2412

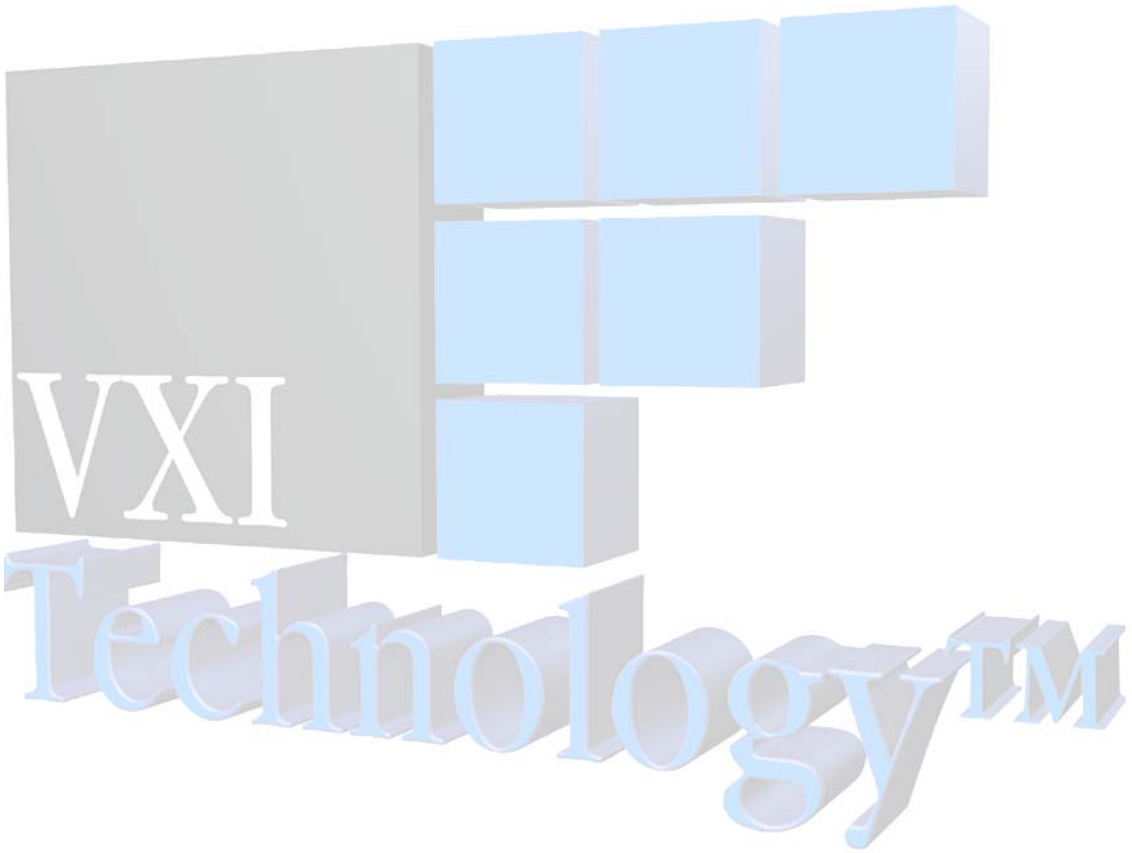
DUAL-CHANNEL PROGRAMMABLE DIGITIZER

USER'S MANUAL

82-0044-000
Rev. April 7, 2003

VXI Technology, Inc.

2031 Main Street
Irvine, CA 92614-6509
(949) 955-1894


VXI
Technology™

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CERTIFICATION

VXI Technology, Inc. (VTI) certifies that this product met its published specifications at the time of shipment from the factory. VTI further certifies that its calibration measurements are traceable to the United States National Institute of Standards and Technology (formerly National Bureau of Standards), to the extent allowed by that organization's calibration facility, and to the calibration facilities of other International Standards Organization members.

WARRANTY

The product referred to herein is warranted against defects in material and workmanship for a period of one year from the receipt date of the product at customer's facility. The sole and exclusive remedy for breach of any warranty concerning these goods shall be repair or replacement of defective parts, or a refund of the purchase price, to be determined at the option of VTI.

For warranty service or repair, this product must be returned to a VXI Technology authorized service center. The product shall be shipped prepaid to VTI and VTI shall prepay all returns of the product to the buyer. However, the buyer shall pay all shipping charges, duties, and taxes for products returned to VTI from another country.

VTI warrants that its software and firmware designated by VTI for use with a product will execute its programming when properly installed on that product. VTI does not however warrant that the operation of the product, or software, or firmware will be uninterrupted or error free.

LIMITATION OF WARRANTY

The warranty shall not apply to defects resulting from improper or inadequate maintenance by the buyer, buyer-supplied products or interfacing, unauthorized modification or misuse, operation outside the environmental specifications for the product, or improper site preparation or maintenance.

VXI Technology, Inc. shall not be liable for injury to property other than the goods themselves. Other than the limited warranty stated above, VXI Technology, Inc. makes no other warranties, express or implied, with respect to the quality of product beyond the description of the goods on the face of the contract. VTI specifically disclaims the implied warranties of merchantability and fitness for a particular purpose.

RESTRICTED RIGHTS LEGEND

Use, duplication, or disclosure by the Government is subject to restrictions as set forth in subdivision (b)(3)(ii) of the Rights in Technical Data and Computer Software clause in DFARS 252.227-7013.

VXI Technology, Inc.
2031 Main Street
Irvine, CA 92614-6509 U.S.A.

DECLARATION OF CONFORMITY

Declaration of Conformity According to ISO/IEC Guide 22 and EN 45014

MANUFACTURER'S NAME	VXI Technology, Inc.
MANUFACTURER'S ADDRESS	2031 Main Street Irvine, California 92614-6509
PRODUCT NAME	Dual-Channel Programmable Digitizer
MODEL NUMBER(S)	2412
PRODUCT OPTIONS	All
PRODUCT CONFIGURATIONS	All

VXI Technology, Inc. declares that the aforementioned product conforms to the requirements of the Low Voltage Directive 73/23/EEC *and the* EMC Directive 89/366/EEC *(inclusive* 93/68/EEC*) and carries the "CE" mark accordingly. The product has been designed and manufactured according to the following specifications:*

SAFETY	EN61010 (2001)
EMC	EN61326 (1997 w/A1:98) Class A CISPR 22 (1997) Class A VCCI (April 2000) Class A ICES-003 Class A (ANSI C63.4 1992) AS/NZS 3548 (w/A1 & A2:97) Class A FCC Part 15 Subpart B Class A EN 61010-1:2001

The product was installed into a C-size VXI mainframe chassis and tested in a typical configuration.

I hereby declare that the aforementioned product has been designed to be in compliance with the relevant sections of the specifications listed above as well as complying with all essential requirements of the Low Voltage Directive.

April 2003

CE

Jerry Patton, QA Manager

GENERAL SAFETY INSTRUCTIONS

Review the following safety precautions to avoid bodily injury and/or damage to the product. These precautions must be observed during all phases of operation or service of this product. Failure to comply with these precautions, or with specific warnings elsewhere in this manual, violates safety standards of design, manufacture, and intended use of the product.

Service should only be performed by qualified personnel.

TERMS AND SYMBOLS

These terms may appear in this manual:

WARNING Indicates that a procedure or condition may cause bodily injury or death.

CAUTION Indicates that a procedure or condition could possibly cause damage to equipment or loss of data.

These symbols may appear on the product:

ATTENTION - Important safety instructions

Frame or chassis ground

WARNINGS

Follow these precautions to avoid injury or damage to the product:

Use Proper Power Cord To avoid hazard, only use the power cord specified for this product.

Use Proper Power Source To avoid electrical overload, electric shock, or fire hazard, do not use a power source that applies other than the specified voltage.

Use Proper Fuse To avoid fire hazard, only use the type and rating fuse specified for this product.

WARNINGS (CONT.)

Avoid Electric Shock

To avoid electric shock or fire hazard, do not operate this product with the covers removed. Do not connect or disconnect any cable, probes, test leads, etc. while they are connected to a voltage source. Remove all power and unplug unit before performing any service. ***Service should only be performed by qualified personnel.***

Ground the Product

This product is grounded through the grounding conductor of the power cord. To avoid electric shock, the grounding conductor must be connected to earth ground.

Operating Conditions

To avoid injury, electric shock or fire hazard:

- Do not operate in wet or damp conditions.
- Do not operate in an explosive atmosphere.
- Operate or store only in specified temperature range.
- Provide proper clearance for product ventilation to prevent overheating.
- DO NOT operate if any damage to this product is suspected. ***Product should be inspected or serviced only by qualified personnel.***

Improper Use

The operator of this instrument is advised that if equipment is used in a manner not specified in this manual, the protection provided by this equipment be may be impaired.

SUPPORT RESOURCES

Support resources for this product are available on the Internet and at VXI Technology customer support centers.

Internet Support

E-mail: support@vxitech.com
Web Address: http://www.vxitech.com

Telephone Support (U.S.)

Tel: (949) 955-1894 **West Coast**
(216) 447-8950 **East Coast**

Fax: (949) 955-3041 **West Coast**
(216) 447-8951 **East Coast**

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SECTION 1

INTRODUCTION

GENERAL DESCRIPTION

The 2412 Dual-Channel Programmable Digitizer is a microprocessor-based waveform-digitizing instrument. Digitized data is stored in 4k by 8-bits or 2048 words per channel of local memory for subsequent display or data transfer. The 2412 uses an IEEE 488 interface for programming and data movement. The interface conforms to the IEEE Standard 488, which is commonly referred to as GPIB (*General Purpose Interface Bus*), for consistency and ease of programming.

Local data memory can be partitioned into as many as eight records of equal length. These records can then be divided into up to fourteen segments with a programmable sampling interval in each one. The sampling interval is selectable from 5 ns to 1 s using the internal clock. When an external clock is used, the period of the applied signal can be multiplied by a selectable multiplier from 1 to 200 x 10^6. The sample interval is logical, where the last sample of a segment is the time-origin of the following segment.

Two separate digital time bases can be individually programmed for memory partitioning, sampling interval and triggering functions. Because the two channels are independent, digitized data can be read from one channel while the other channel is acquiring data.

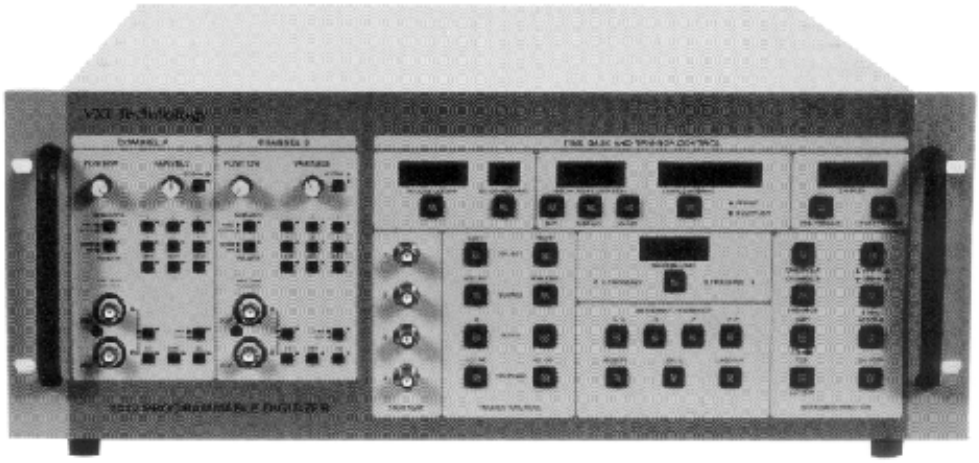


FIGURE 1-1 2412 DUAL-CHANNEL PROGRAMMABLE DIGITIZER

The front panel of the 2412 allows local control of the instrument. Operating parameters are set by pressing the appropriate function key and decrementing or incrementing the parameter. See *Section 2: Operation* for more information. The parameter cycles through only the values that are valid for the current state of the instrument. The instrument checks the settings each time the ARM command is received by means of the front panel or by word-serial command. Errors are reported over the interface bus.

Remote control, front-panel operation and data output through the interface bus are simplified by the microprocessor system. The firmware operating system makes the front panel user-friendly and allows the programmer to use high-level mnemonics to communicate with the instrument over the interface bus.

Extended IEEE 488 addresses are used so that the 2412 can act as an interface for the programmable amplifiers. The logical address may be set locally, from the front panel, or remotely, through the GPIB interface. See the *Section 2: Operation* for information on local control and the *Command Dictionary* section for remote access via the GPIB interface.

TIME BASES AND DATA MEMORIES

The 2412 has an independent digital time-base per channel, each controlling a 2k by 8-bit block of memory. The output is continuously sampled at 5 ns intervals. The time bases select samples from this continuous stream and store them in the waveform memory at the programmed sample rate.

Each channel time base can be individually programmed to partition their 2k block of memory into one to eight records of equal length. Since each record requires a separate trigger to initiate data acquisition, several occurrences of a signal may be acquired before data must be read from memory. Valid record lengths are 256, 512, 1024 and 2048 points, as long as the total number of points does not exceed 2048 (number of records multiplied by the record length $\leq$ 2048).

Records can further divide into one to fourteen segments each with a programmable sampling interval. The segment boundaries are marked by breakpoints which can be located at any integer multiple of eight samples from sixteen to eight less than the record length. Breakpoint locations and sampling intervals are the same for all records within one channel.

Pre-and post-triggering modes are provided to allow acquisition of samples both before and after the trigger event.

ANALOG SIGNALS

The analog input signals from the amplifiers are coupled to the instrument through the amplifier interface. The amplifier interface also carries the analog trigger signals to generate triggers. Signals can be selected from the amplifiers or the rear-panel connectors to generate digital trigger signals for the time bases.

INSTRUMENT CONTROL

The microprocessor system is the instrument master controller. It accepts and decodes commands from the front panel or the interface bus and sets the instrument operating parameters. It also controls the interface to the programmable amplifiers.

In Local state, the microprocessor monitors the front-panel buttons and controls the display. When a parameter is modified with the DECREMENT/INCREMENT buttons, the microprocessor cycles through only those values that are valid for the current state of the instrument.

In Remote state, commands are accepted from the interface bus. The front panel remains operational but front-panel inputs that would modify the state of the instrument will not be accepted and changes will not be executed.

Other tasks performed by the microprocessor include: acting as an interface for the programmable amplifiers, performing a power-up test of the instrument, monitoring the state of the power supplies and refreshing the XYZ display.

POWER SUPPLY

The 2412 power supply provides regulated voltages for the analog and digital circuitry, as well as the amplifiers. In addition to the front-panel ON/OFF switch, remote control of the supply is provided through two rear-panel connectors. The supply can be turned on and off by applying a TTL-level signal to the ACTUATE connector. The ENABLE output can control the ACTUATE input of another similar instrument.

UNPACKING THE 2412

When the 2412 is unpacked from its shipping carton, the contents should include the following items:

(1) 2412 Dual-Channel Programmable Digitizer
(1) 2412 Dual-Channel Programmable Digitizer User's Manual (this manual)
(1) Power Cord

All components should be immediately inspected for damage upon receipt of the unit.

TABLE 1-1 2412 GENERAL SPECIFICATIONS

GENERAL SPECIFICATIONS	
DUAL 90 MHZ BANDWIDTH INPUTS	
	200 MSample/s each
RESOLUTION	
	8-bit resolution
LINE INPUT	
	90 to 132 VAC 180 to 250 VAC 48 to 440 Hz Line Input
SOFTWARE	
	Software command set compatible with the Tektronix 7612D
MECHANICAL	
	Mechanical design compatible with the Tektronix 7612D

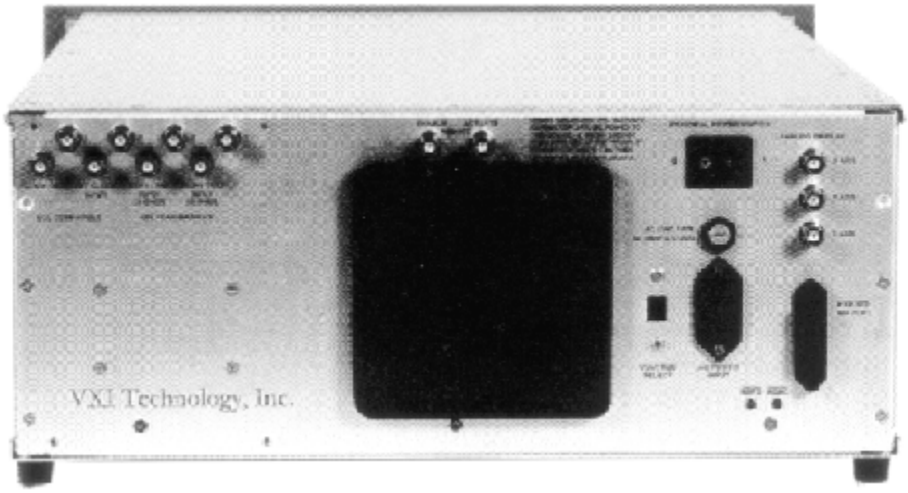


FIGURE 1-2 2412 DUAL-CHANNEL PROGRAMMABLE DIGITIZER - REAR VIEW

SECTION 2

OPERATION

This section describes the operation of the 2412 and the Programmable Amplifiers. It is divided into front-panel functions, essential instrument settings to get started, rear-panel connections, followed by detailed operating procedures.

FRONT PANEL FUNCTIONS

The 2412 front-panel controls and indicators are divided into four main function sets:

Instrument Control Functions	Controls the basic functions of the 2412, such as powering on and off, clock source and copying values from one time base to another.
Time Base Functions	The time base controls program the time bases for memory partitioning, sample intervals, and pre- and post-trigger modes.
Trigger Functions	The trigger controls program the trigger level, source, slope, and coupling parameters.
Programmable Amplifier Functions	There are two separate channels.

The following sections describe the functions of each of these front-panel sets in detail. Each section includes a front-panel breakout of the function set that shows the location of each item described. The entire front panel is shown in Appendix A.

The connector section on the front panel labeled FROM REAR (connectors 1, 2, 3 and 4), provide straight-through connection to the corresponding rear-panel connectors. See the Rear-Panel Connections section for a functional description of these connectors.

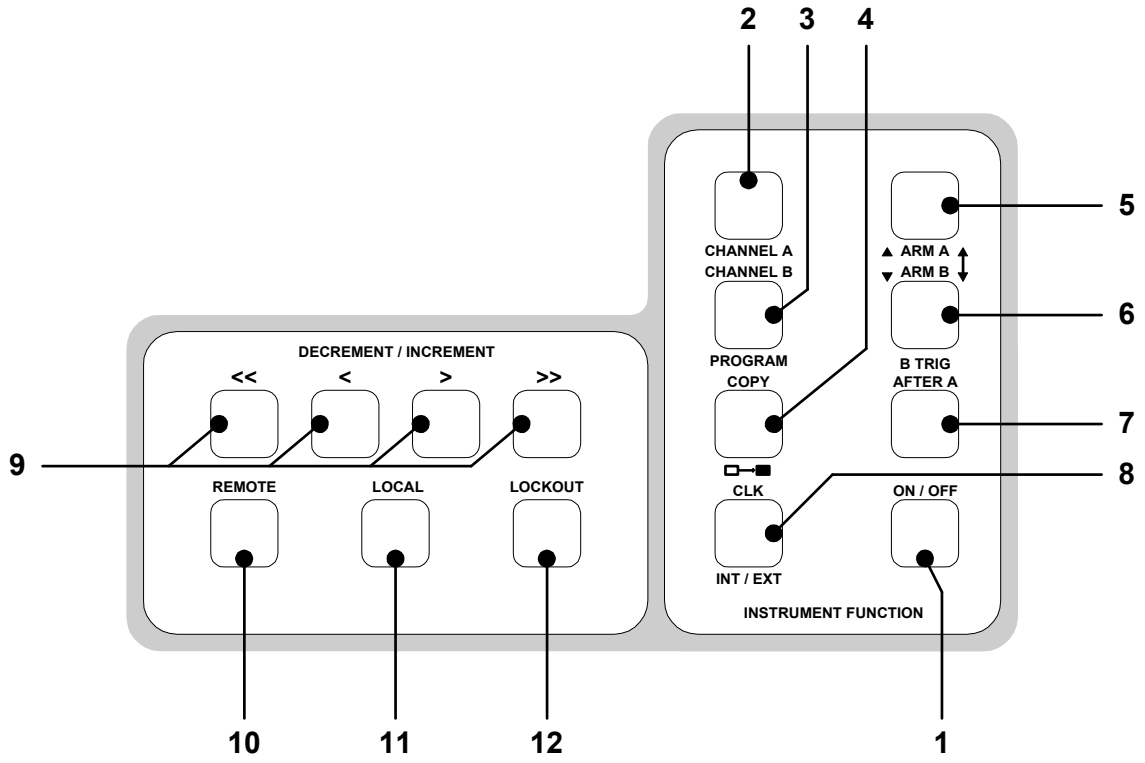


FIGURE 2-1 FRONT-PANEL INSTRUMENT CONTROLS

1	**ON/OFF**	Turns the 2412 power ON or OFF if the rear-panel PRINCIPLE POWER SWITCH is ON. The rear-panel ACTUATE connector overrides the ON/OFF switch. The ON/OFF button illuminates when power is on.
2	**CHANNEL A**	Selects the A channel to be programmed by subsequent time base and trigger function entries. Also causes the current settings for Channel A to be displayed on the front panel.
3	**CHANNEL B**	Selects the B channel to be programmed by subsequent time base and trigger function entries. Also causes the current settings for Channel B to be displayed on the front panel.

4	**COPY**	Copies the settings from the selected time base to the other time base. For example, if time base A is selected (CHANNEL A button lit), pressing the COPY button will copy all settings from time base A to time base B.
5	**ARM A**	Arms the A time base. If any changes were made to the A time base settings since the last ARM operation, the validity of the settings is first verified. If any errors are found during verification, a warning message is generated that is retrievable over the interface bus. When the ARM operation is complete, the time base becomes triggerable.
6	**ARM B**	Arms the B time base. If any changes were made to the B time base settings since the last ARM operation, the validity of the settings is first verified. If any errors are found during verification, a warning message is generated that is retrievable over the interface bus. When the ARM operation is complete, the time base becomes triggerable.
7	**B TRIG AFTER A**	Set the 2412 to B TRIGgerable AFTER A mode. In this mode, time base B becomes triggerable after the first record of A is acquired. If only time base B is armed, it will not trigger until A is armed and has acquired one record of data. MANual TRIGger will not trigger time base B until this condition is satisfied.
8	**CLK**	Selects the internal or external clock as the clock source for both channels. When set for INTernal, the CLK button lights and the SAMPLE INTERVAL function selects a sample period in seconds. When set for EXTernal, the SAMPLE INTERVAL function selects a period multiplier for the externally supplied clock signal.
9	**DECREMENT /INCREMENT**	Allows the user to decrement or increment the current values for a selected time base or trigger parameter. The value is only decremented or incremented through valid values, and does not wrap around. When the value reaches its upper or lower limit, it stops. For example, to set a new record length, the user presses RECORD LENGTH to modify that value using the decrement/increment buttons. The value can be cycled through all the valid settings for RECORD LENGTH. If any other button other than DECREMENT/INCREMENT, ON/OFF, or LOCAL is pressed, the new value is entered. If the instrument goes to remote state before another button is pressed, the previously selected value is automatically entered. The << and >> buttons cause the value to decrement/increment at a faster rate than the < and > buttons.

