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Printing History

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CENC-TAC8 Tachometer Module User's Manual - Edition 1 ..... November 1993
CENC-TAC8 Tachometer Module User's Manual - Edition 2 ..... August 1996

Safety Symbols



Instruction manual symbol affixed to product. Indicates that the user must refer to the manual for specific WARNING or CAUTION information to avoid personal injury or damage to the product.



Frame or chassis ground terminal. typically connects to the equipment's metal frame.

WARNING Calls attention to a procedure, practice, or condition *that could cause bodily injury or death.*

CAUTION Calls attention to a procedure, practice, or condition that could possibly cause damage to equipment or permanent loss of data.



Alternating current (AC).



Direct current (DC).



Indicates hazardous voltages.

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Keep away from live circuits: Operating personnel must not remove equipment covers or shields. Procedures involving the removal of covers or shields are for use by service-trained personnel only. Under certain conditions, dangerous voltages may exist even with the equipment switched off. To avoid dangerous electrical shock, DO NOT perform procedures involving cover or shield removal unless you are qualified to do so.

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according to ISO/IEC Guide 22 and EN 45014

Manufacturer's Name: Hewlett-Packard Company
Loveland Manufacturing Center

Manufacturer's Address: 815 14th Street S.W.
Loveland, Colorado 80537
U.S.A

declares, that the product:

Product Name: Tachometer Module

Model Number: CENC-TAC8

Product Options: All

conforms to the following Product Specifications:

Safety: IEC 1010-1 (1990) Incl. Amend 1 (1992)/EN61010-1 (1993)
CSA C22.2 #1010.1 (1992)
UL 1244

EMC: CISPR 11:1990/EN55011 (1991): Group 1, Class A
IEC 801-2:1991/EN50082-1 (1992): 4kVCD, 8kVAD
IEC 801-3:1984/EN50082-1 (1992): 3 V/m
IEC 801-4:1988/EN50082-1 (1992): 1kV Power Line
.5kV Signal Lines

Supplementary Information: The product herewith complies with the requirements of the Low Voltage Directive 73/23/EEC and the EMC Directive 89/336/EEC.

Tested in a typical configuration in an HP C-Size VXI mainframe.

December 9, 1993

Jim White, QA Manager

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Chapter 1
Getting Started

Chapter Contents

This chapter contains general information about using the CENC-TAC8 Tachometer Module in a VXI system with the Compiled SCPI driver. The sections are as follows.

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Configuring the Tachometer Module 1-2
Setting the Logical Address Switch 1-2
Setting the VXIbus Interrupt Level 1-2
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Tachometer Module Description

The Tachometer Module is a C-size register-based VXIbus and VMEbus module that counts pulses from magnetic pickups and tachometer generators which are typically used to monitor rotor speeds on turbine and piston engines. It properly counts low-tooth or high-tooth signals for encoded 1/rev tachometers. Unlike some systems, both low and high teeth are sensed, ensuring an accurate reading of low and high tooth counts. Low teeth are sensed down to a 2:1 ratio. The Tachometer Module may also be used as a general purpose frequency counter allowing measurement of signals over a wide variety of amplitudes and waveshapes.

The Tachometer Module is capable of simultaneous measurement on all eight channels at a rate of up to 50 measurements per channel per second. Output can be returned as frequency (Hertz), raw timer counts, or engineering units such as RPM, rad/sec, period, and fuel flow.

There are three measurement schemes available on a per-channel basis: user-specified constant measurement aperture, auto-ranged terminal event count, and user-specified terminal event count. These measurement schemes are further defined in Chapter 3, "Theory of Operation."

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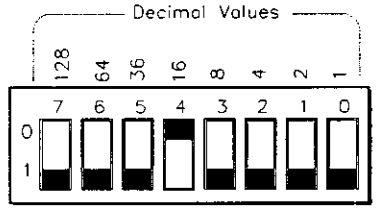
Configuring the Tachometer Module

The Tachometer Module must be properly configured before it is install a VXIbus mainframe. Configurable parameters include the logical addr switch and the VXIbus interrupt level.

The Tachometer Module can be installed in any VXI mainframe slot except for slot 0. For complete module installation instructions, refer to the appropriate VXIbus mainframe manual.

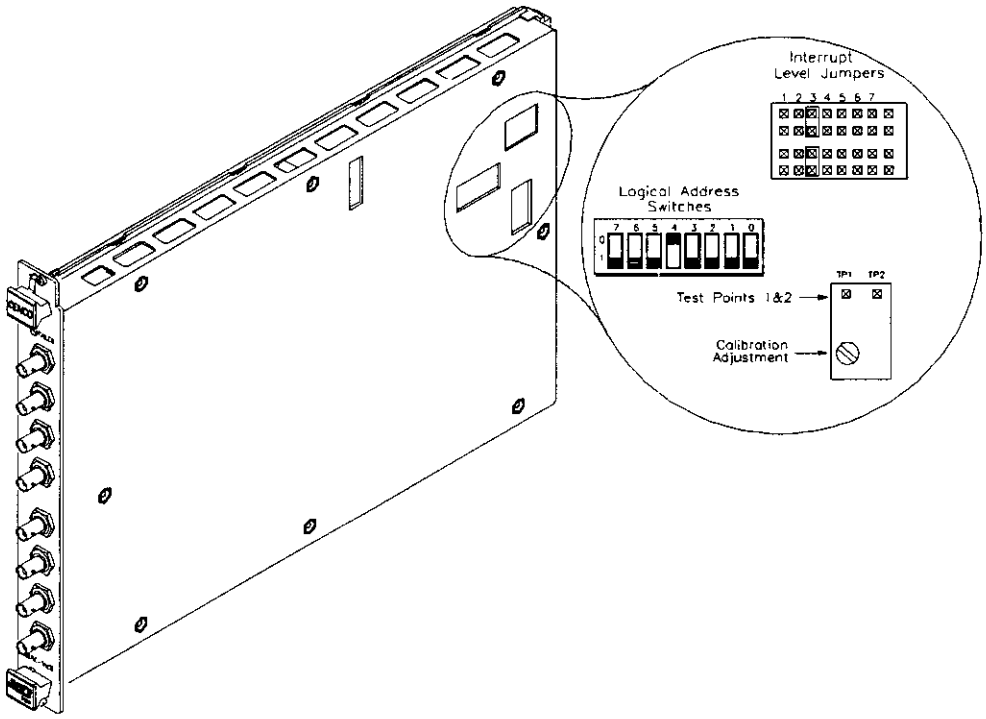
Setting the Logical Address Switch

The logical address is used to determine the base address of the Tachometer Module's registers in A16 address space. The Tachometer Module is shipped with a logical address setting of decimal 16. When the module is oriented as illustrated in the following figure, the least significant bit of the logical address switch is on the right. To set an address bit to logical 1, push down on the lower part of the switch.



Setting the VXIbus Interrupt Level

The Tachometer Module may assert an interrupt on any one of levels 1 through 7. The following figure shows the locations of the jumpers used to select an interrupt level.



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Note Both jumpers must be installed at the same priority level.

FAILED Indicator The FAILED LED is located on the front panel of the Tachometer Module. It is illuminated at power-on and any other commanded self-test and goes out upon successful completion. If any of the Tachometer Module's eight channels does not pass the self-test, the FAILED LED lights.

Verifying a Successful Configuration An example C-SCPI program follows. This program uses the *IDN? query command to verify the instrument is operational and responding to commands.

Note Refer to the HP Compiled SCPI manual set for information on compiling, linking, and running a Compiled SCPI program.

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```
/*****************************************************************************/
/* This program uses the *IDN? command to verify Tachometer Module operation*/
/*****************************************************************************/

#include <stdio.h>
#include "cscpi.h"

        /* Defines the Tachometer Module's logical address */
#define LA_TA "8"

        /* Specifies the Tachometer Module as a register address */
INST_DECL( tach, "CENCt08", REGISTER);

void main(void)
{
  char          in[80];

                /* Start the register-based operating system */
   INST_STARTUP();

                /* Open the I/O path to the Tachometer Module */
   INST_OPEN(tach, "vxi," LA_TA);

                /* Check if the path is good */
   if ( !tach )
   {
      printf( "INST_OPEN failed (ladd = %s). %d\n", LA_TA, cscpi_open_error);
      exit(1);
   }

/* *IDN? check */
   INST_QUERY(tach,"*idn?\n","%t",in);
   printf( "card output: \n",%t,in);
}

/*****************************************************************************/
```

Response should be: `"card output:  *IDN? = HEWLETT-PACKARD,TACH,0,B.01.00"`

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Chapter 2
Using the CENC-TAC8 Tachometer Module

Chapter Contents

This chapter includes the following sections:

Using Compiled SCPI..... 2-1
FIFO Operation 2-2
Triggering 2-3
Error Checking 2-3
Using the Status System 2-4
C-SCPI Programming Examples..... 2-8

Using Compiled SCPI

Compiled SCPI (C-SCPI) is a productivity tool designed to take advantage of the high throughput rates of register-based VXI instrumentation while allowing the ease of use, readability, and standardization of the SCPI language.

The C-SCPI preprocessor that runs prior to the C compiler substitutes the SCPI syntax within users' code with low-level C function calls. These function calls effectively perform the actions specified by the SCPI commands.

Because the Tachometer Module works with Compiled SCPI, the SCPI interface is supported only in environments that provide the C-SCPI driver. The C compiler for the HP E1499A (V382) slot 0 controller provides a C-SCPI driver for the Tachometer Module. If the user chooses not to use SCPI for some reason (perhaps SCPI is not supported in the user's environment), then register programming and the low-level commands may be used to program the Tachometer Module.

This chapter assumes that the user programs the Tachometer Module with SCPI commands.

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FIFO Operation

For more information on FIFO data, refer to Chapter 5, "Register-Based Programming."

To access the contents of the FIFO, use the following SCPI commands.

[SENSe]:DATA:FIFO[:ALL]?
[SENSe]:DATA:FIFO:CHANnels <*enable*>,<*ch_lst*>
[SENSe]:DATA:FIFO:CHANnels? <*channel*>
[SENSe]:DATA:FIFO:COUNt:HALF?
[SENSe]:DATA:FIFO:COUNt?
[SENSe]:DATA:FIFO:HALF?
[SENSe]:DATA:FIFO:PART? <*n*>
[SENSe]:DATA:FIFO:RESet

Refer to Chapter 4, "Command Reference," for documentation on the above SCPI commands.

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Triggering

The TRIGger subsystem is used to initiate measurements and to synchronize the Tachometer Module's actions (measurement data acquisition) with outside events. The following SCPI commands are used to access the trigger system. Refer to Chapter 4, "Command Reference," for more information.

```
TRIGger[:IMMediate]
TRIGger:SOURce <srce>
TRIGger:SOURce?
```

Error Checking

Errors may be reported from several different sources. Within the SCPI environment, SYSTem:ERRor? (refer to Chapter 4) provides information specific to the SCPI commands and their parameters, if any. The SCPI STATus subsystem (described in the next chapter) also provides some error reporting and contains operating and error conditions specific to the Tachometer Module. The Common command, *TST? (refer to Chapter 4), lists any and all errors specific to the Tachometer Module.

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Using the Status System

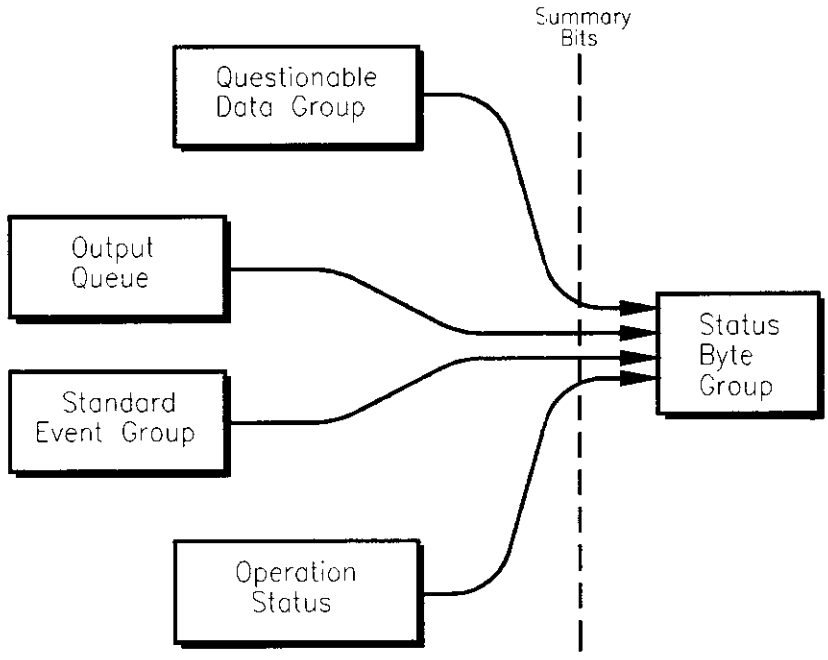
The status system records various instrument conditions and some errors in these four register groups.

Standard Event Group reports that power-on has been detected, command errors, and when an operation is complete (*OPC command). This group is controlled using IEEE-488.2 Common Commands. See the "IEEE-488.2 Common Command Reference" in Chapter 4 of this manual.

Operation Status Group reports on operations in progress or completed. These operations are: measurement complete, and FIFO buffer half full. This group is controlled using SCPI commands in the STATus subsystem.

Questionable Data Group reports conditions that may harm data. These conditions are: measurement error, trigger too fast, and FIFO buffer full. This group is controlled by STATus subsystem SCPI commands.

Status Byte Group records high-level summary information reported by the other register groups and when data is available in the module's output buffer. This group is controlled using IEEE-488.2 Common commands. See the "IEEE-488.2 Common Command Reference" in Chapter 4 of this manual.



Status Register Group

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Status Group Registers
Each status group is composed of a number of different registers. These are the Condition, Event, and Enable registers.

Condition Register
The Standard Event, Operation Status, and Questionable Data Groups have condition registers. The condition register continuously monitors events that can be reported by a status group. There is no latching or buffering for this register; it is updated in real time. Condition registers are read-only. The condition registers for the operation status and questionable data groups are accessed by SCPI commands. For example, to read the Operation Status Condition register:

```
STAT:OPER:COND?
```

NOTE: The condition register for the standard event group cannot be accessed directly. You must instead access the standard event group's event register by using *ESR?.

Event Register
The Standard Event, Operation Status, and Questionable Data Groups have event registers. An event register is a read-only register that latches transition events from the condition register. Since the bits in the event register are latched, once they are set they remain set until cleared by a query (such as (*ESR? or STAT:QUES:EVEN?) or the *CLS command. There is no buffering, so while an event bit is set, subsequent events corresponding to that bit are ignored. Event registers are read only. Querying an event register returns a decimal value which corresponds to the binary-weighted sum of all bits set in the register.

Enable Register
All status groups contain enable registers. The enable register specifies which bits in the event register can generate a summary bit. The module logically ANDs corresponding bits in the event and enable registers, and ORs all the resulting bits to obtain a summary bit. Summary bits are in turn recorded in the Status Byte Summary Register. Enable registers are both readable and writable. Querying an enable register does not clear it. The *CLS (clear status) command does not clear enable registers but it does clear the bits in the event registers. The STATus:PRESet command clears the Questionable Data Enable Register. To enable bits in an enable register, you must write a decimal value which corresponds to the binary-weighted sum of the bits you wish to enable in the register.

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The Standard Event Group

The Standard Event Group reports the following types of instrument events.

- power-on detected
- command syntax errors
- command execution errors
- self-test errors
- when an operation is complete and the *OPC command has been executed

When enabled, any or all of these events can be reported in the Standard Event Status Byte Bit (bit 5 of the Status Byte). To set the enable register mask, set the decimally weighted sum of the bits you want to enable using the *ESE (event status enable).

NOTE: An error condition (standard event register bits 2, 3, 4, or 5) will always record one or more errors in the module's error queue. Read the error queue using SYSTem:ERRor? command.

The Standard Event Register is cleared when:

- You send a *CLS (clear status) command.
- You query the event register using the *ESR? (event status register) command.

The Standard Event Enable Register is cleared when you execute an *ESE 0 command.

The Operation Status Group

The Operation Status Group reports operations that are in progress or have completed. These operations are: measurement complete, and FIFO buffer half full. This group is controlled using SCPI commands in the STATus subsystem.

When enabled, this information can be reported in the Operation Status Byte Bit (bit 7 in the Status Byte). To set the enable register mask, send the decimally weighted sum of the bits you want to enable using the STATus:OPERation:ENABle command.

The Operation Event Register is cleared when:

- You execute a *CLS (clear status) command.
- You query the event register using STATus:OPERation:EVENt?

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The Operation Enable Register is cleared when:

- You turn on the power.
- You execute the STATus:PRESet command.
- You execute the STATus:OPERation:ENABLE 0 command.

The Questionable Data Group

The Questionable Data Group reports conditions that may adversely affect data. These conditions are: measurement error, trigger too fast, and FIFO buffer full.

When enabled, any or all of these events can be reported in the Questionable Data Status Byte (bit 3 of the Status Byte). To set the enable register mask, send the sum of the decimally weighted values of the bits you want to enable using the STATus:QUEStionable:ENABle command.

The Questionable Data Event Register is cleared when:

- You execute a *CLS (clear status) command.
- You query the event register using STATus:QUEStionable:EVENt?

The Questionable Data Enable Register is cleared when:

- You turn on the power.
- You execute the STATus:PRESet command.
- You execute the STATus:QUEStionable:ENABle 0 command.

The Status Byte Group

The Status Byte Group records high-level summary information reported by the other status groups. Query data that is waiting in the module's output buffer is immediately reported through the message available bit (bit 4). Bits in the Status Byte Summary Register are not latched. Clearing an event register clears the corresponding bits in the Status Byte Summary Register. Reading all messages in the output buffer, including any pending queries, clears the message available bit.

- The Status Byte Summary Register is cleared when you execute a *CLS (clear status) command.
- Clearing the Standard Event, Operation Status, or Questionable Data Groups clears their respective summary bits in the Status Byte Summary Register.
- The Status Byte Enable Register (Service Request Enable Register) is cleared when you execute a *SRE 0 command.

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C-SCPI Programming Examples

```
/*************************************************************************/
/* This program uses the Tachometer to take continuous readings using */
/* engineering units, signal conditioning and status information.     */
/*************************************************************************/

#include <stdio.h>
#include "cscpi.h"

        /* Defines the Tachometer Module's logical address */
#define LA_TA "8"

        /* Specifies the Tachometer Module as a register device */
INST_DECL( tach, "CENCt08", REGISTER);

        /* Prototype Functions */
void config (void);
void monitor (void);

main ()
{

              /* Start the register-based operating system */
   INST_STARTUP();

              /* Open the I/O path to the Tachometer Module */
   INST_OPEN(tach, "vxi," LA_TA);

              /* Check if the path is good */
   if ( !tach )
   {
      printf( "INST_OPEN failed (ladd = %s). %d\n", LA_TA, cscpi_open_error);
      exit(1);
   }

   config ();          /* Run function to configure the card          */
   monitor();          /* Run function to monitor measurements       */
}
```


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```
/*************************************************************************/
/* This function configures the card.  Channels are set differently.     */
/*************************************************************************/

void config (void)
{

    /* set up input characteristics                                      */
   INST_SEND(tach, "*RST;*CLS\n");
   INST_SEND(tach, "FORM REAL,32 \n" );
   INST_SEND(tach, "FUNC CUST, (@100,104) \n");
   INST_SEND(tach, "FUNC FREQ, (@101:103,105:107) \n");
   INST_SEND(tach, "DATA:FIFO:CHAN 1, (@100:107) \n");
   INST_SEND(tach, "INP:FILT:FREQ 1e4, (@100,101) \n");
   INST_SEND(tach, "INP:FILT:FREQ 1e5, (@102:107) \n");
   INST_SEND(tach, "SENS:EVEN:LEV 0.5, (@100:105) \n");
   INST_SEND(tach, "SENS:EVEN:LEV 0.01, (@106,107) \n");

    /* set up trigger characteristics for repetitive                     */
   INST_SEND(tach, "TRIG:SOUR IMM \n");

    /* define Engineering Units conversion for RPM                       */
   INST_SEND( tach, "MEM:TABL:SEL CHAN0 \n" );
   INST_SEND( tach, "MEM:TABL:DEF \"\",%d \n",2 );
   INST_SEND( tach, "MEM:TABL:FREQ 1200,12000 \n" );
   INST_SEND( tach, "MEM:TABL:EUN 20,200 \n" );

    /* define Engineering Units conversion for gallons per hour          */
   INST_SEND( tach, "MEM:TABL:SEL CHAN4 \n" );
   INST_SEND( tach, "MEM:TABL:DEF \"\",%d \n",2 );
   INST_SEND( tach, "MEM:TABL:FREQ 100,10000 \n" );
   INST_SEND( tach, "MEM:TABL:EUN 600,60000 \n" );

}
```


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```
/*************************************************************************/
/* This function monitors measurements for limit conditions.             */
/*************************************************************************/

void monitors (void)
{

   float32       cvt[8] ,fifo[1024];
   int16         count,data16,i;

    /* begin making measurements                                          */
   INST_SEND(tach, "INIT \n");

    /* see if the FIFO is half full                                      */
   INST_QUERY( tach, "STAT:OPER:COND? \n", "%hd",  &data16 );
   if ( data16 == 1024)  {

     /* get 256 readings                                                  */
     INST_QUERY(tach, "DATA:FIFO:HALF? \n", "%f", &fifo);

     /* look for certain limit conditions                                 */
     for (i = 0; i < 1024; i += 4)  {

       /* first, see if any channel has lost its signal                   */
       if (fifo[i + 1] < 10.0)  {
         printf ("channel %d has lost its signal \n", (int16) fifo[i]);

          /* terminate measurements
         INST_SEND(tach, "ABOR \n");
         goto monitor_exit;
       }        /* end of lost signal                                    */

       /* next, look at channel 4                                         */
       if ((int16) fifo[i] == 4)  {

         /* check the flow rate                                           */
        if (fifo[i + 1] < 100.0)  {
          printf ("Warning:  Flow has dropped to %f \n", fifo[i + 1]);
        }       */ end of low flow                                        */

       }         */ end of channel 4                                      */

       /* (continue this process for other channels)                      */

    }           */ end of for loop                                        */

  }             */ end of FIFO is half full                               */

monitor_exit:;
}               */ end of function                                        */

