.

Module State

There are two module state LEDs on the counter's front panel:

- The ACT LED lights under three conditions:
  1. The module has keyboard control of the display.
  2. The module's master has keyboard control of the display and the module is configured to take part in the measurement.
  3. The module is the highlighted module in the display's address map.
- The ERR LED lights when there is a problem (error) related to one or more modules in the system. To learn the nature of the error and its source, press (DISPLAY), REPORT ERRORS. The screen displays the error code and identifies the module where the error originated.

Note It is normal for the ERR and ACT LEDs to flash on, then off, during the module self-test. Self-test occurs each time the instrument is turned on.

Instrument State

There are five instrument state LEDs on the counter's front panel:

- INPUTS: Four green LEDs, located adjacent to each Input connector, flash to indicate signal arming and triggering.
- GATE: A green LED to indicate when the measurement gate is open.

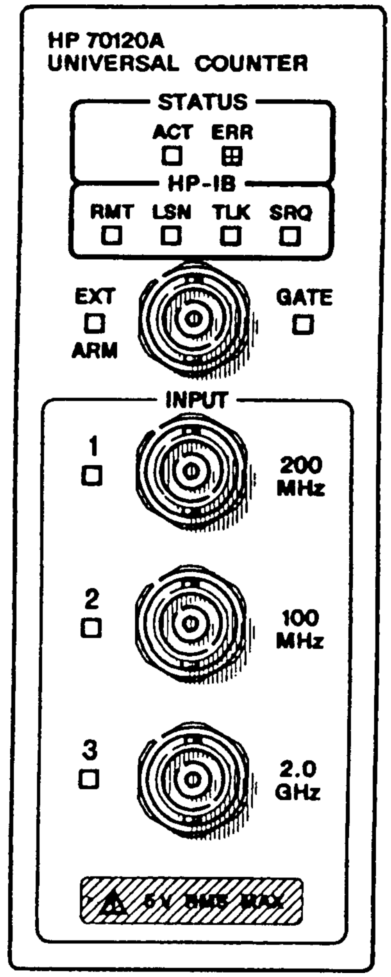


Figure 9-1. HP 70120A universal counter Front Panel

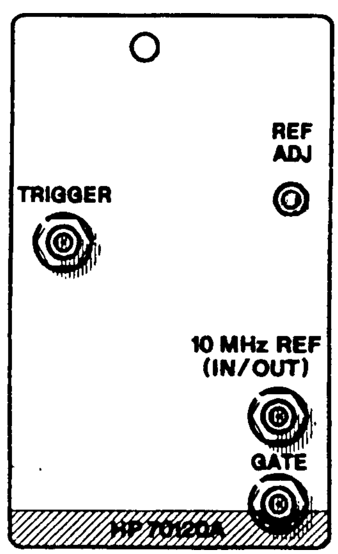


Figure 9-2. HP 70120A universal counter Rear Panel

Installation and Verification

This section provides you with information to get your HP 70120A universal counter up and running as soon as possible. This "hands-on" tour covers the following: inspection, configuration, installation, and functional verification.

Inspection

Inspect the shipping carton for damage before unpacking your HP 70120A universal counter. After the unit is unpacked, check for any damage (which may have occurred during shipment) as follows:

- Visually inspect all exterior surfaces for broken elements and damaged connectors.
- Report damaged shipments to the carrier and the nearest Hewlett-Packard Sales and Service office immediately.

Note Do not discard the counter's packing materials. They may be needed for reshipment.

Switch Configuration

Figure 9-3 shows the switches on the top panel of the counter.

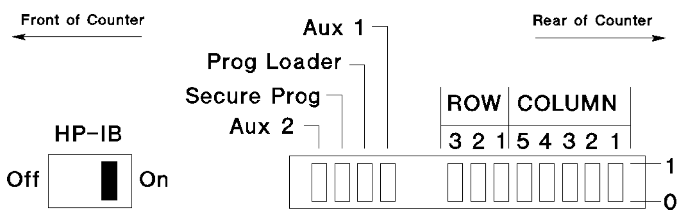


Figure 9-3. HP-MSIB Switches

Setting the HP-MSIB Address

The row and column address switches shown in Figure 9-3 set the MSIB address of the counter.