10 **REMOTE** The REMOTE button lights when the 2412 is set to remote state by the bus system controller. When REMOTE is pressed and the system controller has enabled the Remote Request function (REM ON command), the 2412 requests service from the controller and reports remote request status.

11 **LOCAL** Returns the 2412 from remote state to local state unless the system controller has set the instrument to remote with lockout state. The LOCAL button is lit when in local state.

12 **LOCKOUT** Lights to indicate that the 2412 is in local with lockout state or remote with lockout state.

When pressed, the LOCKOUT button causes the instrument primary and secondary bus addresses to be displayed in the RECORD LENGTH and SAMPLES indicators respectively.

The normal front-panel display can be restored by pressing any other button except ON/OFF or LOCAL.

This button is also used for special front-panel operations. See *Instrument Settings* later in this section for more information.

TIME BASE FUNCTIONS

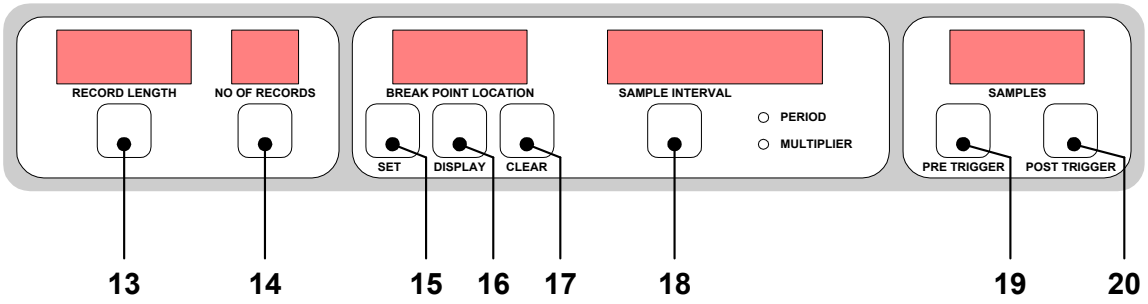


FIGURE 2-2 FRONT-PANEL TIME BASE CONTROLS

13 **RECORD LENGTH** When pressed, the length of the record(s) for the selected time base can be set with the DECREMENT/INCREMENT buttons. The RECORD LENGTH button lights when selected.

The display shows the length of the record(s) for the currently selected time base.

14	**NO OF RECORDS**	When pressed, the number of records for the selected time base can be set with the DECREMENT/INCREMENT buttons. The NO OF RECORDS button lights when selected. The display shows the number of records for the currently selected time base.
15	**SET**	When pressed, a new breakpoint location can be set with the DECREMENT/INCREMENT buttons. The breakpoint is set in all record(s) in the selected time base.
16	**DISPLAY**	Causes the existing breakpoint(s) and the corresponding sample interval(s) to be displayed in the BREAKPOINT LOCATION display. The DECREMENT/INCREMENT buttons allow the user to cycle through all the existing breakpoints. The DISPLAY function also selects the breakpoint to be cleared with the CLEAR function. Breakpoints can only be cleared after they are DISPLAYed. Breakpoints can be displayed and cleared from the front panel in local state, but they can only be displayed in remote state.
17	**CLEAR**	Clears the breakpoint displayed on the BREAKPOINT LOCATION display. The sample interval from the preceding breakpoint is applied to all samples up to the next breakpoint. The breakpoint is cleared in all record(s) in the selected time base. Breakpoints must be selected with the display function before they can be cleared.
18	**SAMPLE INTERVAL**	Sets the sample interval or external clock-period multiplier for all samples after the displayed breakpoint, and up to the next breakpoint (or the end of the record). The display shows the current sample interval or external clock-period multiplier. The PERIOD indicator lights when the internal clock is selected and the value shown in the SAMPLE INTERVAL display is the period in seconds. The MULTIPLIER indicator lights when the external clock input is selected, and the value in the SAMPLE INTERVAL display is the external clock-period multiplier.
19	**PRE TRIGGER**	When pressed, the number of pre-trigger samples to be stored for the selected time base can be set with the DECREMENT/INCREMENT buttons. The range of values is from zero to sixteen less than the number of samples in the first segment.
20	**POST TRIGGER**	When pressed, the DECREMENT/INCREMENT buttons set the number of samples that are ignored after the trigger before the instrument begins storing data. Allowable post-trigger values range from eight to the record length. When POST TRIGGER mode is selected, only one record may be selected for that channel.

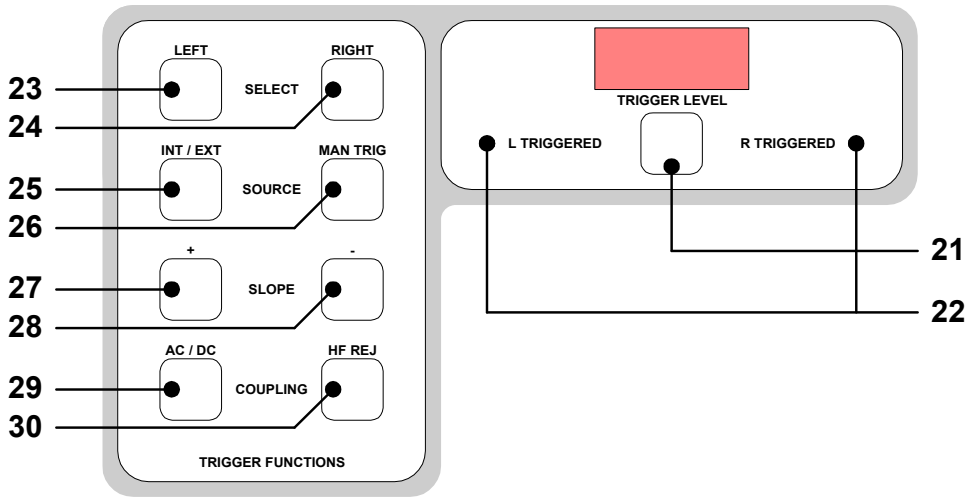


FIGURE 2-3 FRONT-PANEL TRIGGER CONTROLS

21	**TRIGGER LEVEL**	When pressed, the trigger level for the currently selected trigger channel can be set by the DECREMENT/INCREMENT buttons. The display indicates the trigger level value for the currently selected trigger channel.
22	**L and R TRIGGERED**	The L or R TRIGGERED indicator lights to indicate that the corresponding trigger channel has received a valid trigger.
23	**LEFT**	Selects the left trigger channel for programming by subsequent trigger function entries. Also causes the left trigger channel to be used as the trigger source for the time base currently being programmed. The trigger level for the left channel is displayed in the TRIGGER LEVEL display.
24	**RIGHT**	Selects the right trigger channel for programming by subsequent trigger function entries. Also causes the right trigger channel to be used as the trigger source for the time base currently being programmed. The trigger level for the right channel is displayed in the TRIGGER LEVEL display.
25	**INT/EXT**	Selects internal or external source for the trigger signal. The INT/EXT button lights when INTernal is selected.

26	**MAN TRIG**	Causes the currently armed channel(s) to trigger. MAN TRIG does not affect the trigger function settings. One record of data is acquired for each MAN TRIG. If multiple records are selected, one MAN TRIG per record is required to manually complete acquisition.
27	+	Sets the selected trigger channel to trigger on the positive slope of the waveform. The + button lights when selected.
28	-	Sets the selected trigger channel to trigger on the negative slope of the waveform. The - button lights when selected.
29	**AC/DC**	Selects the AC or DC coupling of the triggering signal. The AC/DC button lights when AC is selected.
30	**HF REJ**	When selected, trigger signal frequencies above approximately 50 kHz are attenuated. The HF REJ button lights when selected.

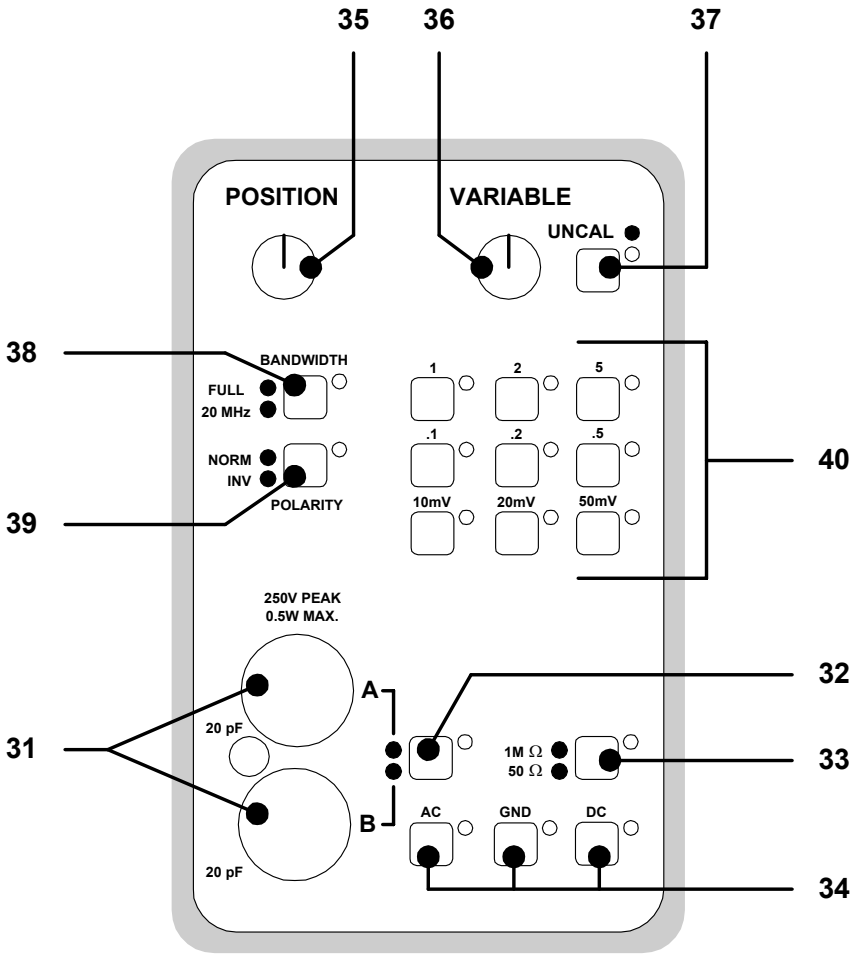


FIGURE 2-4 FRONT-PANEL AMPLIFIER CONTROLS

31	**INPUT Connectors**	Two BNC input connectors are provided to aid in switching between two inputs, such as a signal source and a calibration source. The A or B input is selected by the button switch adjacent to the connectors (item 32).
32	**A-B Switch**	Selects either the A or B input connector. When unlit, the A input is selected; when lit, the B input is selected.
33	**1 MΩ/50 Ω Switch**	Selects an amplifier input impedance of 1 MΩ or 50 Ω. When unlit, 1 MΩ is selected; when lit, 50 Ω is selected.

34 **AC-GND-DC Switches**

These three switches select one of the following input coupling modes:

AC	The AC component of the signal is coupled to the input while the DC component is blocked.
GND	The input connectors are disconnected from the amplifier input, and the amplifier input is connected to ground.
DC	Both the AC and DC components of the signal are coupled to the amplifier input.

The button that is currently lit indicates the selected input-coupling mode.

35 **POSITION Control**

Controls the vertical position of the trace by injecting a DC offset into the amplifier along with the input signal.

36 **VARIABLE Control**

Provides continuously variable scale factors between calibrated ranges. The variable scale factors overlap and are uncalibrated. When the 2412 is set to Local mode, this control is operative only when the UNCAL button is lit (Item 37). When the 2412 is in Remote mode, the VARIABLE control is inoperable regardless of the UNCAL function setting, unless enabled under program control. Its control setting is not programmable. When changing from Local to Remote mode, the VARIABLE control is automatically set to OFF so that the vertical scale factors are calibrated.

37 **UNCAL**

When pressed and lit (selected), the VARIABLE control (described above) is operable.

38 **BANDWIDTH Switch**

Selects full amplifier bandwidth or reduced amplifier bandwidth of 20 MHz. When unlit, full bandwidth is selected; when lit, reduced bandwidth is selected.

39 **POLARITY Switch**

Selects normal or inverted amplifier mode. When unlit, normal mode is selected; when lit, inverted mode is selected.

40 **VOLTS/DIV Switches**

These nine switches select calibrated scale factors from 10 mV/div to 5 V/div, in nine steps, with a 1-2-5 sequence. The button indicator that is currently lit indicates the selected scale factor.

INSTRUMENT SETTINGS

The following shows detailed steps for some of the instrument setups, such as addressing, gain and product identification, from the front panel.

SET GPIB PRIMARY ADDRESS

This sets the lower five bits of the GPIB primary address. The following sequence sets both My Talk Address (MTA) and My Listen Address (MLA).

Step 1 From the front panel, press the LOCKOUT key. This results in displaying the Primary address in the Record Length LED display field and the Secondary address in the Samples LED display field.

Step 2 Press the LOCKOUT key 4 more times in a row.

Step 3 Press the Record Length key. This will cause the Primary Address to flash indicating that it is ready to be edited.

Step 4 Decrement or increment the Primary Address by using the arrow keys

<< < > >>

until the desired address appears in the Record Length display window.

Step 5 Save the address by pressing the LOCAL key (just to the left of the LOCKOUT key). This results in saving the Primary Address to nonvolatile memory and restoring the 2412 to normal operation.

Note *Inserting any other keystrokes into this procedure will result in restoring the 2412 to normal operation without saving the new address to nonvolatile memory.*

To access this setting from the front panel, the *Calibration Sticker GPIB* function must be disabled, which is the factory default. See the *Command Dictionary* section for more detail on this command.

SET GPIB SECONDARY ADDRESSES

This sets the lower five bits of My Secondary Address (MSA) for the main frame, the Channel A amplifier, and the Channel B amplifier. The selected number is MSA for the main frame. The Channel A amplifier is assigned the mainframe address **MSA + 1**. The Channel B amplifier is assigned the mainframe address **MSA + 2**.

Step 1 From the front panel, press the LOCKOUT key. This results in displaying the Primary address in the Record Length LED display field and the Secondary address in the Samples LED display field.

Step 2 Press the LOCKOUT key more 4 times in a row.

Step 3 Press the PRE TRIGGER or POST TRIGGER key (same effect). This will cause the Secondary Address to flash indicating that it is ready to be edited.

Step 4 Decrement or increment the flashing number by using the arrow keys

<< < > >>

until the desired address appears in the Record Length display window.

Step 5 Save the address by pressing the LOCAL key (just to the left of the LOCKOUT key). This results in saving the Secondary Address to nonvolatile memory and restoring the 2412 to normal operation.

Note *Inserting any other keystrokes into this procedure will result in restoring the 2412 to normal operation without saving the new address to non-volatile memory.*

To access this setting from the front panel, the *Calibration Sticker GPIB* function must be disabled, which is the factory default. See the *Command Dictionary* section for more detail on this command.

SET PRODUCT ID

This GPIB command allows the user to change the unit's ID string.

The defaults are:	VXI/VM2412S-Mainframe,1.07	*mainframe*
	VXI/VM2412S-Plugin A,V1.02	*Channel A amplifier*
	VXI/VM2412S-Plugin B,V1.02	*Channel B amplifier*

Note: The default version numbers may be different than listed above.

ID "<ID string>" — *where <ID string> is the customer input string, which must be enclosed in double quotation marks..*

Example:

```
ID "VXI/VM2412S-Mainframe,107"
```

SET GPIB TERMINATION

This sets the type of message terminator recognized by the instrument. The two choices are **EOI** or **LF**. The **EOI** setting uses the GPIB EOI (End or Identify) signal to indicate the end of the message. The **LF** setting uses a Line Feed character to signal the end of the message.

Step 1 From the front panel, press the LOCKOUT key. This results in displaying the Primary address in the Record Length LED display field and the Secondary address in the Samples LED display field.

Step 2 Press the LOCKOUT key more 4 times in a row.

Step 3 Press the TRIGGER LEVEL key. This will cause the currently selected GPIB termination mode to flash (EOI or LF) in the TRIGGER LEVEL display window.

Step 4 Toggle between EOI and LF by using the arrow keys:

<< < > >>

Step 5 Save the selection by pressing the LOCAL key (just to the left of the LOCKOUT key). This results in saving the GPIB Termination selected to nonvolatile memory and restoring the 2412 to normal operation.

To access this setting from the front panel, the *Calibration Sticker TERM* function must be disabled, which is the factory default. See the *Command Dictionary* section for more detail on this command.

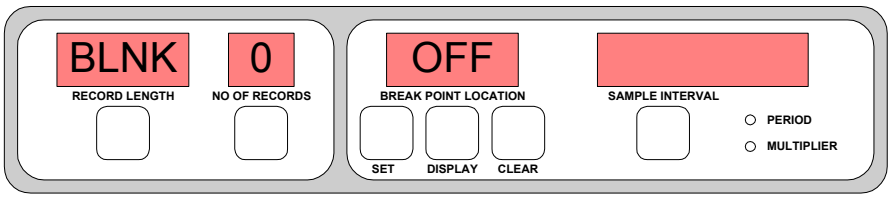
Z BLANKING MODE ON XYZ OUTPUT

This sets the blanking of data at the upper and lower limits (railed data). In addition, the polarity of the blanking pulse is controlled by this function to allow use of the XYZ display with modern oscilloscopes.

Step 1 From the front panel, press the LOCKOUT key. This results in displaying the Primary address in the Record Length LED display field and the Secondary address in the Samples LED display field.

Step 2 Press the LOCKOUT key 4 more times in a row.

Step 3 Press the BREAKPOINT LOCATION DISPLAY key. This will cause the currently selected blanking mode to appear in the 3 left most display fields.



This is the default setting.

Step 4 Toggle between the 4 possible choices by using the arrow keys:

<< < > >>

	Z Blank Polarity	Blank	
BLNK	1	OFF	*The Z Blank rear-panel output will not blank over-ranged data; a high/low level is generated to blank the display*
BLNK	0	OFF	*The Z Blank rear-panel output will not blank over-ranged data; a low/high level is generated to blank the display*
BLNK	1	ON	*The Z Blank rear-panel output will blank over-ranged data; a high/low level is generated to blank the display*
BLNK	0	ON	*The Z Blank rear-panel output will blank over-ranged data; a low/high level is generated to blank the display*

Note: 1 - is for working with newer scopes
0 - is for working with older scopes, TEK7612 compatible

Step 5 Save the selection by pressing the LOCAL key (just to the left of the LOCKOUT key). This results in saving the Blanking Mode selected to nonvolatile memory and restoring the 2412 to normal operation.

SET CHANNEL GAIN

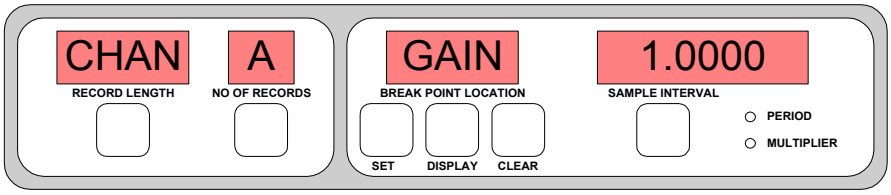
The 2412 allows access to set the gain of the selected channel through the front panel or remotely via GPIB Commands. Below is an example of setting the gain through the front panel. See the *Command Dictionary* section for information on remote access.

Note *This function/feature is equivalent to that of the TEK7612 amplifier front-panel gain-adjustment screws. The 2412 applies the Channel Gain to all samples of recorded data for all ranges, and in effect is a simple multiplier of the recorded data samples. For example, setting the Channel Gain to 0.99 will multiply the input signals recorded samples by the factor 0.99; a 1% decrease in the reported value. Normally, Channel Gain is used for fine adjustment of Channels A and B to help match the amplifier channels to the test station into which the unit is installed.*

Step 1 From the front panel, press the LOCKOUT key. This results in displaying the Primary address in the Record Length LED display field and the Secondary address in the Samples LED display field.

Step 2 Press the LOCKOUT key 4 more times in a row.

Step 3 Press the SAMPLE INTERVAL key. This will result in the display of current gain setting for the selected channel (Channel A/Channel B), as follows:



This is the default setting.

Step 4 Adjust the gain setting up or down using the following keys with the specified effect:

<	=	-0.0001
>	=	+0.0001
<<	=	-0.001
>>	=	+0.001

Step 5 Save the selection by pressing the LOCAL key (just to the left of the LOCKOUT key). This results in saving the gain setting to nonvolatile memory and restoring the 2412 to normal operation.

To access this setting from the front panel, the *Calibration Sticker GAIN* function must be disabled, which is the factory default. See the *Command Dictionary* section for more detail on this command.

SET ARM DELAY

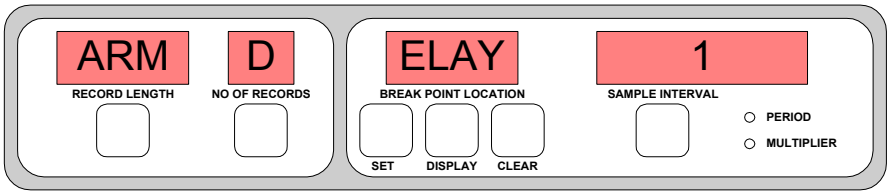
This sets the delay from the receipt of the ARM command until the instrument actually arms. Because the processor and the GPIB interface of the 2412 are fast at handling GPIB commands, the user can adjust the arm delay to closely match their individual situation.

Note	*Use this function/feature to help match the arming delay of the 2412 to that of the TEK7412D for the individual test station into which the unit is installed.*

Step 1 From the front panel, press the LOCKOUT key. This results in displaying the Primary address in the Record Length LED display field and the Secondary address in the Samples LED display field.

Step 2 Press the LOCKOUT key 4 times in a row.