/*************************************************************************/
```


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Chapter 3
Theory of Operation

Chapter Contents

This chapter describes the basic operating principles of the CENC-TAC8 Tachometer Module, including:

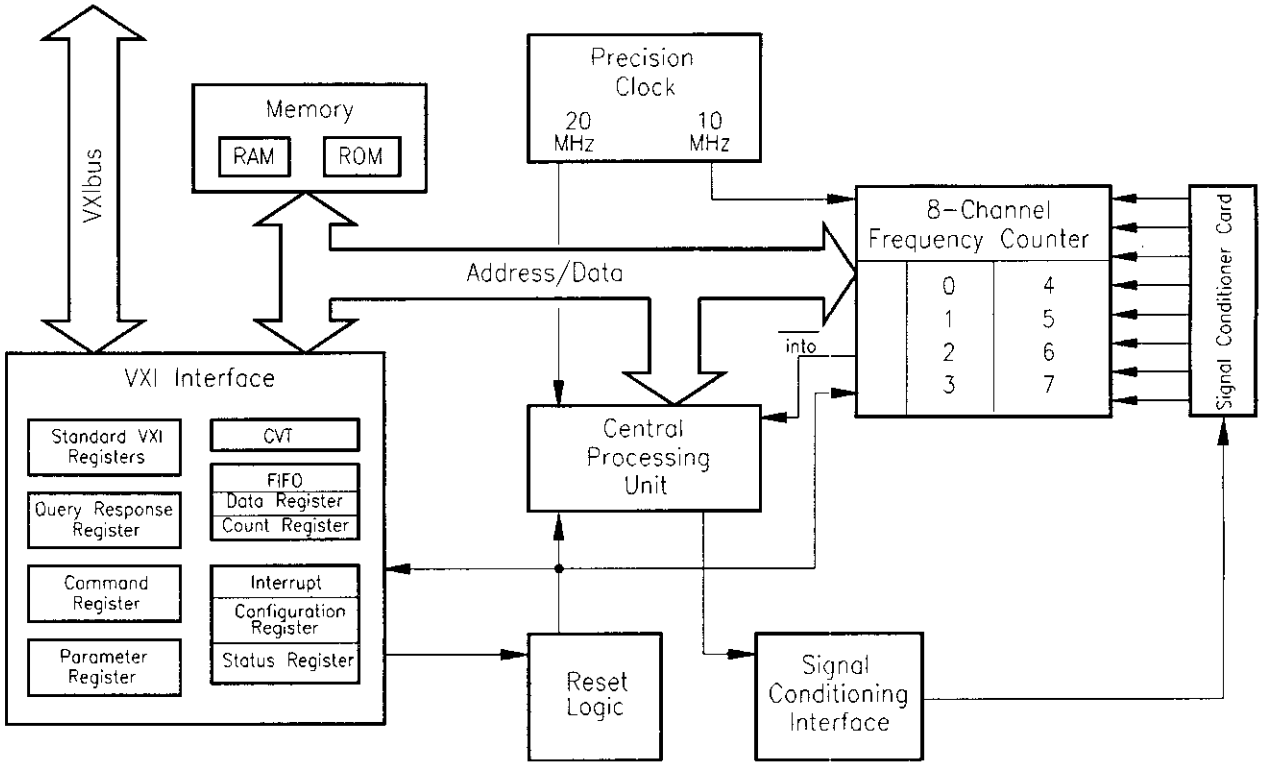
Hardware Overview 3-1
Signal Conditioning 3-3
VXI Interface 3-8
Frequency Measurement Methods 3-10

Hardware Overview

The Tachometer Module is a C-size VXI module that occupies a single slot in a VXI mainframe. The module incorporates two boards: a mother board and a daughter board. The daughter board is the analog signal conditioner, and the mother board contains the balance of the electronics including the registers, the counters, the clock, the input BNC connectors, and more.

The Tachometer Module Functional Block Diagram on the following page provides an architectural overview of the signal conditioning and digital logic incorporated into the Tachometer Module. Descriptions of the diagram components follow.

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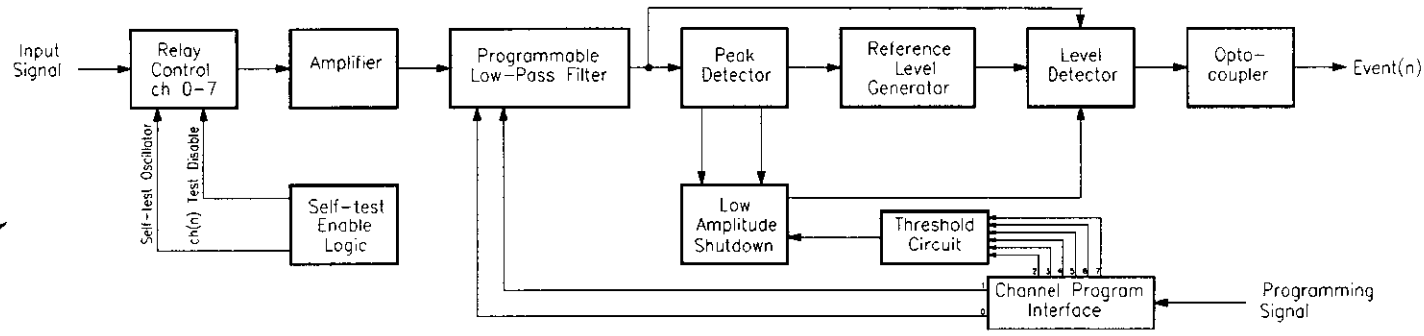


Tachometer Module Functional Block Diagram

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Signal Conditioning

The eight-channel signal conditioner accepts signals of 1 Hz to 100 kHz at a voltage range of 20 mVp to 200 Vp, either single-ended and ground-referenced or fully differential, and outputs a TTL-level signal at the same frequency. The signal conditioner is powered by eight DC-DC converters which receive 12 VDC from the mother board and provide ±15 VDC. Separate power supplies provide electrical isolation. Refer to the following illustration and the descriptive text for more information.



Signal Conditioner Functional Block Diagram

Input Signal Connection

The Tachometer Module receives signals on each of the eight channels through an isolated BNC connector on the mother board. Voltage surge protectors on both HI and LO lines protect the input circuitry from high voltage spikes.

WARNING: The BNC inner conductor is signal HI, and the shield is signal LO and floats with respect to chassis ground. For this reason, it is necessary to take precautions against electrical shock.

Self-Test Enable Logic and Relay Control

Each of the eight channels has a control relay that switches between the input signal from the BNC connector and the signal from the self-test oscillator on the mother board. When the relay is de-energized, the channel is enabled, and the BNC input signal continues through the signal conditioning electronics. When the relay is energized, the self-test oscillator is connected to the circuit, and the BNC signal input lines are opened.

The self-test enable command from the self-test logic causes the oscillator to send a signal to the signal conditioner. When the oscillator is not energized, the input relay provides a short circuit for the channel disable function.

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Amplification and Filtering
To allow for large input voltages, the input signals are attenuated through a voltage divider and clamped by parallel diodes to ± 0.7 V. The signal is then boosted by an instrumentation amplifier with a gain of 10. A programmable low-pass filter follows the amplifier. Its filter characteristics are 2 poles, 40 dB per decade, with -3 dB cutoffs at 1 kHz, 2 kHz, 10 kHz, or 100 kHz. The cutoff frequency is selected through the channel program interface.

Peak Detectors and Reference Level Generator
The peak detector sends the positive and negative voltage peaks to the reference level generator which then determines the low reference signal voltage and the high reference signal voltage. The reference signal voltage levels are then provided to the level detectors.

Level Detector
The level detector is a configuration of three voltage comparators. The first two compare the positive and negative halves of the signal to the positive and negative reference voltages, respectively. Their combined outputs are input into the third comparator whose configuration is such that both previous comparators must change state before the third comparator can change state. This feature, plus hysteresis at each comparator, eliminates false triggering.

The peak detectors and the reference levels have decay time constants of 0.5 seconds to accommodate frequencies down to 1 Hz. These time constants will not allow the peak detectors to follow a signal that rapidly decreases to less than 50% of its previous amplitude. The channel will stop counting until the peak detectors decay to levels within 200% of the signal's current peak-to-peak voltage.

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Low Amplitude Shutdown

The primary function of the low amplitude shutdown circuit is to eliminate the reading of low-level noise in the absence of a larger input signal. The low amplitude shutdown circuit receives the peak-to-peak voltage from the peak detector, and the threshold voltage from the threshold circuit. When the peak-to-peak voltage falls below the threshold, the positive reference voltage is set to -15 volts to shut down the channel.

The threshold voltage is set using the SCPI command [SENS]EVEN:LEV or the SENS low-level command. The relationship between input threshold voltage and the <*sens*> parameter of the SENS low-level command is shown in the graph on the following page. The table following the graph shows the actual values of the 64 points of the <*sens*> parameter. See page 4-45 for a description of the [SENS]EVEN:LEV command, and page 5-27 for a description of the SENS command.

There is a 10% tolerance band on the data in the graph and table to allow for component variance. The input waveform shape also has an effect. A 50% duty cycle square wave will be read as a slightly higher input voltage, whereas a low-duty cycle sine wave will read as a slightly lower input voltage. The low-pass filter selected will also attenuate the input signal, beginning at about 50% of the -3 dB frequency, and the input voltage must be increased by about +3 dB at 1 Hz. Therefore, if precise cutoff levels are required, some experimentation is necessary.

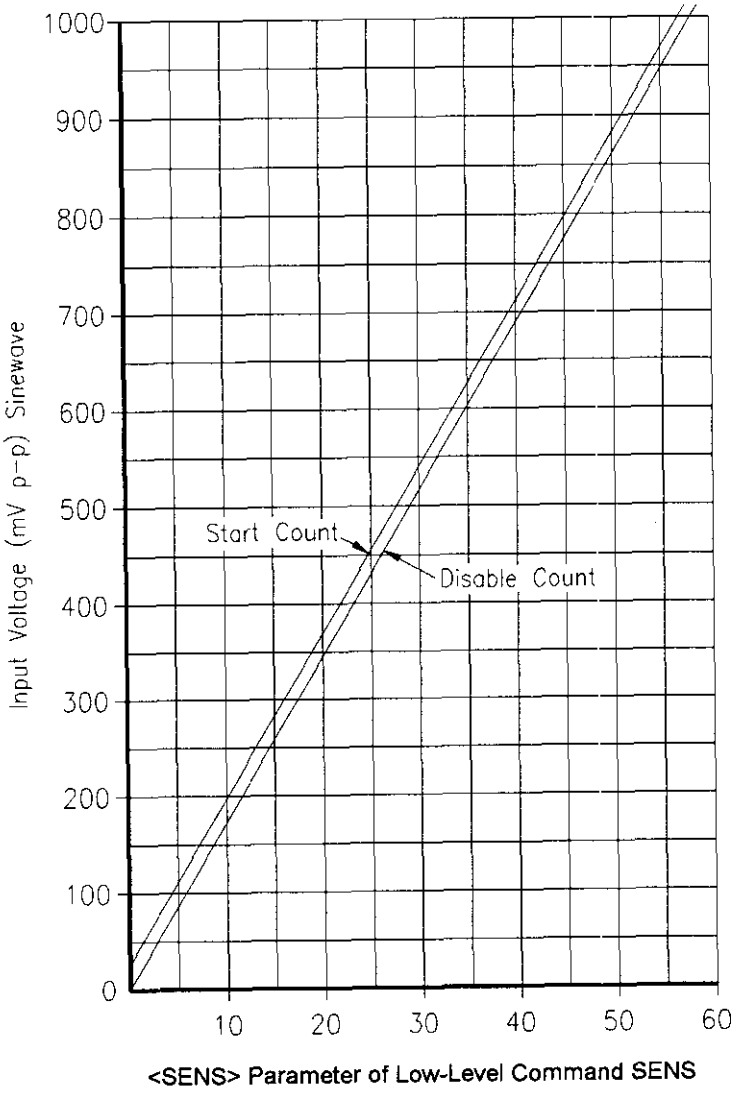
Channel Program Interface

Each channel's low-pass cutoff frequency and threshold voltage are individually programmable by the user. The processor on the mother board sends an 8-bit word to the channel program interface for each of the eight channels. The first two bits select the low-pass filter cutoff frequency, and the last six bits are input to the threshold circuit where a digital-to-analog converter generates the 0 - 9.84 VDC threshold voltage.

Opto-Coupler

The output from the level detector drives the opto-coupler whose function is to electrically isolate each channel's output from the mother board while providing a 5-V TTL-compatible output signal in response to its input signal.

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Low Amplitude Shutdown Graph

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Low Amplitude Shutdown Parameter Values					
<*sens*> parameter	start count	disable count	<*sens*> parameter	start count	disable count
0	<8	<8	32	568	554
1	31	20	33	585	571
2	48	37	34	602	588
3	65	45	35	619	605
4	82	71	36	636	622
5	99	88	37	653	639
6	116	105	38	670	656
7	136	122	39	687	673
8	153	139	40	707	693
9	170	158	41	724	710
10	189	175	42	741	727
11	206	192	43	758	744
12	223	209	44	775	761
13	240	226	45	792	778
14	257	243	46	809	775
15	274	260	47	826	812
16	291	277	48	843	829
17	308	294	49	860	846
18	328	311	50	880	865
19	345	331	51	897	882
20	362	348	52	914	899
21	379	365	53	931	916
22	396	382	54	948	933
23	413	399	55	964	950
24	430	416	56	981	967
25	447	433	57	998	984
26	464	450	58	1015	1001
27	481	467	59	1032	1018
28	498	484	60	1052	1035
29	515	501	61	1069	1052
30	535	520	62	1086	1069
31	552	537	63	1103	1089

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VXI Interface

The VXI interface consists of the following registers. The standard VXI registers include the ID register, the device-type register, the status register, and the control register. For more detailed information, refer to Chapter 5.

The **ID Register**, also called the logical address register, is a read-only register. The contents of this register should be: $FEE3_{16}$. This indicates the classification of the VXIbus device (register-based), the addressing mode of the Tachometer Module's registers (A16 only), and the manufacturer ID.

The **Device-Type Register** is a read-only register which indicates the model code: a unique module identifier which is defined by the manufacturer.

The **Status Register** is a read-only register that provides device-specific information to the system controller including how the module is selected, if an error condition exists, if data is in the FIFO, whether the module is ready or in initialization stage, the self-test status, if data is available, and if the module is ready for a command.

The **Control Register** is the write-only counterpart of the status register. It is used by the system controller to execute specific Tachometer Module functions. A resource manager lacking specific knowledge of a device always writes a 1 to each of the device-dependent bits of a device's control register. It indicates the FIFO status, the status of the SYSFAIL* line, and the status of the reset function.

Command Register and Parameter Register. Module commands are sent to the command register using the C-SCPI command language or low-level commands. Tachometer Module commands usually have parameters associated with them which must first be loaded into the FIFO Parameter Register prior to writing to the command register.

Query-Response Register. When the module receives a query command, the reply is sent to the query response register. Since the query response register implements a FIFO, all data returned by a query command may be read completely and directly from this register after the query response ready bit in the status register is asserted.

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Current Value Table. The CVT holds the most current reading for all eight channels. When a measurement is completed on a channel, the most significant and least significant words of an IEEE float are written to this register. This float represents either frequency data or engineering units data.

FIFO Data Register. Measurements are buffered by this register. The FIFO may hold up to 512 measurements. A channel number and a timestamp (measured from the last trigger) is applied to each measurement in the FIFO.

FIFO Count Register. An unsigned 16-bit integer in the FIFO count register specifies the number of 16-bit words in the FIFO data register. Each read of the FIFO data register decrements the FIFO count register.

Interrupt Configuration Register. This register selects the VXI interrupt level and the interrupt sources. It indicates the measurement error interrupt status, the trigger-too-fast situation interrupt status, the measurement-complete situation status, the FIFO-full situation status, the FIFO-half-full situation status, and the level on which the module interrupts.

Interrupt Status Register. The interrupt status register returns the state of all sources of an interrupt regardless of the state of the interrupt configuration register. There are two types of interrupts: level and strobed. Level interrupts persist from an interrupt source and require the host to service the interrupt through reads of the interrupt source. FIFO full and FIFO half full are level interrupts. Trigger too fast, measurement complete, and measurement error are strobed interrupts and do not persist. Strobed interrupts require the host to acknowledge the interrupt by writing a 1 to the appropriate bit in the interrupt status register. These bits indicate if there are more measurements than event counts, whether a trigger-too-fast condition has not occurred, whether the measurement has completed, and the FIFO status (either full or half full). Refer to the SCPI STATus command for access to the interrupt status register.

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Frequency Measurement Methods

Frequency measurement occurs through period averaging. A 16-bit counter, called the event counter, counts the number of input signal pulses during a given measurement. At the same time, a 32-bit counter accumulates the number of 10-MHz pulses. An averaged frequency measurement is computed by dividing the number of event pulses by the time taken for those pulses to occur. Except under special circumstances, measurements begin and end on the rising edge of the input pulse from the signal conditioning so that a whole number of signal periods are counted by the event counter.

The Tachometer Module provides three frequency measurement methods. The type of measurement method is specified on a per-channel basis.

1. **Constant Measurement Window**. APER time > 0.0
In this method, the user specifies the minimum measurement time. When the specified measurement time expires, the module waits for the next rising event edge before completing the measurement.

2. **Constant Event Count**. APER time < 0.0
The user specifies the number of events to count before completing the measurement.

3. **Autoranged Measurement**. APER time = 0.0
The module automatically specifies the number of events to count before completing the frequency measurement. From the input signal frequency, a terminal event count is computed to maximize a fast measurement rate and ensure a user-specified measurement resolution.

terminal event count = (user-specified autorange resolution) * (measured event count) % (measured timebase count) + 1

"%" is the modulo operator. Note that the user-specified autoranging resolution is defined in terms of 1 part in (user-specified autorange resolution). For example, if the user-specified autorange resolution is 100000, then the measurement resolution is 1 part in 100,000 plus the timebase resolution plus one timebase count.

For more information, refer to the [SENSe]:FREQuency:APERture SCPI command in Chapter 4, "Command Reference," and to the ASSIGN and ARANGERES low-level commands in Chapter 5, "Register-Based Programming."

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Chapter 4
Command Reference

Chapter Contents

This chapter describes the Standard Commands for Programmable Instruments (SCPI) and the IEEE-488.2 Common Commands that can be used with the Tachometer Module. This chapter contains the following sections.

IEEE-488.2 Common Command Format 4-2
SCPI Command Format 4-3
SCPI Command Quick Reference 4-9
SCPI Command Index 4-13
IEEE-488.2 Common Command Reference 4-63
SCPI Programming Examples 4-70

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IEEE-488.2 Common Command Format

The Tachometer Module conforms to the *IEEE Standard 488.1-1987 Standard Digital Interface for Programmable Instrumentation*, and the *IEEE 488.2-1987 Codes, Formats, and Common Commands for Use With IEEE Standard 488.1-1987*. The IEEE-488.2 standard defines the common commands that perform functions like reset, self-test, and status byte query. Like SCPI, these common commands help to reduce language semantics and syntax problems by defining the syntax, data structures, and query format between programmable instrumentation.

IEEE-488.2 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. The following IEEE-488 Common commands are documented at the end of this chapter.

*CLS	Clear Status
*ESE<*mask*>	Event Status Enable
*ESE?	Event Status Enable Query
*ESR?	Event Status Register Query
*IDN?	Identification Query
*OPC	Operation Complete
*OPC?	Operation Complete?
*RST	Reset
*SRE<*mask*>	Service Request Enable
*SRE?	Service Request Enable Query
*STB?	Read Status Byte Query
*TRG	Bus Trigger
*TST?	Self-Test Query
*WAI	Wait to Continue

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SCPI Command Format

Standard Commands for Programmable Instruments (SCPI) is a high-level ASCII-based instrumentation command language based on the basic concepts and standards presented by the previously mentioned IEEE documents. SCPI is intended to reduce program development time by providing a consistent programming environment for instrument control and data usage.

SCPI commands describe the signal being measured instead of the instrument that is measuring the signal This provides both horizontal and vertical consistency (also called compatibility). Vertical programming consistency provides common syntax within an instrument class. For example, the same SCPI commands are used for several different multimeters. Horizontal consistency allows the same commands to be used by a variety of instruments. SCPI also standardizes headers, mnemonics, and parameter formats of the commands.

Compiled SCPI (C-SCPI) is used with user-written C or C++ programs to achieve easy programming while maintaining high throughput with VXI register-based instruments. The SCPI command is embedded in a standard C-SCPI command in the user's C program. The C-SCPI preprocessor is run during the compile-link sequence to translate the C-SCPI commands into standard C source code. The C source code is compiled as usual and linked with a standard C library, the I/O library, and the SCPI instrument drivers library. The resulting source code communicates with the Tachometer Module at the register level for fast throughput.

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SCPI commands perform functions like configuring the module, transmitting data, querying instrument states, or retrieving data. The hierarchical SCPI command structure 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 SCPI subsystem.