To establish proper system function and MSIB communication, each element has an address switch that is set to a binary, 8-bit MSIB address. Each element in a system must be assigned a unique address. The row address of the MSIB address is determined by three address bits, and the column address is determined by five address bits. For example:

	Row	Column
Binary	000	10110
Decimal	0	22

Each system has the possibility of 8 row and 32 column addresses. Address row 0, column 31 (0,31) is an illegal address; therefore 255 MSIB addresses are available. (The typical counter address is row 0, column 22 (0, 22)).

Setting the Configuration Switches

Figure 9-3 shows the configuration switches for the counter. They are as follows:

Aux 2: The Aux 2 switch is supplied for possible future use. There is no function associated with this switch.

Secure Prog: When in the secure program position the program memory can not be altered. This switch enables loading a new module program.

CAUTION Do not put the secure program switch in the unsecure position without specific factory instructions. Program memory can be erased, requiring service on the module.

Program Loader: When in the program loader position the module will power up in the program loader. Normal position is not program loader.

Aux 1: Aux 1 is supplied for possible future use. There is no function associated with this switch.

Setting the HP-IB Disconnect Switch

Figure 9-3 also shows the HP-IB Disconnect Switch for the counter. When HP-IB is off, the dc loading of the HP-IB interface is removed, allowing more HP-IB device connections.

To Install Your HP 70120A universal counter

The following paragraphs explain how to install the HP 70120A universal counter into the MMS mainframe.

After you have set the correct address (if needed), follow the procedure below to install the counter.

1. Ensure that ac power *is not* applied to the mainframe.
2. Slide the counter module into the appropriate slot.
3. Tighten the module latch screw (located on the bottom-front of the module) with a $\frac{5}{16}$ or 8 mm hex driver.
4. Verify initial operation as described in the next paragraph.

To Verify Operation

Verify operation of the counter with the following procedure:

1. Power up the MMS mainframe.
2. Observe that the front panel LEDs are all lit (indicating that self-test is in progress). After successful completion of the self-test, the LEDs should turn off, possibly with the exception of the active LED. The counter is now in the power up state and is ready for use.

Power Up State

The power up state is the configuration that occurs immediately after the counter powers up and successfully completes self-test. Table 3-2 gives a summary of the counter's default configuration parameters present in the power up initialized state.

Executing Self-Test (*TST?)

You can execute self-test by sending the self-test query common command *TST?. The results of the test are placed in the output queue indicating whether or not the counter completed self-test without any detected errors. Upon successful completion of *TST?, the counter configuration is left unchanged.

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Program Loader

The HP 70120A universal counter has an internal microprocessor that executes a program from erasable programmable read only memory (EPROM). A program loader is included that allows the memory to be programmed. In the event that future options or upgrades are available, the program loader may be used to load the universal counter's program memory.

Setting the program loader configuration switch or sending the DIAGnostic:BOOT command to the universal counter will indicate that the program loader is to be run on the next power up. The program loader is separate from the normal universal counter operation. When the program loader is running no universal counter commands will be operational.

Program Loader Command Reference

This section describes the SCPI commands applicable to the program loader of the HP 70120A universal counter. The same command and parameter formats described in the universal counter command section apply to the program loader. In addition the program data parameter is sent using the *IEEE Std 488.2-1987* arbitrary block program data format.

IEEE Std 488.2-1987 Common Commands

The following *IEEE Std 488.2-1987* commands are implemented. Refer to *IEEE Std 488.2-1987* Command Reference for description.

```
*CLS
*ESE
*ESE?
*ESR?
*IDN?
*OPC?
*RST
*SRE
*SRE?
*STB?
*TST?
*WAI
```

Common Universal Counter Commands

The following commands are implemented in the program loader as well as the universal counter. Refer to Chapter 8 for the command descriptions. The Operation Status Register and Questionable Data Register commands are provided for SCPI consistency, but have no operational bits.

```
:SYSTem
   :ERRor?
:STATus
   :OPERation
      :[EVENt]
      :CONDition?
      :ENABle
      :ENABle?
   :PRESet
   :QUEStionable
      :[EVENt]?
      :CONDition?
      :ENABle
      :ENABle?
```

Specific Program Loader Commands

The following commands are specific to the program loader. Command descriptions are provided on the pages that follow.

```
DIAGnostic
   :BOOT[:SOURce]
   :PMEMory
      :ERASe
      :LOAD
```

DIAGnostic

The DIAGnostic command subsystem:

- Loads new program memory images.
- Specifies universal counter or program loader boot source.
- Can erase program memory.