Step 3 Press the NO OF RECORDS key. This will result in the display of ARM DELAY setting for the selected channel



Step 4 Set the desired delay by using the arrow keys:

<< < > >>

***NOTE**: Each delay count is worth 10 ms.*

To access this setting from the front panel, the *Calibration Sticker DELAY* function must be disabled, which is the factory default. See the *Command Dictionary* section for more detail on this command.

REAR PANEL CONNECTIONS

The back-panel control and connectors are shown in the following figure, followed by detailed descriptions.

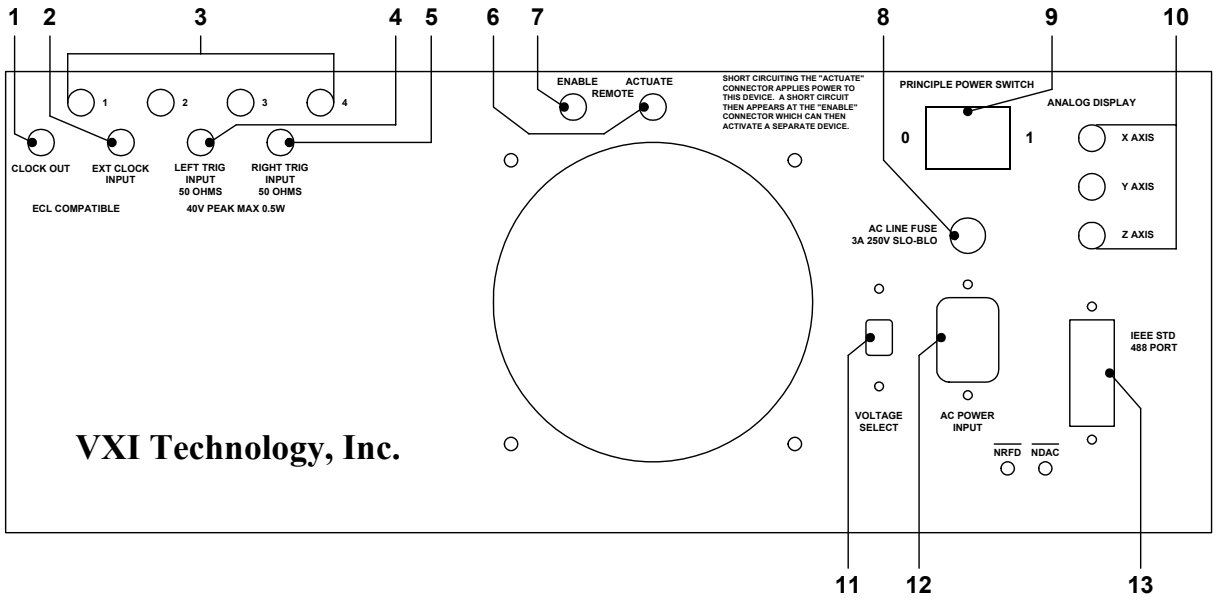


FIGURE 2-5 REAR-PANEL CONNECTORS

1	CLOCK OUT	The ECL level internal clock signal is available at this connector. This output is active in external or internal clock modes.
2	EXT CLOCK INPUT	An ECL-level external clock signal applied to this connector drives the A and B time bases when external clock is selected.
3	1, 2, 3, 4 Connectors	Rear-panel connectors 1, 2, 3, and 4 provide straight through connection to the front-panel connectors 1, 2, 3 and 4 respectively.
4	LEFT TRIG INPUT	Input connector for the left-channel external trigger signal. Terminated in 50 Ω.
5	RIGHT TRIG INPUT	Input connector for the right-channel external trigger signal. Terminated in 50 Ω.

6	ACTUATE	A TTL low applied between the center conductor and outer conductor turns the 2412 power supply on.
7	ENABLE	Applies a TTL low between center conductor and outer conductor shortly after the instrument is powered-up. This allows the power control of the 2412 to be daisy chained with other similar instruments in a system.
8	AC LINE FUSE	Replaceable fuse for AC line. Use 3 A 250 V SLO-BLO fuse.
9	PRINCIPLE POWER SWITCH	Power line switch that controls line input power to the 2412 power supply.
10	X, Y, Z AXIS	Provides X-Y-Z analog equivalents of the waveform data stored in memory for display on an XYZ monitor.
11	VOLTAGE SELECT	Selects 115 VAC or 230 VAC operation.
12	AC POWER INPUT	CAE-22 three prong power connector; IEC coded.
13	IEEE STD 488 PORT	Provides connection to the interface bus specified in IEEE Standard 488-1978.

OPERATING PROCEDURES

Before operating the 2412, ensure the instrument has adequate airflow and nothing is blocking the fan-intake (screen on rear panel) or the air exhaust holes on the sides of the instrument.

XYZ DISPLAY

An XYZ monitor connected to the rear-panel XYZ outputs provides a convenient method of visually setting up the instrument. The 2412 automatically displays the contents of both data memories after each acquisition. During acquisition and while the microprocessor is busy executing commands, the display refresh is disabled. This may cause some normal display flicker during execution of commands. No scale factor readout is displayed on the XYZ monitor.

The XYZ display is divided into two halves. The upper half displays the contents of Channel A and the lower half displays Channel B.

APPLYING POWER

The 2412 power cord must be connected to an outlet with a security grounded protective-ground contact and the correct single-phase voltage.

For the front-panel ON/OFF switch or the rear-panel ACTUATE connector to power-up the instrument, the PRINCIPLE POWER SWITCH must be turned on.

To avoid electrical shock, ensure that the protective ground circuit is not interrupted. A poor or missing circuit can allow the chassis to float to hazardous potentials. Ensure that the power cord, plug, and outlet provide a secure are undamaged and provide a secure path to earth ground.

Press the ON/OFF button or apply a TTL active low on the ACTUATE connector. The ON/OFF button should light and the fan should start. The microprocessor performs a self-test at power-up that requires about three seconds to complete. If the test fails, the microprocessor generates an error message that is retrievable over the interface bus. When the test is complete, the front-panel indicators and buttons come up in their default states.

THE ACQUISITION PROGRAM

An acquisition sequence or “program” stored in the 2412 for each time base controls data acquisition. These programs consist of the number of records, length of record(s), breakpoint locations, sampling intervals, and trigger parameters for each channel. At power-up, the settings for both time bases are:

NO OF RECORDS:	1
RECORD LENGTH:	2048
BREAK POINT LOCATION:	0
SAMPLE INTERVAL:	5 ns
TRIGGER MODE:	Pre-Trigger (0 samples)

The default acquisition program can be modified from the front panel in local state or over the interface bus in remote state. At power-up, the PROGRAM CHANNEL A button lights to indicate that any changes in the time base parameters will affect the A time base. Pressing CHANNEL B causes subsequent time base entries to modify the program for Channel B.

The power-up state also lights the SELECT LEFT button to indicate that the left trigger channel is assigned to the current time base (time base A at power-up). The trigger for the time base will be derived from the settings in the left channel. Any modifications to the trigger parameters will affect the left trigger channel. Pressing SELECT RIGHT will assign the right trigger channel to the currently selected time base and cause subsequent trigger function entries to modify the right trigger-channel parameters. The left trigger channel gets its internal trigger signal from the left amplifier. The right trigger channel gets its internal trigger signal from the right amplifier. The power-up settings for both trigger channels are:

SOURCE:	Internal
SLOPE:	Positive
COUPLING:	AC
HF REJ:	Off
LEVEL:	0

ARMING THE TIME BASE

The 2412 time bases must be armed before they can be triggered to start an acquisition. The flow chart in the next figure illustrates the ARM operation.

If any of the time base settings have been modified since the last arming, the first step is to check the validity of the new settings. Conflicts, such as breakpoints set beyond record length, are corrected with record length having the highest priority (the record length is never changed to resolve a conflict in the settings). If conflicts are found, an error message is generated that can be retrieved over the interface bus.

The second step in the process is also performed only when the time base settings have been modified. In this step, the settings are loaded from the acquisition program into the time base hardware. A typical verify and load process takes approximately 50 ms; the time may vary slightly with different time base settings.

The next step is to initialize the hardware for acquisition, which takes approximately 300 μs.

If the time base is set to PRE TRIGGER mode, one full record of pre-trigger data is acquired before the time base becomes triggerable. The time required for this acquisition can be calculated by multiplying the number of samples in the record (record length) by the sample interval for the first segment. All pre-trigger samples are acquired at the sampling interval of the first segment. This pre-trigger acquisition is repeated before each record when multiple records are selected.

If POST TRIGGER is selected, the pre-trigger acquisition step is skipped. Otherwise, when pre-trigger acquisition is complete, the time base becomes triggerable. The next valid trigger initiates acquisition.

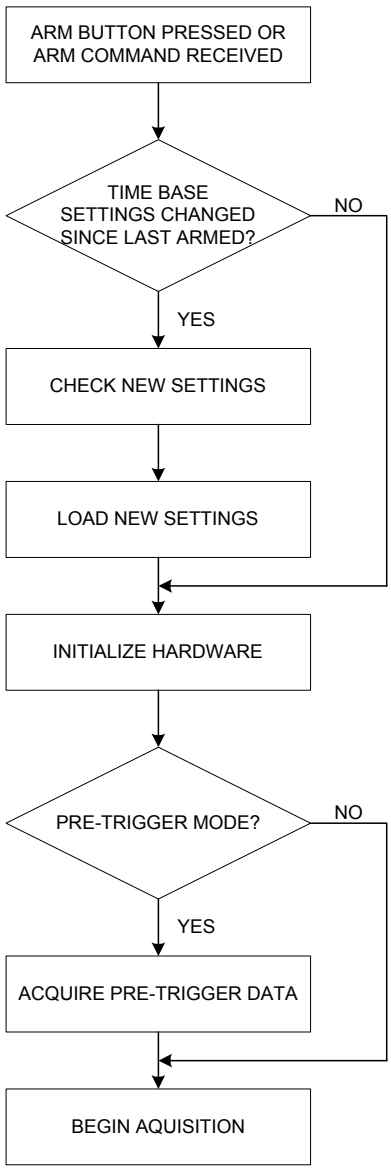


FIGURE 2-6 ARM PROCESS FLOW CHART

ACQUIRING A BASE LINE

1. Connect a compatible XYZ monitor to the 2412.
2. Power up the 2412 and allow it to warm up for 5 minutes.
3. Turn on the monitor and set it for normal intensity.
4. Ground the inputs of programmable amplifiers.
5. Press ARM A and ARM B simultaneously. The ARM buttons should light, indicating that the instrument is armed and triggerable.
6. Press MAN TRIG to trigger the time bases. The instrument acquires one record of 2048 samples for each channel. Two flat lines should appear on the XYZ monitor and the ARM buttons should extinguish.
7. If the base lines do not appear, check the connections and adjustments of the monitor. Then re-ARM the time bases and press MAN TRIG again.
8. If the lines still do not appear, check the Position controls on the programmable amplifiers and repeat the previous step.

SETTING THE TRIGGER FUNCTIONS

The 2412 has two independent trigger channels. Triggering parameters such as level, slope, source, and coupling can be individually programmed for each trigger channel. The trigger channels receive analog trigger signals from the programmable amplifiers, an external source, or the MANual TRIGger button on the front panel. If the programmed trigger conditions are met, the trigger circuits generate digital trigger signals for the time bases.

Each time base can be programmed to use either of the trigger channels as a source for the trigger signal. At power-up, time base A is set to receive its trigger from the left trigger channel, and time base B is set to receive its trigger from the right channel. The user may change these assignments by pressing the SELECT LEFT or RIGHT buttons while setting up the instrument. The selected trigger channel is assigned to the time base currently being programmed, and all subsequent trigger function entries modify the parameters of that channel.

All of the trigger functions except LEVEL are selected by pressing a single button on the front panel. The trigger level is set by pressing TRIGGER LEVEL and using the DECREMENT/INCREMENT buttons to change the value. The selected value does not take effect until another button is pressed, or the instrument goes to remote state. If the trigger channel is receiving a valid trigger, the corresponding L or R TRIGGERED light illuminates.

DESCRIPTION OF TRIGGER FUNCTIONS

SOURCE The source functions selects the internal (signal from the amplifiers) or external trigger signal as the trigger source. In most applications, the internal signal from the amplifiers provides an acceptable trigger source. The pre- and post-trigger modes can be used to vary the time relationship between the trigger and the acquired signal. The external source can be used where the input signal is unusually small in amplitude, noisy, or for some reason does not provide adequate triggering.

The external trigger signal is applied to the rear panel LEFT or RIGHT TRIG INPUT connectors. These connectors may be looped through from the front panel with a short 50 Ω coax cable from the TRIG connectors to the number 3 and 4 connectors on the rear panel. This allows the external trigger to be applied to the corresponding front-panel connectors.

COUPLING The COUPLING button selects AC or DC coupling of the trigger signal. When AC coupling is selected (the power-up default), any DC level on the signal is ignored and frequencies below approximately 30 Hz are attenuated. In general, AC coupling can be used for most applications. However, if the sweep is to be triggered on a low-frequency signal or DC level, DC coupling may provide better triggering.

DC coupling provides more stable triggering on low-frequency signal. Remember that the amplifier POSITION control affects the level with DC coupling.

HF REJ When HF REJ (High Frequency REJect) is on (button lit), trigger signal frequencies above approximately 50 kHz are attenuated. This provides a means of filtering complex or noisy signals to provide more stable triggering.

SLOPE The SLOPE functions determines whether the trigger occurs on the positive or negative slope of the trigger signal. The exact level at which the trigger occurs is set by the LEVEL parameter.

TRIGGER LEVEL The TRIGGER LEVEL parameter sets the amplitude level on the trigger signal at which the trigger occurs. The level ranges from +127 to -128, corresponding to the 8-bit resolution of the instrument (256 discrete levels). A setting of +127 means that the trigger will not occur until the signal reaches full-scale amplitude. A setting of 0 means that the trigger occurs when the signal crosses through zero. If the SLOPE is set to +, the time base triggers when the trigger signal passes through the selected level on the positive slope of the signal. If SLOPE is set to -, the time base triggers at the selected level on the negative slope of the signal.

Note ***When AC coupling is used in either the vertical signal path (using internal triggering) or in the Trigger signal path, the DC component of the trigger signal is lost. Therefore, the trigger point on the signal can be very difficult to determine. This trigger point is affected by the wave shape of the signal, by the repetition rate of the signal, by the crest factor, and by the coupling time constants of both the vertical and the trigger coupling capacitors. The vertical coupling time constant is approximately 22 ms and the triggering coupling time constant is approximately 4.7 ms.***

In general, the 2412 will trigger on the trigger setting if the peak value of the input signal, minus the average value of the signal, exceeds the trigger setting by greater than 10 LSB's (internal) or 50 mV (external).

SETTING UP A SIMPLE ACQUISITION PROGRAM

The following is a simple acquisition program to acquire 512-point records of a sine wave in Channel A. For a repetitive input signal, such as a sine wave, all records will be identical (they start at the same trigger point).

1. Power up the 2412.

2. Set the amplifier's VOLT/DIV to 0.5 volts/division.

3. Connect a sine wave generator to the Channel A amplifier input and adjust the generator controls for approximately 4 V_{P-P} (peak-to-peak) output amplitude at 1.5 kHz.

4. Press CHANNEL A to program time base A. (CHANNEL B could also be used; this is just for an example.)

5. Press RECORD LENGTH. The button lights to indicate that the function has been selected and can be cycled through the valid values with the DECREMENT/INCREMENT buttons.

6. Press and the < or << button until the value in the record length display decrements to 512 (the instrument's default powered-up record length is 2048).

7. Press NO OF RECORDS and increment the value to 4. Notice that the number of records will not increment past 4, since four 512-point records fill the entire data memory (2048 points).

8. Press SAMPLE INTERVAL and increment the value to 1 μs (1E-6). For this example, the entire record will be acquired at this sampling interval, so no breakpoints are needed.

9. Check that the trigger functions are set as follows:

SOURCE:	Internal
SLOPE:	Positive (+)
COUPLING:	AC
HF REJ:	Off

10. Check that the L TRIGGERED indicator is on. If not, adjust the trigger level by pressing the TRIGGER LEVEL button. Decrement or increment the value and press the TRIGGER LEVEL again to load the new level. (Pressing any button except DECREMNT/INCREMENT, ON/OFF, or LOCAL loads the new value.) Repeat this procedure until the L TRIGGERED indicator lights and stays on.

11. Recheck the settings made in the above steps. The settings can be changed as long as the resulting settings do not conflict. If they do conflict (e.g. setting the record length to 2048 when 4 records are set up), the instrument modifies the settings (with record length as highest priority) to resolve the conflict. (In the case of setting the record length to 2048, the number of records is set to one).

12. Press ARM A. The instrument checks the validity of the settings and, if errors are found, a warning or error message is generated that is retrievable over the interface bus. Otherwise, the channel becomes triggerable. On the next valid trigger, the instrument acquires the first 512-point record at 1 μs sampling interval. Then it waits for another trigger. When the next trigger occurs, it acquires a second 512-point record, and so on until all four records are acquired.

13. The XYZ monitor will display four identical waveforms as shown in Fig. 2-7. Notice that all waveforms start at the same trigger point. All four records are displayed successively on one line, starting with record zero.

14. If the display is clipped on the top or bottom of the waveform, adjust the amplifier POSITION control or decrease the output amplitude of the generator as required. Press ARM to acquire and display the new data. Repeat this step until the display is similar to Fig. 2-7.

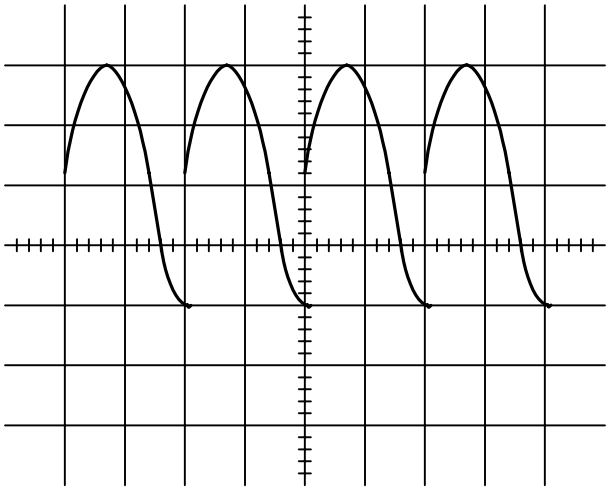


FIGURE 2-7 XYZ DISPLAY - FOUR 512-POINT RECORDS @ 1.5 kHZ

SETTING BREAKPOINTS

In many situations, a small part of a waveform is of particular interest (e.g. the rising edge of a fast pulse), but the remainder of the waveform also contains useful information. Sampling at a high enough rate to provide good time resolution during the rising edge of the pulse produces a large amount of unnecessary data during the slower parts of the waveform (e.g. the flat top of a pulse). The 2412 provides a simple means of changing the sampling interval during an acquisition to expand the important part(s) of a waveform, while recording the remainder at a slower sampling interval.

For example, if the rise time and width of a square-wave pulse is to be measured, the fast rising edge could be sampled at a 50 ns rate. When the pulse reached maximum amplitude, the sampling interval might be increased to 1 μs to acquire the slower part of the waveform.

A sampling interval change is marked by a *breakpoint* set with the front-panel BRAEKPOINT function in local state, or with the SBPT (Set BreakPoinT) command in remote state. Three front-panel buttons are provided to set, display, or clear breakpoints. Breakpoints can be set at any integer multiple of eight samples from sixteen, to eight less than the record length. Remember that all records are identical, so breakpoints apply to all records in the selected channel.

Breakpoints divide the records into *segments*. A segment contains all the samples from the specified breakpoint to the next breakpoint (or the end of the record). One breakpoint at sample zero defines the first segment (segment 0). This breakpoint is always present and cannot be cleared.

The following example illustrates the use of breakpoints and sample interval switching to measure the rise time or pulse width of a long pulse. To reproduce the example, a square-wave generator, with a controlled rise time of approximately 0.1 μs, is required.

1. Connect the square-wave generator to the inputs of both amplifiers with a BNC T-connector. Set the amplifiers VOLT/DIV to 0.5 volts/division and adjust the generator for about 3 V_{P-P} output.

2. Set the generator frequency to 600 Hz.

3. Press PROGRAM CHANNEL B.

4. Press RECORD LENGTH and set the value to 2048 with the DECREMENT/INCREMENT buttons.

5. Press NO OF RECORDS. The number of records changes to one (1) automatically since one 2048-point record fills the waveform memory.

6. Set the sampling interval for the first segment to 1 μs by pressing the SAMPLE INTERVAL button and incrementing the value to 1E-6.

7. Press the COPY button. This copies the current settings of Channel B into Channel A. The result is a single record of 2048 points in Channel A, with no breakpoints and a sampling interval of 1 μs. This will provide a comparison for the waveform acquired with breakpoints in Channel B.

8. Now set the breakpoints in Channel B. Press SET BREAKPOINT. Increment the value in the BREAKPOINT LOCATION display to 856. Notice that the display cycles through multiples of eight samples.

Note *The value will not increment beyond 2040, since this is the last multiple of eight that is less than the current record length of 2048.*

9. Next, set the sample interval for the segment defined previously by pressing SAMPLE INTERVAL. Set the value to 50 ns (50E-9) using the DECREMENT/INCREMENT buttons.

10. Set another BREAKPOINT LOCATION to 944. Set the SAMPLE INTERVAL for this segment to 1 μs.

11. Set another BREAKPOINT LOCATION to 1800. Set the SAMPLE INTERVAL for this segment to 50 ns.

12. Set one last BREAKPOINT LOCATION to 1976. Set the SAMPLE INTERVAL for this last segment to 1 μs.

13. Before arming the instrument, check the breakpoint locations and sampling intervals with the DISPLAY BREAKPOINT function:

    a. Press DISPLAY. The last breakpoint set and its associated sampling interval will be displayed in the BREAKPOINT LOCATION and SAMPLE INTERVAL displays respectively.

    b. Press the < key once to display the next lower breakpoint and sample interval. By pressing < repeatedly, each breakpoint location/sample interval will be displayed one by one until the lowest breakpoint, at location zero, is displayed along with the sampling interval for the first segment. See Fig. 2-8 for an illustration of the memory partitions set in the previous steps.

    c. To change one of the breakpoints, DISPLAY the location to be changed and press CLEAR. The breakpoint is cleared and the sample interval from the preceding breakpoint is applied to all samples up to the next breakpoint. Then, set the new breakpoint using the previous steps.