```
STATus
        :OPERation
                :CONDition?
                :ENABle         <mask>
        :QUEStionable
                :CONDition?
                :ENABle         <mask>
```

STATus is the root command, :OPERation and :QUEStionable are second-level commands, and :CONDition and :ENABle are third-level commands. *<mask>* is a parameter.

Angle brackets (< >) are used to enclose parameter type names. Square brackets ([ ]) are used to enclose one or more parameters that are optional when controlling the instrument. Braces ({ }), or curly brackets, are used to enclose parameters that may be included zero or more times. The vertical bar (|) can be read as "or" and is used to separate alternative parameter options. Most commands have a query form which is indicated by the command header with a question mark appended (for example, FORM:DATA?).

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Compound Command Separator

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

STATus:OPERation:ENABle <*mask*>

The parameter <*mask*> is separated from the command by a space.

Abbreviated Commands

Most commands in this manual are shown as a mixture of upper- and lowercase letters. The uppercase letters indicate the abbreviated spelling for the command which allows for shorter program lines. Alternatively, the command can be spelled out to increase readability. Use either the abbreviated form or the entire command.

For example, if the command syntax shows STATus, then STAT and STATUS are both acceptable forms. Other abbreviations such as STATU will cause an error. The system is not case-sensitive: status or StAtUs and STATUS are all acceptable.

Implied Commands

Implied commands appear in square brackets ([command]) in the command syntax. The brackets are not actually part of the command, and they are not sent to the instrument.

FORMat
[:DATA] <*type*>[,<*length*>]

The second-level :DATA is an implied command. To set the data format, you can send either of the following command statements.

FORM:DATA or FORM

Parameter Types

The following table contains explanations and examples of parameter types that are used with the commands.

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Parameter Type	Explanation
numeric	Accepts all commonly used decimal representations of numbers including optional signs, decimal points, and scientific notation. NR1, NR2, and NR3 (numeric representations as defined in ANSI X3.42-1975[5]. See the following definitions for NR1, NR2, and NR3.
NR1	NR1 Numeric Response Data has the form ±<*digits*>. For example: 123, -123.
NR2	NR2 Numeric Response Data has the form ±<*digits*>.<*digits*>. For example: 0.123, 12.123.
NR3	NR3 Numeric Response Data has the form ±<*digits*>.<*digits*>E±<*digits*>. For example: 123E2, -1.23E2, 1.23000E-01
character data	Also referred to as string or structure string. 12 characters maximum, first character must be an alpha character, the character set is alpha-numeric (A - Z, 0 - 9) and includes the underscore.
discrete	Represents a single binary condition that is either true or false. (1 | 0 | ON | OFF) 1 = ON, 0 = OFF
channel list	Channel specifications for the Tachometer Module's 8 channels are as follows. 100 = channel 0 101 = channel 1 102 = channel 2 103 = channel 3 104 = channel 4 105 = channel 5 106 = channel 6 107 = channel 7 (@100) one channel (channel 0) (@100,102,107) three separate channels (@100:105) six channels, inclusive

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Optional Parameters

Parameters shown in square brackets ([ ]) are optional parameters. The brackets are not actually part of the parameter, and they are not sent to the instrument. If no value is specified for an optional parameter, a default value is used.

For example, the FORMat:DATA <*type*>[,<*length*>] can be sent without the <*length*> parameter. In that case, the system will use a default value for <*length*> which depends on which type parameter is specified.

Parameter Data and Returned Value Types

The following table shows the allowable types and sizes of the parameter data to send to the module and query data returned by the module. Knowledge of the parameter type and returned value type are necessary for programming and are documented in each command in this chapter.

Data Types/Sizes	Description
int16	Signed 16-bit integer number.
int32	Signed 32-bit integer number.
uint16	Unsigned 16-bit integer number.
uint32	Unsigned 32-bit integer number.
float32	32-bit floating point number.
float64	64-bit float point number.
string	String of characters (null-terminated).

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Linking Commands

Linking is used to send more than one complete command in a single command statement. These commands will be executed in order when a program message terminator is encountered (a new line character, an EOI, or both). Combining commands increases programming efficiency, providing a more compact listing and faster execution.

To link IEEE-488.2 common commands with SCPI commands, use a semicolon (;)between the commands. For example:

```
*RST;*CLS  or  TRIG:SOUR IMM;*TRG
```

To link multiple complete SCPI commands, use both a semicolon and a colon between the commands. For example:

```
INIT;:TRIG
```

To link multiple SCPI commands at the same hierarchical level, use a semicolon to separate commands and omit higher-level commands from the header. For example:

```
    SENS:DATA:CVT? (@100)
+   SENS:DATA:FIFO:ALL?
=   SENS:DATA:CVT? (@100);FIFO:ALL?
```

Usage Examples

Note that the usage examples provided with the SCPI command descriptions work from the default state of the Tachometer Module.

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SCPI Command Quick Reference

Page	Command	Explanation
4-13	ABORt	Cancels the measurement in progress.
4-14	DIAGnostic:DEBug	Turns on and off the annunciation of debugging information.
4-15	DIAGnostic:DEBug?	Returns a number to indicate the state of the debug annunciation.
4-15	DIAGnostic:WDOG	Selects a value for the watchdog timeout timer to ensure that measurements complete when very low frequencies are anticipated.
4-16	DIAGnostic:WDOG?	Returns a number to indicate the value for the watchdog timeout timer.
4-18	FORMat[:DATA]	Chooses the type of data and the number of bits used for a transmission.
4-19	FORMat[:DATA]?	Returns the currently set data format.
4-21	INITiate:CONTinuous	Turns on and off the continuous trigger mode.
4-22	INITiate:CONTinuous?	Returns a number to indicate the state of the continuous trigger mode.
4-22	INITiate[:IMMediate]	Places the trigger system in the wait-for-trigger state.
4-23	INPut:FILTer[:LPASs]:FREQuency	Selects a value for the cutoff frequency used by the low-pass filters specified in the channel list.
4-24	INPut:FILTer[:LPASs]:FREQuency?	Returns a number to indicate the cutoff frequency of the filter for the specified channel.
4-25	INPut:FILTer[:LPASs][:STATe]	Does nothing since filters on the Tachometer Module are always enabled.
4-25	INPut:FILTer[:LPASs][:STATe]?	Returns a number to indicate the state of the filter for the specified channel.
4-26	MEMory:TABLe:DEFine	Allocates space for the currently selected conversion table and defines the structure of that table.
4-27	MEMory:TABLe:DEFine?	Returns the structure_string and size for the currently selected conversion table.
4-28	MEMory:TABLe:EUNits	Allows the specification of the data points in the engineering units column for the currently selected conversion table.
4-29	MEMory:TABLe:EUNits:POINts?	Returns the number of the data points in the Engineering Units column of the currently selected conversion table.

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SCPI Command Quick Reference (continued)

Page	Command	Explanation
4-29	MEMory:TABLe:EUNits?	Returns the values of the data points in the Engineering Units column of the currently selected conversion table.
4-31	MEMory:TABLe:FREQuency	Allows the specification of the data points in the FREQuency column for the currently selected conversion table.
4-32	MEMory:TABLe:FREQuency:POINts?	Returns the number of the data points in the FREQuency column of the currently selected conversion table.
4-32	MEMory:TABLe:FREQuency?	Returns the values of the data points in the FREQuency column of the currently selected conversion table.
4-33	MEMory:TABLe:SELect	Determines which conversion table is currently selected.
4-34	MEMory:TABLe:SELect?	Returns which conversion table is currently selected.
4-35	[SENSe]:DATA:CVTable?	Returns from the Current Value Table the most recently measured values for the channels specified by the channel list when FUNCtion is CUSTom or FREQuency.
4-36	[SENSe]:DATA:CVTable:CHANnels	Specifies which channels are to be sent to the Current Value Table based on the channel list.
4-37	[SENSe]:DATA:CVTable:CHANnels?	Returns a number to indicate the CVT enable state for the channel specified.
4-38	[SENSe]:DATA:CVTable:RESet	Resets (clears) the Current Value Table.
4-38	[SENSe]:DATA:FIFO[:ALL]?	Returns all readings that are in the FIFO Reading Buffer at the time this command is executed.
4-40	[SENSe]:DATA:FIFO:CHANnels	Specifies which channels are to be sent to the FIFO based on the channel list.
4-40	[SENSe]:DATA:FIFO:CHANnels?	Returns a number to indicate the FIFO enable state for the channel specified.
4-41	[SENSe]:DATA:FIFO:COUNt?	Returns the number of readings currently in the FIFO Reading Buffer.
4-41	[SENSe]:DATA:FIFO:HALF?	Returns 256 readings from the FIFO Reading Buffer if it is at least half full.
4-42	[SENSe]:DATA:FIFO:COUNt:HALF?	Used as a way to poll the FIFO for the half-full condition.
4-43	[SENSe]:DATA:FIFO:PART?	Returns *n* readings from the FIFO Reading Buffer.
4-44	[SENSe]:DATA:FIFO:RESet	Resets the FIFO Reading Buffer.

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SCPI Command Quick Reference (continued)

Page	Command	Explanation
4-45	[SENSe]:EVENt:LEVel	Sets the peak-to-peak threshold voltage level at which the event occurs for the channels specified by the channel list.
4-45	[SENSe]:EVENt:LEVel?	Returns the peak-to-peak threshold voltage level at which the event occurs for the channel specified.
4-46	[SENSe]:FREQuency:APERture	Sets the aperture time or window length on frequency measurements for the channels specified by the channel list.
4-47	[SENSe]:FREQuency:APERture?	Returns the aperture time or window length for the channel specified.
4-48	[SENSe]:FUNCtion	Selects the measurement function for the Tachometer Module for the channels specified by the channel list.
4-49	[SENSe]:FUNCtion?	Returns the measurement function for the Tachometer Module for the channel specified.
4-53	STATus:OPERation:CONDition?	Returns the value of the Operation Condition register for the Tachometer Module.
4-54	STATus:OPERation:ENABle	Sets the Operation Enable mask which allows the true conditions in the Operation Event register to be reported in the summary bit.
4-54	STATus:OPERation:ENABle?	Returns the value of the Operation Enable mask to the output buffer.
4-55	STATus:OPERation[:EVENt]?	Returns the contents of the Operation Event register to the output buffer.
4-55	STATus:PRESet	Clears the Operation Enable register and the Questionable Enable register.
4-56	STATus:QUEStionable:CONDition?	Returns the value of the Questionable Condition register for the Tachometer Module.
4-56	STATus:QUEStionable:ENABle	Sets the Questionable Enable mask which allows the true conditions in the Questionable Event register to be reported in the summary bit.
4-57	STATus:QUEStionable:ENABle?	Returns the value of the Questionable Enable mask to the output buffer.
4-57	STATus:QUEStionable[:EVENt]?	Returns the contents of the Questionable Event register to the output buffer.
4-58	SYSTem:ERRor?	Returns the oldest error message that is in the error queue.
4-58	SYSTem:VERSion?	Returns the version of SCPI with which the Tachometer Module complies.

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SCPI Command Quick Reference (continued)

Page	Command	Explanation
4-59	TRIGger[:IMMediate]	Causes the Tachometer Module to begin a measurement sequence if the TRIGger:SOURce is either BUS or HOLD.
4-60	TRIGger:SOURce	Configures the trigger system to respond to a specified source.
4-60	TRIGger:SOURce?	Returns the current setting for the trigger system source.
4-61	VXI:REGister:READ?	Returns the contents of the specified 16-bit register which is at the currently selected logical address.
4-62	VXI:REGister:WRITe	Writes the data to the specified 16-bit register which is at the currently selected logical address.

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ABORt

ABORt is used to cancel the measurement in progress. It places the Tachometer Module in an idle state and aborts any readings that were being taken. ABORt is part of the trigger system. It performs the opposite function of the INITiate command. INITiate enables measurements; ABORt disables measurements by resetting the module from the wait-for-trigger state to the idle state.

Subsystem Syntax ABORt

Comments

- The Tachometer Module stops measurements immediately, cancelling the result of the previous INITiate command.
- ABORt does not affect any other settings. When the INITiate command is sent, the Tachometer Module will respond exactly as it did before the ABORt command was sent.
- If INITiate:CONTinuous is ON, the trigger system will immediately return to the wait-for-trigger state. If the trigger source is TRIGger:SOURce IMMediate, the Tachometer Module begins making measurements again.
- To guarantee measurement termination, first send the INITiate:CONTinuous OFF command, then send ABORt.
- This command does not have a query form.

Usage Example

```
ABORT
```

If the Tachometer Module has been INITiated, it goes to idle state.

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The DIAGnostic subsystem provides maintenance capabilities and specialized commands that are unique to this instrument.

Subsystem Syntax

```
DIAGnostic
    DEBug    <enable>
    DEBug?
    WDOG     <value>
    WDOG?
```

DIAGnostic:DEBug

The **DIAGnostic:DEBug** command turns on and off the annunciation of debugging information.

Parameters The following table defines the parameters for this command.

Parameter Name	Parameter Type	Range of Values	Default Value	Default Units
<enable>	discrete	0 | 1 | OFF | ON	OFF	none

Comments

- This command is not expected to be used during normal operation.
- Debugging information is annunciated via the 'printf' function and will work only for the C-SCPI version of the driver.
- *RST Condition: DIAGnostic:DEBug is set to OFF.

Usage Example DIAG:DEB OFF disables the debug annunciation.

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DIAGnostic:DEBug?

The **DIAGnostic:DEBug?** command returns a number to indicate the state of the debug annunciation.

Comments

- Returned Value: A `1` is returned if the state is ON, and a `0` is returned if it is OFF. The C-SCPI type is int16.

Usage Example

DIAG:DEB? returns `0` or `1`.

DIAGnostic:WDOG

The **DIAGnostic:WDOG** command selects a value for the watchdog timeout timer to ensure that measurements complete when very low frequencies are anticipated.

Parameters

The following table defines the parameters for this command.

Parameter Name	Parameter Type	Range of Values	Default Value	Default Units
<value>	numeric	1.0 to 210.0 | DEFault | MINimum | MAXimum	10.0	seconds

Comments

- The watchdog timeout timer prevents the Tachometer Module from waiting forever in cases where the input frequency is 0.
- When the input frequency is at or near 0, it will take one or two watchdog periods to complete a measurement.
- The range of values allowed is 1.0 to 210.0, values outside this range will cause an error -222, "Data out of range".
- More information on the watchdog timeout timer can be found in Chapter 5 in the section on low-level commands.
- *RST Condition: the timer is set to 10.0 seconds.

Usage Example

DIAG:WDOG MIN causes the Tachometer Module to have the quickest response when no transition events have occurred.

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DIAGnostic:WDOG?

The **DIAGnostic:WDOG?** command returns a number to indicate the value for the watchdog timeout timer.

Comments

- The return value is the watchdog timeout in seconds as a 32-bit floating-point number. The output buffer will contain the present value if neither MAXimum or MINimum is specified.
- The output buffer will contain 1.0 if MINimum is specified regardless of the present value.
- The output buffer will contain 210.0 if MAXimum is specified regardless of the present value.

Usage Example

DIAG:WDOG	allows the Tachometer Module to wait at least 5 seconds for an event.
DIAG:WDOG?	returns `4.993844E+000`.

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The FORMat subsystem sets the format for data transferred from the Tachometer Module to the computer when using the following commands.

MEM:TABL:EUN?
MEM:TABL:FREQ?
[SENSe]:DATA:CVTable?
[SENSe]:DATA:FIFO[:ALL]?
[SENSe]:DATA:FIFO:HALF?
[SENSe]:DATA:FIFO:PART?

Subsystem Syntax

FORMat
[:DATA] <*type*>[,<*length*>]
[:DATA]?

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The **FORMat[:DATA]** command chooses the type of data and the number of bits used for a transmission.

Parameters The following table defines the parameters for this command.

Parameter Name	Parameter Type	Range of Values	Default Value	Default Units
<type>	discrete	ASCII | INTeger | REAL	ASCii	none
<length>	numeric	7 | 32 | 64	none	none

Comments

- When *<type>* is ASCII and *<length>* is not sent, the length defaults to 7.
- When *<type>* is ASCII and *<length>* is sent, the length must be 7 or it will generate an error -224, "illegal parameter".
- ASCII readings are sent using ASCII bytes in NR3 format.
- When *<type>* is REAL, *<length>* can be either 32 or 64. The default is 64.
- REAL readings are sent as floating-point numbers using a definite-length block.
- *RST Condition: ASCII

Usage Example

FORM REAL,64	the format is set to REAL,64.
DATA:FIFO?	returns readings from the FIFO using 8 bytes each.

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FORMat[:DATA]?

The **FORMat[:DATA]?** command returns the current data format.

Comments The returned value consists of a string for <*type*> followed by an 16-bit integer in the IEEE NR1 format for <*length*>. The returned value will be one of the following.

- `ASC,7`
- `REAL,32`
- `REAL,64`

Usage Example

FORM REAL	sets the format to REAL,64.
FORM?	returns `REAL,64`.

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The INITiate subsystem places the Tachometer Module trigger system in a wait-for-trigger state.

Subsystem Syntax

```
INITiate
    :CONTinuous <enable>
    :CONTinuous?
    [:IMMediate]
```


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INITiate:CONTinuous

The **INITiate:CONTinuous** command turns on and off the CONTinuous trigger mode. ON moves the trigger system from the idle state to the wait-for-trigger state. OFF cancels the CONTinuous trigger mode and returns the card to the idle state after the current measurement has been completed.

Parameters The following table defines the parameters for this command.

Parameter Name	Parameter Type	Range of Values	Default Value	Default Units
<enable>	discrete	0 | 1 | OFF | ON	OFF	none

Comments

- ABORt places the Tachometer Module in the idle state and terminates any measurement. If INITiate:CONTinuous is ON, the trigger system will immediately return to the wait-for-trigger state. If the trigger source is TRIGger:SOURce IMMediate, the Tachometer Module begins making measurements again.
- Sending INITiate:CONTinuous ON while the card is in the wait-for-trigger state (already initiated) will cause an error -213, "Init ignored".
- To guarantee measurement termination, first send INITiate:CONTinuous OFF, then send ABORt.
- *RST Condition: INITiate:CONTinuous is set to OFF.

Usage Example

INIT:CONT ON	enables the CONTinuous trigger mode.
TRIG	triggers the module and puts the first reading into the selected destination.
TRIG	triggers the module and puts the second reading into the selected destination.
INIT:CONT:OFF	disables the CONTinuous trigger mode.
ABOR	resets the trigger system and terminates the measurement.

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INITiate:CONTinuous?

The **INITiate:CONTinuous?** command returns a number to indicate the state of the CONTinuous trigger mode.

Comments

- Returned Value: A 1 is returned if the state is ON, and a 0 is returned if it is OFF. The C-SCPI type is int16.

Usage Example

INIT:CONT OFF	disables the CONTinuous trigger mode on channel 0.
INIT:CONT?	returns 0.

INITiate[:IMMediate]

The **INITiate[:IMMediate]** command places the Tachometer Module in the wait-for-trigger state. When a trigger is received, the Tachometer Module begins making measurements.

Comments

- INITiate[:IMMediate] clears the FIFO and the Current Value Table.
- ABORt places the Tachometer Module in the idle state and terminates any measurements in progress.
- If the trigger source is immediate (TRIGger:SOURce IMMediate), the Tachometer Module begins making measurements as soon as the INITiate[:IMMediate] command is executed.
- Sending a trigger before the card has been initiated will cause error -211, "Trigger ignored".
- Sending INITiate[:IMMediate] while the module is in the wait-for-trigger state (already initiated) will cause error -213, "Init ignored".
- *RST Condition: the Tachometer Module is set to the idle state.

Usage Example

TRIG:SOUR:HOLD	suspends triggering.
INIT	move to the wait-for-trigger state.
TRIG	triggers the card and puts the reading into the selected destination.

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The INPut subsystem controls the parameters for the low-pass filters which are used by the signal measurement connections.

Subsystem Syntax

```
INPut
    :FILTer
        [:LPASs]
            :FREQuency    <value>,<ch_lst>
            :FREQuency?   [MAXimum|MINimum,]<channel>
            [:STATe]      <enable>,<ch_lst>
            [:STATe]?     <channel>
```

INPut:FILTer[:LPASs]:FREQuency

The **INPut:FILTer[:LPASs]:FREQuency** command selects a value for the cutoff frequency used by the low-pass filters specified in the channel list.

Parameters The following table defines the parameters for this command.

Parameter Name	Parameter Type	Range of Values	Default Value	Default Units
<value>	numeric string	1E3|2E3|1E4|1E5|DEFault| MINimum|MAXimum	1E5	hertz
<ch_lst>	string	100 to 107	none	none

Comments

- There is a separate filter for each of the 8 channels.
- More than 1 channel at a time can be set to a given frequency.
- The filters have discrete cutoff frequencies and will be set to the one closest to *<value>*.
- Sending a value greater than two times the highest cutoff frequency or less than one half the lowest cutoff frequency will cause error -222, "Data out of range".
- *RST Condition: set to MAX.

Example

```
INP:FILT:FREQ 8000,(@100:103)
```

Sets the filters on the first four channels to 10 kHz.

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INPut:FILTer[:LPASs]:FREQuency?

The **INPut:FILTer[:LPASs]:FREQuency?** command returns a number to indicate the cutoff frequency of the filter for the specified channel.

Parameters The following table defines the parameters for this command.

Parameter Name	Parameter Type	Range of Values	Default Value	Default Units
<channel>	string	100 to 107	none	none

Comments

- *<channel>* allows only a single channel.
- The return value is the filter frequency in Hertz which is a 32-bit floating-point number. The output buffer will contain one of the following: 1E3|2E3|1E4|1E5, and will be the present value for this channel if neither MAXimum nor MINimum is specified.
- The output buffer will contain 1E3 if MINimum is specified regardless of the present value.
- The output buffer will contain 1E5 if MAXimum is specified regardless of the present value.

Example

```
INP:FILT:FREQ 2000,(@100)      sets the filter on channel 0 to 2 kHz.