Subsystem Syntax

```
DIAGnostic
   :BOOT[:SOURce]
   :PMEMory
      :ERASe
      :LOAD
```

:BOOT[:SOURce]

DIAGnostic:BOOT[:SOURce] <*source*> instructs the instrument to run the universal counter or the program loader on the next power up.

Parameters

Parameter Name	Parameter Type	Range of Values	Default Units
source	discrete	LOADer|INSTrument	none

Example Select the program loader to be run on the next power up.

Comments

- LOAD instructs the module to run the program loader on the next power up.
- INST instructs the module to run the universal counter instrument on the next power up.
- The DIAGnostic:BOOT[:SOURce] <*source*> is stored in non- volatile electrically erasable memory. It is recommended to only use this command when necessary because this memory is limited to 10,000 write cycles.
- If the Program Loader configuration switch is set then the Program Loader will be run regardless of the state of the DIAGnostic:BOOT <*source*> command.
- During power up of the program loader DIAGnotic:BOOT[:SOURce] is set to INST. This setting will be used in the next power up.
- ***RST Condition:** INST

:BOOT[:SOURce]?

DIAGnostic:BOOT[:SOURce]? returns the current boot source, either LOAD or INST.

:PMEMory:ERASe

DIAGnostic:PMEMory:ERASe instructs the program loader to erase the universal counter program memory. The program memory must be first erased before loading a new program image.

Example **Erasing program memory**

`DIAG:PMEM:ERAS` *Erase program memory.*

Comments
- The program loader may be protected from accidental erasure with the "secure program" configuration switch. The default position for this switch is in the secured position.
- If the "secure program" configuration switch is set a −258 Media Protected error is generated.

:PMEMory:LOAD

DIAGnostic:PMEMory:LOAD <*program data*> instructs the program loader to load the *program data* into program memory.

Parameters

Parameter Name	Parameter Type	Range of Values	Default Units
program data	arbitrary block	8 bit binary	none

Comments

- If a program record calls for a memory location outside the available memory range a −223 Too much data error is generated.
- If the program storage memory can not be programmed, a −253 Corrupt Media error is generated.
- A successful load command will set the DIAGnostic:BOOT <*source*> to INST.

Program Loader Error Messages

The following error messages are specific to the Program Loader.

Code	Message	Cause
−161	Invalid Block data	A block data element was expected, but was invalid for some reason.
−223	Too much data	A legal program data element of block expression or string was received that contained more data than the device could handle.
−253	Corrupt Media	Program storage memory can not be programmed.
−258	Media protected	Program memory is secured and an erase command was attempted
3501	Unknown file format	The Program Loader did not recognize the format of the load data.
3502	Instrument program invalid	The Program Loader has determined that the Instrument Firmware Image is corrupted.
3503	Instrument program protected	The Program Loader can not modify the Instrument Firmware Image since the protect switch is set to PROTECTED.
3504	Nonvolatile memory invalid	The Program Loader has determined that the nonvolatile memory is corrupt.
3505	Nonvolatile memory write failure	The Program Loader is not able to write to the nonvolatile memory.
3506	Nonvolatile memory read failure	The Program Loader is not able to successfully read the nonvolatile memory
3507	Program enable failure	The Program Loader is not able to enable the Instrument Memory Image to be programmed.
3508	Program disable failure	The Program Loader is not able to disable the Instrument Memory Image from being programmed.
3509	Program load failure	The Program Loader was not able to successfully complete the Instrument Firmware Image load.
3510	Program erase failure	The Program Loader was not able to erase the Instrument Firmware Image.
3511	Program memory not erased	The instruction DIAG:PMEM:LOAD was sent before DIAG:PMEM:ERAS, so the Instrument Firmware Image has not been erased, and the load cannot proceed.

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