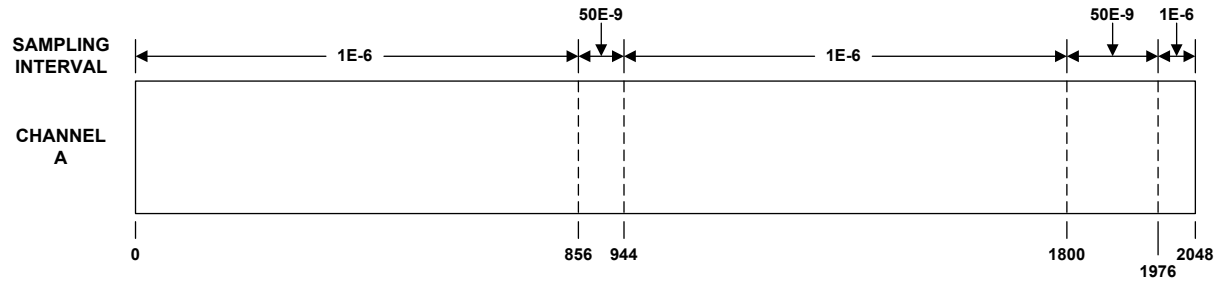


FIGURE 2-8 BREAKPOINT EXAMPLE - MEMORY PARTITIONS

14. When the settings have be set as desired, press ARM A and ARM B simultaneously. The instrument checks the validity of the settings and reports any warning or error messages, which are retrievable over the interface bus.

15. Once a trigger occurs, the instrument begins acquiring data in both channels. If either of the channels do not trigger, check the trigger settings and re-ARM both channels.

The display on the XYZ monitor should be similar to Fig. 2-9 for Channel A. It may not appear the same for Channel B if the rise and fall of the square-wave do not fall within the narrow segments that are sampled at 50 ns. By carefully readjusting the generator frequency, or moving the breakpoints, and repeatedly arming Channel B, there should be a point at which the rise and fall are within these windows and the display is similar to Fig. 2.9. In practice, a computer can acquire the waveform and calculate the exact breakpoint locations and sampling intervals for best results.

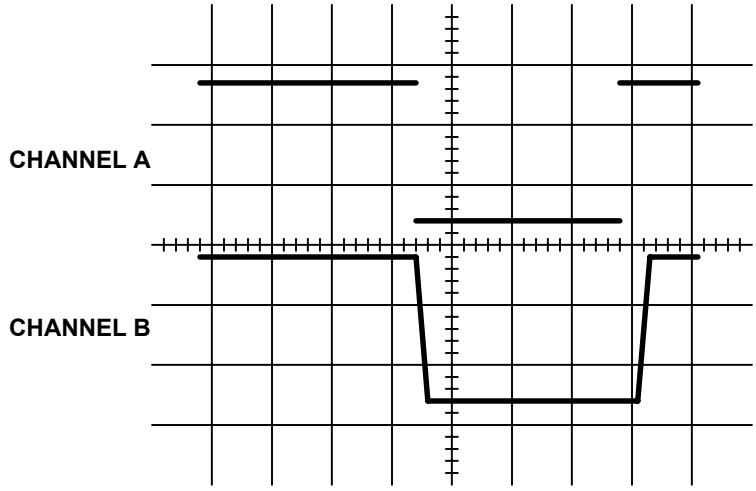


FIGURE 2-9 BREAKPOINT EXAMPLE - XYZ DISPLAY

When the leading and trailing edges of the pulses are expanded with breakpoints, an accurate measurement of rise and fall times, and pulse width can be made in a single acquisition. All sampling intervals are derived from the highly stable 200 MHz internal clock, and the sample interval switching is coherent (the last sample of a segment is the time origin of the following segment). Therefore, time measurements of long periods can be made with 10 ns resolution (worst case).

COPY

In some cases, it may be required to set up the same or similar acquisition programs in both channels of the 2412. The COPY function provides a simple means of copying all the time base settings from one channel to the other. When COPY is pressed, the settings of the selected channel are copied to the unselected channel. All previous settings in the unselected channel are lost. For example, to copy the settings of Channel A to Channel B, first press CHANNEL A to select it. Next, press COPY. Note that the instrument control functions (e.g. CLK, B TRIG AFTER A, etc.) are unaffected by the COPY function.

PRE-TRIGGER MODE

It is often necessary to acquire part of a signal that occurs before the trigger event. For example, the leading edge of a transient pulse may be used to trigger an acquisition. To capture the full leading edge, some samples must be stored just before the trigger occurs. The PRE TRIGGER mode causes the 2412 to store a programmed number of samples before the trigger event.

To visualize the pre-trigger process, think of a record of 2412 data memory as a pipeline, as shown in Fig. 2-10. Data is acquired and stored in the waveform memory, entering the pipeline from the right. As the acquisition progresses, new data entering from the right pushes the previous data toward the left end of the pipeline.

In PRE TRIGGER mode, the 2412 begins acquiring pre-trigger data shortly after the time base is armed. Triggers are ignored during this period. Pre-trigger data is acquired at the sampling interval selected for the first segment and is stored in the waveform memory "pipeline". When a full record of pre-trigger data has been acquired, the time base becomes triggerable, but pre-trigger data acquisition continues until a trigger is received. The new pre-trigger data entering the pipeline forces old data out at the other end. (New data actually over-writes old data in the data memory; the "pipeline" is just an analogy.)

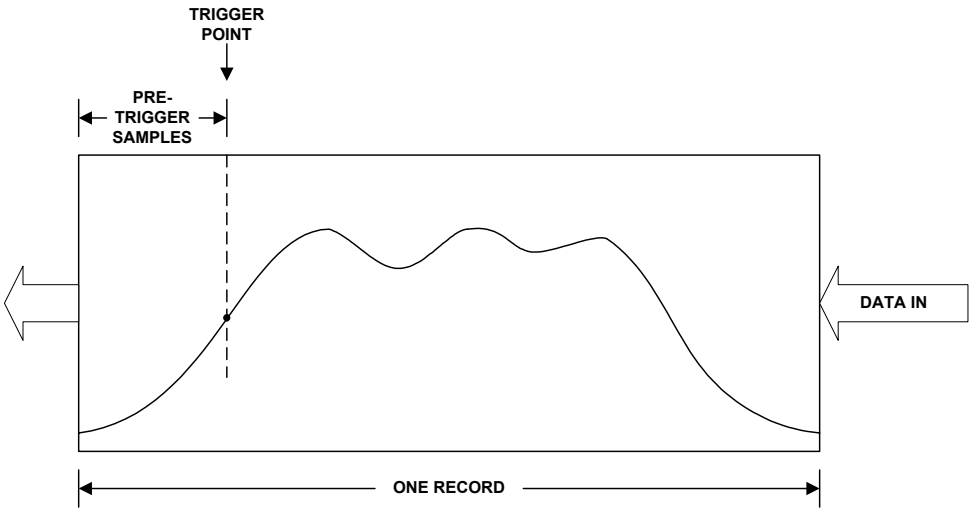


FIGURE 2-10 PRE-TRIGGER ILLUSTRATION

Data is continuously acquired and circulated through the pipeline until a trigger occurs. Then, data is acquired for each of the segments in the record at the selected sampling interval. This data enters the pipeline, pushing the pre-trigger data to the left. The acquisition stops when the selected number of pre-trigger samples and the samples acquired after the trigger fill the record as shown in the above figure.

This process is repeated for each record in the channel.

The pre-trigger value is set with the front-panel PRE TRIGGER button or with the MODE PRE command in remote state. The range of valid values is from zero to sixteen less than the first segment (or the record length when no breakpoints are set). All pre-trigger data is acquired at the sample interval of the first segment. Follow these steps to set up pre-trigger mode:

1. To select the pre-trigger mode from the front panel, press PRE TRIGGER and DECREMENT/INCREMENT to the desired value (the power-up default value is zero samples). Notice that the value cannot be incremented beyond sixteen less than the length of the first segment (or record length).

2. ARM the selected time base. Remember that the instrument acquires one full record of data at the interval programmed for the first segment before becoming triggerable. Any triggers that occur during this hold-off period are ignored.

3. The waveform displayed on the XYZ monitor will be shifted to the right by the programmed number of pre-trigger samples. The selected number of samples is stored before the trigger event.

POST-TRIGGER MODE

If the targeted signal occurs significantly after the trigger event, post-trigger can be used to delay the start of acquisition from the trigger. In this mode, a programmed number of samples are ignored before data storage begins. (These samples serve only as a delay timer; they do not occupy space in data memory.) Figure 2-11 illustrates a waveform acquired with post-trigger mode. Post-trigger can only be implemented when the number of records is set to one. The range of valid values is from eight to the record length. All post-trigger data is acquired at the sample interval of the first segment.

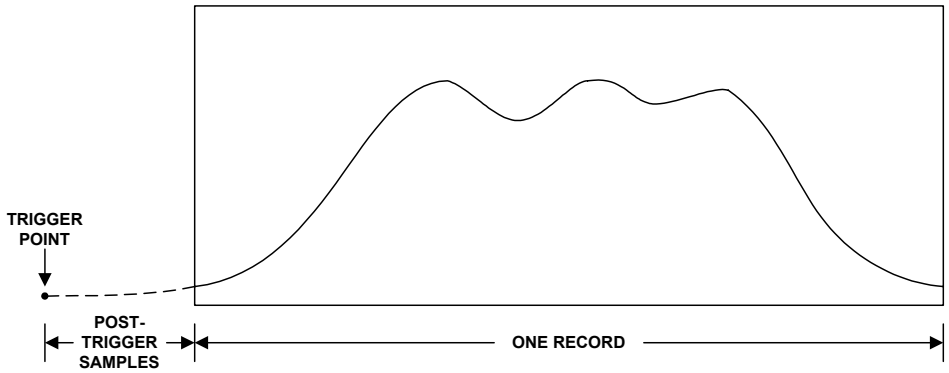


FIGURE 2-11 POST-TRIGGER ILLUSTRATION

Follow these steps to set up post-trigger mode:

1. Before selecting post-trigger mode, be sure that the number of records is set to 1.

2. Press POST TRIGGER and DECREMENT/INCREMENT the value in the SAMPLES display to the desired value. The value cannot be incremented beyond the record length.

3. ARM the selected time base. The instrument begins storing data after it is triggered and the programmed number of samples has been taken.

The effects of pre- and post-trigger modes can be illustrated by feeding identical signals to the vertical inputs of both channels, and programming the time bases with identical settings (use the COPY function).

Next, set time base A to pre-trigger mode with 0 samples, and time base B to pre-trigger mode with 128 samples. ARM both time bases and compare the XYZ displays. The Channel B data will begin 128 samples before Channel A as shown in Fig. 2-12.

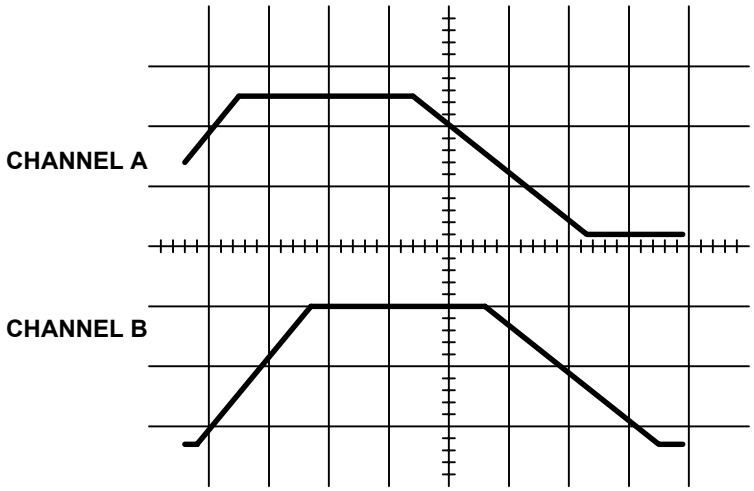


FIGURE 2-12 CHANNEL A/B PRE-TRIGGER EXAMPLE

Repeat this procedure, setting Channel B for post-trigger mode. Ensure that both time bases are set for one record. The acquired waveform from Channel B will appear delayed by 128 samples from Channel A's data.

B TRIGGERABLE AFTER A MODE

This mode provides a means of inhibiting Channel B trigger until the first record of Channel A is acquired. When selected, the B time base becomes triggerable after the first record of A is acquired. The B channel trigger conditions must be met to actually trigger the time base. After the first record, both time bases act independently, requiring a separate trigger for each record as illustrated in Fig. 2-13.

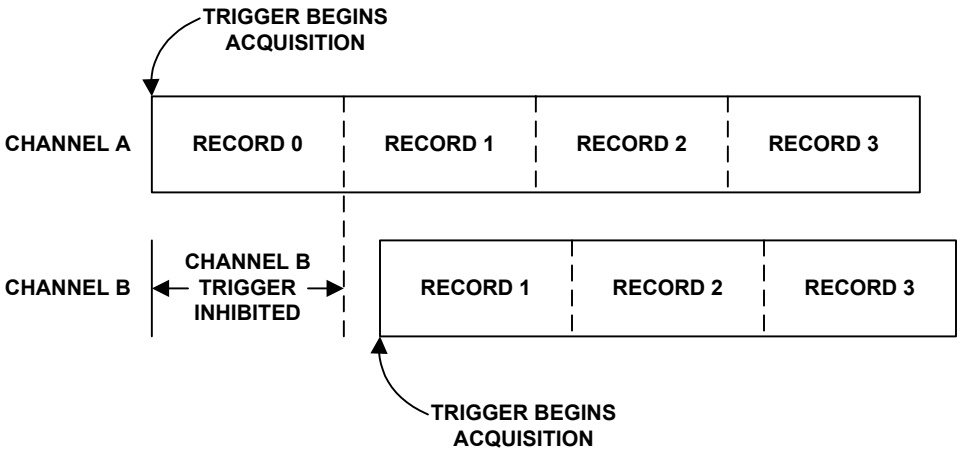


FIGURE 2-13 B TRIGGERABLE AFTER A - ILLUSTRATION

If only Channel B is armed with B Triggerable After A mode selected, time base B will not accept a trigger until Channel A is armed and has acquired its first complete record. If only Channel A is armed, it triggers normally, but Channel B does not trigger until it is armed.

EXTERNAL CLOCK

An external-sampling, ECL-level clock, applied to the rear-panel EXT CLOCK INPUT connector, can drive the 2412 time bases. The clock source is selected with the front-panel CLK function. When the button is dark, the external clock signal is selected; when the button is lit, the internal clock signal is selected.

The selected clock source applies to both channels; they are not separate. When the external clock is selected, the MULTIPLIER indicator lights indicating that the SAMPLE INTERVAL function selects a period multiplier for the external clock signal. For example, if a 1MHz (1 μs period) clock is applied, selecting a period multiplier of 1 results in a 1 μs sampling interval. A multiplier of 1000 (1E+3) results in a 1ms sampling interval. The effective sampling interval is calculated as follows:

SI = (External Clock Period) x (External Clock Period Multiplier)

The external clock input allows the 2412 to synchronously sample a signal with respect to the externally supplied clock. The period of the clock signal need not be consistent. However, the period multiplier divides the external clock; therefore, for a period of 10, a sample is taken on every 10^{th} pulse regardless of the period of the individual pulse.

The external clock-period multiplier is set by pressing the SAMPLE INTERVAL button and using the DECREMENT/INCREMENTS buttons to set the desired value. The range of valid values is 1 to 200 x 10^6.

LOCAL CONTROL IN A BUS INTERFACE SYSTEM

When the 2412 is interfaces to a IEEE 488 bus system, there are a few special considerations for local operation. The following are some guidelines for operating under these circumstances.

The 2412 goes to local state automatically at power-up. All local operating controls are active and the LOCAL button lights. A bus interface controller can then set the instrument to remote state. In remote state, font-panel controls that do not affect the state of the instrument or data memory are still enabled. For example, DISPLAY BREAKPOINT functions in local or remote state, but the ARM buttons are disabled in remote state. The ON/OFF, LOCAL, and REMOTE buttons are active and the REMOTE button lights. Local control can be restored by pressing LOCAL.

To prevent local control, the bus controller can set the 2412 to remote with lockout state. The instrument operates exactly as it does in remote state, except that pressing LOCAL does not restore local control. In this state, the REMOTE and LOCKOUT buttons light.

The instrument may also be set to local with lockout state. The instrument responds the same as in local state. The LOCAL and LOCKOUT buttons light.

When the 2412 returns from remote to local control, the instrument performs a validity check of the current settings and reports any errors on the front panel. This validity check is identical to the one performed when a time base is armed. Therefore, when returning from remote to local state, ensure the settings are valid.

The instrument returns to local state with the settings left from the remote state. No settings are changed unless conflicts are found in the validity check.

ACQUIRING DATA

The 2412 is a waveform-digitizing instrument. Since it samples the analog input at discrete time intervals, the output data is a collection of values that represent the amplitude of the input signal at the sampling points. Keeping this in mind, and observing a few guidelines when setting up the instrument, will ensure that the digitized data accurately represents the analog input signal.

SELECTING A SAMPLING INTERVAL

It is important to remember that the digitized data is simply a string of numbers stored in waveform memory - not the actual signal. These numbers represent the signal amplitudes at discrete sample points. One value is stored for each sample at the sampling rate programmed for the current segment. Fig. 2-14 shows an input waveform and illustrates the digitized data that results.

It is clear that the more samples taken of the input waveform, the more accurately the output data represents the analog signal. A simple example is the input waveform shown in Fig. 2-15. Here, the analog input signal is a slowly varying signal with a fast noise spike. If the sample interval is considerably longer than the width of the noise spike, the spike may occur between two samples and be completely lost in the digitized data. Decreasing the sampling interval slightly (increasing the sampling frequency) may cause one or two samples to be taken during the spike, but to accurately determine its amplitude and width may require many samples (a very short sampling interval). If the spike is consistent, a breakpoint can be set to shorten the sampling interval for the duration of the pulse.

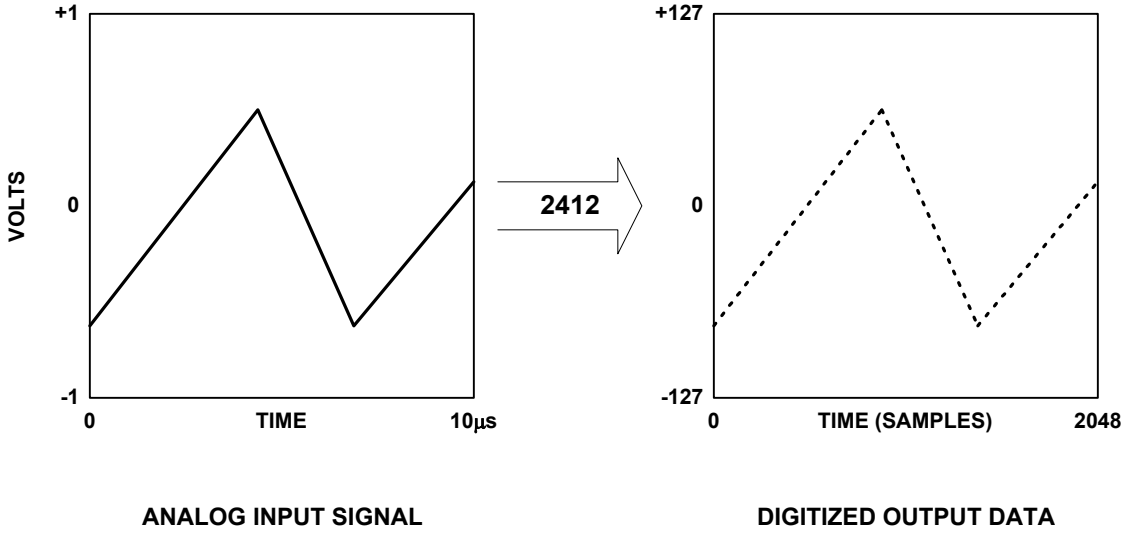


FIGURE 2-14 ANALOG SIGNAL INPUT W/ DIGITIZED DATA OUTPUT

Another less obvious problem caused by sampling at too slow a rate is called aliasing. Fig. 2-16 illustrates a simple case of aliasing. The input signal is a 20 kHz sine wave. Part **b** of the figure shows the digitized data that results from sampling the sine wave at 200 ns intervals. At this rate, there are approximately 250 samples per cycle of the input signal. This is more than enough data to accurately reconstruct the input signal.

If the sampling interval is increased to exactly match the period of the input waveform (50 μs), the output data represents a flat line, since all the samples would be taken at the same point on the sine wave. In practice, it is very difficult to match the period and phase of the input signal. Part **c** of the figure shows the case where the sampling interval is slightly longer than the period of the input waveform. Here, the output data represents a sine wave, but not at the original input frequency. Instead, it is a sine wave of the same amplitude as the original, but with a much longer period time. This effect is called aliasing, and it can occur with any input waveform (though it is more difficult to detect with non-sinusoidal waveforms).

It is essential to be aware of the potential problems with insufficient sampling. A general rule to follow is that the input waveform should be sampled at least twice per period. In other words, the sample interval should be no longer than one half of the period of the input waveform. Of course, the higher the sampling rate the more accurately the output data will represent the analog signal.