INP:FILT:FREQ? (@100)          returns 2.000000E+003.
```


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INPut:FILTer[:LPASs][:STATe]

The **INPut:FILTer[:LPASs][:STATe]** command is provided because it is required by the language. It does nothing since filters on the Tachometer Module are always enabled.

Parameters The following table defines the parameters for this command.

Parameter Name	Parameter Type	Range of Values	Default Value	Default Units
<enable>	discrete	1 | ON	ON	none
<ch_lst>	string	100 to 107	none	none

Comment

- The Tachometer Module hardware is not capable of disabling filters.
- Sending INPut:FILTer[:LPASs][:STATe] OFF|0 will cause error -224, "Illegal parameter value".
- *RST Condition: all filters are set to ON.

INPut:FILTer[:LPASs][:STATe]?

The **INPut:FILTer[:LPASs][:STATe]?** command returns a number to indicate the state of the filter for the specified channel. The filters on the Tachometer Module are always enabled.

Parameters The following table defines the parameters for this command.

Parameter Name	Parameter Type	Range of Values	Default Value	Default Units
<channel>	string	100 to 107	none	none

Comments

- *<channel>* allows only a single channel.
- Returned Value: A 1 is returned to indicate the state is ON. The C-SCPI type is int16.

Example INP:FILT? (@107) returns 1 for channel 7.

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The MEMory subsystem defines and selects tables in instrument memory. The tables, used for engineering units conversion, consist of two columns: FREQuency and EUNits. The FREQuency column contains input values, and the EUNits column contains conversion output values. Table entries occur in pairs consisting of input and output values. Conversion is done by linear interpolation between two points in a table and linear extrapolation outside these points.

Conversion tables are used only for channels whose FUNCtions are CUSTom. Because of this, there is coupling between the MEMory subsystem and the [SENSe]:FUNCtion command. Any tables will be erased when the FUNCtion for those channels is changed to something other than CUSTom. Also, most MEMory subsystem commands are allowed only for channels whose FUNCtions are CUSTom.

Subsystem Syntax

```
MEMory
    :TABLe
        :DEFine      <structure_string>[,<size>]
        :DEFine?
        :EUNits      <value>{,<value>}
            :POINts?
        :EUNits?
        :FREQuency   <value>{,<value>}
            :POINts?
        :FREQuency?
        :SELect      <name>
        :SELect?
```

MEMory:TABLe:DEFine

The **MEMory:TABLe:DEFine** command will allocate space for the currently selected conversion table and define the structure of that table.

Parameters The following table defines the parameters for this command.

Parameter Name	Parameter Type	Range of Values	Default Value	Default Units
<structure_string>	string	"FREQuency, EUNits" | ""	none	none
<size>	numeric	2 to 128	2	none

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Comments

- A separate conversion table is used for each channel.
- Before a table is DEFined, it must first be SELected.
- [SENSe]:FUNCtion for the currently selected channel must be CUSTom to use this command otherwise an error -221, "Settings conflict" will be issued. If a table has been DEFined and the currently selected channel has its FUNCtion changed to something other than CUSTom, the table will be erased.
- The only values allowed for <*structure_string*> are FREQuency, EUNits, their short forms, or the null string. Other values will cause error -224, "Illegal parameter value".
- <*size*> is the number of the data points in conversion table. The range of values allowed is 2 to 128, values outside this range will cause error -222, "Data out of range".
- Each table data point takes 8 bytes. If there is insufficient internal storage, it will cause an error -225, "Out of memory".
- *RST Condition: "FREQ,EUN",+2.

Usage Example

MEM:TABL:SEL CHAN0	selects the conversion table for channel 0.
MEM:TABL:DEF "",20	defines a table with 20 points.

MEMory:TABLe:DEFine?

The **MEMory:TABLe:DEFine?** command returns the structure_string and size for the currently selected conversion table.

Comments

- Before a table definition is queried, be sure that the correct table has been SELected.
- [SENSe]:FUNCtion for the currently selected channel must be CUSTom to use this command, otherwise an error -221, "Settings conflict" will be issued. If a table has been DEFined and the currently selected channel has its FUNCtion changed to something other than CUSTom, the table will be erased.
- The query return value consists of a string for <*structure_string*> (always FREQ,EUN) followed by a 16-bit integer in the IEEE NR1 format for <*size*>.

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Usage Example

MEM:TABL:SEL CHAN2	selects the conversion table for channel 2.
MEM:TABL:DEF "FREQ,EUN",40	defines a table with 40 points.
MEM:TABL:DEF?	returns "FREQ,EUN" +40.

MEMory:TABLe:EUNits

The **MEMory:TABLe:EUNits** command allows the specification of the data points in the Engineering Units column for the currently selected conversion table.

Parameters The following table defines the parameters for this command.

Parameter Name	Parameter Type	Range of Values	Default Value	Default Units
<value>	numeric	any	none	none

Comments

- A separate conversion table is used for each channel.
- Before the data points are specified, a table must first be DEFined.
- Before a table is DEFined, it must first be SELected.
- [SENSe]:FUNCtion for the currently selected channel must be CUSTom to use this command, otherwise an error -221, "Settings conflict" will be issued. If a table has been DEFined and the currently selected channel has its FUNCtion changed to something other than CUSTom, the table will be erased.
- Values for the data points are entered sequentially in table-ascending order as a comma-separated list of numbers.
- The number of values entered should be equal to *<size>* specified in MEMory:TABLe:DEFine. If the number of values entered is less than *<size>*, error -226, "Lists not same length" will be issued. If the number of values entered is more than *<size>*, error -223, "Too much data" will be issued.
- *RST Condition: 2.0, 2.0.

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Example

MEM:TABL:SEL CHAN0	selects table 0.
MEM:TABL:DEF "FREQ,EUN",6	defines a table with 6 points.
MEM:TABL:EUN 5,6,7,8,9,10	enters 6 engineering units points.

MEMory:TABLe:EUNits:POINts?

The **MEMory:TABLe:EUNits:POINts?** command returns the number of the data points in the Engineering Units column of the currently selected conversion table.

Comments

- Before the number of data points is queried, be sure that the correct table has been SELected.
- [SENSe]:FUNCtion for the currently selected channel must be CUSTom to use this command, otherwise an error -221, "Settings conflict" will be issued. If a table has been DEFined and the currently selected channel has its FUNCtion changed to something other than CUSTom, the table will be erased.
- The return value is a 16-bit integer in the IEEE NR1 format.
- *RST Condition: +2.

Example

MEM:TABL:SEL CHAN1	selects the conversion table for channel 1.
MEM:TABL:DEF "FREQ,EUN",10	defines a table with 10 points.
MEM:TABL:EUN:POIN?	returns `+10`.

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MEMory:TABLe:EUNits?

The **MEMory:TABLe:EUNits?** command returns the values of the data points in the Engineering Units column of the currently selected table.

Comments

- Before the data points are queried, be sure that the correct table has been SELected.
- [SENSe]:FUNCtion for the currently selected channel must be CUSTom to use this command, otherwise an error -221, "Settings conflict" will be issued. If a table has been DEFined and the currently selected channel has its FUNCtion changed to something other than CUSTom, the table will be erased.
- Values for the data points are returned sequentially in table-ascending order as a comma-separated list of 32-bit floating-point numbers.

  The format of the numbers is set by the FORMat command. ASCII formatted values will be returned in a comma-separated list, REAL formatted values will be returned in Definite Length Arbitrary Block form (see IEEE Std. 488.2 - 1987, section 8.7.9).

Usage Example

MEM:TABL:SEL CHAN7	selects table 7.
MEM:TABL:DEF "FREQ,EUN",3	defines a table with 3 points.
MEM:TABL:EUN 30,60,90	enters 3 engineering units points.
MEM:TABL:EUN?	returns `3.000000E+001, 6.000000E+001,9.000000E+001`

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MEMory:TABLe:FREQuency

The **MEMory:TABLe:FREQuency** command allows the specification of the data points in the FREQuency column for the currently selected conversion table.

Parameters The following table defines the parameters for this command.

Parameter Name	Parameter Type	Range of Values	Default Value	Default Units
<*value*>	numeric	2 to 1E5	none	none

Comments

- A separate conversion table is used for each channel.
- Before the data points are specified, a table must first be DEFined.
- Before a table is DEFined, it must first be SELected.
- [SENSe]:FUNCtion for the currently selected channel must be CUSTom to use this command, otherwise an error -221, "Settings conflict" will be issued. If a table has been DEFined and the currently selected channel has its FUNCtion changed to something other than CUSTom, the table will be erased.
- Values for the data points are entered sequentially in table-ascending order as a comma-separated list of numbers.
- The range of values allowed for FREQuency is 2 to 1E5, values outside this range will cause error -222, "Data out of range".

  Each succeeding value must be greater than the previous, otherwise it will cause error -222, "Data out of range".
- The number of values entered should be equal to <*size*> specified in MEMory:TABLe:DEFine. If the number of values entered is less than <*size*>, error -226, "Lists not same length" will be issued. If the number of values entered is more than <*size*>, error -223, "Too much data" will be issued.
- *RST Condition: 5.0E2, 2.0E5.

Usage Example

MEM:TABL:SEL CHAN6	selects table 6.
MEM:TABL:DEF "FREQ,EUN",5	defines a table with 5 points.
MEM:TABL:FREQ 2E0,2E1, 2E2,2E3,2E4	enters 5 frequency points.

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MEMory:TABLe:FREQuency:POINts?

The **MEMory:TABLe:FREQuency:POINts?** command returns the number of the data points in the FREQuency column of the currently selected conversion table.

Comments

- Before the number of data points is queried, be sure that the correct table has been SELected.
- [SENSe]:FUNCtion for the currently selected channel must be CUSTom to use this command, otherwise an error -221, "Settings conflict" will be issued. If a table has been DEFined and the currently selected channel has its FUNCtion changed to something other than CUSTom, the table will be erased.
- The return value is a 16-bit integer in the IEEE NR1 format.
- *RST Condition: +2.

Usage Example

MEM:TABL:SEL CHAN1	selects the conversion table for channel 1.
MEM:TABL:DEF "FREQ,EUN",10	defines a table with 10 points.
MEM:TABL:FREQ:POIN?	returns `+10`.

MEMory:TABLe:FREQuency?

The **MEMory:TABLe:FREQuency?** command returns the values of the data points in the FREQuency column of the currently selected conversion table.

Comments

- Before the data points are queried, be sure that the correct table has been SELected.
- [SENSe]:FUNCtion for the currently selected channel must be CUSTom to use this command, otherwise an error -221, "Settings conflict" will be issued. If a table has been DEFined and the currently selected channel has its FUNCtion changed to something other than CUSTom, the table will be erased.
- Values for the data points are returned sequentially in table-ascending order as a comma-separated list of 32-bit floating-point numbers.

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- The format of the numbers is set by the FORMat command. ASCII formatted values will be returned in a comma-separated list, REAL formatted values will be returned in Definite Length Arbitrary Block form (see *IEEE Std. 488.2 - 1987*, section 8.7.9).

Usage Example

MEM:TABL:SEL CHAN7	selects table 7.
MEM:TABL:DEF "FREQ EUN",3	defines a table with 3 points.
MEM:TABL:FREQ 1000,2000, 3000	enters 3 frequency points.
MEM:TABL:FREQ?	returns `1.000000E+003, 2.000000E+003, 3.000000E+003.`

MEMory:TABLe:SELect

The **MEMory:TABLe:SELect** command is used to determine which conversion table is currently selected.

Parameters The following table defines the parameters for this command.

Parameter Name	Parameter Type	Range of Values	Default Value	Default Units
<name>	discrete	CHAN0 to CHAN7	none	none

Comments

- A separate conversion table is used for each channel.
- Before a table is DEFined, is queried, or can accept data points, it must first be SELected.
- [SENSe]:FUNCtion for the currently selected channel must be CUSTom to use this command, otherwise an error -221, "Settings conflict" will be issued. If a table has been DEFined and the currently selected channel has its FUNCtion changed to something other than CUSTom, the table will be erased.
- The *<name>* of a table must be "CHAN" followed by its corresponding channel number. Values outside of this range will cause error -224, "Illegal parameter value".
- *RST Condition: CHAN0 is selected.

Usage Example

MEM:TABL:SEL CHAN4	SELects the conversion table for channel 4.

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MEMory:TABLe:SELect?

The **MEMory:TABLe:SELect?** command returns which conversion table is currently selected.

Comments

- Conversion tables are used only for channels whose FUNCtions are CUSTom. The currently selected table will have been erased if its FUNCtion has been changed to something other than CUSTom.
- The return value is a string containing "CHAN" followed by one of the numerals 0 to 7.

Usage Example

MEM:TABL:SEL CHAN5	SELects the conversion table for channel 5.
MEM:TABL:SEL?	returns CHAN5 .

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The SENSe subsystem is used to provide access to the Current Value Table and the FIFO Reading Buffer, to control the event voltage level, and set the measurement function.

Subsystem Syntax

```
[SENSe]
    :DATA
        :CVTable?       <ch_lst>
            :CHANnels   <enable>,<ch_lst>
            :CHANnels?          <channel>
            :RESet
        :FIFO
            [:ALL]?
            :CHANnels   <enable>,<ch_lst>
            :CHANnels?          <channel>
            :COUNt?
                :HALF?
            :HALF?
            :PART?      <n>
            :RESet
    :EVENt
        :LEVel          <voltage>,<ch_lst>
        :LEVel?         [MAXimum|MINimum,]<channel>
    FREQuency
        :APERture       <value>,<ch_lst>
        :APERture?      [MAXimum|MINimum,]<channel>
    :FUNCtion           <func>,<ch_lst>
    :FUNCtion?          <channel>
```

[SENSe]:DATA:CVTable?

The **[SENSe]:DATA:CVTable?** command returns from the Current Value Table the most recently measured values for the channels specified by the channel list when FUNCtion is CUSTom or FREQuency.

Parameters The following table defines the parameters for this command.

Parameter Name	Parameter Type	Range of Values	Default Value	Default Units
<ch_lst>	string	100 to 107	none	none

Comments

- The Current Value Table can be chosen as a data destination by [SENSe]:DATA:CVTable:CHANnels ON,*<ch_lst>*.
- The Current Value Table entries for channels that have not been measured will be IEEE "Not a Number" (+9.910000E+37).

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- The format of the numbers is set by the FORMat command. ACSII formatted values will be returned in a comma-separated list, REAL formatted values will be returned in Definite Length Arbitrary Block form (see IEEE Std. 488.2 - 1987, section 8.7.9).

- The Current Value Table cannot be chosen as a data destination when FUNCtion is TCOunts (for more detail see [SENSe]:FUNCtion).

- *RST Condition: the readings for all 8 entries are set to the IEEE "Not a Number" (+9.910000E+37).

Usage Example DATA:CVT? (@100) allows viewing current values for channel 0 even while a long measurement is in progress.

[SENSe]:DATA:CVTable:CHANnels

The **[SENSe]:DATA:CVTable:CHANnels** command specifies which channels are to be sent to the Current Value Table based on the channel list.

Parameters The following table defines the parameters for this command.

Parameter Name	Parameter Type	Range of Values	Default Value	Default Units
<enable>	discrete	0|1|OFF|ON	OFF	none
<ch_lst>	string	100 to 107	none	none

Comments

- The Current Value Table can be chosen as a data destination by [SENSe]:DATA:CVTable:CHANnels ON,*<ch_lst>*.

- Any or all of the Tachometer Module channels can have their measurements placed in the Current Value Table by using *<ch_lst>*.

- The Current Value Table entries for channels that have not been measured will be IEEE "Not a Number" (+9.910000E+37).

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- If, for a given channel, [SENSe]:FUNCtion is TCOunts and DATA:CVT:CHAN ON is sent, an error -221, "Settings conflict" will be issued and DATA:CVT:CHAN will remain OFF for that channel. If DATA:CVT:CHAN is ON and [SENSe]:FUNCtion is changed to TCOunts, DATA:CVT:CHAN will be set to OFF for that channel.

- *RST Condition: None of the channels are sent to the Current Value Table (DATA:CVT:CHAN is OFF for all channels).

Usage Example

DATA:CVT:CHAN ON, (@100:107) — enables the current values for all channels to be placed in the Current Value Table.

[SENSe]:DATA:CVTable:CHANnels?

The **[SENSe]:DATA:CVTable:CHANnels?** command returns a number to indicate the Current Value Table enable state for the channel specified.

Parameters

The following table defines the parameters for this command.

Parameter Name	Parameter Type	Range of Values	Default Value	Default Units
<channel>	string	100 to 107	none	none

Comments

- Returned Value: A `1` is returned if the state is ON, and a `0` is returned if it is OFF. The C-SCPI type is int16.

Usage Example

DATA:CVT:CHAN ON, (@104) — enables the Current Value Table for channel 4.

DATA:CVT:CHAN? (@104) — returns `1`.

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[SENSe]:DATA:CVTable:RESet

The **[SENSe]:DATA:CVTable:RESet** command resets (clears) the Current Value Table.

Comments

- The readings for all 8 entries are set to the IEEE "Not a Number" (+9.910000E+37).
- *RST Condition: The readings for all 8 entries are set to the IEEE "Not a Number" (+9.910000E+37).

Usage Example DATA:CVT:RES clears the Current Value Table.

[SENSe]:DATA:FIFO[:ALL]?

The **[SENSe]:DATA:FIFO[:ALL]?** command returns all readings from the FIFO Reading Buffer.

Comments

- The FIFO will hold 512 readings.
- This command will return a maximum of 512 readings.
- It will return all readings from the FIFO Reading Buffer if the buffer is less than full.
- Note that unless the measurement is complete (see STATus:OPERation:CONDition?) additional entries could be added to the FIFO in the time between the beginning and the end of this command.
- No more readings should be taken after the FIFO has become full to prevent loss of data. Use STATus:QUEStionable:CONDition? to detect when the FIFO has become full.
- When the FUNCtion is CUSTom or FREQuency, each reading consists of 4 values which are 32-bit floating-point numbers made up as follows:
  - the first value is the channel number for this reading, which is a number between 0 and 7.
  - the second value is the measurement for this reading (either frequency or engineering units).
  - the third value is the FIFO update clock period for this reading.
  - the fourth value is always 0.

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- When the FUNCtion is TCOunts, each reading consists of 4 values which are 32-bit floating-point numbers made up as follows:
  - the first value is the channel number for this reading, which is a number between 0 and 7.
  - the second value is Timebase Counts.
  - the third value is the FIFO update clock period for this reading.
  - the fourth value is the Event Counts.

- The format for each of these numbers is set by the FORMat command. ASCII formatted values will be returned in a comma-separated list. REAL formatted values will be returned in Definite Length Arbitrary Block form (see IEEE Std. 488.2 - 1987, section 8.7.9).

- For more detail on these values, see the description of the FIFO in chapter 5, Register-Based Programming.

- *RST Condition: The FIFO is empty ([SENSe]:DATA:FIFO:COUNt? will return 0).

Usage Example DATA:FIFO[:ALL]? returns all readings from the FIFO.

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[SENSe]:DATA:FIFO:CHANnels

The **[SENSe]:DATA:FIFO:CHANnels** command specifies which channels are to be sent to the FIFO based on the channel list.

Parameters The following table defines the parameters for this command.

Parameter Name	Parameter Type	Range of Values	Default Value	Default Units
<enable>	discrete	0|1|OFF|ON	OFF	none
<ch_lst>	string	100 to 107	none	none

Comments

- The FIFO can be chosen as a data destination by [SENSe]:DATA:FIFO:CHANnels ON, *<ch_lst>*.
- Any or all of the Tachometer Module channels can have their measurements placed in the FIFO by using *<ch_lst>*.
- *RST Condition: None of the channels are sent to the FIFO (DATA:FIFO:CHAN is OFF for all channels).

Usage Example

DATA:FIFO:CHAN 1,(@107) enables the current values for channel 7 to be placed in the FIFO.

[SENSe]:DATA:FIFO:CHANnels?

The **[SENSe]:DATA:FIFO:CHANnels?** command returns a number to indicate the FIFO enable state for the channel specified.

Parameters The following table defines the parameters for this command.

Parameter Name	Parameter Type	Range of Values	Default Value	Default Units
<channel>	string	100 to 107	none	none

Comments

- Returned Value: A `1` is returned if the state is ON, and a `0` is returned if it is OFF. The C-SCPI type is int16.

Usage Example

DATA:FIFO:CHAN ON, (@104) enables the FIFO for channel 4.

DATA:FIFO:CHAN? (@104) returns `1`.

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[SENSe]:DATA:FIFO:COUNt?

The **[SENSe]:DATA:FIFO:COUNt?** command returns the number of readings currently in the FIFO Reading Buffer.

Comments

- The FIFO will hold 512 readings, one reading will occupy 4 words.
- The return value is a 16-bit integer in the IEEE NR1 format ranging from 0 to 512.
- *RST Condition: The FIFO is empty (DATA:FIFO:COUN? returns 0).

Usage Example

DATA:FIFO:COUN?	returns the number of readings, *n*.
DATA:FIFO:PART? <*n*>	returns *n* readings.

[SENSe]:DATA:FIFO:HALF?

The **[SENSe]:DATA:FIFO:HALF?** command returns 256 readings from the FIFO Reading Buffer if it is at least half full.

Comments

- The FIFO will hold 512 readings.
- This command will return a maximum of 256 readings.
- It will return all readings from the FIFO Reading Buffer if the Buffer is less than half full.
- Use [SENSe]:DATA:FIFO:COUNt:HALF? or STATus:OPERation:CONDition? to poll the FIFO for the half-full condition.
- Note that unless the measurement is complete (see STATus:OPERation:CONDition?) additional entries could be added to the FIFO in the time between [SENSe]:DATA:FIFO:COUNt:HALF? and [SENSe]:DATA:FIFO:HALF? or before [SENSe]:DATA:FIFO:HALF? finishes.
- When the FUNCtion is CUSTom or FREQuency, each reading consists of 4 values which are 32-bit floating-point numbers made up as follows:

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- the first value is the channel number for this reading, which is a number between 0 and 7.
- the second value is the measurement for this reading (either frequency or engineering units).
- the third value is the FIFO update clock period for this reading.
- the fourth value is always 0.

- When the FUNCtion is TCOunts, each reading consists of 4 values which are 32-bit floating-point numbers made up as follows:
  - the first value is the channel number for this reading, which is a number between 0 and 7.
  - the second value is Timebase Counts.
  - the third value is the FIFO update clock period for this reading.
  - the fourth value is the Event Counts.

- The format for each of these numbers is set by the FORMat command. ASCII formatted values will be returned in a comma-separated list. REAL formatted values will be returned in Definite Length Arbitrary Block form (see *IEEE-488.2 - 1987*, section 8.7.9).

- For more detail on these values, see the description of the FIFO in Chapter 5, "Register-Based Programming."

- *RST Condition: The FIFO is empty ([SENSe]:DATA:FIFO:COUNt? will return 0).

Usage Example:

```
DATA:FIFO:COUN?      returns a value, n, for the number of readings.

DATA:FIFO:HALF?      returns 256 readings (1024 values) if n>=256.
```

[SENSe]:DATA:FIFO:COUNt:HALF?

The **[SENSe]:DATA:FIFO:COUNt:HALF?** command is used as a way to poll the FIFO for the half-full condition.

Comments

- The return value is a 16-bit integer in the IEEE NR1 format and will be one of the following:
  - 0 if the FIFO is less than half full.
  - 1 if the FIFO contains at least 256 readings.

- *RST Condition: :DATA:FIFO:COUN:HALF? returns a 0.

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Usage Example:

DATA:FIFO:RES	clears the FIFO Reading Buffer.
DATA:FIFO:COUN:HALF?	returns a 0.

[SENSe]:DATA:FIFO:PART?

The **[SENSe]:DATA:FIFO:PART?** command returns *n* readings from the FIFO Reading Buffer.

Parameters The following table defines the parameters for this command.

Parameter Name	Parameter Type	Range of Values	Default Value	Default Units
<*n*>	numeric	1 to 256	none	none

Comments

- The range of values allowed for <*n*> is 1 to 256, values outside this range will cause an error -222, "Data out of range".
- The FIFO will hold 512 readings.
- This command is used to move smaller blocks of data than SENSe:DATA:FIFO:HALF?.
- This command will return a maximum of 256 readings.
- It will return all readings from the FIFO Reading Buffer if the buffer has less than <*n*> readings.
- Use [SENSe]:DATA:FIFO:COUNt? to get the number of readings currently in the FIFO Reading Buffer. Note that unless the measurement is complete (see STATus:OPERation:CONDition?) additional entries could be added to the FIFO in the time between [SENSe]:DATA:FIFO:COUNt? and [SENSe]:DATA:FIFO:PART? or before [SENSe]:DATA:FIFO:PART? finishes.
- When the FUNCtion is CUSTom or FREQuency, each reading consists of 4 values which are 32-bit floating-point numbers made up as follows:
  - the first value is the channel number for this reading, which is a number between 0 and 7.
  - the second value is the measurement for this reading (either frequency or engineering units).
  - the third value is the FIFO update clock period for this reading.
  - The fourth value is always 0.

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- When the FUNCtion is TCOunts, each reading consists of 4 values which are 32-bit floating-point numbers made up as follows:
  - the first value is the channel number for this reading, which is a number between 0 and 7.
  - the second value is Timebase Counts.
  - the third value is the FIFO update clock period for this reading.
  - the fourth value is the Event Counts.

- The format for each of these numbers is set by the FORMat command. ASCII formatted values will be returned in a comma-separated list. REAL formatted values will be returned in Definite Length Arbitrary Block form (see *IEEE-488.2 - 1987*, section 8.7.9).

- For more detail on these 3 values, see the description of the FIFO in Chapter 5, "Register-Based Programming."

- *RST Condition: The FIFO is empty ([SENSe]:DATA:FIFO:COUNt? will return 0).

Usage Example

DATA:FIFO:COUN?	returns a value (for example, 2) for the number of readings.

DATA:FIFO:PART? 2	returns 2 readings (8 values):
	`0.000000 3001.113281 14.000000 0.000000`
	`1.000000 3001.113281 18.000000 0.000000`

[SENSe]:DATA:FIFO:RESet

The **[SENSe]:DATA:FIFO:RESet** command resets the FIFO Reading Buffer.

Comments

- After [SENSe]:DATA:FIFO:RESet, [SENSe]:DATA:FIFO:COUNt? will return 0.

- *RST Condition: The FIFO is empty.

Usage Example

DATA:FIFO:RESet	clears the FIFO Reading Buffer.

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[SENSe]:EVENt:LEVel

The **[SENSe]:EVENt:LEVel** command sets a threshold voltage level. When the input signal level falls below this threshold, the channel is disabled.

Parameters The following table defines the parameters for this command.

Parameter Name	Parameter Type	Range of Values	Default Value	Default Units
<voltage>	numeric string	0.0 to 1.103|DEFault| MINimum|MAXimum	0.0	volts p-p
<ch_lst>	string	100 to 107	none	none

Comments

- *RST Condition: The event voltage level is set to 0.0 volts.

Usage Example EVENt:LEVel .5,(@100:107) sets the event level for all channels.

[SENSe]:EVENt:LEVel?

The **[SENSe]:EVENt:LEVel?** command returns the peak-to-peak threshold voltage level at which the event occurs for the channel specified.

Parameters The following table defines the parameters for this command.

Parameter Name	Parameter Type	Range of Values	Default Value	Default Units
<channel>	string	100 to 107	none	none

Comments

- *<channel>* allows only a single channel.
- The return value is the event level in volts as a 32-bit floating-point number. The output buffer will contain the present value for this channel if neither MAXimum or MINimum is specified.

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- The output buffer will contain 0.0 if MINimum is specified regardless of the present value for this channel.
- The output buffer will contain 1.103V if MAXimum is specified regardless of the present value for this channel.

Usage Example

EVEN:LEV 0.0,(@100:107)	sets the event level for all channels.
EVEN:LEV? (@107)	returns `0.000000E+000` for channel 7.

[SENSe]:FREQuency:APERture

The **[SENSe]:FREQuency:APERture** command sets the aperture time (window length) or event counts on frequency measurements for the channels specified by the channel list. The window length determines the length of time to measure the input signal frequency. (See page 5-17 for more information on window length and event counts.)

Parameters The following table defines the parameters for this command.

Parameter Name	Parameter Type	Range of Values	Default Value	Default Units
<value>	numeric string	-65535.0 to 210.0 AUTO|DEFault|MINimum|MAXimum	AUTO	seconds
<ch_lst>	string	100 to 107	none	none

Comments

- If the window length is set to AUTO, DEFault, or 0.0, the Tachometer Module automatically sets its aperture time.
- If the window length is set to a value greater than 0.0, the Tachometer Module will use that value for its aperture time.
- If the window length is set to a value less than 0.0, the Tachometer Module will use that value for its event counts.
- The range of values allowed for the window length is -65535.0 to 210.0, values outside this range will cause an error -222, "Data out of range".
- *RST Condition: The window length is set to AUTO.

Usage Example

FREQ:APER .1,(@104)	sets the window length to 100 mSec. for channel 4.

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[SENSe]:FREQuency:APERture?

The command **[SENSe]:FREQuency:APERture?** returns the aperture time (window length) or event counts for the channels specified.

Parameters The following table defines the parameters for this command.

Parameter Name	Parameter Type	Range of Values	Default Value	Default Units
<channel>	string	100 to 107	none	none

Comments

- *<channel>* allows only a single channel.
- The return value is the window length in seconds as a 32-bit floating point number. The output buffer will contain the present value for this channel if neither MAXimum or MINimum is specified.
- The output buffer will contain -65535.0 if MINimum is specified regardless of the present value for this channel.
- The output buffer will contain 210.0 if MAXimum is specified regardless of the present value for this channel.

Usage Example

FREQ:APER .05,(@100:107)	sets the event level for all channels.
FREQ:APER? (@102)	returns `5.000000E-002` for channel 2.

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[SENSe]:FUNCtion

The **[SENSe]:FUNCtion** command selects the measurement function for the Tachometer Module for the channels specified by the channel list. This command may alter the states of DATA:CVT:CHAN and MEMory:TABLe:DEFine as explained under "Comments".

Parameters The following table defines the parameters for this command.

Parameter Name	Parameter Type	Range of Values	Default Value	Default Units
<func>	discrete	CUSTom | FREQuency | OFF | TCOunts	OFF	none
<ch lst>	string	100 to 107	none	none

Comments

- The CUSTom function causes those channels to measure and return the frequency of the input signals in engineering units using a conversion table. Conversion tables are allowed only for channels whose FUNCtions are CUSTom. Any tables will be erased when the FUNCtion for those channels is changed.
- The FREQuency function causes those channels to measure and return the frequency of the input signals directly in units of Hertz.
- The OFF function causes those channels to be disconnected.
- The TCOunts function causes those channels to measure and return the frequency of the input signals as time-base counts and event counts. More information on time-base counts can be found in the description of the FIFO in Chapter 5, "Register-Based Programming." If DATA:CVT:CHAN is ON for those channels and [SENSe]:FUNCtion is changed to TCOunts, DATA:CVT:CHAN will be set to OFF for those channels.
- [SENSe]:FUNCtion is accumulative, so that the function for a given channel will be that most recently sent.
  If FUNC FREQ, (@100:104) is followed by
  FUNC OFF, (@104:107) then channels 0 through 3 are still FREQ while channel 4 is OFF.
- *RST Condition: FUNCtion is set to OFF.

Usage Example

```
FUNC CUST (@104)
```

sets the function to CUSTom on channel 4.

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[SENSe]:FUNCtion?

The **[SENSe]:FUNCtion?** command returns the measurement function for the Tachometer Module for the channel specified.

Parameters The following table defines the parameters for this command.

Parameter Name	Parameter Type	Range of Values	Default Value	Default Units
<channel>	string	100 to 107	none	none

Comments

- The output buffer will contain one of the following strings: "CUST" or "FREQ" or "OFF" or "TCO".

Usage Example FUNC? (@102) returns FREQ for channel 2.

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The STATus subsystem communicates with the SCPI-defined Operation and Questionable Data status register sets. Each is comprised of a Condition register, an Event register, and an Enable register. Condition registers allow you to view the current real-time states of their status signal inputs (signal states are not latched). Event registers contain latched representations of signal transition events from their Condition register. The CENC-TAC8 Tachometer Module has no programmable Transition Filter registers so any low-to-high transition in a Condition register will cause the corresponding bit in an Event register to be set to one. Querying an Event register reads and then clears its contents, making it ready to record further event transitions from its Condition register. Enable registers are used to select which signals from an Event register will be logically ORed together to form a summary bit in the Status Byte Summary register. Setting a bit to one in an Enable register enables the corresponding bit from its Event register. The Status system contains four status groups:

- Operation Status Group
- Questionable Data Group
- Standard Event Group
- Status Byte Group

The SCPI STATus subsystem communicates with the first two groups while IEEE-488.2 Common Commands (documented later in this chapter) communicate with Standard Event and Status Byte Groups.

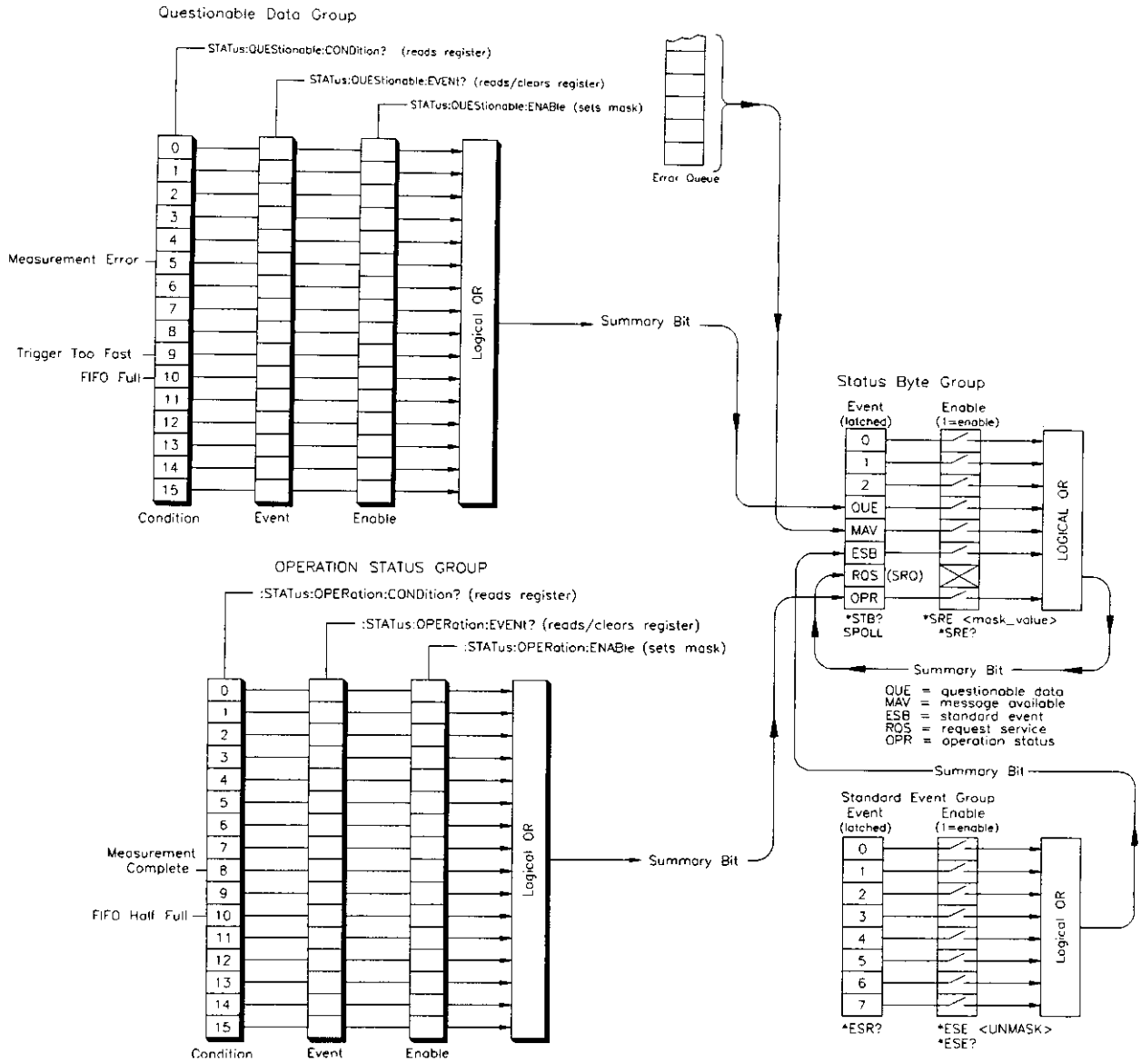
Register queries are returned using decimal-weighted bit values. Enable registers can be set using decimal, hex, octal, or binary. The following table can be used to help set Enable registers using decimal and decode register queries.

bit#	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
value	always 0	16,384	8,192	4,096	2,048	1,024	512	256	128	64	32	16	8	4	2	1

Subsystem Syntax

```
STATus
    :OPERation
        :CONDition?
        :ENABle          <mask>
        :ENABle?
        [:EVENt]?
    :PRESet
    :QUEStionable
        :CONDition?
        :ENABle          <mask>
        :ENABle?
        [:EVENt]?
```


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Tachometer Module Status Register Group

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Status Bit Descriptions

Questionable Data Group			
Bit	**Bit Value**	**Event Name**	**Description**
5	32	Measurement Error	When either the Measurement Overflow or Measurement Timeout bit is set in the Error Flag Word (refer to ERRFLAGSQ in Chapter 5), then the Measurement Error bit is set.
9	512	Trigger Too Fast	Measurement not complete when another trigger event received.
10	1024	FIFO Full	Attempt to store more than 512 readings in FIFO.

Operation Status Group			
Bit	**Bit Value**	**Event Name**	**Description**
8	256	Measurement Complete	The trigger system, when configured for single measurements (i.e., non-continuous), sets this bit once measurements on all enabled channels have completed.
10	1024	FIFO Half Full	FIFO contains at least 256 readings.

Standard Event Group			
Bit	**Bit Value**	**Event Name**	**Description**
0	1	Operation Complete	*OPC command executed and instrument has completed all pending operations.
2	4	Query Error	Attempting to read empty output queue or output data lost.
3	8	Device Dependent Error	A device dependent error occurred.
4	16	Execution Error	Parameter out of range, or instrument cannot execute a proper command because it would conflict with another instrument setting.
5	32	Command Error	Unrecognized command or improper parameter count or type.
7	128	Power-On	Power has been applied to the instrument.

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STATus:OPERation:CONDition?

The **STATus:OPERation:CONDition?** command returns the value of the Operation Condition register for the Tachometer Module. This allows a user to determine if the FIFO is half full and if the measurement is complete.

For a further discussion on the Tachometer Module STATus subsystem, refer to Chapter 2, "Using the Tachometer Module."

Comments

- The Operation Condition register reflects the current state of the status signals; they are not latched.
- Reading the Operation Condition register has no effect upon it.
- Bit 10 will be true if the FIFO has at least 256 readings.
- Bit 8 will be true if the measurement is complete.
- The return is a number which is the decimal-weighted value of the bits set in the Operation Condition register and is a 16-bit integer in the IEEE NR1 format.
- *RST Condition: No change.

Usage Example

STAT:OPER:COND?	returns a copy of the Operation Condition register to the output buffer.

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STATus:OPERation:ENABle

The **STATus:OPERation:ENABle** command sets the Operation Enable mask which allows the true conditions in the Operation Event register to be reported in the summary bit.

Parameters The following table defines the parameters for this command.

Parameter Name	Parameter Type	Range of Values	Default Value	Default Units
<mask>	numeric	0 to 32767	0	none

Comments

- Values outside the allowed range will cause an error -222 "Data out of range".
- *RST Condition: No change.

Usage Example

```
STAT:OPER:ENAB 1024
```

enables bit 10 of the Operation Condition register (FIFO half full) to be reported to the Status Byte.

STATus:OPERation:ENABle?

The **STATus:OPERation:ENABle?** command returns the value of the Operation Enable mask to the output buffer.

Comments

- The return is a number that is the decimal-weighted value of the mask and is a 16-bit integer in the IEEE NR1 format.
- *RST Condition: No change.

Usage Example

```
STAT:OPER:ENAB 1280
```

enables bits 10 and 8.

```
STAT:OPER:ENAB?
```

returns `1280`.

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STATus:OPERation[:EVENt]?

The **STATus:OPERation[:EVENt]?** command returns the contents of the Operation Event register to the output buffer.

Comments

- The Operation Event register contains latched representations of signal transition events from the Operation Condition register and is a 16-bit integer in the IEEE NR1 format.
- Reading the Operation Event register clears it.
- *RST Condition: No change.

Usage Example

```
STAT:OPER?
```

returns a copy of the Operation Event register to the output buffer.

STATus:PRESet

The **STATus:PRESet** command clears the Operation Enable register and the Questionable Enable register.

Comments

- After executing this command, none of the events in the Operation Event register or the Questionable Event register will be reported as a summary bit in either the Status Byte Group or Standard Event Status Group.
- STATus:PRESet does not clear either of the Event registers.
- *RST Condition: No change.

Usage Example

```
STAT:PRES
```

sets both of the Enable registers to 0.

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STATus:QUEStionable:CONDition?

The **STATus:QUEStionable:CONDition?** command returns the value of the Questionable Condition register for the Tachometer Module.

Comments

- The Questionable Condition register reflects the current state of the status signals; they are not latched.
- Reading the Questionable Condition register has no effect upon it.
- Bit 10 will be true is the FIFO is full.
- Bit 9 will be true if the trigger is too fast.
- Bit 5 is the summary-of-frequency bit and will be true if there is a measurement error.
- The return is a number which is the decimal-weighted value of the bits set in the Questionable Condition register and is a 16-bit integer in the IEEE NR1 format.
- *RST Condition: no change.

Usage Example

STAT:QUES:COND? returns a copy of the Questionable Condition register to the output buffer.

STATus:QUEStionable:ENABle

The **STATus:QUEStionable:ENABle** command sets the Questionable Enable mask which allows the true conditions in the Questionable Event register to be reported in the summary bit.

Parameters

The following table defines the parameters for this command.

Parameter Name	Parameter Type	Range of Values	Default Value	Default Units
<mask>	numeric	0 to 32767	0	none

Comments

- Values outside the allowed range will cause error -222, "Data out of range".
- *RST Condition: No change.

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Usage Example

STAT:QUES:ENAB 1024	enables bit 10 of the Questionable Condition register (Measurement Error) to be reported to the Status Byte.

STATus:QUEStionable:ENABle?

The **STATus:QUEStionable:ENABle?** command returns the value of the Questionable Enable mask to the output buffer.

Comments

- The return is a number that is the decimal-weighted value of the mask and is a 16-bit integer in the IEEE NR1 format.
- *RST Condition: no change.

Usage Example

STAT:QUES:ENAB 1568	enables bits 10, 9, and 5.
STAT:QUES:ENAB?	returns `1568`.

STATus:QUEStionable[:EVENt]?

The **STATus:QUEStionable[:EVENt]?** command returns the contents of the Questionable Event register to the output buffer.

Comments

- The Questionable Event register contains latched representations of signal transition events from the Questionable Condition register and is a 16-bit integer in the IEEE NR1 format.
- Reading the Questionable Event register clears it.
- *RST Condition: no change.

Usage Example

STAT:QUES?	returns a copy of the Questionable Event register to the output buffer.

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The SYSTem subsystem is used for global information reporting on the Tachometer Module.

Subsystem Syntax

```
SYSTem
    :ERRor?
    :VERSion?
```

SYSTem:ERRor?

The **SYSTem:ERRor?** command returns the oldest error message that is in the error queue.

Comments

- SYST:ERR? returns a single error message each time it is invoked.
- Errors are returned in the form: +-<error number>,"<error message string>".
- When the error queue is empty, SYST:ERR? returns +0, "No error".
- *RST Condition: The error queue is empty.

Usage Example

*RST	resets SENS:FUNC to OFF.
MEM:TABL:FREQ:POIN?	requires SENS:FUNC to be CUST.
SYST:ERR?	returns ERROR: -221,"Settings Conflict".

SYSTem:VERSion?

The **SYSTem:VERSion?** command returns the version of SCPI that the Tachometer Module complies with.

Comments

- The return value is a string of the form "YYYY.N".
- *RST Condition: no change.

Usage Example

SYST:VERS?	returns 1990.0.

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The TRIGger subsystem controls the behavior of the trigger system for the Tachometer Module.

Subsystem Syntax

```
TRIGger
    [:IMMediate]
    :SOURce          <srce>
    :SOURce?
```

TRIGger[:IMMediate]

The **TRIGger[:IMMediate]** command causes the Tachometer Module to begin a measurement sequence if the TRIGger:SOURce is either BUS or HOLD.

Comments

- This command is equivalent to either the *TRG common command or the IEEE-488.2 "GET" bus command.

  Sending a trigger before the card has been initiated will cause an error -211, "Trigger ignored".

- *RST Condition: the trigger system is not triggered.

Usage Example

TRIG:SOUR:HOLD	suspends triggering.
TRIG	causes the Tachometer Module to be triggered.

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TRIGger:SOURce

The **TRIGger:SOURce** command configures the trigger system to respond to a specified source.

Parameters The following table defines the parameters for this command.

Parameter Name	Parameter Type	Range of Values	Default Value	Default Units
<srce>	discrete	BUS | HOLD | IMMediate	HOLD	none

Comments

- If the trigger source is TRIGger:SOURce BUS or TRIGger:SOURce HOLD, the Tachometer Module begins making measurements as soon as the TRIGger[:IMMediate] or *TRG commands are executed or the IEEE-488.2 "GET" bus command is received.
- If the trigger source is TRIGger:SOURce IMMediate, the Tachometer Module begins making measurements as soon as the INITiate[:IMMediate] command is executed.
- *RST Condition: TRIG:SOUR is set to HOLD.

Usage Example

TRIG:SOUR HOLD	suspends triggering.
TRIG	causes the Tachometer Module to be triggered.

TRIGger:SOURce?

The **TRIGger:SOURce?** command returns the current setting for the trigger system source.

Comments

- The output buffer will contain one of the following strings: `BUS` or `HOLD` or `IMM`.

Usage Example

TRIG:SOUR HOLD	suspends triggering.
TRIG:SOUR?	returns `HOLD`.

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The VXI subsystem contains commands that allow direct access of the VXI registers on the Tachometer Module.

Subsystem Syntax