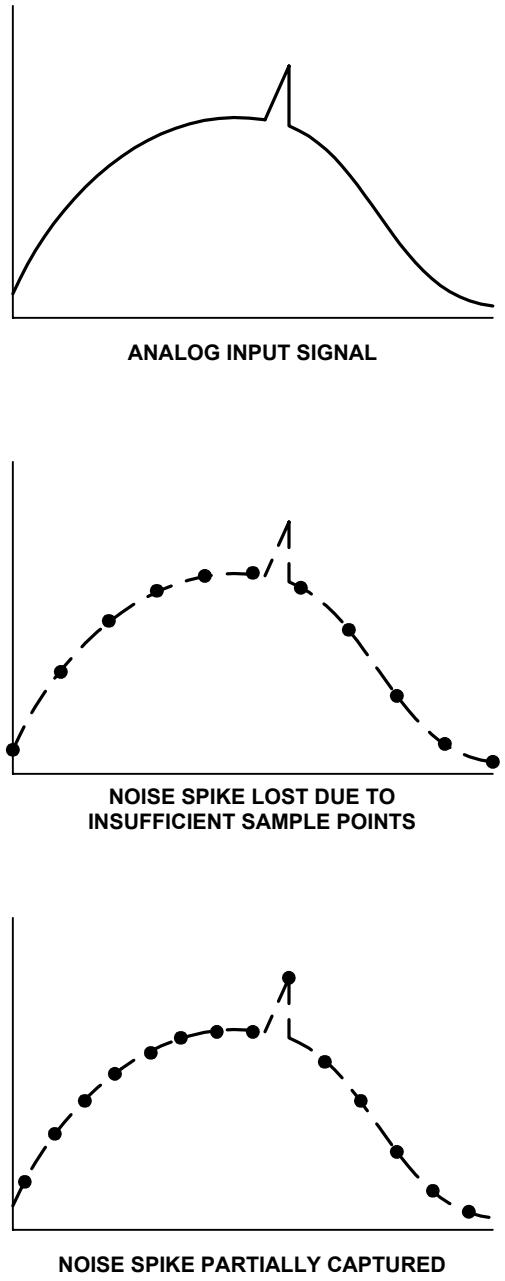


FIGURE 2-15 INSUFFICIENT SAMPLING EXAMPLES

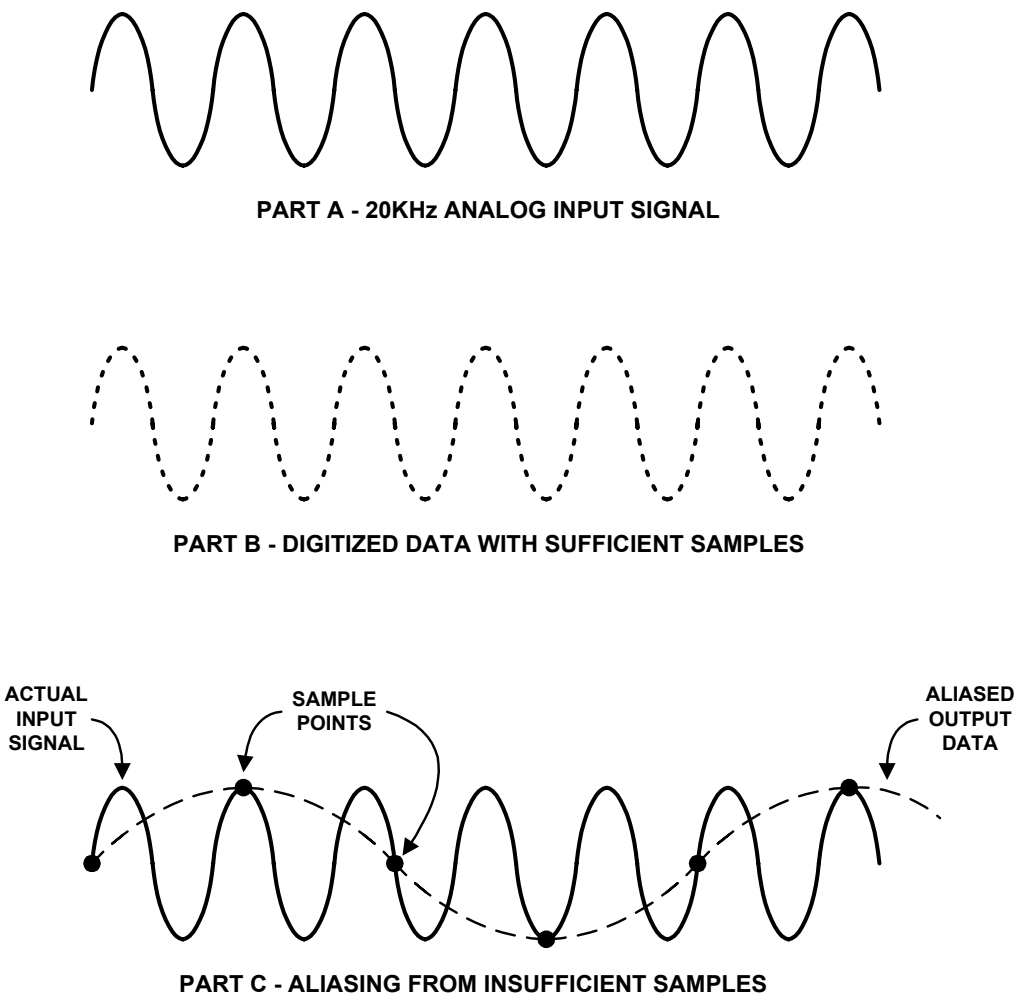


FIGURE 2-16 ALIASING EXAMPLE

OVER-RANGE DATA

Full-scale vertical deflection for the 2412 corresponds to eight divisions as specified for the vertical amplifier. For example, a 4 V input signal produces full-scale deflection when the amplifier is set for 0.5 Volts/Division. The XYZ monitor screen displays the data for both channels by displaying Channel A data in the top half of the screen and Channel B in the bottom half. Therefore, the display amplitude is one half of the normal amplitude. For example, a six-division signal produces a three-division display on the monitor.

Input signals that are beyond the full-scale range of the instrument cause the data byte stored in waveform memory to be set to all 1's for positive over-range, and all 0's for negative over-range. These bytes are blanked on the XYZ monitor. Therefore, parts of the input waveform that are positioned off the target area appear to be missing on the XYZ display (see Fig. 2-17). The Blank Bit internal jumper can be set to display over-range data at the positive and negative limits of the XYZ display range. In this mode, over-range data appears to be clipped on the display. The data stored in the 2412 data memory is not affected.

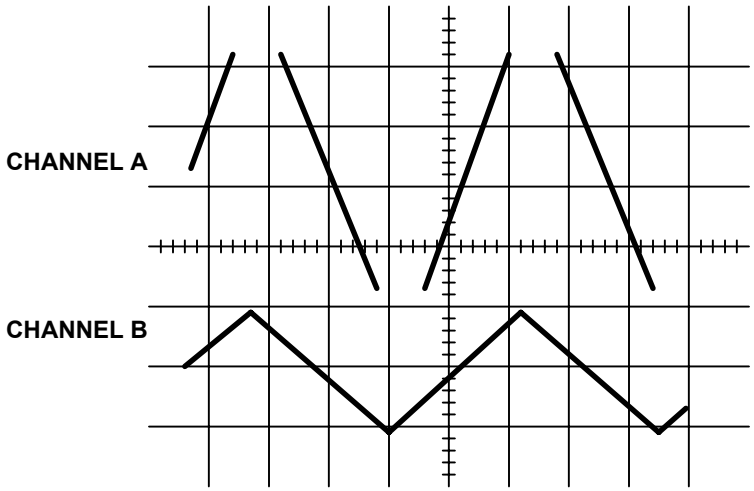


FIGURE 2-17 OUTPUT DATA CLIPPING

SECTION 3

PROGRAMMING

INTRODUCTION

The 2412 conforms to the *IEEE Standard 488-1978* for general-purpose bus for instrument systems. Referred to as the interface bus in this manual, the IEEE 488 bus is also known as the General Purpose Interface Bus (GPIB).

The interface bus uses eight data and eight control lines. Information is transferred bit-parallel, byte-serial by an asynchronous handshake. The 2412 Programmable Digitizer has both listener and talker functions as defined by the standard. See *IEEE Standard 488-1978* for more information.

IEEE 488 INTERFACE

The 2412 can be operated by remote control over the IEEE 488 interface bus (GPIB). The 2412 is fully programmable; all front-panel functions except ON/OFF can be controlled over the interface bus. The 2412 is fast; waveform data can be output at the maximum rate allowed by the listener. Commands are simple and mnemonic, simplifying the programming task.

The 2412 also provides an interface between the IEEE 488 bus and the programmable amplifiers. In effect, the IEEE 488 bus is extended to the amplifiers through the 2412interface. The interface and commands for the amplifiers are discussed in the *Command Dictionary* section.

IEEE INTERFACE FUNCTION SUBSETS

IEEE Standard 488-1978 identifies the interface functions of a device on the bus in terms of interface function subsets. These subsets are defined in the standard. The subsets that apply to the 2412 are shown in Table 3-1.

How these functions are implemented is explained as part of the description of the commands used to program the 2412 and its response to interface control messages.

TABLE 3-1 2412 INTERFACE FUNCTIONS

FUNCTION	SUBSET	CAPABILITY
Source handshake	SH1	Complete. Instrument allows minimum settling time on the DIO (data) line before asserting DAV (T_1 in the SH state diagram in the standard): ≥ 1100 ns for the first byte after ATN is released and ≥ 500 ns for the remaining bytes in a message.
Acceptor handshake	AH1	Complete.
Extended talker	TE6	Complete except instrument cannot be set to talk-only mode locally; includes response to serial poll; requires secondary address.
Extended listener	LE4	Complete except instrument cannot be set to listen-only mode locally; requires secondary address.
Service request	SR1	Complete.
Remote/local	RL1	Complete.
Parallel poll	PP0	No response to parallel poll.
Device clear	DC1	Complete.
Device trigger	DT0	No device trigger capability.
Controller	C0	None.

COMMAND SYNTAX

The following format symbols are used:

< > indicates a parameter or defined element

[ ] indicates the element or group of elements is optional and may be omitted

… follows an element or group of elements that may be repeated

The following delimiters are used to punctuate 2412 commands:

Delimiter	**Follows**
<space>	Command
<comma>	Parameter
<semicolon>	Message unit (command)

NUMBERS

Numbers are assumed to be ASCII-coded decimal digits (except for waveform data). Three kinds of numbers are used:

Representation	Description
<NR1>	Signed or unsigned integers including 0
<NR2>	Signed or unsigned numbers with a decimal point
<NR3>	Signed scientific notation
<N8>	Unsigned integer multiples of 8

Numbers in NR1 notation are signed or unsigned integers; for positive integers, the plus sign is optional. Examples are:

+127

-64

2048

Numbers in NR2 notation are signed or unsigned numbers with a decimal point. The NR2 representation of the value "zero" must not contain a minus sign. Examples are:

0.123

-6.42

0.000

Numbers in NR3 notation are floating-point numbers expressed in scientific notation. Examples are:

1.37e-3	(for 1.37×10^{-3})
-1.e+4	(for -1×10^{4})
<space>0.e+0	(for 0)

Numbers in N8 notation are integer multiples of eight without a sign. Examples are:

16

64

2048

WAVEFORM DATA I/O

Waveform data is output in binary rather than ASCII. This enables greater throughput, in that data is moved in fewer bytes so data transfers require less bus time.

Waveform data is sent in response to a READ, REP, or ALT command sent in binary block(s) of the following format:

```
%<BYTE COUNT>[<DATA BYTES>]<CHECKSUM>;
```

Where:

% is the ASCII percent character.

BYTE COUNT is a 16-bit binary number sent in two bytes, most significant byte first. The value indicates the number of bytes that remain to be transmitted in the block, including the checksum, but not including the message unit delimiter (semicolon).

DATA BYTES are 8-bit binary data values in the range of 0 to 255.

CHECKSUM is an 8-bit, twos-compliment binary number that is the modulo-256 sum (which is +127 through -128) of all preceding bytes in the block, excluding the % character.

; is the ASCII semicolon character.

When data is sent in response to a REP or ALT command, all blocks are in this format. However, EOI is asserted with the message unit delimiter (semicolon) between ALT or REP cycle only. It is not asserted with the semicolon that separates the A and B data blocks. For example, when waveform data is sent in response to a REP 2,A,B command, a semicolon separates the A and B data blocks, but EOI is not asserted. EOI is asserted with each semicolon that separates the block pairs (i.e. the semicolon that follows the B data blocks).

SET COMMANDS

All commands, except those listed as Query-Only commands, can be used as set commands. Note that set commands can only be executed in REMOTE state (query commands can be executed in either REMOTE or LOCAL state). The format for a single set command is:

```
<command><space><parameter>[<semicolon>]
```

More than one parameter is required for several commands, such as REC (set the number and length of records). For example:

```
REC<space><parameter><comma><parameter>[<semicolon>]
```

The SBPT command (set breakpoint and sampling interval) requires at least two parameters, and may have as many as twenty-eight. Again, commas separate the parameters.

Examples of single set commands are:

```
TMBS A;
SBPT 128,1.e-6,496,3.e-8;
READ A,1,4;
```

More than one set command can be sent as part of a single message if the commands are separated by semicolons. This requires the following syntax:

```
<set command><semicolon><set command>
[<semicolon><set command>]…[<semicolon>]
```

An example of multiple set commands in a single message is:

```
TMBS A;TRIG RIGHT;REC 4,512;ARM A;
```

Multiple READ commands may also be included in a message with other commands. However, the instrument must be addressed to talk for the response to each READ command. For example, the following message might be sent to the instrument:

```
REC 4,512;ARM A;READ A;READ A,3;TMBS B
```

The instrument sets the number and length of records and arms time base A. The first READ command is buffered and the instrument waits for Channel A's acquisition to complete. Then it expects to be addressed to talk (the talk address may be sent while the acquisition is in progress). The instrument begins sending the data acquired in record one of Channel A as soon as the acquisition is complete and it is addressed to talk. When the transmission is complete, it expects to be addressed again to send the response to the second READ command. Because the response to the READ command will not fit in the output buffer, the instrument remains busy until the data is transmitted. In this condition, the 2412 asserts NRFD and refuses any further input. When the second transmission is complete, the TMBS B command is executed.

QUERY COMMANDS

Unless noted as a set command only, all commands can be used as query commands. A query is executed in either REMOTE or LOCAL state (unlike set commands, which can only be executed in REMOTE state). A message that contains only a query command requires the following syntax:

```
<query><question mark>[ <parameter><semicolon>]
```

An example is:

```
TMBS?
```

A message can contain multiple queries just as it can contain multiple set commands. The set and query commands can also be used together and be mixed in any order. However, the instrument must be addressed to talk for the response to each query. If instead, another set command is sent, the response to the remaining query or queries is abandoned.

The 2412 responds to a query with a message similar to the set command format. Unless noted, the syntax of the reply is:

```
<command><space><parameter><semicolon>
```

For example, the query:

```
TMBS?
```

is answered with (when time base A is selected):

```
TMBS A;
```

Note *If the 2412 receives a message that is too long for its internal 128-byte input buffer, and the message generates output that is too long for the output buffer (128 bytes), the instrument will generate a NRFD, preventing any further communication on the interface bus. A DCL message will clear this state.*

INSTRUMENT STATUS

The 2412 reports a status byte when serial polled by the system controller. The status byte contains the internal status of the instrument. Two main types of status may be reported: *system status* and *device status*. System status indicates conditions that are general. Device status indicates conditions that are unique to a single instrument type.

The status byte read from the 2412, during a serial poll, contains the following information:

Bit	**8**	-	1 = Device status; 0 = System status
	7	-	Service requested
	6	-	1 = Abnormal condition; 0 = Normal condition
	5	-	Busy
	4	-	Device/system status
	3	-	Device/system status
	2	-	Device/system status
	1	-	Device/system status

Normal condition system status:

Bit	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**		
	0	1	0	X	0	0	0	1	-	Power-on
	0	1	0	X	0	0	1	0	-	Remote request

Power-on condition exists after the instrument is powered on. This condition exists until the status byte is read.

Abnormal condition system status:

Bit	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**		
	0	1	1	X	0	0	0	1	-	Command Error
	0	1	1	X	0	0	1	0	-	Execution Error
	0	1	1	X	0	0	1	1	-	Internal Error
	0	1	1	X	0	1	0	0	-	Power Fail Error
	0	1	1	X	0	1	0	1	-	Execution Warning
	0	1	1	X	0	1	1	0	-	Internal Error Warning

Command Error Indicates that the 2412 has received a command that it cannot understand or implement under any circumstances. The command does not affect the state of the instrument.

Execution Error Indicates that the 2412 has received a command that it understands but cannot implement due to the current state of the instrument. The command does not affect the state of the instrument.

Internal Error Indicates that an internal hardware failure has occurred.

Power Fail Error Indicates that a power fail is about to happen or that an internal analog supply has failed. The instrument remains capable of responding to a serial poll for at least 10ms. If a power fail occurs and the power is restored, this condition is replaced by the power-on condition.

Execution Warning Indicates that the instrument has found a conflict in the settings and has changed the settings for the specified channel to resolve the conflict. This warning may also alert the user to potential problems with a particular setting combination.

Internal Warning Indicates that the instrument has detected an internal error. The instrument remains operational, but the source of the problem should be found and corrected as soon as possible.

DEVICE DEPENDENT STATUS

Device dependent status is reported only when there is no system status to report.

Bit	8	7	6	5	4	3	2	1		
	1	X	0	X	0	0	0	0	-	Neither channel is readable
	1	X	0	X	0	X	0	1	-	Channel A data is readable
	1	X	0	X	X	0	1	0	-	Channel B data is readable
	1	X	0	X	X	X	1	1	-	Both channels are readable

Bit 3 is set if a waveform readable interrupt is generated by Channel A; bit 4 is set when Channel B generates the interrupt.

WARNING AND ERROR MESSAGES

WARNING MESSAGES

The first 18 warning messages describe errors that occur as the result of conflicting settings (e.g. breakpoints set beyond the record length). These warnings indicate unique combinations of four possible conditions. The combinations and associated warning messages are shown in Table 3-2.

The eight remaining execution-warning messages are summarized in Table 3-3 and the internal warning messages are listed in Table 3-4.

TABLE 3-2 EXECUTION WARNING MESSAGES

CHANNEL A	CHANNEL B	PRE TRIG	POST TRIG	NO of REC	BRK PTS
501	511	0	0	0	1
502	512	0	0	1	0
503	513	0	0	1	1
504	514	0	1	0	0
505	515	0	1	0	1
506	516	0	1	1	0
507	517	0	1	1	1
508	518	1	0	0	0
509	519	1	0	0	1

PRE TRIG 1 - Indicates that the number of pre-trigger samples has been set to 16 less that the length of the first segment.

POST TRIG 1 - Indicates that the number of post-trigger samples has been set to the record length.

NO of REC 1 - Indicates that the number of records has been set to one because the channel is in post-trigger mode.

BRK PTS 1 - Indicates that all breakpoints greater than or equal to the record length were deleted.

TABLE 3-3 EXECUTION WARNING MESSAGES

MESSAGE NUMBER	DESCRIPTION
521	Numeric argument is set to next lower number divisible by eight
522	Sample interval or external clock-period multiplier is rest to first valid lower value
523	Breakpoint not found in CBPT command
524	BTA is on and only time base A is armed
525	BTA is on and only time base B is armed
526	<NR1> number is greater than 65535 - the value is truncated
527	Attempt to clear breakpoint zero is ignored
528	Attempt to execute a command that changes settings or data memory is ignored in local state

TABLE 3-4 INTERNAL WARNING MESSAGE

MESSAGE NUMBER	DESCRIPTION
601	Instrument failed to trigger properly in power-up test

ERROR MESSAGES

The error messages returned by the ERR? query are divided into four groups: Command Error messages, Execution Error messages, Internal Error messages, and Power Fail Error messages. Tables 3-5 through 3-8 summarize these messages.

TABLE 3-5 COMMAND ERROR MESSAGES

MESSAGE NUMBER	DESCRIPTION
101	Invalid command header
102	Invalid argument string
103	Non-numeric argument found where a numeric argument is required
104	Invalid hexadecimal argument
105	Missing argument

TABLE 3-6 EXECUTION ERROR MESSAGES

MESSAGE NUMBER	DESCRIPTION
201	Maximum number of breakpoints exceeded
202	Negative argument invalid
203	Argument out of range
204	Invalid record length
205	Conflicting arguments
206	Invalid sampling interval or external clock period multiplier

TABLE 3-7 INTERNAL ERROR MESSAGES

MESSAGE NUMBER	DESCRIPTION
302	RAM failed self-test
303	Interrupt fault
304	Checksum error found in ROM
305	Data transmitter failed to begin or complete in allotted time

TABLE 3-8 POWER FAIL ERROR MESSAGE

MESSAGE NUMBER	DESCRIPTION
401	Power failure is imminent

SECTION 4

COMMAND DICTIONARY

INTRODUCTION

This section presents the instrument command set in three parts as follows:

- A listing of the commands for the 2412 Programmable Digitizer
- Detail descriptions of the commands for the 2412 Programmable Digitizer
- A listing of the commands for the Programmable Amplifiers
- Detail descriptions of the commands for the programmable Amplifiers

The first part is a listing of the instrument specific or device dependent commands for the 2412 Programmable Digitizer (see Table 4-1). The list is grouped by command type and includes a brief description of each command function.

The second part of this section is devoted to describing each command for the 2412 in detail, one per page, listed in alphabetical order. The description is presented in a way to assist the user in the use of each command. Every command entry describes the exact command and/or query syntax, the use and range of parameters, and a description of the command's purpose.

The third part shows both the high-level and low-level commands for the Programmable Amplifiers. The high-level command set (see Table 4-2) lists the commands by type, and includes a brief description of each command. The low-level code set (see Table 4-3) lists the input codes with a description of the corresponding setting.

The fourth part of this section is devoted to describing each high-level command for the amplifiers in detail, one per page, listed in alphabetical order. The description is presented in a way to assist the user in the use of each command. Every command entry describes the exact command and/or query syntax, the use and range of parameters, and a description of the command's purpose.

COMMAND DICTIONARY

This second part of this section is devoted to the command dictionary for the 2412 Programmable Digitizer. Each command is fully described on its own page, and the pages are ordered alphabetically. In defining how each command is used, the following items are described:

Purpose	Describes the purpose of the command.
Type	Describes the type of command such as an event or setting.
Command Syntax	Details the exact command format.
Command Parameters	Describes the parameters sent with the command and their legal range.
Power-Up State	Describes the values assumed at power-up.
Query Syntax	Details the exact query form of the command.
Query Parameters	Describes the parameters sent with the command and their legal range. The default parameter values are assumed the same as in the command form unless described otherwise.
Query Response	Describes the format of the query response and the valid range of output.
Description	Describes in detail what the command does and refers to additional sources.
Examples	Present the proper use of each command and its query (when available).