```
VXI
    REGister
        READ?       <register>
        WRITe       <register>,<data>
```

VXI:REGister:READ?

The **VXI:REGister:READ?** command returns the contents of the specified 16-bit register which is at the currently selected logical address.

Parameters The following table defines the parameters for this command.

Parameter Name	Parameter Type	Range of Values	Default Value	Default Units
<register>	numeric	0 to 62	none	none

Comments

- This command is not expected to be used during normal operation but is included for an emergency where register access must be done and it is desired to use SCPI to do it.
- The register is specified as an address which can be any even number in the allowed range, values other than this will cause an error -222, "Data out of range".
- *RST Condition: not applicable.

Usage Example VXI:REG:READ? 0 returns `-285.`

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The **VXI:REGister:WRITe** command writes the data to the specified 16-bit register which is at the currently selected logical address.

Parameters The following table defines the parameters for this command.

Parameter Name	Parameter Type	Range of Values	Default Value	Default Units
<register>	numeric	0 to 62	none	none
<data>	numeric	-32768 to 32767	0	none

Comments

- This command is not expected to be used during normal operation but is included for an emergency where register access must be done and it is desired to use SCPI to do it.
- The register is specified as an address which can be any even number in the allowed range, values other than this will cause an error -222, "Data out of range".
- *<data>* is a 16-bit integer in the IEEE NR1 format. Values other than this will cause an error -222, "Data out of range".
- *RST Condition: not applicable.

Usage Example `VXI:REG:WRIT 10,0` causes a low-level CLEAR command.

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IEEE-488.2 Common Command Reference

This section includes information on the following IEEE-488.2 Common Commands.

*CLS	Clear Status
*ESE<*mask*>	Event Status Enable
*ESE?	Event Status Enable Query
*ESR?	Event Status Register Query
*IDN?	Identification Query
*OPC	Operation Complete
*OPC?	Operation complete?
*RST	Reset
*SRE<*mask*>	Service Request Enable
*SRE?	Service Request Enable Query
*STB?	Read Status Byte Query
*TRG	Bus Trigger
*TST?	Self-Test Query
*WAI	Wait to Continue

*CLS Clear Status Register

The Clear Status Register command clears all status event registers (Standard Event Status Register, Standard Operation Status Event Register, Questionable Data Event Register) and the error queue. This clears the corresponding summary bits (bits 3, 5, and 7) in the Status Byte Register. *CLS does not affect the enable bits in any of the status register groups. (The SCPI command STATus:PRESet does clear the Operation Status Enable and Questionable Data Enable registers.) *CLS disables the Operation Complete function (*OPC command) and the Operation Complete Query function (*OPC? command).

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*ESE <*mask*> Event Status Enable

The Event Status Enable command enables one or more events in the Standard Event Status Enable Register to be reported in bit 5 (the Standard Event Status Summary Bit) of the Status Byte Register. You enable an event by specifying its decimal weight for <*mask*>. To enable more than one event (bit), specify the sum of the decimal weights. The C-SCPI type for <*mask*> is int16.

Bit #	7	6	5	4	3	2	1	0
Weighted Value	128	64	32	16	8	4	2	1
Event	power on	user request	command error	execution error	device dependent error	query error	request control	operation complete

*ESE? Event Status Enable Query

The Event Status Enable Query command queries the current contents in the Event Status Enable register. It returns the weighted sum of all enabled (unmasked) bits in the Standard Event Status Register. The C-SCPI type for this returned value is int16.

*ESR? Event Status Register Query

The Event Status Register Query command returns the weighted sum of all set bits in the Standard Event Status Register. After reading the register, *ESR? clears the register. The events recorded in the Standard Event Status Register are independent of whether or not those events are enabled with the *ESE command to set the Standard Event Summary Bit in the Status Byte Register. The Standard Event bits are described in the *ESE command. The C-SCPI type for this returned value is int16.

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*IDN? Identity

The Identity command returns the device identity. The response consists of the following four fields (fields are separated by commas):

- manufacturer
- model number
- serial number (returns 0 if not applicable)
- firmware revision (returns 0 if not applicable)

The *IDN? command returns the following command string for the CENC-TAC8:

```
HEWLETT-PACKARD,TACH,0,B.01.00
```

The C-SCPI type for this returned value is string.

NOTE: The revision will vary with the revision of the driver firmware.

*OPC Operation Complete

The Operation Complete command causes the Tachometer Module to set bit 0 (Operation Complete Message) in the Standard Event Status Register when all pending operations have been completed. By enabling this bit to be reflected in the Status Byte Register (*ESE 1 command), you can ensure synchronization between the instrument and an external computer or between multiple instruments.

*OPC? Operation Complete Query

The Operation Complete Query command causes an instrument to place a 1 into the instrument's output queue when all pending instrument operations are finished. By requiring your computer to read this response before continuing program execution, you can ensure synchronization between one or more instruments and the computer. The C-SCPI type for this returned value is int16.

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*RST — Device Reset

The *RST command performs a device reset operation for the Tachometer Module. This command sets most device-specific functions to their power-on state.

Comments

- The *RST action is listed under "comments" for each SCPI command.
- The following non-query commands' functions are not affected by *RST: MEMory:TABLe:EUNits and MEMory:TABLe:FREQuency.
- In addition, none of the status conditions are changed by *RST.

*SRE<*mask*> — Service Request Enable

When a service request event occurs, it sets a corresponding bit in the Status Byte Register (this happens whether or not the event has been enabled (unmasked) by *SRE). The *SRE command allows you to identify which of these events will assert an HP-IB service request (SRQ). When an event is enabled by *SRE and that event occurs, it sets a bit in the Status Byte Register and issues an SRQ to the computer (sets the HP-IB SRQ line true). You enable an event by specifying its decimal weight for <*mask*>. To enable more than one event, specify the sum of the decimal weights. The C-SCPI type for <*mask*> is int16.

bit #	7	6	5	4	3	2	1	0
weighted value	128	64	32	16	8	4	2	1
event	operation status	request service	standard event	message available	questionable status	not used	not used	not used

*SRE? — Service Request Enable Query

The Service Request Enable Query command queries the current contents in the Service Request Enable Register. It returns the weighted sum of all enabled (unmasked) events (those enabled to assert SRQ) in the Status Byte Register. The C-SCPI type for this returned value is int16.

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*STB? Read Status Byte Query

The Read Status Byte Query command returns the weighted sum of all set bits in the Status Byte Register. Refer to the *ESE command earlier in this chapter for a table showing the contents of the Status Byte Register. *STB? does not clear bit 6 (Service Request). The Message Available bit (bit 4) may be cleared as a result of reading the response to *STB?. The C-SCPI type for this returned value is int16.

*TRG Trigger

The Trigger command triggers the Tachometer Module when the trigger source is set to bus (refer to the TRIG:SOUR BUS command), and the instrument is in the Wait for Trigger state.

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Self-Test Query

The *TST? command causes the Tachometer Module to execute an internal self-test and return a response showing the results of the self-test. This allows a user to inspect 13 different bits in the Tachometer Module's Error Flag Word. A zero response indicates that the self-test passed. A value other than zero indicates a self-test failure or error.

Comments

- The return value is a 16-bit integer in the IEEE NR1 format.
- This can be used after any commands which set the Tachometer Module's hardware state. In the unlikely event that they fail, that failure will be indicated with a non-zero result.
- The bit assignments are as follows.

Bit #	Function
0	True if channel 0 fails self-test.
1	True if channel 1 fails self-test.
2	True if channel 2 fails self-test.
3	True if channel 3 fails self-test.
4	True if channel 4 fails self-test.
5	True if channel 5 fails self-test.
6	True if channel 6 fails self-test.
7	True if channel 7 fails self-test.
8	True if a command error occurs.
9	True if a parameter error occurs.
10	True if a measurement overflow occurs.
11	True if a measurement times out.
12	True if the trigger is too fast.
13	Unused.
14	Unused.
15	Unused.

- *RST Condition: no change.

Usage Example

*TST? returns the contents of the Tachometer Module's Error Flag Word to the output buffer.

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The Wait to Continue command prevents an instrument from executing another command until the operation begun by the previous command is finished (the No Operation Pending message is true). This allows for sequential operation.

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Programming Examples

```
/*****************************************************************************/
/* This program uses the Tachometer Module to take a single set of readings */
/*****************************************************************************/

#include <stdio.h>
#include "cscpi.h"

        /* Defines the Tachometer Module's logical address */
#define LA_TA "8"

        /* Specifies the Tachometer Module as a register address */
INST_DECL( tach, "CENCt08", REGISTER);

        /*Prototype Functions */
void meas_freq (void);

main()
{

                /* Start the register-based operating system */
   INST_STARTUP();

                /* Open the I/O path to the Tachometer Module */
   INST_OPEN(tach, "vxi," LA_TA);

                /* Check if the path is good */
   if ( !tach )
   {
      printf( "INST_OPEN failed (ladd = %s). %d\n", LA_TA, cscpi_open_error);
      exit(1);
   }

   meas_freq();     /* Run function to measure frequency */

}
```


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```
/*****************************************************************************/
/* This function measures frequency on 2 channels, retrieves the readings   */
/* from both the CVT and the FIFO, and prints the results.                   */
/*****************************************************************************/


void meas_freq (void)
{

  float32       cvt[8],fifo[24];
  int16         count;

   /* make a CVT reading                                                     */

  INST_SEND(tach, "FUNC FREQ,(@100,101) \n");
  INST_SEND(tach, "DATA:CVT:CHAN 1,(@100:101) \n");
  INST_SEND(tach, "INIT;TRIG \n");
  INST_QUERY(tach, "DATA:CVT? (@100:101)\n", "%f", &cvt);

  printf ("CVT for chan 0 = %f \n",cvt[0]);
  printf ("CVT for chan 1 = %f \n",cvt[1]);

   /* make a FIFO reading                                                    */

  INST_SEND(tach, "DATA:FIFO:CHAN 1,(@100:101) \n");
  INST_SEND(tach, "INIT;TRIG \n");
  INST_QUERY(tach, "DATA:FIFO:COUN? \n", "%hd", &count );
  printf ("DATA:FIFO:COUN is %d \n",count);
  INST_QUERY(tach, "DATA:FIFO:PART? %d \n", "%f", count, &fifo);
  printf ("FIFO readings:    chan    frequency   tics \n");
  printf ("%22d %13.6f %5d \n", (int16) fifo[0],fifo[1], (int16) fifo[2]);
  printf ("%22d %13.6f %5d \n", (int16) fifo[4],fifo[5], (int16) fifo[6]);

}

/*****************************************************************************/
```

For the above program, the output will be:

```
CVT for chan 0 = 3000.750244
CVT for chan 1 = 3000.300049
DATA:FIFO:COUN is 2
FIFO readings:    chan    frequency   tics
                     0   3000.750244      5
                     1   3000.300049      9
```


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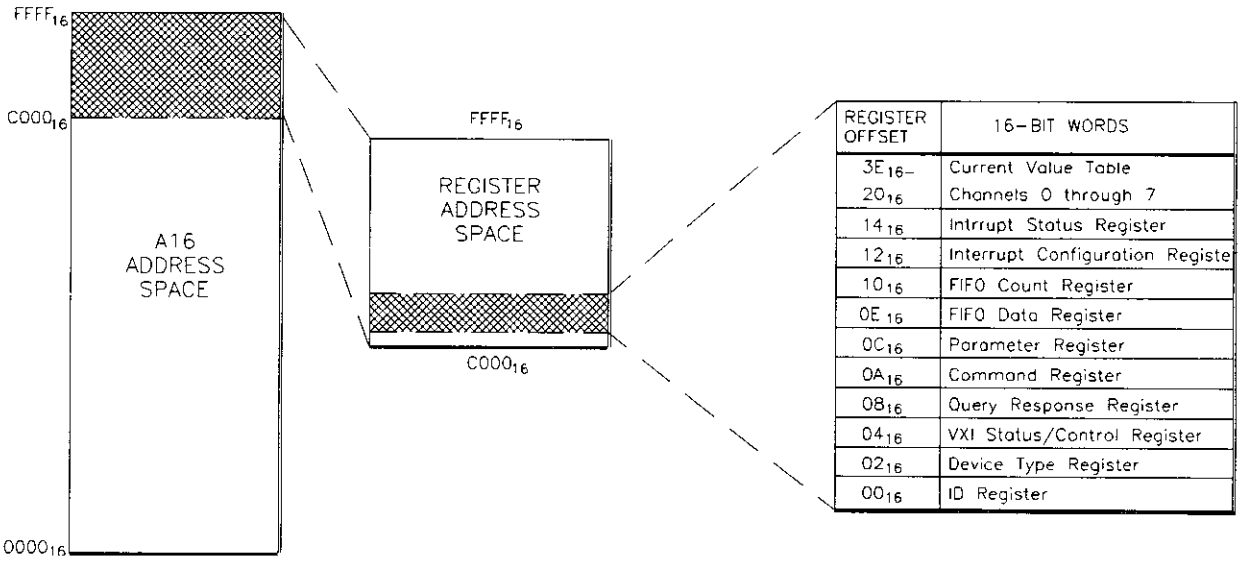
5
Register-Based Programming

Chapter Contents

The CENC-TAC8 Tachometer Module is a register-based slave device. It is programmed at the register level using compiled SCPI (C-SCPI). C-SCPI uses a preprocessor which replaces SCPI commands with function calls to driver libraries. The driver libraries send the low-level commands to the Tachometer Module. For more information on SCPI, refer to Chapter 4, "Command Reference."

The first part of this chapter describes the Tachometer Module registers, and the second half of this chapter describes the low-level commands which perform writes and reads on the registers. The following Tachometer Module registers are described in this chapter.

1. ID Register
2. Device Type Register
3. Status Register
4. Control Register
5. Query Response Register
6. Command Register
7. Parameter Register
8. FIFO Data Register
9. FIFO Count Register
10. Interrupt Configuration Register
11. Interrupt Status Register
12. Current Value Table Channel n Most Significant Word
13. Current Value Table Channel n Least Significant Word



REGISTER OFFSET	16-BIT WORDS
$3E_{16}$–20_{16}	Current Value Table Channels 0 through 7
14_{16}	Intrrupt Status Register
12_{16}	Interrupt Configuration Registe
10_{16}	FIFO Count Register
$0E_{16}$	FIFO Data Register
$0C_{16}$	Parameter Register
$0A_{16}$	Command Register
08_{16}	Query Response Register
04_{16}	VXI Status/Control Register
02_{16}	Device Type Register
00_{16}	ID Register

Figure 5-1: Tachometer Module Registers Within A16 Address Space

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Register Addressing

Register addresses for register-based devices are located in the upper 25% of the VXI A16 address space. Every VXI device (up to 256) is allocated a 64-byte block of addresses. The address consists of a base address plus a register offset.

When reading or writing to a register, a hexadecimal or decimal address is specified. The base address is the starting location of the registers for this device.

$$base = C000_{16} + (LADDR * 40_{16})$$

or

$$base = 49{,}152 + LADDR * 64$$

Where:

base	starting location of the register addresses for the device.
$C000_{16}$	starting location of the register addresses.
LADDR	module's logical address.
40_{16}	hexadecimal number of bytes per device (equals 64_{10}).

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Register Table

Category	Address	Read Registers	Write Registers	See Page
Required VXI Registers	base + 00_{16}	ID Register		5-4
	base + 02_{16}	Device Type Register		5-4
	base + 04_{16}	VXI Status Register	Control Register	5-5, 5-6
	base + 06_{16}			
Register-based Command and Response	base + 08_{16}	Query Response Register		5-6
	base + $0A_{16}$	Command Register	Command Register	5-7
	base + $0C_{16}$		Parameter Register	5-7
FIFO Registers	base + $0E_{16}$	FIFO Data Register		5-8
	base + 10_{16}	FIFO Count Register		5-9
Interrupt Registers	base + 12_{16}	Interrupt Configuration Reg	Interrupt Configuration Reg	5-10
	base + 14_{16}	Interrupt Status Register	Interrupt Status Register	5-11
	base + 16_{16}			
	base + 18_{16}			
	base + $1A_{16}$			
	base + $1C_{16}$			
	base + $1E_{16}$			
Current Value Table	base + 20_{16}	CVT Ch0 MSW		5-12
	base + 22_{16}	CVT Ch0 LSW		5-12
	base + 24_{16}	CVT Ch1 MSW		5-12
	base + 26_{16}	CVT Ch1 LSW		5-12
	base + 28_{16}	CVT Ch2 MSW		5-12
	base + $2A_{16}$	CVT Ch2 LSW		5-12
	base + $2C_{16}$	CVT Ch3 MSW		5-12
	base + $2E_{16}$	CVT Ch3 LSW		5-12
	base + 30_{16}	CVT Ch4 MSW		5-12
	base + 32_{16}	CVT Ch4 LSW		5-12
	base + 34_{16}	CVT Ch5 MSW		5-12
	base + 36_{16}	CVT Ch5 LSW		5-12
	base + 38_{16}	CVT Ch6 MSW		5-12
	base + $3A_{16}$	CVT Ch6 LSW		5-12
	base + $3C_{16}$	CVT Ch7 MSW		5-12
	base + $3E_{16}$	CVT Ch7 LSW		5-12

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ID Register

Base + 00_{16}

Read only, returns $FEE3_{16}$. The module's ID Register indicates the classification, addressing mode, and the manufacturer of the device.

Address	15 ← 14	13 ← 12	11 ← 0
Base + 00_{16}	Device Class	Address Space	Manufacturer ID

Device Classification: Indicates the classification of the VXIbus device according to the following table. The Tachometer Module is a register-based device.

Value	Class
00	Memory
01	Extended
10	Message-based
11	Register-based

Address Space: Indicates the addressing mode of the tachometer card's registers according to the following table. The Tachometer Module is an A16-only device.

Value	Class
00	A16/A24
01	A16/A32
10	Reserved
11	A16 only

Manufacturer ID: Indicates the manufacturer. The list of manufacturer IDs is maintained by the VXIbus Consortium. Central Engineering's manufacturer ID is $EE3_{16}$ or decimal 3811.

Device Type Register

Base + 02_{16}

Read only, returns 0100_{16}. The module's Device Type Register contains a unique card identifier which is defined by the manufacturer.

Address	15 ← 0
Base + 02_{16}	Model code

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Read only. This register provides generic VXI status as well as Tachometer Module-specific information.

Address	15	14	13 ← 6	5	4	3	2	1	0
Base + 04_{16}	Undefined	MODID*	Undefined	No Error	FIFO Ready	Card Ready	Passed	Query/ Resp Ready	Cmd/Parm Ready

MODID*: Indicates whether the module is selected by the P2 MODID line.
0 Indicates that the module is selected by a high state on the P2 MODID line.
1 Indicates that the module is not selected by the P2 MODID line.

No Error: Indicates if an error condition exists.
0 Indicates that an error has occurred. The register-level ERRFLAGS? command may be used to determine the types of errors.
1 Indicates that no error condition exists.

FIFO ready: Indicates data in the FIFO Data Register.
0 Indicates that the FIFO is empty.
1 Indicates that there is at least one 16-bit word to be read from the FIFO Data Register.

Card Ready: Indicates health and operational status of the Tachometer Module.
0 Indicates that module is busy with reset initialization or self test, or that the module has failed self-test.
1 Indicates that module has successfully completed reset initialization or self-test.

Passed: Indicates the self-test status.
0 Indicates that the Tachometer Module is either executing or has failed its self-test.
1 Indicates that self-test completed successfully.

Query Resp Ready: Indicates if data is available in the Query Response Register.
0 This bit clears after reading all data within the Query Response Register. Data placed in the Query Response Register must be read completely before this bit clears.
1 Indicates that some data returned by a query command is available in the Query Response Register.

Cmd/Parm Ready: Indicates if the card is ready for a command.
0 This bit clears upon a write to the Command Register. It indicates that the card is not ready for a command or command parameters. This bit is also clear during reset initialization condition.
1 Indicates that a command or command parameter(s) can be written to the Command Register or Parameter Register.

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Control Register — Base + 04_{16}

Write only: The Control Register commands generic VXI functions and some Tachometer Module-specific functions.

Address	15	14 ← 4	3	2	1	0
Base + 04_{16}	Reserved	Undefined	FIFO Clear*	Undefined	Sysfail Inhibit	Reset

FIFO Clear*: Clears FIFO Data Register and zeros the FIFO Count Register.
0 Resets FIFO. FIFO remains reset until this bit is set to 1. Parameter Register FIFO and Query Response FIFO are unaffected by this bit.
1 Normal FIFO operation.

Sysfail Inhibit: Inhibits the Tachometer Module from asserting the SYSFAIL* line.
0 Enables device to drive SYSFAIL* line.
1 Disables device from driving SYSFAIL* line.

Reset: Resets the Tachometer Module.
0 Turns the reset function off and allows device to operate normally.
1 Forces the Tachometer Module into a reset state. While Reset bit is 1, the module continually resets.

Query Response Register — Base + 08_{16}

Read only: When the module receives a query command, the reply is sent to the Query Response Register. Since the Query Response Register implements a FIFO, all data returned by a query command may be read completely and directly from this register after the Cmd/Parm Ready bit in the Status Register is set to 1. Note that the complete query response is ensured of being in the Query Response Register when the Cmd/Parm Ready bit is set after issuing a query command. A 1 in the Query Resp Ready bit of the Status Register only specifies that at least one 16-bit word exists in the Query Response Register. Data from the Query Response Register may be incomplete or incorrect if read after assertion of the Query Resp Ready bit but prior to assertion of the Cmd/Parm Ready bit.

Address	15 ← 0
Base + 08_{16}	Query Response

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Command Register — Base + $0A_{16}$

Read/write: Module commands are sent to the Command Register. All parameters associated with a module command must first be loaded into the Parameter Register prior to writing to the Command Register.

Address	15 ← 0
Base + $0A_{16}$	Command Opcode

Parameter Register — Base + $0C_{16}$

Module command parameters are written to the Parameter Register. This register utilizes a FIFO. Therefore all parameters and data associated with a command must be written to this register prior to writing to the Command Register.

Address	15 ← 0
Base + $0C_{16}$	Command Parameter

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Ready only: The format of the measurement data in the FIFO Data Register depends on a particular channel's assignment (see the ASSIGN command in the Low-Level Commands section, pages 5-16 through 5-19).

Address	15 ← 0
Base + $0E_{16}$	FIFO Data

Four 16-bit words are placed in the FIFO for each measurement. The FIFO Data Register may contain up to 2048 16-bit words or 512 measurements. The first 16-bit word specifies the measurement channel and the number of FIFO update clock tics since the last trigger. A frequency measurement timeline may be constructed from the FIFO update clock information. This allows the user to view when measurements completed with respect to the trigger. For more information on the FIFO update clock, refer to the FIFOCLKPER low-level command (page 5-23).

The remaining three 16-bit words contain the actual measurement data. If a channel measures frequency or engineering units, IEEE floating point data is returned in the second and third words. The fourth word does not contain any useful information. The following table illustrates FIFO data for frequency or engineering units measurements.

16-Bit Word	FIFO Data										
1	15 ← 3 FIFO Update Clock Tics									2 ← 0 Channel	
2	15 ← 0 IEEE Floating Point Data Most Significant Word										
3	15 ← 0 IEEE Floating Point Data Least Significant Word										
4	15 1	14 1	13 1	12 1	11 1	10 1	9 1	...		1 1	0 1

Measurement data is returned as engineering units or frequency.

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If a channel returns raw counter data, timebase counts and event counts are placed in the FIFO. The second and third word compose the most significant and least significant word of the timebase counter, respectively. The fourth word is the event count. The following table shows the FIFO data format for a measurement made in terms of timer counts.

16-Bit Word	FIFO Data	
1	15 ← 3 FIFO Update Clock Tics	2 ← 0 Channel
2	15 ← 0 Timebase Counts Most Significant Word	
3	15 ← 0 Timebase Counts Least Significant Word	
4	15 ← 0 Event Counts	

Measurement data returned as timer counts.

The following equation describes how to convert timer counts to frequency.

$$\text{frequency} = \frac{\text{event counts}}{\text{timebase counts} * 100.0 \text{ nsec}}$$

FIFO Count Register — Base + 10_{16}

Read only: An unsigned 16-bit integer in the FIFO Count Register specifies the number of 16-bit words in the FIFO Data Register. Each read of the FIFO Data Register decrements the FIFO Count Register by one.

Address	15 ← 0
Base + 10_{16}	FIFO Count

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Read/write: The Interrupt Configuration Register selects the interrupt sources.

Address	15 ← 8	7	6	5	4	3	2 ← 0
Base + 12_{16}	Undefined	Measurement Error	Trigger Too Fast	Measurement Complete	FIFO Full	FIFO Half Full	Undefined

Measurement Error: Provides interrupt on measurement error condition. A measurement error occurs upon either a measurement timeout (see the WDOGTOUT low-level command) or a measurement overflow. A measurement overflow occurs when the event counter overflows before the specified aperture time expires for a constant measurement window (see the ASSIGN low-level command).

0 Disables measurement error interrupt.
1 Enables measurement error interrupt.

Trigger Too Fast: Provides interrupt on a trigger-too-fast condition. A trigger-too-fast condition occurs when a TRIGGER low-level command is issued before a triggered measurement completes. A measurement initiated by the low-level command MEASUREQ is not a triggered measurement. Free-running triggered measurements never complete unless the low-level commands FINISH, ABORT, or ARM is sent or the trigger system is changed to one-shot or one-shot with auto re-arm while measurements are in progress.

0 Disables trigger-too-fast interrupt.
1 Enables trigger-too-fast interrupt.

Measurement Complete: Provides an interrupt upon measurement complete condition. A measurement complete condition occurs when all enabled channels' measurements have completed. Note that measurements never complete with a free-running trigger.

0 Disables measurement complete interrupt.
1 Enables measurement complete interrupt.

FIFO Full: Provides interrupt on FIFO Full condition.

0 Disables FIFO Full interrupt.
1 Enables FIFO Full interrupt.

FIFO Half Full: Provides interrupt on FIFO Half Full condition. A FIFO Half Full condition occurs when the FIFO Data Register is more than half full.

0 Disables FIFO Half Full interrupt.
1 Enables FIFO Half Full interrupt.

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Read/write: The Interrupt Status Register returns the state of all interrupt sources regardless of the state of the Interrupt Configuration Register. There are two types of interrupts: level and strobed. Level interrupts persist from an interrupt source and require the host to service the interrupt through reads of the interrupt source. FIFO Full and FIFO Half Full are level interrupts. Trigger Too Fast, Measurement Complete, and Measurement Error are strobed interrupts and do not persist. Strobed interrupts require the host to acknowledge the interrupt by writing a 1 to the appropriate bit in the Interrupt Status Register.

If either of the level interrupts are enabled through the Interrupt Configuration Register and the corresponding condition is asserted, then the other sources of interrupts are prevented from asserting an interrupt until the source providing the level interrupt is serviced (i.e., the FIFO Data Register read) or until that level interrupt is disabled.

Address	15 ← 8	7	6	5	4	3	2 ← 0
Base + 14_{16}	Undefined	Measurement Error	Trigger Too Fast	Measurement Complete	FIFO Full	FIFO Half Full	Undefined

Measurement Error: Strobed interrupt that indicates measurement error status.
0 Indicates that no measurement error has occurred.
1 Indicates that a measurement error occurred.

Trigger Too Fast: Strobed interrupt that indicates trigger-too-fast condition.
0 Indicates that a trigger-too-fast condition has not occurred.
1 Indicates that a trigger-too-fast condition has occurred.

Measurement Complete: Strobed interrupt that indicates measurement complete condition.
0 Indicates that measurement has not completed.
1 Indicates that measurement has completed.

FIFO Full: Level interrupt that indicates FIFO full condition.
0 Indicates that FIFO Data Register is not full.
1 Indicates that FIFO Data Register is full. Reading the FIFO Data Register clears this condition.

FIFO Half Full: Level interrupt that indicates that the FIFO Data Register is more than half full.
0 Indicates that the FIFO Data Register is not more than half full.
1 Indicates that the FIFO Data Register is more than half full. Reading the FIFO Data Register until it is half full or less than half full clears this condition.

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Current Value Table Channel 0 Most Significant Word — Base + 20_{16}

Read only: When a measurement completes on channel 0, the most significant word of an IEEE floating point number is written to this register if channel 0 is ASSIGNed (see the ASSIGN low-level command) to measure either frequency or engineering units and the measurement destination is CVT. The registers at offset addresses 24_{16}, 28_{16}, $2C_{16}$, 30_{16}, 34_{16}, 38_{16}, and $3C_{16}$ work identically to this register but are for channels 1 through 7, respectively.

Address	15 ← 0
Base + 20_{16}	CVT Ch0 MSW

Current Value Table Channel 0 Least Significant Word — Base + 22_{16}

Read only: When a measurement completes on channel 0, the least significant word of an IEEE floating point number is written to this register if channel 0 is ASSIGNed (see the ASSIGN low-level command) to measure either frequency or engineering units and the measurement destination is CVT. The registers at offset addresses 26_{16}, $2A_{16}$, $2E_{16}$, 32_{16}, 36_{16}, $3A_{16}$, and $3E_{16}$ work identically to this register but are for channels 1 through 7, respectively.

Address	15 ← 0
Base + 22_{16}	CVT Ch0 LSW

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Low-Level Commands

This section describes the low-level register commands and command parameters of the Tachometer Module. The Command Register and the Parameter Register are the hardware interfaces used to command the Tachometer Module to perform most of its functions. Low-level command parameters are written to the Parameter Register before the command opcode is written to the Command Register. Query type commands, indicated by a "Q" at the end of the command mnemonic, issue responses at the Query Response Register.

Commands and parameters can be written to the Tachometer Module only when the Cmd/Parm Ready bit of the Status Register is asserted. The Cmd/Parm Ready bit de-asserts upon a write to the Command Register. When the Tachometer Module completes the command, the Cmd/Parm Ready bit is re-asserted. If a query command was executed, the complete response to the command is available in the Query Response Register upon re-assertion of the Cmd/Parm Ready bit.

Do not use the Status Register's Query Resp Ready bit to determine the availability of a complete response to a query command. This bit only indicates that at least one 16-bit word response to a query command exists in the Query Response Register. Use the Cmd/Parm Ready bit to determine when to read a query command response as previously described.

The Parameter Register uses a 2k x 16-bit FIFO. All command parameters must be written to the FIFO prior to writing the command opcode to the Command Register. A 2k x 16-bit FIFO is also used for the Query Response Register. When a query command completes, the response can be read in its entirety. Unless otherwise specified, command parameters and query command responses are 16-bit unsigned integers.

The low-level commands recognized by the Tachometer Module are described below. The ASCII command names, or mnemonics, are shown for descriptive purposes only. The actual Tachometer Module command is a 16-bit word at the right of the command name. Parameters are indicated by angle brackets (<*parameter*>). Square brackets around a parameter ([<*parameter*>]) indicate that the parameter is optional.

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ABORT ..... 0010_{16}

This command aborts all TRIGGERed measurements in progress. The trigger system is placed in the idle or wait-for-arm state.

Reset State: Not applicable.

ARANGERES *<tb counts high word>* ..... 0015_{16}
<tb counts low word>

This command specifies the terminal event count auto-ranging (see the ASSIGN low-level command) measurement resolution. The auto-ranging resolution applies to all channels making auto-ranged measurements.

Parameter: *<tb counts>*
<tb counts high word> is the most significant 16-bit word of a 32-bit unsigned integer. *<tb counts low word>* is the least significant word. The term *<tb counts>* will be used to refer to the full 32-bit integer.

For a steady-state input signal, measurement resolution is specified as one part in *<tbcounts>*. That is, for a non-transient input signal, measurement resolution will be equal to or better than (100.0 / *<tbcounts>*) percent.

Valid Range: 1 to 10000000
Reset State: After reset initialization, ARANGERES resolution is set to 1 part in 100000.

ARANGERESQ ..... 0016_{16}

This command causes two 16-bit integers specifying the auto-ranging resolution to be returned to the Query Response Register. The first 16-bit word is the most significant word of the 32-bit unsigned integer and the second word is the least significant word.

Reset State: Not applicable.

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ARM ..... **$000D_{16}$**

This command arms the trigger system to accept a TRIGGER command by placing the trigger system in the wait-for-trigger state. If the module is not in the wait-for-trigger state prior to a TRIGGER command, a trigger too fast condition occurs. Refer to the TRIGCONFIG low-level command for details on the module response to a trigger too fast condition.

Reset State: After reset initialization, the trigger system is in the idle or wait-for-arm state.

ARMQ ..... **$000E_{16}$**

This command returns one (1) to the Query Response Register if the trigger system is armed and returns zero (0) if it is not.

Reset State: Not applicable.

ASSIGN ***<n> <destination>*** ..... **$000B_{16}$**
<aperture length high word> <aperture length low word>
<entries>
<freq1 high word> <freq1 low word>
<EU conv1 high word> <EU conv1 low word>
[*<freq2 high word> <freq2 low word>*
***<EU conv2 high word> <EU conv2 low word>*...]**

This command configures a channel for signal measurement.

Parameter: *<n>*
Channel to configure.

Valid Range: 0 to 7

Parameter: *<destination>*
This parameter specifies the destination for measurement data. Measurement data may be placed in the FIFO Data Register, in the Current Value Table, in both, or in neither. The following table describes the format of this parameter.

Valid Range: 0 to 3

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Bit Number			Measurement
15 ← 2	1	0	Data Destination
Undefined	0	0	No data destination
Undefined	0	1	Current Value Table
Undefined	1	0	FIFO Data Register
Undefined	1	1	Current Value Table and FIFO Data Register

Parameter: <*aperture length*>
The term <*aperture length*> refers to a 32-bit IEEE floating point number. <*aperture length high word*> is the most significant 16 bits of the IEEE 32-bit floating point number. <*aperture length low word*> is the least significant 16 bits. This parameter specifies the measurement method. Measurements may be made in terms of a constant aperture length, a constant event count, or an autoranged event count.

If <*aperture length*> is greater than 0.0, this parameter specifies the measurement duration in seconds. For this measurement method, <*aperture length*> may be specified as any number greater than 0.0 and less than or equal to 210.0. The Tachometer Module's true aperture length actually occurs in multiples of 6.5535 msecs. If <*aperture length*> is specified to less than 6.5535 msecs, the true aperture length is set to 6.5535 msecs. If this parameter is not a multiple of 6.5535 msecs, the true aperture length is rounded to the nearest integral multiple for an aperture length greater than 6.5535 msecs.

Once a measurement begins, it does not complete until a final event pulse occurs after the <*aperture length*> time expires. Therefore, the actual measurement duration always exceeds the <*aperture length*> time unless the event counter overflows before the <*aperture length*> time expires, or the measurement duration exceeds the timeout period (refer to the WDOGTOUT and MEASUREQ low-level commands).

A negative <*aperture length*> specifies that measurements occur in constant event counts. The number of event counts required for a given measurement, or terminal event count, is the absolute value of <*aperture length*> rounded to the nearest whole number. For example, <*aperture length*> = -23.52 specifies a terminal event count of 24. If the measurement duration exceeds the timeout period, the measurement may be forced complete prematurely (refer to the WDOGTOUT and MEASUREQ low-level commands).

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If <*aperture length*> equals 0.0, then autoranged terminal event counts are specified. The module automatically computes the terminal event count for the next measurement. Measurement resolution is specified by the ARANGERES command for this measurement mode. If the measurement durations exceeds the timeout period, the measurement may be forced to complete prematurely (refer to the WDOGTOUT and MEASUREQ low-level commands).

Valid Range: -65535.0 to 210.0

Parameter: <*entries*>
This parameter defines the number of entries in the engineering units conversion table. Depending on how the <*freq1*> and <*EU conv1*> parameters are specified, measurement data may be formatted in one of three ways:
1) engineering units as a 32-bit IEEE floating point number,
2) frequency as a 32-bit IEEE floating point number, or
3) raw event counts and timebase counts

By defining an engineering units conversion table, the module may return measurement data in engineering units. This EU table is a two-dimensional table of constants specifying frequency at various points and the engineering units value at each of those points. <*entries*> specifies the number of table entry pairs. <*freq1 high word*> and <*freq1 low word*> form the most and least significant 16 bit words, respectively, of a 32-bit IEEE floating point number representing a frequency entry. The term <*freq1*> refers to this number. <*EU conv1 high word*> and <*EU conv1 low word*> similarly form a 32-bit IEEE floating point number representing the engineering units at the given frequency. <*EU conv1*> refers to this number. <*freq1*> and <*EU conv1*> form the first x-y pair in the engineering units table. <*freq2*> and <*EU conv2*> form the second x-y pair, and so on.

Up to 128 x-y pairs, or points, may be given to form a linear, piece-wise approximation of the true conversion. A frequency measurement that does not fall exactly on a specified EU table point will be linearly interpolated from specified points on either side of the measured frequency to provide an engineering units conversion. This table must be ordered from lowest frequency to highest frequency. Measured frequencies that fall outside the user-specified range return EU values derived from the slope and offset of the first or last EU table segment. An EU table segment is formed by a line connecting two consecutive x-y pairs from the defined EU table.

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To measure frequency directly, only one entry is placed in the engineering units table. <*freq1*> must be less than 0.0 and <*EU conv1*> greater than 0.0.

Event counts and timebase counts may be returned as measurement data by setting <*freq1*> and <*EU conv1*> to less than 0.0. Event count and timebase count data cannot be written to the Current Value Table.

For EU conversions, at least 2 x-y pairs must be defined. Frequency or timer counts measurements can only have one x-y pair defined.

Valid Range: 1 to 128

Parameter: <***freq1***>,...,<***freq128***>
Frequency values in EU table. See <*entries*> for more details.

Valid Range: 0.0 to 100000.0

Parameter: <***EU conv1***>,...,<***EU conv128***>
Engineering units values in EU table. See <*entries*> for more details.

Valid Range: Any valid 32-bit IEEE floating point number.
Reset State: After reset initialization, all channels are ASSIGNed or configured as described below:
<*destination*> = NODEST (no destination)
<*aperture length*> = 0.0 sec (auto-ranging)
<*entries*> = 1
<*freq*> = -1.0 (measure frequency)
<*EU conv*> = 1.0 (measure frequency)

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ASSIGNQ <*n*> ..... $000C_{16}$

This command returns the ASSIGNment for channel <*n*>. Data is returned to the Query Response Register in the same order and format as that sent using the ASSIGN command above. However, the channel number <*n*> is not returned to the Query Response Register.

Parameter: <*n*>
Channel for ASSIGNQ query.

Valid Range: 0 to 7
Reset State: Not applicable.

CHNENABLE <*mask*> ..... 0008_{16}

This command enables or disables channels for signal measurement. A disabled channel is also physically disconnected from its input.

Parameter: <*mask*>
A one (1) in any one of bits 0 through 7 enables the corresponding channel(s). A zero (0) in any of these bits disables the corresponding channel(s). The table below illustrates <*mask*>.

<*mask*> Definition								
15 ← 8	7	6	5	4	3	2	1	0
Undefined	Ch7	Ch6	Ch5	Ch4	Ch3	Ch2	Ch1	Ch0

Valid Range: 0 to 255
Reset State: After reset initialization, all eight channels are disabled.

CHNENABLEQ ..... 0009_{16}

This command returns the CHNENABLE mask to the Query Response Register.

Reset State: Not applicable.

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CLEAR ..... 0000_{16}

This command clears the Error Flag Word (see ERRFLAGSQ low-level command) and empties the Parameter Register FIFO and the Query Response Register FIFO.

Reset State: During reset initialization, Error Flag Word is cleared and the Parameter Register and Query Response Register are emptied.

CVTINIT ..... 0007_{16}

This command loads the entire current value table with IEEE not-a-number (0x7FFFFFFF).

Reset State: After reset initialization, current value table for all eight channels contains IEEE not-a-number.

ERRFLAGSQ ..... 0001_{16}

This command returns the contents of the Error Flag Word to the Query Response Register. The Error Flag Word provides information on the success or failure of previously executed commands. The self-test status for each channel and the integrity of measurements are also indicated through the Error Flag Word. The following table details the Error Flag Word. A one (1) in any bit position indicates an error and a zero (0) denotes the lack of an error condition.

Bit #	Function
0	Channel 0 Self-test Error
1	Channel 1 Self-test Error
2	Channel 2 Self-test Error
3	Channel 3 Self-test Error
4	Channel 4 Self-test Error
5	Channel 5 Self-test Error
6	Channel 6 Self-test Error
7	Channel 7 Self-test Error
8	Command Error
9	Parameter Error
10	Measurement Overflow
11	Measurement Timeout
12	Trigger Too Fast
13 - 15	Undefined

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A self-test occurs during reset initialization and when commanded by the SELFTEST command. Self-test results appear in bits 0 through 7 of the Error Flag Word.

A command error occurs when an invalid command opcode is written to the Command Register.

A parameter error occurs when data written to the Parameter Register falls outside the valid range. This error occurs only after a write to the Command Register. If more data is written to the Parameter Register than is used for a given command, the extraneous data remains in the Parameter Register. Successive commands may incorrectly use this extraneous data.

For a channel ASSIGNed as constant aperture, a long aperture and a high input frequency may cause the 16-bit event counter to overflow. While the measurement is valid, the measurement accuracy is reduced due to the shortened aperture. This causes the Measurement Overflow bit to be set to one (1).

For MEASUREQ measurements, the Measurement Timeout bit is set to one (1) when a measurement does not complete by the timeout period. Triggered measurements that do not complete from a range of one watchdog period to two watchdog periods set this bit to one (1).

A TRIGGER command issued before the module is in the ARMed (and wait-for-trigger) state, sets the Trigger Too Fast bit to one (1).

Reset State: Error Flag Word cleared during reset initialization.

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FIFOCLKPER *<clock period high word>* ..... 0017_{16}
<clock period low word>

FIFOCLKPER defines the FIFO update clock period. The first of four 16-bit words in the FIFO Data Register for a given measurement specify the channel on which the measurement occurred and a 13-bit count specifying the number of FIFO update clock periods since the last trigger. The FIFO update clock count occupies the upper 13 bits of the FIFO word.

The FIFO update count freezes once it reaches the maximum 13-bit value ($1FFF_{16}$). A TRIGGER command causes the FIFO update counter to zero but may affect measurements under progress. To prevent this problem, an ABORT and ARM command should be issued prior to the TRIGGER for a freerunning trigger system. If the trigger system is configured as one-shot with automatic re-arm, a TRIGGER should not be issued until all measurements in progress have completed or until an ABORT and ARM command are issued. There are no special requirements for a one-shot configured system. The FIFO update clock counter may be off by as much as -1 count per update from the last TRIGGER.

For more information on the FIFO update clock, refer to the section on the FIFO Data Register.

Parameter: *<clock period>*
<clock period high word> is the most significant 16 bits of an IEEE 32-bit floating point number.
<clock period low word> is the least significant 16 bits. The term *<clock period>* will refer to the 32-bit IEEE floating point number. This parameter specifies the period of the FIFO Data Register update clock in seconds.

Valid Range: 0.00015 to 0.03932 seconds
Reset State: After reset initialization, FIFO Data Register update clock period is 1.00 msec.

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FIFOCLKPERQ ..... 0018_{16}

This command returns two 16-bit words specifying the FIFO Data Register update clock period in seconds to the Query Response Register. The first 16-bit word is the most significant word of the 32-bit IEEE floating point number. The second word contains the least significant 16 bits. If the FIFO update clock is used, use FIFOCLKPERQ to provide an accurate value for the clock period. The FIFO update clock is derived from the on-board 20-MHz oscillator.

Reset State: Not applicable.

FINISH ..... 0011_{16}

This command places the trigger system in the idle or wait-for-arm state. No new measurements are initiated and all measurements in progress are completed.

Reset State: Not applicable.

FIRMLEVLQ ..... $001B_{16}$

This command places three 16-bit words in the Query Response Register describing the module's firmware version. Firmware level is ASCII coded with no termination character. The following defines the output format: "###.##"

Example: "001.00"
Reset State: Not applicable.

LPF *<n> <freq>* ..... 0004_{16}

This command configures a channel's low-pass filter.

Parameter: *<n>*
Channel on which to configure low-pass filter.

Valid Range: 0 to 7

Parameter: *<freq>*
Frequency of low-pass filter cut-off. The table below illustrates *<freq>* values and corresponding low-pass filter cut-off frequencies.

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<*freq*>	Low-pass Filter Cut-off Frequency
0	100 kHz
1	10 kHz
2	2 kHz
3	1 kHz

Valid Range: 0 to 3
Reset State: After reset initialization, all channels are configured with a 100-kHz low-pass filter.

LPFQ <*n*> ..... 0005_{16}

This command returns a channel's low-pass filter configuration as a 16-bit integer to the Query Response Register.

Parameter: <*n*>
Module channel.

Valid Range: 0 to 7
Reset State: Not applicable.

MEASUREQ <*n*> [<*timeout high word*> ..... $000A_{16}$
<*timeout low word*>]

This command enables the specified channel (see the low-level command CHNENABLE), performs a measurement, and restores the channel enabling to its previous state. Measurement data is placed in Query Response Register. The result is also placed in the CVT and the FIFO Data Register, if enabled. MEASUREQ may be used to perform quick and simple measurements. Because MEASUREQ does not use the trigger system and the command automatically enables the specified channel, a measurement can be performed using only this command. MEASUREQ can be used immediately after power-on initialization or reset initialization.

Note that if the specified channel is not enabled, measurements may not be very accurate due to the settling time of the signal conditioning during the auto-enabling process. It is recommended that the specified channel be enabled first (see CHNENABLE) before performing a MEASUREQ.

For channels ASSIGNed to measure frequency or engineering units, two 16-bit words are returned to the Query Response Register. See the low-level command ASSIGN. The first

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word forms the most significant 16-bit word of a 32-bit IEEE floating point number, and the second word forms the least significant 16-bit word. Channels ASSIGNed to measure event and timebase counts return three 16-bit words. The order of data is shown below.