2412 PROGRAMMABLE DIGITIZER COMMANDS

TABLE 4-1 2412 DIGITIZER COMMANDS

INSTRUMENT COMMANDS		
Command	**Description**	**Power-Up State**
TMBS	Specify the time base to be programmed or queried by subsequent time base commands	A
ARM	Arms the time base(s) specified by the parameter(s)	-
MTRIG	Generates triggers for both channels	-
WRI	Enable or disable asserting SRQ when waveform data is readable	OFF
RQS	Enable or disable asserting SRQ to request service	ON
CLK	Select internal or external clock for both time bases	INT
BTA	Enable or disable B Triggerable after A mode	OFF
REP	Set Repeat ARM/READ sequence for <channel> time base *n* times	-
ALT	Repeats the ARM A, READ A, ARM B, READ B sequence *n* times	-
REM	Enable or disable asserting SRQ when REMOTE is pressed	OFF
COPY	Copy the time base or trigger setting from one channel to another	-
TIME BASE COMMANDS		
Command	**Description**	**Power-Up State**
REC	Set the number and length of records	1,2048
SBPT	Set breakpoint locations and the sampling interval for the segment	0,5e-9
CBPT	Clear all breakpoints or the specified breakpoints	-
LTC	Select trigger channel	A = LEFT B = RIGHT
MODE	Set to pre-trigger or post-trigger by *n* samples	PRE,0
TRIGGER CHANNEL COMMANDS		
Command	**Description**	**Power-Up State**
SRC	Select internal or external triggering source	INT
SLO	Set trigger slope to positive or negative	POS
LEV	Set trigger level for selected trigger channel	0
CPL	Set trigger coupling to AC or DC	AC
HFR	Enable or disable high-frequency reject trigger	OFF

Table 4-1 - Continued

DATA TRANSFER COMMANDS		
Command	**Description**	**Power-Up State**
READ	Read data from Channel A or B	-

SPECIAL FUNCTION / PROPRIETARY COMMANDS	
Command	**Description**
BLANK	Enable or disable over-range data blanking
BLANK BIT	Set blanking polarity
CALibration:SECure:STATe	Enable or disable security
CALibration:SECure:CODE	Set the Calibration Security code
CALibration:STICker:GAIN	Enable or disable gain adjustment controls
CALibration:STICker:GPIB	Enable or disable front-panel GPIB address controls
CALibration:STICker:TERM	Enable or disable front-panel GPIB termination controls
CALibration:STICker:DELAY	Enable or disable front-panel ARM Delay controls
CALibration:STRing	Allows storage up to 255 characters
CAL STORE	Commit changes to nonvolatile memory
DELAY ARM	Set ARM delay
DOWNLOAD	Download firmware
GAIN POT	Set channel gain
GPIB	Set the primary and secondary addresses
GPIB TERM	Set terminator type
ID	Set instrument ID
ID? VXI	Query the VXI identification string
NV?	Query model, non-volatile seed value, calibration count, and GPIB primary and secondary addresses
SLO GAIN	Set Gain DAC
SLO OFFSET?	Query gain offset
SN	Load a serial number into nonvolatile memory
TDAC	Load Trigger DAC

Table 4-1 - Continued

QUERY-ONLY COMMANDS	
Query	**Description**
SET?	Returns all settings
ERR?	Returns code for current error condition
NBPT?	Returns number of breakpoints
HSF<CH>?	Returns the horizontal scale factors for <channel>
VSL<#>?	Returns the vertical scale factors for the <#> channel of the left amplifier
VSR<#>?	Returns the vertical scale factors for the <#> channel of the right amplifier
RDO?	Returns 40 characters of readout information as acquired from the amplifiers
DIAGNOSTIC COMMANDS	
Command	**Description**
DEP	Put Data in the specified address
FET	Fetch Data from the specified address
EXEC	Begin executing at the specified address

ALT

Purpose	Repeats the ARM A, READ A, ARM B, READ B sequence *n* times.	
Type	Set only	
Command Syntax	ALT <NR1>	
Command Parameters	<NR1> = number of times to execute alternate sequence	
Power-Up State	N/A	
Query Syntax	N/A	
Query Parameters	N/A	
Query Response	N/A	
Description	The ALTernate command allows the user to alternately acquire data from Channel A and Channel B with minimal controller intervention. Throughput is improved because data can be read from one channel while an acquisition is in progress on the other channel.	
Examples	**Command / Query**	**Response *(Description)***
	`ALT 5`	*(Set to execute alternating channel acquisition five times.)*
	`ALT 0`	*(The sequence is repeated until the instrument receives a device clear interface message.)*

ARM

Purpose	Arms the time base(s) specified by the parameter(s).	
Type	Set only	
Command Syntax	ARM <channel>	
Command Parameters	<channel> = A | B | A,B | B,A	
Power-Up State	N/A	
Query Syntax	N/A	
Query Parameters	N/A	
Query Response	N/A	
Description	The ARM command verifies the time base settings and prepares the channel to accept a trigger. Valid parameters are A or B, or both A and B listed in any order.	
Examples	**Command / Query**	**Response *(Description)***
	`ARM A`	*(ARM time base A.)*
	`ARM A,B`	*(ARM both time bases.)*

BLANK

Purpose	Enable or disable over-range data blanking.
Type	Set or Query
Command Syntax	BLANK <state>
Command Parameters	<state> = ON | OFF
Power-Up State	N/A
Query Syntax	BLANK?
Query Parameters	N/A
Query Response	BLANK ON | BLANK OFF
Description	The Blank command enables or disables over-range data blanking on the XYZ display. The following shows the four possible settings:

	Z Blank Polarity	**Blank**	
BLNK	1	OFF	*The Z Blank rear-panel output will not blank over-ranged data; a high/low level is generated to blank the display*
BLNK	0	OFF	*The Z Blank rear-panel output will not blank over-ranged data; a low/high level is generated to blank the display*
BLNK	1	ON	*The Z Blank rear-panel output will blank over-ranged data; a high/low level is generated to blank the display*
BLNK	0	ON	*The Z Blank rear-panel output will blank over-ranged data; a low/high level is generated to blank the display*

Note: Blank - this command setting
Z Blank Polarity - BLANK BIT command setting
1 - is for working with newer scopes
0 - is for working with older scopes, TEK7612 compatible

Examples

Command / Query	**Response *(Description)***
`BLANK ON`	*(Enables blanking over-range data.)*
`BLANK?`	BLANK ON

BLANK BIT

Purpose	Set blanking polarity.
Type	Set or Query
Command Syntax	BLANK BIT <state>
Command Parameters	<state> = 0 | 1
Power-Up State	N/A
Query Syntax	BLANK BIT?
Query Parameters	N/A
Query Response	0 | 1
Description	The Blank Bit command sets the polarity of the Z blanking signal for the XYZ display. The following shows the four possible settings: **Z Blank Polarity** / **Blank** BLNK 1 OFF — *The Z Blank rear-panel output will not blank over-ranged data; a high/low level is generated to blank the display* BLNK 0 OFF — *The Z Blank rear-panel output will not blank over-ranged data; a low/high level is generated to blank the display* BLNK 1 ON — *The Z Blank rear-panel output will blank over-ranged data; a high/low level is generated to blank the display* BLNK 0 ON — *The Z Blank rear-panel output will blank over-ranged data; a low/high level is generated to blank the display* **Note**: Blank - this command setting Z Blank Polarity - BLANK BIT command setting 1 - is for working with newer scopes 0 - is for working with older scopes, TEK7612 compatible

Examples

Command / Query	**Response *(Description)***
`BLANK BIT 1`	*(Set the Z blanking polarity to a high/low level to blank the display.)*
`BLANK BIT?`	0 *(Verifies that the Z blank polarity is set to generate a high/low level.)*

BTA

Purpose	Enable or disable B Triggerable after A mode.
Type	Set or Query
Command Syntax	BTA <state>
Command Parameters	<state> = ON | OFF
Power-Up State	OFF
Query Syntax	BTA?
Query Parameters	N/A
Query Response	BTA ON; BTA OFF;
Description	The BTA command turns B Triggerable after A mode ON or OFF. **ON** Sets the instrument to B Triggerable after A mode. This mode causes the B time base to become triggerable shortly after the first record of Channel A has been acquired. One restriction is that the pre-trigger hold-off for Channel B must be satisfied before B will become triggerable. **OFF** Disables the B Triggerable after A mode. Both channels trigger independently.

Examples	**Command / Query**	**Response *(Description)***
	`BTA ON`	*(Enables the B Triggerable after A mode.)*
	`BTA?`	BTA OFF; *(Verifies that the B Triggerable after A mode is enabled.)*

CALibration:SECure:STATe

Purpose	Enable or disable security.	
Type	Set or Query	
Command Syntax	CALibration:SECure:STATe <boolean>,<"security_code">	
Command Parameters	<boolean> = 0 | 1 | OFF | ON <"security_code"> = alphanumeric code up to 15 characters, encased in quotation marks	
Power-Up State	1	
Query Syntax	CALibration:SECure:STATe?	
Query Parameters	N/A	
Query Response	0 | 1	
Description	The Calibration Secure State command enable or disables security. While security is on, no stores to nonvolatile memory are allowed. In order to disable the security state, the current security code must be supplied. To enable security, the code does not need to be supplied. The factory default security code is "2412"; the default security state is enabled.	
Examples	**Command / Query**	**Response *(Description)***
	`CAL:SEC:STAT OFF,"2412"` `CAL:SEC:STAT?`	*(Disables the security mode.)* 0 *(Verifies that the security mode is disabled.)*

CALibration:SECure:CODE

Purpose	Set the Calibration Security code.	
Type	Set or Query	
Command Syntax	CALibration:SECure:CODE <"security_code">	
Command Parameters	<security_code> = alphanumeric code up to 15 characters, encased in quotation marks	
Power-Up State	N/A	
Query Syntax	CALibration:SECure:CODE?	
Query Parameters	N/A	
Query Response	Alphanumeric code up to 15 characters	
Description	The Calibration Secure Code command changes the security code required to disable security. Security must first be disabled before the code can be changed. Up to 15 characters, encased within quotation marks, are allowed for the code. The default code set at the factory is "2412". The query form of this command is only allowed if security state is disabled.	
Examples	**Command / Query**	**Response *(Description)***
	`CAL:SEC:STAT OFF,"2412"`	*(Disable security.)*
	`CAL:SEC:CODE "UP TO 15 CHAR"`	*(Set the new code up to 15 characters in length (encased within quotation marks).)*
	`CAL:SEC:CODE?`	"2412"

CALibration:STICker:GAIN

Purpose	Enable or disable gain adjustment controls.
Type	Set or Query
Command Syntax	CALibration:STICker:GAIN <boolean>
Command Parameters	<boolean> = 0 | 1 | OFF | ON
Power-Up State	N/A
Query Syntax	CALibration:STICker:GAIN?
Query Parameters	N/A
Query Response	0 | 1
Description	The Calibration Sticker Gain command enables or disables the gain-adjustment controls. When enabled, the front-panel AND remote gain controls are disabled; the current gain can be displayed from the front panel, but gain values cannot be changed. In effect, once gain values are set, enabling this function keeps the setting until purposefully changed through multiple commands. When disabled, gain can be adjusted from the front panel or remotely via the interface bus. The security state must first be disabled to change this function setting. Use the Calibration Store command to commit the current setting to nonvolatile memory. The factory default is disabled.

Examples

Command / Query	**Response *(Description)***
`CAL:SEC:STAT OFF,"2412"`	*(Disable security.)*
`CAL:STIC:GAIN 1`	*(Enabling this function disables the gain controls; gain values cannot be changed, only displayed.)*
`CAL STORE`	*(Store the new setting in nonvolatile memory.)*
`CAL:SEC:STAT ON`	*(Re-enable security.)*
`CAL:STIC:GAIN?`	1 *(Verifies that the Calibration Sticker Gain function is enabled and the gain controls are disabled.)*

CALibration:STICker:GPIB

Purpose	Enable or disable front-panel GPIB address controls.
Type	Set or Query
Command Syntax	CALibration:STICker:GPIB <boolean>
Command Parameters	<boolean> = 0 | 1 | OFF | ON
Power-Up State	N/A
Query Syntax	CALibration:STICker:GPIB?
Query Parameters	N/A
Query Response	0 | 1
Description	The Calibration Sticker GPIB command enables or disables the front-panel GPIB address controls. When enabled, the front-panel GPIB address controls are disabled; the current addresses can be displayed from the front panel, but the address values cannot be changed. When disabled, both the primary and secondary addresses can be set from the front panel. The security state must first be disabled to change this function setting. Use the Calibration Store command to commit the current setting to non-volatile memory. The factory default is disabled.

Examples

Command / Query	Response *(Description)*
`CAL:SEC:STAT OFF,"2412"`	*(Disable security.)*
`CAL:STIC:GPIB 1`	*(Enabling this function disables the front-panel address controls; the address values cannot be changed from the front panel, only displayed.)*
`CAL STORE`	*(Store the new setting in nonvolatile memory.)*
`CAL:SEC:STAT ON`	*(Re-enable security.)*
`CAL:STIC:GPIB?`	1 *(Verifies that the Calibration Sticker GPIB function is enabled and the front-panel address controls are disabled.)*

CALibration:STICker:TERM

Purpose	Enable or disable front-panel GPIB termination controls.
Type	Set or Query
Command Syntax	CALibration:STICker:TERM <boolean>
Command Parameters	<boolean> = 0 | 1 | OFF | ON
Power-Up State	N/A
Query Syntax	CALibration:STICker:TERM?
Query Parameters	N/A
Query Response	0 | 1
Description	The Calibration Sticker Termination command enables or disables the front-panel GPIB termination controls. When enabled, the front-panel GPIB termination controls are disabled; the current termination can be displayed from the front panel, but the value cannot be changed. When disabled, the GPIB termination (**EOI** or **LF**) can be set from the front panel. The security state must first be disabled to change this function setting. Use the Calibration Store command to commit the current setting to nonvolatile memory. The factory default is disabled.

Examples

Command / Query	**Response *(Description)***
`CAL:SEC:STAT OFF,"2412"`	*(Disable security.)*
`CAL:STIC:TERM 1`	*(Enabling this function disables the front-panel GPIB termination controls; the termination values cannot be changed from the front panel, only displayed.)*
`CAL STORE`	*(Store the new setting in non-volatile memory.)*
`CAL:SEC:STAT ON`	*(Re-enable security.)*
`CAL:STIC:TERM?`	1 *(Verifies that the Calibration Sticker Termination function is enabled and the front-panel GPIB termination controls are disabled.)*

CALibration:STICker:DELAY

Purpose	Enable or disable front-panel ARM Delay controls.
Type	Set or Query
Command Syntax	CALibration:STICker:DELAY <boolean>
Command Parameters	<boolean> = 0 | 1 | OFF | ON
Power-Up State	N/A
Query Syntax	CALibration:STICker:DELAY?
Query Parameters	N/A
Query Response	0 | 1
Description	The Calibration Sticker Delay command enables or disables the front-panel ARM Delay controls. When enabled, the front-panel ARM delay controls are disabled; the current delay can be displayed from the front panel, but the value cannot be changed. When disabled, the ARM delay can be set from the front panel. The security state must first be disabled to change this function setting. Use the Calibration Store command to commit the current setting to nonvolatile memory. The factory default is disabled.

Examples

Command / Query	**Response *(Description)***
`CAL:SEC:STAT OFF,"2412"`	*(Disable security.)*
`CAL:STIC:DELAY 1`	*(Enabling this function disables the front-panel ARM delay controls; the delay values cannot be changed from the front panel, only displayed.)*
`CAL STORE`	*(Store the new setting in nonvolatile memory.)*
`CAL:SEC:STAT ON`	*(Re-enable security.)*
`CAL:STIC:DELAY?`	1 *(Verifies that the Calibration Sticker Delay function is enabled and the front-panel ARM delay controls are disabled.)*

CALibration:STRing

Purpose	Allows storage up to 255 characters.	
Type	Set or Query	
Command Syntax	CALibration:STRing <user_string>	
Command Parameters	<user_string> = alphanumeric string up to 255 characters	
Power-Up State	N/A	
Query Syntax	CALibration:STRing?	
Query Parameters	N/A	
Query Response	alphanumeric string up to 255 characters	
Description	The Calibration String command stores user information up to 255 characters. This function may be used for any purpose, such as entering the most recent calibration date. The security state must first be disabled to change this function setting. Use the Calibration Store command to commit the current setting to nonvolatile memory. The factory default is "Calibration date: MM/DD/YY".	
Examples	**Command / Query**	**Response *(Description)***
	`CAL:SEC:STAT OFF, "2412"`	*(Disable security.)*
	`CAL:STR "Enter any info up to 255 char"`	*(Enter user string.)*
	`CAL STORE`	*(Store the new information in nonvolatile memory.)*
	`CAL:SEC:STAT ON`	*(Re-enable security.)*
	`CAL:STR?`	"Enter any info up to 255 char" *(The query returns the user string stored in nonvolatile memory.)*

CAL STORE

Purpose	Commit changes to nonvolatile memory.	
Type	Event	
Command Syntax	CAL STORE	
Command Parameters	N/A	
Power-Up State	N/A	
Query Syntax	N/A	
Query Parameters	N/A	
Query Response	N/A	
Description	The Calibration Store command saves current settings into nonvolatile memory. If the instrument power is cycled, these stored settings will be recalled. The Calibration Security State must first be disabled before this command will function.	
Examples	**Command / Query**	**Response *(Description)***
	`CAL STORE`	*(Saves current setting to nonvolatile memory.)*

CBPT

Purpose	Clears all breakpoints or the specified breakpoints.	
Type	Set only	
Command Syntax	CBPT [<N8>[,<N8>]]…	
Command Parameters	<N8> = an unsigned integer multiple of eight	
Power-Up State	N/A	
Query Syntax	N/A	
Query Parameters	N/A	
Query Response	N/A	
Description	The Clear BreakPoinT command allows the user to delete one or more breakpoints from all records in the selected channel. A specific breakpoint or breakpoints can be deleted by specifying the breakpoint location(s) in the command parameters. If no parameters are specified, all breakpoints, except the fixed one at location zero, are deleted. When a breakpoint is deleted, the sampling interval for the segment preceding the breakpoint is applied to all samples from the preceding breakpoint to the next breakpoint. If all breakpoints are deleted, the sampling interval for the first segment is applied to the entire record. If an invalid breakpoint value is specified, a warning message is issued, the invalid breakpoint is ignored, and all valid breakpoints are deleted.	
Examples	**Command / Query**	**Response *(Description)***
	`CBPT 520,256`	*(Deletes the breakpoints at 256 and 520.)*
	`CBPT`	*(Deletes all breakpoints)*

CLK

Purpose	Select internal or external clock for both time bases.
Type	Set or Query
Command Syntax	CLK <source>
Command Parameters	<source> = INT | EXT
Power-Up State	INT
Query Syntax	CLK?
Query Parameters	N/A
Query Response	CLK INT; CLK EXT;
Description	The CLocK command selects the internal or external clock signal as the source for both time bases. **INT** Selects the internal 200 MHz clock signal to drive **both** time bases. Sample intervals specified in the SBPT command are in seconds. The front-panel PERIOD indicator lights. **EXT** Selects the external clock signal applied to the rear-panel EXT CLK IN connector. Sample intervals specified in the SBPT command are external clock multipliers. The front-panel MULTIPLIER indicator lights. When the external clock is selected, the instrument multiplies the period of the external clock by the selected multiplier. The period of the external clock signal does not to be consistent. However, the instrument simply divides the input signal, so for an external clock-period multiplier of 10, a sample is taken every 10th pulse, regardless of the individual period of the pulses.

Examples	**Command / Query**	**Response *(Description)***
	`CLK EXT`	*(Selects the external clock source.)*
	`CLK?`	CLK EXT; *(Verifies that the external clock source is selected.)*

COPY

Purpose	Copy the time base or trigger setting from one channel to another.
Type	Set only
Command Syntax	COPY <from_to>
Command Parameters	<from_to> = AB | BA | LR | RL
Power-Up State	N/A
Query Syntax	N/A
Query Parameters	N/A
Query Response	N/A
Description	The COPY command allows the user to copy the setting of one time base or trigger channel to the other time base or trigger channel. AB Copy the settings of time base A to time base B. BA Copy the settings of time base B to time base A. LR Copy the settings of the left trigger channel to the right trigger channel. RL Copy the settings of the right trigger channel to the left trigger channel. The time base functions copied with a COPY AB or COPY BA command are: 1. Record length and number of records (REC command) 2. Breakpoint locations and sample intervals (SBPT command) 3. Logical trigger channel (LTC command) 4. Pre-/Post-trigger mode and number of samples (MODE command) The trigger functions copied with a COPY LR or COPY RL command are: 1. Trigger source (SRC command) 2. Trigger slope (SLO command) 3. Trigger level (LEV command) 4. Trigger coupling (CPL command) 5. High-Frequency Reject (HFR command)

Examples	**Command / Query**	**Response *(Description)***
	`COPY AB`	*(Copies the settings of time base A to time base B.)*
	`COPY LR`	*(Copies the trigger settings of the left trigger channel to the right trigger channel.)*

CPL

Purpose	Set trigger coupling to AC or DC.	
Type	Set or Query	
Command Syntax	CPL <coupling>	
Command Parameters	<coupling> = AC | DC	
Power-Up State	AC	
Query Syntax	CPL?	
Query Parameters	N/A	
Query Response	CPL AC, CPL DC;	
Description	The CouPLing command selects AC or DC coupling of the trigger signal for the selected trigger channel. **AC** Select AC coupling of the rigger channel. The DC level of the signal is ignored and frequencies below about 30 Hz are attenuated. **DC** Select DC coupling of the trigger signal. DC coupling provides more stable triggering of low-frequency signals.	
Examples	**Command / Query**	**Response *(Description)***
	`CPL DC` `CPL?`	*(Selects DC coupling.)* CPL DC; *(Verifies DC coupling.)*

DELAY ARM

Purpose	Set ARM delay.	
Type	Set or Query	
Command Syntax	DELAY ARM <numeric_value>	
Command Parameters	<numeric_value> = each delay count equals 10 ms (e.g. 1 = 10 ms, 2 = 20 ms, 3 = 30 ms)	
Power-Up State	N/A	
Query Syntax	DELAY ARM?	
Query Parameters	N/A	
Query Response	Numeric value	
Description	The Delay Arm command sets the delay from the receipt of the ARM command until the instrument actually arms. The value entered represents multiples or 10 ms. For example, entering a value of 20 would set a delay of 200 ms (0.2 sec). The default factory setting is 1.	
Examples	**Command / Query**	**Response *(Description)***
	`DELAY ARM 2` `DELAY ARM?`	*(Sets the delay to 20 ms.)* 2 *(Verifies that the delay is set to 20 ms.)*

DEP

Purpose	Put Data in the specified address (included for 7612D compatibility only; does not actually perform an operation).	
Type	Set only	
Command Syntax	DEP H<address>,H<data>	
Command Parameters	<address> = hexadecimal address value <data> = hexadecimal data value	
Power-Up State	N/A	
Query Syntax	N/A	
Query Parameters	N/A	
Query Response	N/A	
Description	The first parameter specifies the address into which the data byte will be written. A one- to four-digit hexadecimal number is required, preceded by the letter "H". The second parameter specifies the byte to be written to the specified address. A one- to two-digit hexadecimal number is required, preceded by the letter "H." **Note** This command is included for 7612D compatibility only; it does not actually perform an operation.	
Examples	**Command / Query**	**Response *(Description)***
	`DEP H420,H3F`	

DOWNLOAD

Purpose	Download firmware.	
Type	Event	
Command Syntax	DOWNLOAD <section>	
Command Parameters	<section> = 0 | 1 | 2 | 3 0 = GPIB interface code and support software 1 = mainframe 2 = left channel 3 = right channel	
Power-Up State	N/A	
Query Syntax	N/A	
Query Parameters	N/A	
Query Response	N/A	
Description	The Download command loads new firmware into the 2412. Follow the command with data from an S-record file.	
Examples	**Command / Query**	**Response *(Description)***
	`DOWNLOAD 1`	*(Downloads firmware into the mainframe section of the 2412.)*

ERR?

Purpose	Returns code for current error condition.	
Type	Query only	
Command Syntax	N/A	
Command Parameters	N/A	
Power-Up State	N/A	
Query Syntax	ERR?	
Query Parameters	N/A	
Query Response	ERR <NR1>	
Description	The ERRor query returns a numeric error code in NR1 notation if an error has occurred since the last ERR query. If no error has occurred, the code is zero. The error code is not cleared by executing a valid command; the code is unchanged until another error occurs or the ERR query is executed. See *Warning and Error Messages* in Section 3.	
Examples	**Command / Query**	**Response *(Description)***
	ERR?	ERR 0; *(Returns that no errors have occurred.)*

EXEC

Purpose	Begin executing at the specified address (included for 7612D compatibility only; does not actually perform an operation).	
Type	Set only	
Command Syntax	EXEC H<address>	
Command Parameters	<address> = hexadecimal address value	
Power-Up State	N/A	
Query Syntax	N/A	
Query Parameters	N/A	
Query Response	N/A	
Description	The parameter is a one- to four-digit hexadecimal address preceded by the letter “H”. **Note** This command is included for 7612D compatibility only; it does not actually perform an operation.	
Examples	**Command / Query**	**Response *(Description)***
	`EXEC H420`	

FET

Purpose	Fetch Data from the specified address (included for 7612D compatibility only; always returns a H00;).
Type	Set only
Command Syntax	FET H<address>
Command Parameters	<address> = hexadecimal address value
Power-Up State	N/A
Query Syntax	N/A
Query Parameters	N/A
Query Response	N/A
Description	The address is specified as a one- to four-digit hexadecimal number preceded by the letter “H”. The response is returned in ASCII with an “H” followed by two digits representing the hexadecimal value read from the specified location. **Note** This command is included for 7612D compatibility only; it always returns a H00;.

Examples

Command / Query	**Response *(Description)***
`FET H420`	H000;

GAIN POT

Purpose	Set channel gain.	
Type	Set or Query	
Command Syntax	GAIN POT <channel>,<gain_value>	
Command Parameters	<channel> = 0 | 1 (*0 = Channel A; 1 = Channel B)* <gain_value> = floating point number	
Power-Up State	N/A	
Query Syntax	GAIN POT <channel>?	
Query Parameters	<channel> = 0 | 1 (*0 = Channel A; 1 = Channel B)*	
Query Response	Floating point number	
Description	The Gain Pot command sets the gain value for the specified channel. Use the CAL STORE command to save the new setting to nonvolatile memory. The factory default setting is 1.0000. The Security State must first be disabled to change this setting.	
Examples	**Command / Query**	**Response *(Description)***
	`CAL:SEC:STAT OFF,"2412"`	*(Disable security.)*
	`GAIN POT 1,0.0000`	*(Sets the gain for Channel A to zero.)*
	`CAL STORE`	*(Store the new setting in nonvolatile memory.)*
	`CAL:SEC:STAT ON`	*(Re-enable security.)*
	`GAIN POT 1?`	0.0000 *(Verifies that the gain setting for Channel A is zero.)*

GPIB

Purpose	Set the primary and secondary addresses.
Type	Set or Query
Command Syntax	GPIB <primary>,<secondary>
Command Parameters	<primary> = numeric value <secondary>= numeric value
Power-Up State	N/A
Query Syntax	GPIB?
Query Parameters	N/A
Query Response	<primary>:<secondary>
Description	The GPIB command sets the GPIB primary and secondary addresses. The first number sets the lower five bits of the GPIB primary address, which represents both My Talk Address (MTA) and My Listen Address (MLA). The second number sets the lower five bits of My Secondary Address (MSA) for the main frame, the Channel A amplifier, and the Channel B amplifier. The selected number is MSA for the main frame. The Channel A amplifier is assigned the mainframe address **MSA + 1**. The Channel B amplifier is assigned the mainframe address **MSA + 2**. A CAL STORE command must be sent to store the values into nonvolatile memory.

Examples

Command / Query	**Response *(Description)***
`CAL:SEC:STAT OFF,"2412"`	*(Disable security.)*
`GPIB 20,0`	*(Sets the primary address to 20 and the secondary address to 0.)*
`CAL STORE`	*(Store the new setting in nonvolatile memory.)*
`CAL:SEC:STAT ON`	*(Re-enable security.)*
`GPIB?`	20:0 *(Verifies that the primary address is set to 20 and the secondary address to 0.)*

GPIB TERM

Purpose	Set terminator type.	
Type	Set or Query	
Command Syntax	GPIB TERM <term_type>	
Command Parameters	<term_type> = LINEFEED | EOI	
Power-Up State	N/A	
Query Syntax	GPIB TERM?	
Query Parameters	N/A	
Query Response	GPIB LINEFEED | GPIB EOI	
Description	The GPIB TERM command sets the type of terminator message recognized by the instrument. The two possible selections are LINEFEED or EOI. The LINEFEED setting uses a Line Feed character to signal the end of a message. The EOI setting uses the GPIB EOI (End or Identify) signal to indicate the end of a message. Use the CAL STORE command to save this setting into nonvolatile memory.	
Examples	**Command / Query**	**Response *(Description)***
	`CAL:SEC:STAT OFF,"2412"`	*(Disable security.)*
	`GPIB TERM LINEFEED`	*(Sets the GPIB termination to LINEFEED.)*
	`CAL STORE`	*(Store the new setting in nonvolatile memory.)*
	`CAL:SEC:STAT ON`	*(Re-enable security.)*
	`GPIB TERM?`	GPIB LINEFEED *(Verifies that the GPIB termination is set to LINEFEED.)*

HFR

Purpose	Enable or disable high-frequency reject trigger.	
Type	Set or Query	
Command Syntax	HFR <state>	
Command Parameters	<state> = ON | OFF	
Power-Up State	OFF	
Query Syntax	HFR?	
Query Parameters	N/A	
Query Response	HFR ON; HFR OFF;	
Description	When the HFR parameter is ON, frequencies above about 50 kHz are attenuated in the trigger signal. This filters complex or noisy signals to provide more stable triggering.	
Examples	**Command / Query**	**Response *(Description)***
	`HFR ON` `HFR?`	*(Enables high frequency reject trigger.)* HFR ON; *(Verifies high-frequency reject trigger is enabled.)*

HSF<CH>?

Purpose	Returns the horizontal scale factors for <channel>.	
Type	Query only	
Command Syntax	N/A	
Command Parameters	N/A	
Power-Up State	N/A	
Query Syntax	HSF<CH>?	
Query Parameters	<CH> = A | B	
Query Response	See below	
Description	The HSF query returns the horizontal scale factors for the selected channel. The scale factors information includes the number and length of records, number of breakpoints, breakpoint locations, sampling intervals, and trigger mode. The query response is in ASCII. The length of the message returned depends on the number of breakpoints set.	
Examples	**Command / Query**	**Response *(Description)***
	HSFA?	REC 1,2048;NBPT 1;SBPT 0, 5e-9;MODE PRE,0 *(Returns horizontal scale factors for Channel A as follows: number of records = 1, length = 2048; number of breakpoints = 1; location of breakpoint = 0 (default); sampling intervals = 5e-9; trigger mode = pre-trigger, 0 samples))*

ID

Purpose	Set instrument ID.	
Type	Set or Query	
Command Syntax	ID <string>	
Command Parameters	<string> = up to 49 characters encased in quotation marks	
Power-Up State	N/A	
Query Syntax	ID?	
Query Parameters	N/A	
Query Response	Up to 49 characters encased in quotation marks	
Description	The ID command sets the ID model (or other information) reported by the ID? query. A CAL STORE command is required to commit any changes to nonvolatile memory. The factory default settings are: ID VXI/VM2412S-Mainframe,1.07 *mainframe* ID VXI/VM2412S-Plugin A,V1.02 *Channel A amplifier* ID VXI/VM2412S-Plugin B,V1.02 *Channel B amplifier* **Note** The default version numbers may be different than listed above.	
Examples	**Command / Query**	**Response *(Description)***
	`CAL:SEC:STAT OFF,"2412"`	*(Disable security.)*
	`ID "VXI/VM2412S-MAINFRAME,1.07`	*(Input the ID string.)*
	`CAL STORE`	*(Store the new setting in nonvolatile memory.)*
	`CAL:SEC:STAT ON`	*(Re-enable security.)*
	`ID?`	ID "VXI/VM2412S-Mainframe,1.07" (*Verifies the ID string.)*

ID? VXI

Purpose	Query the VXI identification string.	
Type	Query	
Command Syntax	N/A	
Command Parameters	N/A	
Power-Up State	N/A	
Query Syntax	ID? VXI	
Query Parameters	N/A	
Query Response	VXI ID string	
Description	The ID VXI query reports the VXI identification string.	
Examples	**Command / Query**	**Response *(Description)***
	`ID VXI?`	ID “VXI/VM2412S-Mainframe,1.07”

LEV

Purpose	Set trigger level for selected trigger channel.	
Type	Set or Query	
Command Syntax	LEV <NR1>	
Command Parameters	<NR1> = signed integer	
Power-Up State	0	
Query Syntax	LEV?	
Query Parameters	N/A	
Query Response	LEV <NR1>	
Description	The LEVel command selects the amplitude level of the trigger signal at which the trigger occurs. Valid trigger level values range from +127 to -128, corresponding to the 8-bit resolution of the instrument. A setting of +127 means that the time base triggers when the signal reaches full-scale amplitude. The trigger occurs at the selected point on the positive slope of the waveform if SLOpe is set to POSitive. The trigger occurs at the selected point on the negative slope of the waveform if SLOpe is set to NEGative.	
Examples	**Command / Query**	**Response *(Description)***
	`LEV 113` `LEV?`	*(Sets the trigger level to 113.)* LEV 113; *(Verifies the trigger level is set to 113.)*

LTC

Purpose	Selects trigger channel.	
Type	Set or Query	
Command Syntax	LTC <channel>	
Command Parameters	<channel> = L[EFT] | R[IGHT]	
Power-Up State	LTC LEFT (for Channel A) LTC RIGHT (for Channel B)	
Query Syntax	LTC?	
Query Parameters	N/A	
Query Response	LTC LEFT; LTC RIGHT;	
Description	The Logical Trigger Channel command selects the left or right trigger channel as the trigger source for the selected time base. The trigger parameters for the selected trigger channel (i.e. SOURCE, SLOpe, LEVel, and CouPLing) are applied to the currently selected time base. Both time bases may be programmed to receive their trigger signal from the same trigger channel. For example, if both time bases are set for the right logical trigger channel, both time bases receive the same trigger signal and use the same trigger settings. The LTC command provides a convenient way of triggering both time bases simultaneously. However, when pre-trigger mode is selected, both time bases must acquire one full record of pre-trigger data before becoming triggerable. Therefore, it is possible for the time bases to trigger at different times although they are receiving their trigger from the same trigger channel. If the record lengths, trigger modes, or breakpoints are different, the time required to acquire the pre-trigger samples may be different, causing one time base to become triggerable before the other.	
Examples	**Command / Query**	**Response *(Description)***
	`LTC L` `LTC?`	*(Selects the left channel, or Channel A.)* LTC LEFT; *(Verifies that the left channel (A) is selected.)*

MODE

Purpose	Set to pre-trigger or post-trigger by *n* samples.
Type	Set or Query
Command Syntax	MODE <mode>,<N8>
Command Parameters	<mode> = PRE | POST <N8> = an unsigned integer multiple of eight
Power-Up State	PRE,0
Query Syntax	MODE?
Query Parameters	N/A
Query Response	MODE PRE,<N8>; MODE POST,<N8>;
Description	The MODE command selects the triggering mode, Pre- or Post-trigger, for the selected time base. The command parameters specify the trigger mode and the number of pre- or post-trigger samples to be acquired. PRE,<N8> Set the instrument to acquire *n* samples of pre-trigger data. The number of samples must be an integer multiple of eight from zero to sixteen less than the length of the first segment. One full record of pre-trigger samples is acquired at the sampling interval of the first segment. From this data, the programmed number of pre-trigger samples is stored; the remainder is discarded. POST,<N8> Set the instrument to acquire *n* samples of post-trigger data. The number of samples must be an integer multiple of eight from eight to the record length. In post-trigger mode, only one record may be selected. If more than one record is set up, an execution warning message is issued and the number of records is set to one when the instrument is armed. Post-trigger samples are acquired at the sampling interval for the first segment. When the time base is triggered, the programmed number of samples is ignored before the instrument begins storing data.

Examples	**Command / Query**	**Response *(Description)***
	`MODE PRE,56`	*(Set to acquire 56 samples of pre-trigger data.)*
	`MODE?`	MODE PRE,56; *(Verifies that MODE is set to acquire 56 pre-trigger samples.)*

MTRIG

Purpose	Generates triggers for both channels.	
Type	Set only	
Command Syntax	MTRIG	
Command Parameters	N/A	
Power-Up State	N/A	
Query Syntax	N/A	
Query Parameters	N/A	
Query Response	N/A	
Description	The Manual TRIGger command causes the armed time bases to trigger by running the trigger level through its range (+127 to -128). If the input signal is out of this range (off the target), the time base does not trigger. The MTRIG command has no parameters and is not executed in LOCAL state. If the time base(s) are not armed and triggerable when the MTRIG is received, the command is ignored.	
Examples	**Command / Query**	**Response *(Description)***
	`MTRIG`	*(Generates a trigger for both channels.)*

NBPT?

Purpose	Returns number of breakpoints.	
Type	Query only	
Command Syntax	N/A	
Command Parameters	N/A	
Power-Up State	N/A	
Query Syntax	NBPT?	
Query Parameters	N/A	
Query Response	NBPT <NR1>;	
Description	The NBPT query returns the number of breakpoints currently set in the selected time base. The value returned is in NR1 format.	
Examples	**Command / Query**	**Response *(Description)***
	NBPT?	NBPT 4; *(Returns that there are 4 breakpoints set in the selected time base.)*

NV?

Purpose	Query model, non-volatile seed value, calibration count, and GPIB primary and secondary addresses.	
Type	Query	
Command Syntax	N/A	
Command Parameters	N/A	
Power-Up State	N/A	
Query Syntax	NV?	
Query Parameters	N/A	
Query Response	Model, non-volatile seed value, calibration count and GPIB primary and secondary addresses	
Description	The NV query reports the model, non-volatile seed value, calibration count, and GPIB primary and secondary addresses.	
Examples	**Command / Query**	**Response *(Description)***
	VN?	Model= 2412 Seed= 2 CalCount= 20 Primary= 1 Secondary= 2

RDO?

Purpose	Returns 40 characters of readout information as acquired from the amplifiers.	
Type	Query only	
Command Syntax	N/A	
Command Parameters	N/A	
Power-Up State	N/A	
Query Syntax	RDO?	
Query Parameters	N/A	
Query Response	RDO <CHARACTER(S)>;	
Description	The RDO query returns 40 characters of readout information as acquired from the amplifiers. The readout information is in ASCII and is divided into four fields, one for each channel of each amplifier. The readout is returned as it is acquired from the amplifier. Consequently, some special characters may be replaced by ASCII characters. The readout is returned enclosed in quotation marks, as shown, with spaces separating the fields. Empty fields are filled with spaces.	
Examples	**Command / Query**	**Response *(Description)***
	RDO?	RDO “<left ch 1> <left ch 2> <right ch 1> <right ch 2>”;

READ

Purpose	Read data from Channel A or B.	
Type	Set only	
Command Syntax	READ <channel>[,<record>[,segment>]]	
Command Parameters	<channel> = A | B <record> = record number = segment number	
Power-Up State	N/A	
Query Syntax	N/A	
Query Parameters	N/A	
Query Response	N/A	
Description	The READ data command causes the instrument to transmit waveform data to the controller. The entire contents of one channel may be transmitted, or a record or segment may be individually transmitted. The channel (A or B), record number, and segment number are specified parameters. If the record and segment parameters are omitted, the entire contents of the specified channel are transmitted. If included, the record number parameter must be an integer value from zero to the number of records, less one. The first record is designated as record zero (0). For example, the command READ A,2 returns the waveform data from the third record in Channel A. The third parameter (if included) defines the segment number to be read. If the segment number parameter is included, a record number must first be specified. Valid segment numbers range from zero to the number of segments, less one. As with record numbers, the segments are numbered starting with zero, so the first segment is segment zero (0). If a record or segment number specified in a READ command does not exist, an execution error message is issued and the command is ignored. When part of the data memory is unused (e.g. 2 records of 256 points are set up), only the valid waveform data is transmitted. Unused parts of data memory are ignored.	
Examples	**Command / Query**	**Response *(Description)***
	`READ A`	*(Reads Channel A.)*
	`READ B,0,3`	*(Reads Channel B, record 0 (first record), segment 3 (fourth segment).)*

REC

Purpose	Set the number and length of records.
Type	Set or Query
Command Syntax	REC <record>,<length>
Command Parameters	<record> = number of records <length> = 256 | 512 | 1024 | 2048 **Note** The product of the number of records and the record length cannot exceed 2048.
Power-Up State	1,2048
Query Syntax	REC?
Query Parameters	N/A
Query Response	REC <record>,<length>;
Description	The RECord command sets the number and length of the records for the time base selected with the TMBS command. The first parameter defines the number of records. Integer values from 1 to 8 are valid. The second parameter defines the length of the records. Valid lengths are 256, 512, 1024 or 2048 with one restriction: the product of the number of records and the record length cannot exceed 2048 (the maximum record length). All records are the same lengths. Specifying a new length or number of records does not affect the breakpoints set in the record(s) unless the breakpoints are beyond the new record length. Existing breakpoints are applied to the new record(s) automatically. If the new record length causes some breakpoints to be beyond the record boundary, the invalid breakpoints are deleted and an execution warning message is issued.

Examples	**Command / Query**	**Response *(Description)***
	`REC 2,1024`	*(Sets up 2 records with a length of 1024 each.)*
	`REC?`	REC 2,1024; *(Verifies there are 2 records with a length of 1024 each.)*

REM

Purpose	Enable or disable asserting SRQ when REMOTE is pressed.
Type	Set or Query
Command Syntax	REM <state>
Command Parameters	<state> = ON | OFF
Power-Up State	OFF
Query Syntax	REM?
Query Parameters	N/A
Query Response	REM ON; REM OFF
Description	The REMote command controls the response of the instrument when the front-panel REMOTE button is pressed. **ON** Assert SRQ when REMOTE button is pressed if the RQS function is set ON (power-up condition). Set the status byte to reflect the remote request status. **OFF** Do not assert SRQ when REMOTE button is pressed, but set remote request byte. This is the power-up condition.

Examples	**Command / Query**	**Response *(Description)***
	`REM ON`	*(Enables asserting SRQ.)*
	`REM?`	REM ON; *(Verifies asserting SRQ is enabled.)*

REP

Purpose	Set Repeat ARM/READ sequence for <channel> time base *n* times.
Type	Set only
Command Syntax	REP <NR1>,<channel>
Command Parameters	<NR1> = number of times to repeat <channel> = A | B | A,B | B,A
Power-Up State	N/A
Query Syntax	N/A
Query Parameters	N/A
Query Response	N/A
Description	The REPeat command allows the user to improve throughput when acquiring multiple waveforms by acquiring several waveforms with a minimum of controller interaction. The instrument executes ARM and READ commands the specified number of times for the specified channel(s). Two parameters are required. The first parameter is a number in NR1 format that specifies the number of times the ARM and READ sequence is repeated. If this parameter is set to zero (0), the instrument continues to repeat the sequence until it receives a device clear interface message. A negative number results in a command error. The second parameter specifies the channel(s) that will execute the ARM and READ sequence. **A** Repeat the sequence ARM A;READ A the specified number of times. **B** Repeat the sequence ARM B;READ B the specified number of times. **A,B** (or **B,A**) Repeats the ARM A,B; READ A;READ B sequence the specified number of times. The waveform data is sent from Channel A first, then from Channel B, with a semicolon separating the binary data blocks. All waveforms are sent in the binary block form, with blocks separated by semicolons. If the instrument is addressed to talk before an acquisition is complete, data is transmitted when the acquisition completes.

Examples	**Command / Query**	**Response *(Description)***
	`REP 4,A`	*(Repeats the ARM A,READ A sequence for times.)*

RQS

Purpose	Enable or disable asserting SRQ to request service.	
Type	Set or Query	
Command Syntax	RQS <state>	
Command Parameters	<state> = ON | OFF	
Power-Up State	ON	
Query Syntax	RQS?	
Query Parameters	N/A	
Query Response	RQS ON; RQS OFF;	
Description	The ReQuest Service command enables or disables the SRQ function of the instrument.	
Examples	**Command / Query**	**Response *(Description)***
	`RQS OFF` `RQS?`	*(Disables asserting SRQ to service request.)* RQS OFF; *(Verifies that asserting SRQ to service request is disabled.)*

SBPT

Purpose	Set breakpoint locations and the sampling interval for the segment.
Type	Set or Query
Command Syntax	SBPT <N8>,<NR3>[,<N8>,<NR3>]…
Command Parameters	<N8> =unsigned integer multiple of eight <NR3> =signed scientific notation
Power-Up State	0,5e-9
Query Syntax	SBPT?
Query Parameters	N/A
Query Response	SBPT <N8>,<NR3>[,<N8>,<NR3>]…;
Description	The Set BreakPoinT command sets the breakpoints and sampling interval for all records in the selected channel. A breakpoint divides the records into segments. A segment includes all the samples from the specified breakpoint to the next breakpoint or the end of the record. Each segment has an independent sampling interval. All records are identical, so breakpoints apply to all records in the currently selected channel. The SBPT command parameters are specified in pairs. The first parameter defines the breakpoint location. The location is specified as a sample number, and it must be a multiple of eight from sixteen to eight less than the record length (except for the fixed breakpoint at location zero). If the specified location is not a multiple of eight, the number is rounded to the next lower multiple of eight and an execution warning message is issued. The second parameter defines the sampling interval associated with the breakpoint. The sampling interval applies to all samples from the existing breakpoint to the next breakpoint or the end of the record. The range of valid sampling interval values depends on the selected clock source. When the internal clock source is selected (front-panel CLK button lit), sampling intervals range from 1 s to 5 ns and are given by the formula: $S.I. = (5\ ns)(X * 10^{Y})$ Where: $X = 1,2,4,6,\ldots,20$ $Y = 0,1,\ldots,7$ When the external clock source is selected, the sampling interval parameter represents an external clock-period multiplier. The period of the signal applied to the rear-panel EXT CLK connector is multiplied by the selected external clock-period multiplier. Valid values range from 1 to 200 x 10^6 and are given by the formula:

SBPT - Continued

<table>
<tr><td></td><td colspan="2">S.I. = (EXT CLK)(X * 10^{Y})
Where:
X = 1, 2, 4, 6, …, 20
Y = 0, 1, …, 7

Again, if the value specified in the command parameter is within the valid range but does not conform to the formula, the instrument sets it to the next lower valid period multiplier and issues a warning message.