Word	Data
1	Event count
2	Timebase count most significant word
3	Timebase count least significant word

If the specified channel is ASSIGNed as autoranged, then three measurements occur for each MEASUREQ command sent to the module. Also, if that channel is ASSIGNed to output measurements to the FIFO Data Register, then three sets of measurement data (one measurement data set in FIFO Data Register consists of four 16-bit words) are placed in the FIFO. The first two measurements occur during the autoranging process. The resolution of these measurements may not meet that specified by the ARANGERES command. However, the resolution of the third measurement will meet the ARANGERES specification. Only the third measurement is placed in the Query Response Register.

Parameter: ***<n>***
Channel on which measurement is to be made.

Valid Range: 0 to 7

Parameter: ***<timeout high word> <timeout low word>***
These two 16-bit words form a 32-bit IEEE floating point word that specifies the maximum length of time to complete a measurement. If a measurement does not complete by the timeout period, the measurement is forced to complete. When a timeout occurs, measurement data returned to the Query Response Register may be suspect. Therefore, the MEASTIMEOUT bit of the Error Flag word is set to 1 (see the ERRFLAGQ low-level command), the No Error bit of the Status Register is asserted low, and the Measurement Error bit of the Interrupt Status Register is asserted high. This is an optional parameter.

A timeout value of 0.0 seconds specifies no timeout. For an input frequency at or very near 0 Hz, a measurement may not complete until the timebase counter overflows. In this case, the MEASUREQ command could take as long as 7 minutes to complete.

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Valid Range: 0.0 to 10.0 seconds
Default Value: 10.0 seconds
Reset State: Not applicable.

RUNNINGQ ..... **0012_{16}**

A one (1) is returned to the Query Response Register if measurements are in progress, otherwise a zero (0) is returned.

Reset State: Not applicable.

SELFTEST ..... **0006_{16}**

This command causes a self-test to be performed on all eight channels whether or not they are enabled. An on-board self-test oscillator drives the inputs during a self-test. If any of the channels measure a frequency deviating more than 20% from the nominal value, then the appropriate bit in the Error Flag Word is set to one (1). The No Error bit in the Status Register is set to zero (0). This function verifies the general health of the measurement system but does not perform self-calibration functions and does not verify that the card meets performance specifications.

Reset State: Not applicable.

SENS <*n*> <*sens*> ..... **0002_{16}**

This command configures a channel's sensitivity.

Parameter: <*n*>
Channel on which to configure sensitivity.

Valid Range: 0 to 7

Parameter: <*sens*>
This parameter specifies a threshold above which input signals are passed through the signal conditioning. Refer to "Low Amplitude Shutdown" on page 3-5 to determine the proper <*sens*> value for the required threshold voltage.

Valid Range: 0 to 63
Reset State: After reset initialization, all channels are configured with a <*sens*> of zero (0).

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SENSQ <*n*> ..... 0003_{16}

This command returns a channel's sensitivity configuration as a 16-bit integer to the Query Response Register.

Parameters: <*n*>
Module channel.

Valid Range: 0 to 7
Reset State: Not applicable.

TRIGCONFIG <*type*> ..... 0013_{16}

This command configures the trigger system.

Parameter: <*type*>
Three different triggering configurations are available: freerun, one-shot, and one-shot with auto re-arm.

For a freerun configuration, an initial TRIGGER causes measurements to continue indefinitely and asynchronously on all enabled channels. If another TRIGGER command is issued while the trigger system is freerunning, a trigger-too-fast condition occurs. The Trigger Too Fast bit in the Error Flag Word is set to one (1), the No Error bit in the Status Register is set to zero (0), and the Trigger Too Fast bit in the Interrupt Status Register is set to one (1).

A TRIGGER with a one-shot configuration causes a single measurement on all enabled channels. After all measurements complete, the Measurement Complete bit in the Interrupt Status Register is set to one (1) and the trigger system returns to the idle or wait-for-arm state. An ARM command must precede each successive TRIGGER. If a TRIGGER occurs prior to measurements completing on all enabled channels, a trigger-too-fast condition occurs. The previous paragraph describes the module's response to a trigger-too-fast condition.

A TRIGGER with a one-shot with auto re-arm configuration causes a single measurement on all enabled channels. After all measurements complete, the Measurement Complete bit in the Interrupt Status Register is set to one (1) and the trigger system remains in the wait-for-trigger state. If a TRIGGER occurs prior to measurements completing on all enabled channels, a trigger-too-fast condition occurs. The paragraph above describes the module's response to a trigger-too-fast condition.

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The figure below shows <*type*> values for the different trigger configurations.

<*type*>	**Trigger Configuration**
0	Freerun
1	One-shot
2	One-shot with auto re-arm

Valid Range: 0 to 2
Reset State: After reset initialization, the trigger system is configured as one-shot.

TRIGCONFIGQ ..... 0014_{16}

This command returns a 16-bit integer specifying the trigger system configuration to the Query Response Register.

Reset State: Not applicable.

TRIGGER ..... $000F_{16}$

This command triggers the measurement system to begin measurements on all enabled channels. The module must be in a wait-for-trigger state prior to receipt of the TRIGGER command. If the module is not in a wait-for-trigger state prior to the TRIGGER, a trigger-too-fast condition occurs. Refer to the TRIGCONFIG low-level command for details on the module's response to a trigger-too-fast condition.

Reset State: After reset initialization, the trigger system is in an idle or wait-for-arm state.

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WDOGTOUT *<time out high word>* ..... 0019_{16}
<time out low word>

On TRIGGERed measurements (not initiated by MEASUREQ), a watchdog timer ensures that measurements complete and that measurement values are reasonable for input frequencies at or near 0 Hz. When a measurement is forced to complete, it causes the Measurement Timeout bit in the Error Flag Word to be set to one (1), the No Error bit in the Status Register to be set to zero (0), and the Measurement Error bit in the Interrupt Status Register to be set to one (1).

Parameter: *<time out>*
<time out high word> is the most significant 16 bits of an IEEE 32-bit floating point number. *<time out low word>* is the least significant 16 bits. The term *<time out>* refers to the 32-bit floating point number which specifies the time between watchdog time-outs in seconds. When the watchdog timer times out, a check is performed on all enabled channels. If an enabled channel has not completed its measurement since the last time-out, the measurement is forced to complete.

When the input frequency is near or at 0 Hz, it may take from one to two watchdog periods from the start of the measurement to complete the measurement, depending on when the measurement started with respect to the state of the watchdog timer. If the input frequency remains at 0 Hz for a free-running trigger, the next measurement completes in exactly two watchdog periods since the first forced measurement qualifies as a measurement for the next watchdog period.

When the watchdog timer forces a measurement to complete, a non-integral number of input periods are measured, thereby significantly degrading measurement accuracy. For more information on the frequency measurement algorithm, refer to "Frequency Measurement Methods" in Chapter 3.

Valid Range: 1.0 to 210.0 seconds
Reset State: After reset initialization, the watchdog time-out is 10.0 seconds.

WDOGTOUTQ ..... $001A_{16}$

This command returns two 16-bit words to the Query Response Register specifying the watchdog timer period in seconds . The first 16-bit word is the most significant 16 bits of a 32-bit IEEE floating point number. The second word is the least significant 16 bits.

Reset State: Not applicable.

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Appendix A
Error Codes and Messages

Message Number	Message	Generated by
-211	"Trigger ignored"	*TRG TRIG[:IMM] INIT[:IMM] get (over HPIB)
-213	"Init ignored"	INIT:CONT INIT[:IMM]
-221	"Settings conflict"	DATA:CVT:CHAN MEM:TABL:DEF MEM:TABL:DEF? MEM:TABL:EUN MEM:TABL:EUN? MEM:TABL:EUN:POIN? MEM:TABL:FREQ MEM:TABL:FREQ? MEM:TABL:FREQ:POIN? MEM:TABL:SEL
-222	"Data out of range"	DIAG:WDOG INP:FILT:FREQ MEM:TABL:DEF MEM:TABL:FREQ [SENS]:DATA:FIFO:PART? [SENS]:EVEN:LEV [SENS]:FREQ:APER STAT:OPER:ENAB STAT:QUES:ENAB VXI:REG:READ? VXI:REG:WRIT
-223	"Too much data"	MEM:TABL:EUN MEM:TABL:FREQ
-224	"Illegal parameter value"	FORM[:DATA] INP:FILT[:LPAS][:STAT] MEM:TABL:DEF MEM:TABL:SEL

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Message Number	Message	Generated by
-225	"Out of memory"	MEM:TABL:DEF
-226	"Lists not same length"	MEM:TABL:EUN MEM:TABL:FREQ
-240	"Hardware error"	*RST *TRG *TST? ABOR DIAG:WDOG DIAG:WDOG? INIT:CONT INIT:[IMM] INP:FILT:FREQ INP:FILT:FREQ? MEM:TABL:DEF MEM:TABL:EUN MEM:TABL:EUN? MEM:TABL:FREQ MEM:TABL:FREQ? [SENS]:DATA:CVT:CHAN [SENS]:DATA:CVT:CHAN? [SENS]:DATA:CVT:RES [SENS]:DATA:FIFO:CHAN [SENS]:DATA:FIFO:CHAN? [SENS]:DATA:FIFO:RES [SENS]:EVEN:LEV [SENS]:EVEN:LEV? [SENS]:FREQ:APER [SENS]:FREQ:APER? [SENS]:FUNC [SENS]:FUNC? TRIG:IMM TRIG:SOUR get (over HPIB)

Note: when Error Code -240 "Hardware Error" occurs, the user can get more information by executing the *TST? command. If that returns 0, there is no cause for concern.

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Message Number	Message	Generated by
2001	"Invalid channel number"	[SENS]:FREQ:APER [SENS]:FREQ:APER? [SENS]:DATA:CVT:CHAN [SENS]:DATA:CVT:CHAN? [SENS]:DATA:CVT? [SENS]:DATA:FIFO:CHAN [SENS]:DATA:FIFO:CHAN? INP:FILT:FREQ INP:FILT:FREQ? INP:FILT[:LPAS][:STAT] INP:FILT[:LPAS][:STAT]? [SENS]:FUNC [SENS]:FUNC? [SENS]:EVEN:LEV [SENS]:EVEN:LEV?
2009	"Too many channels in channel list"	[SENS]:FREQ:APER [SENS]:FREQ:APER? [SENS]:DATA:CVT:CHAN [SENS]:DATA:CVT:CHAN? [SENS]:DATA:CVT? [SENS]:DATA:FIFO:CHAN [SENS]:DATA:FIFO:CHAN? INP:FILT:FREQ INP:FILT:FREQ? INP:FILT[:LPAS][:STAT] INP:FILT[:LPAS][:STAT]? [SENS]:FUNC [SENS]:FUNC? [SENS]:EVEN:LEV [SENS]:EVEN:LEV?

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Appendix B
Tachometer Module Specifications

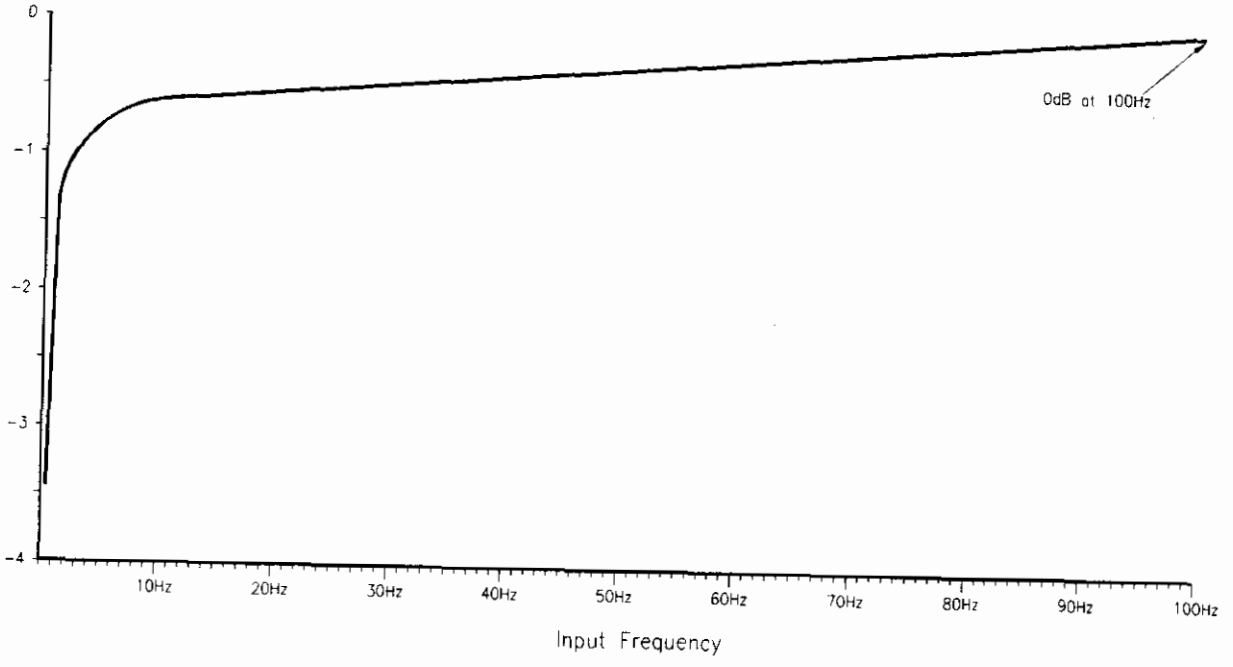
Input Range:	1 Hz to 100 kHz (60 to 6,000,000 RPM) 20 mV p-p to 200 V p-p 10% to 90% duty cycle
Input Isolation:	±250 V peak with respect to earth ground
Input Impedance:	1.6 MΩ for input less than 15 V peak, 150 kΩ for input greater than 15 V peak
Accuracy:	20 MHz ±1 ppm (0°C to 50°C)
Measurement Rate:	Dependent on measurement method and input signal frequency but up to 50 Hz per channel with each channel utilizing 6 millisecond window and each channel returning frequency. Using the measurement criteria stated above, one channel can measure up to a 100-Hz rate..
Attenuation:	2 pole, low-pass filter, 1 kHz < fc < 100 kHz
EU conversion:	Implemented as a 128-segment x-y look-up table
Power:	25 watts
Channels:	Eight (8)
Reading Memory:	2k x 16 FIFO that holds up to 512 measurements
Module Type:	Register-based
Dimensions:	Occupies one C-size VXIbus slot. 9.2 in. W x 13.4 in. D (23.3 x 34 cm)
Cooling:	for 10 °C rise 2.0 liters/sec airflow 0.05 mm H_2O pressure drop across card

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Noise Emission: (German)

LpA = 58 dB
am Arbeitsplatz
normaler Betrieb
nach DIN 45635 T.19

Input Signal vs. Frequency



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Appendix C
Glossary

ACCESSED indicator	An amber LED indicator that lights when the module identity is selected by the Resource Manager module, and flashes during any I/O operation for the module.
ACFAIL	A VXIbus backplane line that is asserted under these conditions: 1) by the mainframe power supply when a power failure has occurred (either AC line source or power supply malfunction) or 2) by the front panel on/standby switch when it is switched to standby.
addressing	External HP-IB addressing. Three types: HP-IB primary addressing, HP-IB secondary addressing, and embedded addressing protocols.
asynchronous communication	Communications that occur outside the normal "command response" cycle. Such communications may have a higher priority than synchronous communications.
backplane	An assembly, usually a printed circuit board, with 96-pin connectors and signal paths that bus the connector pins. VXIbus systems have two sets of bused connectors, called the J1 and J2 backplanes, or have three sets of bused connectors, called the J1, J2, and J3 backplane.
board	A blank printed circuit board.
board assembly	A board and its associated electrical components and connectors.
C-SCPI	See Compiled SCPI
card	VXIbus instrument modules that come in four sizes: A, B, C, and D.
CAT	Computer-aided test.
command	Any communication from a Commander to a Message-Based Servant that consists of a write to the Servant's Data Low Register, possibly preceded by a write to the Data high or Data high and Data Extended registers.
commander	A message-based device that is also a bus master and can control one or more servants.
command module	AKA slot 0 module, GP-IB interface, or Resource Manager. Manages bus communication. May provide clock and trigger signals for synchronizing and initiating measurements. Identifies all VXI devices in the system, manages system self test, configures system's A24 and A32 maps, configures commander/servant hierarchies, initiates normal operation.
communication registers	A set of device registers that are accessible to the commander of the device. Such registers are used for inter-device communications, and are required on all VXIbus message-based devices.

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Compiled SCPI	C-SCPI works with C or C++ programs using an ANSI C compiler. It is used to acheive easy programming while maintaining high throughput with VXI register-based instruments.
configuration registers	The A16 registers of a device which are required for the system configuration process.
device	The lowest logical component of a VXI system, usually on VXIbus board. Multiple-slot devices and multiple-device boards are permitted by the VXIbus System Specification. Devices can include computers, multimeters, oscillators, and counters.
DC-Peak current	I_{Pm} DC-peak current is the peak current consumption of the module.
dynamic current	I_{Dm} Dynamic current is an equivalent ripple current of the module. Determines the dynamic current capacity required of the mainframe.
ECL	Emitter-coupled logic. fastest of all logic families. Uses bipolar junction transistors. AKA current mode logic (CML). Does not operate in the saturation region, consumes more power than TTL.
EMC	Electromagnetic compatibility. VXIbus specifies radiated and conducted EMC limits.
ESD	Electro-static discharge.
events	Signals or interrupts generated by a device to notify another device of an asynchronous event. The contents of events are device dependent.
FAILED Indicator	A red LED indicator that lights when a device on the VXIbus has detected an internal fault. This might result in the assertion of the SYSFAIL* line.
HP 75000	VXI Product Series.
HP-IB	Hewlett-Packard interface bus. 8-bit parallel.
HP ITG	Hewlett-Packard Interactive Test Generator. Software to provide virtual front panels on the system's CRT. Instrument drivers for each type of instrument consist of ASCII files of SCPI commands. Can run in MS-DOS, HP BASIC, and HP-UX.
HP VEE	Hewlett-Packard Visual Engineering Environment. HP VEE features layout solutions with screens, icons, and lines. Code is generated automatically; incorporates DSP functions.
IAC	Instrument on a card.
IEEE-488	Evolved from HP-IB. ASCII or binary instructions and data return. Maximum transfer rate: 1 Mbyte/sec. Easy integration; program in any language.
ITG	Interactive test generator.
local bus	Daisy-chain bus. 12 lines wide each direction through P2, additional 24 lines through P3. Allows for five signal classes: TTL, ECL, analog low, analog med, and analog hi.

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logical address	An 8-bit number that uniquely identifies each VXIbus device in a system. It defines the A16 register addresses of a device, and indicates commander and servant relationships.
mainframe	The chassis of a VXI system which houses VXI modules and the VXI backplane. It ensures that connectors fit properly. Adjacent modules do not contact each other, modules do not disengage from the backplane, and provides cooling airflow.
message-based device	An intelligent device (includes an on-card microprocessor) that implements the defined VXIbus registers and communication protocols.
metrology	The science of measurement for determination of conformance to technical requirements including the development of standards and systems for absolute and relative measurements. (test, measurement and diagnostic equipment).
MODID lines	Module/system identity lines.
module	A board assembly and its associated mechanical parts including the front panel and shields. A module includes everything necessary to occupy one or more slots in a mainframe.
MXIbus	Multisystem eXtension Interface bus. A general-purpose 32-bit multimaster system bus on a flexible, round cable. Used to interconnect VXI mainframes, VME chassis, and/or general purpose computers.
operational register	A device register that is not required for the configuration process.
physical address	The address assigned to a backplane slot during an access.
P1	96-pin DIN connector, carries the data transfer bus (up to 24 bits addressing and 16 bits data), the interrupt buses, and some power.
P2	96-pin DIN connector. Expands the data transfer bus to the full 32 bits, adds four additional power supply voltages, the local bus, the module identification bus (slot number), the analog summing bus (a current summing bus that runs the length of the backplane, TTL and ECL trigger buses that run the length of the backplane with four trigger protocols defined), and a 10-MHz differential ECL clock signal buffered to each slot. Eight 12-MHz trigger lines, two 60-MHz trigger lines, and two STAR trigger lines capable of 200 MHz. Cards with P1 and P2 allow data transfer of 250 Mbyte/s.
P3	96-pin DIN connector. Available only on D-size cards. 24 more local bus lines, 100-MHz clock and star trigger lines for precision synchronization. Cards with P1, P2 and P3 allow data transfer of 1 Gigabyte/s.
Query	A form of command that allows for inquiry to obtain status or data.
register-based device	A servant-only device that has VXIbus configuration registers. Register-based devices are usually controlled by message-based devices via device-dependent reads and writes.

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resource manager	A message-based commander which occupies address 0 and provides configuration management services such as map configuration, commander and servant mappings, and self-test and diagnostics management.
responses	Signals or interrupts generated by a device to notify another device of an asynchronous event. Responses contain the information in the response register of the sender.
RFI	Radio Frequency Interference (10 kHz to 100,000 MHz).
RF link	Radio frequency channel(s) used to connect the unit under test with the testing device.
SCPI	Standard Commands for Programmable Instruments. High-level ASCII commands which describe signals as opposed to instruments. Open standard programming, mnemonics. Evolved from HPSL, HP System Language, which became TMSL, Test and Measurement System Language. Three types of compatibility: vertical (similar instruments, same commands), functional (similar functions, same commands), and horizontal (same measurements, same commands).
servant	A message-based or register-based device that is controlled by a commander.
shared memory protocol	A communication protocol for message-based devices that uses an area of memory accessible to both. The protocol specifies connection and operation sequences to be followed by both devices.
SICL	Standard Instrument Control Library. The I/O function library for HP-UX-based instrument controllers used with the Compiled SCPI function library.
signal	A communication between message-based devices consisting of a write to a signal register.
slot	A position where a module can be inserted into a VXIbus backplane. Each slot provides the 96-pin J connectors to interface with the boards' P connectors. A slot can have one, two, or three connectors.
slot 0 device	A VXI device that provides basic resources to VXI slots 1 through 12. For B- and C-size systems, the resources provided are CLK10 and MODID. for D-size systems, the slot 0 device also provides CLK100.
system	A system consists of one or more mainframes that are all connected and share a common resource manager. Each device in a system is assigned a unique logical address.
trigger	A pulse used to initiate a function.
TTLTRG	Open collector TTL lines used for inter-module timing and communications.
VI	Virtual instrument made using software.
VMEbus	In October, 1981, Motorola, Mostek, and Signetics announced a line of cards based on the VERSAbus with Eurocard Module dimensions: VMEbus.
VXIbus	VMEbus eXtensions for Instrumentation.

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VXIbus instrument	A message-based device which supports the VXIbus instrument protocols.
word serial protocol	The simplest required communication protocol used by message-based devices in the VXI system. It used the A16 communication registers to transfer data with a simple polling handshake method.

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