Up to 14 breakpoints may be specified in one SBPT command as long as one of the parameter pairs defines the sampling interval for the fixed breakpoint at location zero. The total number of breakpoints cannot exceed 14, including the fixed one at location zero. If a specified breakpoint already exists, the sampling interval is applied to the existing segment.</td></tr>
<tr><td>Examples</td><td>Command / Query</td><td>Response (Description)</td></tr>
<tr><td></td><td>SBPT 16,1E-6

SPBT?</td><td>(Sets the breakpoint location to 16 and the samples intervals to 1e-6.)
SBPT 16,1e-6;</td></tr>
</table>

SET?

Purpose	Returns all settings.	
Type	Query only	
Command Syntax	N/A	
Command Parameters	N/A	
Power-Up State	N/A	
Query Syntax	SET?	
Query Parameters	N/A	
Query Response	see below	
Description	The SET query returns the status of all programmable instrument functions. The query response shown in the example is for the default settings. The actual response to the query depends on the instrument settings but the order of the settings returned does not change. The message may be longer if more breakpoints are set. Notice that the settings for Channel A are reported first, followed by the settings for Channel B. The command header (SET) sent with all other query responses is omitted in this case. The string can be stored and directly transmitted back to the instrument without modification to restore the "learned" programmable settings. For example, the user may wish to set the instrument up from the front panel and write an application program that learns the settings when the REMOTE button is pressed. These settings can be restored at any time by sending the string stored from the query response.	
Examples	**Command / Query**	**Response *(Description)***
	SET?	CLK INT;BTA OFF;WRI OFF;RQS ON;REM OFF;TMBS A;REC 1,2048; SBPT 0,5e-9;MODE PRE,0;LTC LEFT;SRC INT;SLO POS;HFR OFF;CPL AC;LEV 0;TMBS B;REC 1,2048;SBPT 0,5e-9;MODE PRE,0;LTC RIGHT;SRC INT;SLO POS;HFR OFF;CPL AC;LEV 0 (*This example shows all the settings at power-up.)*

SLO

Purpose	Set trigger slope to positive or negative.	
Type	Set or Query	
Command Syntax	SLO <slope>	
Command Parameters	<slope> = POS | NEG	
Power-Up State	POS	
Query Syntax	SLO?	
Query Parameters	N/A	
Query Response	SLO POS; SLO NEG;	
Description	The SLOpe command selects the slope on which the time base triggers. The LEVel parameter selects the point on the selected slope at which the trigger occurs.	
Examples	**Command / Query**	**Response *(Description)***
	`SLO NEG` `SLO?`	*(Sets the trigger slope negative.)* SLO NEG; *(Verifies that the trigger slope is set negative.)*

SLO GAIN

Purpose	Set Gain DAC.	
Type	Set or Query	
Command Syntax	SLO GAIN <DAC_gain>	
Command Parameters	<DAC_gain> = floating point number	
Power-Up State	N/A	
Query Syntax	SLO GAIN?	
Query Parameters	N/A	
Query Response	floating point number	
Description	The SLO GAIN command sets the Gain DAC. This command is used in the calibration of the 2412.	
Examples	**Command / Query**	**Response *(Description)***
	`SLO GAIN 0.0500`	*(Sets the gain DAC to 0.0500.)*
	`SLO GAIN?`	0.0500 *(Verifies that the Gain DAC is set to 0.0500.)*

SLO OFFSET?

Purpose	Query gain offset.	
Type	Query	
Command Syntax	N/A	
Command Parameters	N/A	
Power-Up State	N/A	
Query Syntax	SLO OFFSET?	
Query Parameters	N/A	
Query Response	Floating point number	
Description	The SLO OFFSET query reports the gain offset. This command is used in the calibration of the 2412.	
Examples	**Command / Query**	**Response *(Description)***
	`SLO OFFEST?`	0.1000

SN

Purpose	Load a serial number into nonvolatile memory.	
Type	Set or Query	
Command Syntax	SN <serial_no>	
Command Parameters	<serial_no> = numeric value	
Power-Up State	N/A	
Query Syntax	SN?	
Query Parameters	N/A	
Query Response	Numeric value	
Description	The SN command loads a serial number into nonvolatile memory. The number can be up to 31 bits (i.e. 2^{31-1}). A CAL STORE command is required to save this setting in non-volatile memory.	
Examples	**Command / Query**	**Response *(Description)***
	`CAL:SEC:STAT OFF,"2412"`	*(Disable security.)*
	`SN 1234`	*(Load serial number.)*
	`CAL STORE`	*(Store the new setting in nonvolatile memory.)*
	`CAL:SEC:STAT ON`	*(Re-enable security.)*
	`SN?`	SN 1234 *(Reports serial number.)*

SRC

Purpose	Select internal or external triggering source.	
Type	Set or Query	
Command Syntax	SRC <source>	
Command Parameters	<source> = INT | EXT	
Power-Up State	INT	
Query Syntax	SRC?	
Query Parameters	N/A	
Query Response	SRC INT; SRC EXT;	
Description	The SouRCe command selects the trigger source for the selected trigger channel. **INT** Select the internal trigger signal from the amplifier as the trigger source. This signal usually provides adequate triggering for most normal application. **EXT** Select the signal applied to the rear-panel L or R TRIG connector as the signal source.	
Examples	**Command / Query**	**Response *(Description)***
	`SRC EXT` `SRC?`	*(Selects the external trigger source.)* SRC EXT; *(Verifies that the external trigger source is selected.)*

TDAC

Purpose	Load Trigger DAC.	
Type	Set	
Command Syntax	TDAC <dac_value>	
Command Parameters	<dac_value> = floating point number	
Power-Up State	N/A	
Query Syntax	N/A	
Query Parameters	N/A	
Query Response	N/A	
Description	The TDAC command loads the Trigger DAC value. This command is used in the calibration of the 2412.	
Examples	**Command / Query**	**Response *(Description)***
	`TDAC 0.1000`	*(Load Trigger DAC.)*

TMBS

Purpose	Specify the time base to be programmed or queried by the subsequent time base commands.	
Type	Set or Query	
Command Syntax	TMBS <channel>	
Command Parameters	<channel> = A | B	
Power-Up State	A	
Query Syntax	TMBS?	
Query Parameters	N/A	
Query Response	TMBS A; TMBS B;	
Description	The TMBS command selects the time base to be programmed by subsequent time base commands. The front panel displays the current state of the time base selected.	
Examples	**Command / Query**	**Response *(Description)***
	`TMBS B` `TMBS?`	*(Select Channel B.)* TMBS B; *(Returns that Channel B is selected.)*

VSL<#>?

Purpose	Returns the vertical scale factors for the <#> channel of the left amplifier.	
Type	Query only	
Command Syntax	N/A	
Command Parameters	N/A	
Power-Up State	N/A	
Query Syntax	VSR<#>?	
Query Parameters	<#> = 1 | 2	
Query Response	See below	
Description	The Vertical Scale factors query returns the scale factors for the LEFT amplifier (Channel A).	
Examples	**Command / Query**	**Response *(Description)***
	`VSL1?`	VSL1 +500.e0-3,V,CAL;
	`VSL2?`	VSL2 NONE; *(Selecting <2> as the parameter will report back "NONE" if a dual-channel amplifier is not installed.)*

VSR<#>?

Purpose	Returns the vertical scale factors for the <#> channel of the right amplifier.	
Type	Query only	
Command Syntax	N/A	
Command Parameters	N/A	
Power-Up State	N/A	
Query Syntax	VSR<#>?	
Query Parameters	<#> = 1 | 2	
Query Response	See below	
Description	The Vertical Scale factors query returns the scale factors for the RIGHT amplifier (Channel B).	
Examples	**Command / Query**	**Response *(Description)***
	VSR1? VSR2?	VSR1 +500.e0-3,V,CAL; VSR2 NONE; *(Selecting <2> as the parameter will report back "NONE" if a dual-channel amplifier is not installed.)*

WRI

Purpose	Enable or disable asserting SRQ when waveform data is readable.	
Type	Set or Query	
Command Syntax	WRI <state>	
Command Parameters	<state> = ON | OFF	
Power-Up State	OFF	
Query Syntax	WRI?	
Query Parameters	N/A	
Query Response	WRI ON; WRI OFF;	
Description	The Waveform Readable Interrupt command enables or disables the SRQ interrupt generated when a channel completes its acquisition.	
Examples	**Command / Query**	**Response *(Description)***
	`WRI ON`	*(Enables asserting SRQ when waveform data is readable.)*
	`WRI?`	WRI ON; *(Verifies that asserting SRQ when waveform data is readable is enabled.)*

PROGRAMMABLE AMPLIFIER COMMANDS

TABLE 4-2 AMPLIFIER HIGH-LEVEL (ASCII) COMMAND SET

SET COMMANDS		
Command	**Description**	**Power-Up State**
INP	Selects the input connector	**A**
RIN	Selects amplifier input impedance	HI
CPL	Selects the input coupling mode	DC
BW	Selects amplifier bandwidth	FUL
POL	Selects amplifier polarity	NOR
V/D	Set the volts per division range	5
POS	Controls the vertical position of the trace	0
VAR	Enable or disable variable amplifier gain	OFF
ID	Set instrument ID	N/A
READ ONLY OR QUERY COMMANDS		
Command	**Description**	
PRB?	Query the probe setting on the selected input	
ID? VXI	Query the VXI identification string	
SET?	Query the settings of the input amplifier	

TABLE 4-3 AMPLIFIER LOW-LEVEL (HEXADECIMAL) CODES

Address	Parameter	Setting	Description
00	16		Amplifier ID (read only)
01	00	A	Input Connector
	40	B	
02	80	50 Ω	Input Impedance
	00	1 MΩ	
03	00	AC	Input Coupling
	10	DC	
	20	GND	
04	05	10 mV/div	Volts/Division (ignores probe attenuation)
	04	20 mV/div	
	06	50 mV/div	
	01	100 mV/div	
	00	200 mV/div	
	02	500 mV/div	
	09	1 V/div	
	08	2 V/div	
	0A	5 V/div	
05			High two bits of Position
06	03 FF	-10.22 divisions	Low eight bits of Position Step size is 0.02 div.
	02 00	Midscreen	
	00 00	+10.24 divisions	
07	00	Inverted	Polarity
	08	Normal	
08	00	20 MHz limit	Bandwidth Limit
	40	Full bandwidth	
09	00	Deflection factors can be manually varied by VARIALE control	Calibrated/Variable Gain
	20	Returns deflection factors to calibrated value	
0A	00	Probe IDENTIFY switch is pressed	Probe Attenuation (read only). A write to this address is ignored.
	04	100X probe	
	14	10X probe	
	1C	1X or un-encoded probe	

BW

Purpose	Selects amplifier bandwidth.	
Type	Set or Query	
Command Syntax	BW <bandwidth>	
Command Parameters	<bandwidth> = LIM | FUL	
Power-Up State	FUL	
Query Syntax	BW?	
Query Parameters	N/A	
Query Response	BW FUL | BW LIM	
Description	The BandWidth command selects the amplifier bandwidth. **FUL** Selects full amplifier bandwidth. **LIM** Selects a limited, or reduced bandwidth of 20 MHz.	
Examples	**Command / Query**	**Response *(Description)***
	`BW LIM` `BW?`	*(Sets amplifier bandwidth to 20 MHz.)* BW LIM *(Verifies that the amplifier bandwidth is set to LIM.)*

CPL

Purpose	Selects the input coupling mode.	
Type	Set or Query	
Command Syntax	CPL <mode>	
Command Parameters	<mode> = AC | DC | GND	
Power-Up State	DC	
Query Syntax	CPL?	
Query Parameters	N/A	
Query Response	CPL AC | CPL DC | CPL GND	
Description	The CouPLing command selects the input-coupling mode of the amplifier. **AC** The AC component of the input signal is passed while the DC component is blocked. **DC** Both the AC and DC component of the input signal is passed. **GND** The input connectors are disconnected from the amplifier input. The amplifier input is connected to ground.	
Examples	**Command / Query**	**Response *(Description)***

	`CPL GND`
	
	`CPL?`
		(Sets the coupling mode to the GROUND setting.)
		CPL GND *(Verifies that the coupling mode is set to GROUND.)*

ID

Purpose	Set instrument ID.	
Type	Set or Query	
Command Syntax	ID <string>	
Command Parameters	<string> = up to 49 characters encased in quotation marks	
Power-Up State	N/A	
Query Syntax	ID?	
Query Parameters	N/A	
Query Response	up to 49 characters encased in quotation marks	
Description	The ID command sets the ID model (or other information) reported by the ID? query. A CAL STORE command is required to commit any changes to nonvolatile memory. The factory default settings are: ID VXI/VM2412S-Plugin A,V1.02 *Channel A amplifier* ID VXI/VM2412S-Plugin B,V1.02 *Channel B amplifier* **Note** The default version numbers may be different than listed above.	
Examples	**Command / Query**	**Response *(Description)***
	`CAL:SEC:STAT OFF,"2412"`	*(Disable security.)*
	`ID "VXI/VM2412S-PLUGIN A, V1.02"`	*(Input the ID string.)*
	`CAL STORE`	*(Store the new setting in non-volatile memory.)*
	`CAL:SEC:STAT ON`	*(Re-enable security.)*
	`ID?`	ID "VXI/VM2412S-Plugin A,V1.02" *(Verifies the ID string.)*

ID? VXI

Purpose	Query the VXI identification string.	
Type	Query	
Command Syntax	N/A	
Command Parameters	N/A	
Power-Up State	N/A	
Query Syntax	ID? VXI	
Query Parameters	N/A	
Query Response	VXI ID string	
Description	The ID VXI query reports the VXI identification string.	
Examples	**Command / Query**	**Response *(Description)***
	`ID VXI?`	ID “VXI/VM2412S-Plugin A,V1.02”

INP

Purpose	Selects the input connector.	
Type	Set or Query	
Command Syntax	INP <connector>	
Command Parameters	<connector> = A | B	
Power-Up State	A	
Query Syntax	INP?	
Query Parameters	N/A	
Query Response	INP A | INP B	
Description	The INPut command selects either the A or B input connectors on an amplifier.	
Examples	**Command / Query**	**Response *(Description)***
	`INP B` `INP?`	*(Selects input connector B.)* INP B *(Verifies that input connector B is selected.)*

POL

Purpose	Selects amplifier polarity.	
Type	Set or Query	
Command Syntax	POL <polarity>	
Command Parameters	<polarity> = NOR | INV	
Power-Up State	NOR	
Query Syntax	POL?	
Query Parameters	N/A	
Query Response	POL NOR | POL INV	
Description	The POLarity command sets the amplifier mode to normal or inverted polarity. In normal mode, an increasing voltage causes increasing data values. In inverted mode, a decreasing voltage causes increasing data values.	
Examples	**Command / Query**	**Response *(Description)***
	`POL INV` `POL?`	*(Set the amplifier mode to inverted polarity.)* POL INV *(Verifies that the amplifier is set to inverted mode.)*

POS

Purpose	Controls the vertical position of the trace.	
Type	Set or Query	
Command Syntax	POS <position>	
Command Parameters	<position> = -10.22 to +10.24 in 0.02 increments	
Power-Up State	0	
Query Syntax	POS?	
Query Parameters	N/A	
Query Response	POS -10.22 to POS 10.24	
Description	The POSition command controls the vertical position of the trace. Increasing values of position increase the data values. For example, a POS 2 setting corresponds to +2 divisions from center screen.	
Examples	**Command / Query**	**Response *(Description)***
	`POS 1`	*(Sets the vertical position to 1.)*
	`POS?`	POS 1 *(Verifies that the vertical position is set to 1.)*

PRB?

Purpose	Query the probe setting on the selected input.	
Type	Query	
Command Syntax	N/A	
Command Parameters	N/A	
Power-Up State	N/A	
Query Syntax	PRB?	
Query Parameters	N/A	
Query Response	X1 | X10 | X100 | ID	
Description	The PRoBe query returns the probe setting on the selected input. **X1** No probe or a non-attenuating probe is present on the selected input. **X10** X10 probe is present on the selected input. **X100** X100 probe is present on the selected input. **ID** Probe is on IDENTIFY.	
Examples	**Command / Query**	**Response *(Description)***
	PRB?	X1 *(Reports that there is no probe connected (or a non-attenuating probe).)*

RIN

Purpose	Selects amplifier input impedance.	
Type	Set or Query	
Command Syntax	RIN <impedance>	
Command Parameters	<impedance> = HI | LOW	
Power-Up State	HI	
Query Syntax	RIN?	
Query Parameters	N/A	
Query Response	RIN HI | RIN LOW	
Description	The RIN command selects the amplifier input-impedance. **HI** The amplifier is set to 1 MΩ input impedance. **LOW** The amplifier is set to 50 Ω input impedance.	
Examples	**Command / Query**	**Response *(Description)***
	`RIN LOW` `RIN?`	*(Sets the input impedance to 50 Ω.)* RIN LOW *(Verifies that the input impedance is set to 50 Ω.)*

SET?

Purpose	Query the settings of the input amplifier.	
Type	Query	
Command Syntax	N/A	
Command Parameters	N/A	
Power-Up State	N/A	
Query Syntax	SET?	
Query Parameters	N/A	
Query Response	See below	
Description	The SET query returns the settings of the input amplifier.	
Examples	**Command / Query**	**Response *(Description)***
	SET?	BW FUL;CPL DC;RIN HI;POL NOR;INP A (*These are the default settings of the input amplifier.)*

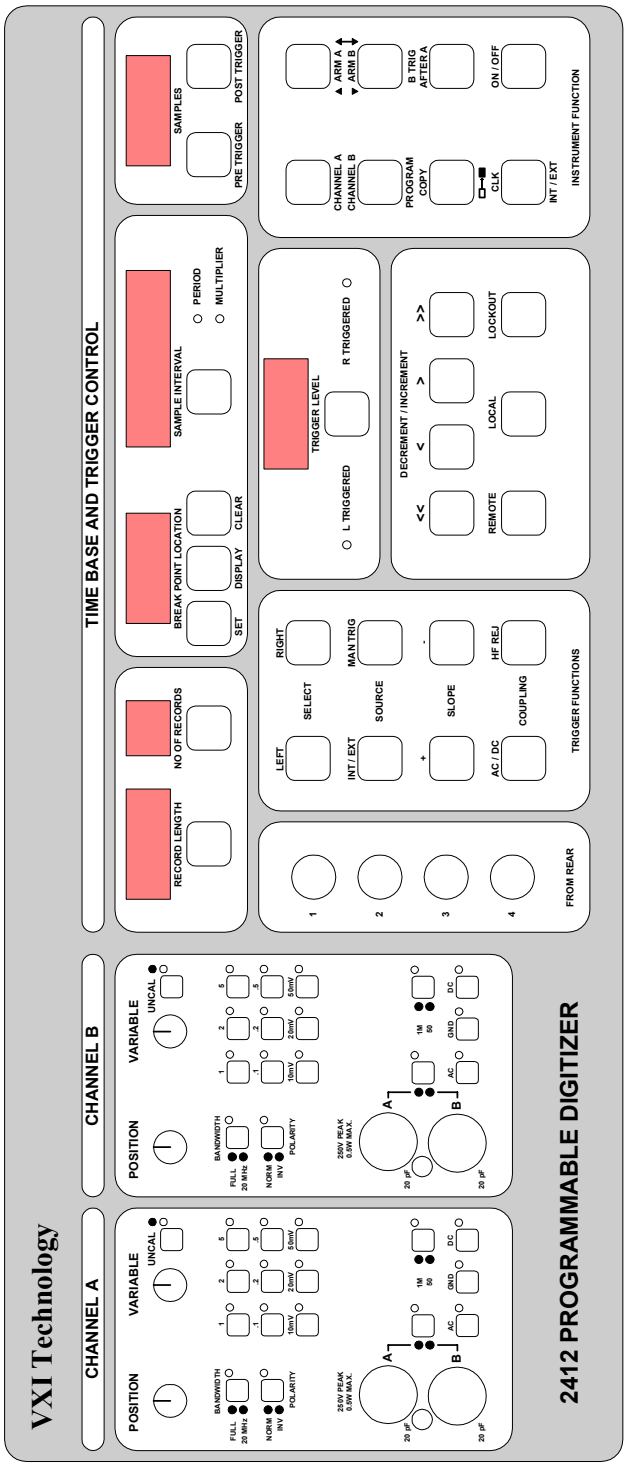
VAR

Purpose	Enable or disable variable amplifier gain.	
Type	Set or Query	
Command Syntax	VAR <mode>	
Command Parameters	<mode> = ON | OFF	
Power-Up State	OFF	
Query Syntax	VAR?	
Query Parameters	N/A	
Query Response	VAR ON | VAR OFF	
Description	The VAR command enables or disables the variable amplifier gain. **OFF** The amplifier deflection factors (ranges) are calibrated. **ON** The amplifier deflection factor is controlled by the range and the front-panel VARIABLE control. In this mode, the amplifier is not calibrated but can be continuously adjusted across all ranges.	
Examples	**Command / Query**	**Response *(Description)***
	`VAR ON` `VAR?`	*(Enables variable gain.)* *(Verifies that variable gain is enabled.)*

V/D

Purpose	Set the volts per division range.	
Type	Set or Query	
Command Syntax	V/D <range>	
Command Parameters	<range> = 0.01 | 0.02 | 0.05 | 0.1 | 0.2 | 0.5 | 1.0 | 2.0 | 5.0	
Power-Up State	5	
Query Syntax	V/D?	
Query Parameters	N/A	
Query Response	V/D 0.01 | V/D 0.02 | V/D 0.05 | V/D 0.1 | V/D 0.2 | V/D 0.5 | V/D 1 | V/D 2 | V/D 5	
Description	The Volts/Division command sets the calibrated deflection factors (ranges) from 10 mV per division to 5 V per division in a 1-2-5 sequence.	
Examples	**Command / Query**	**Response *(Description)***
	`V/D 1` `V/D?`	*(Sets the range to 1 V per division.)* V/D 1.E+0 *(Verifies the 1 V per division setting.)*

APPENDIX A - FRONT PANEL OVERLAY



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