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VXI bus

VX4250 Waveform Tester Module Instruction Manual

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Preface

Purpose of this Document

This manual provides the information necessary to install, configure, operate, and service the VX4250 Waveform Tester module.

Organization of this Manual

This list shows the titles of the sections in this manual, and includes a brief description of each one.

Section 1. General Information — provides a brief overview of the VX4250 capabilities and architecture. The complete instrument specifications appear at the end of this section.

Section 2. Preparation for Use — provides information on how to configure and install the VX4250.

Section 3. Introduction to Operation and Programming — describes the front panel connectors and indicators. This section also contains several examples which guide the user through all layers of the instruments' capabilities.

Section 4. Advanced Operation — provides more detailed information on various options within the command set. Information is presented on methods to optimize system throughput, and details on the internal parametric measurements.

Section 5. Command Notation and Formats — contains the introductory information about the command dictionary.

Section 6. Command Dictionary — contains an alphabetical listing of all of the instrument command set broken down into three major groupings: Channel Commands, Instrument Commands, and System Commands.

Section 7. Errors, Warnings, and Events — lists these conditions and their causes. Also contains a description of the error and event reporting mechanism.

Section 8. Maintenance — gives diagnostic procedures to allow fault isolation to the Field Replaceable Unit. Also describes instrument disassembly and reassembly procedures.

Section 9. Checks and Adjustments — describes Performance Verification and Calibration procedures.

Section 10. Replaceable Parts List of Field Replaceable Units — provides replaceable mechanical and electrical parts lists, manufacturer code numbers, and an exploded view drawing of the VX4250.

The manual also contains these appendices and an index:

Appendix A. IEEE Standard 488.2 Reference — provides information about standard terms and command tree structures.

Appendix B. Pulse Measurement Definitions — contains information about built-in pulse measurements, mathematical formula used in calculating pulse measurement, definitions of the terms used in pulse measurement, a list of their names and the corresponding VX4250 commands, and a description of each one.

Appendix C. VXI Rear-Panel Interface — gives the pinout of the VXI P1 and P2 connectors which are used by the VX4250.

Appendix D. Fast Data Channel Reference — presents information about the layout and use of Physical Share Memory.

Index

Tabbed Sections

For user convenience, the command reference (Section 6. *Command Dictionary*), error messages (Section 7. *Errors, Warnings, and Events*), and *Index* have tab dividers for quick access. Only these sections have tab dividers because these sections are most likely to be used for reference.

Related Publications

The following documents on related subjects may be helpful in efficient use of the VX4250:

ANSI/IEEE Standard 181-1977, IEEE Standard on Pulse Measurements and Analysis by Objective Techniques

IEEE Standard 194-1977, IEEE Standard Pulse Terms and Definitions

VXIbus System Specification, Version 1.3, July 14, 1989

VMEbus Specification Manual, Revision C.1, October, 1985

ANSI/IEEE Standard 1014-1987, IEEE Standards for a Versatile Backplane Bus: VMEbus

Table of Contents

Preface

Purpose of this Document i
Organization of this Manual i
Tabbed Sections ii
Related Publications ii

GENERAL SAFETY SUMMARY

TERMS IN THIS MANUAL
TERMS AS MARKED ON EQUIPMENT
SYMBOLS AS MARKED ON EQUIPMENT
GROUNDING THE PRODUCT
DANGER ARISING FROM LOSS OF GROUND
USE PROPER FUSE
REMOVE LOOSE OBJECTS
DO NOT OPERATE WITHOUT COVERS
REMOVE FROM OPERATION
DO NOT OPERATE IN EXPLOSIVE ATMOSPHERES
SAFETY CERTIFICATION OF MODULES

Section 1. General Information

Introduction 1-1
Description 1-1
Flexible Measurements 1-3
Acquisition 1-3
Triggering Sources 1-5
Input Signal Conditioning 1-6
Acquisition Modes 1-7
Autonomous Testing 1-8
Waveform Testing Modes 1-8
Sequencing Modes 1-9
Fast Runtime Communications 1-10
Stored Settings and Waveforms 1-10
Fast Access to Instrument Data 1-10
Standard Accessories 1-11
Specifications 1-12
Performance Conditions 1-12
Power-Up Default Control Settings 1-18
Trigger Range 1-19

Section 2. Preparation for Use

Module Installation 2-1
Calculating System Power and Cooling Requirements 2-2
Example of calculating cooling requirements: 2-3
Module Configuration 2-4
Logical Address Switch 2-4
Configuring the Backplane Jumpers 2-5
Installation 2-5
Module Installation Using Ejector Handles 2-5
Module Removal Using Ejector Handles 2-6
Power Up Self Test 2-6

Section 3. Introduction to Operation and Programming

Getting Started 3-1
Front Panel Indicators and Connectors 3-1
Establishing Word Serial Communications 3-2
Introduction to Instrument Programming 3-3
Introduction to Operation 3-4
Initializing and Setting up the Instrument for Acquisition 3-5
- Starting an Acquisition 3-5
- Determining the Status of an Acquisition 3-5
- Terminating an Acquisition 3-6
- Operational Commands 3-6
- Query Commands 3-6
- Setting up the Signal Path Parameters 3-6
- Settings Commands 3-7
- Setting the Time Base 3-8
- Setting the Trigger Control Parameters 3-9
- Controlling the Trigger-time Relationship with Pretrigger. 3-10

Waveform Measurements 3-11
- Generating a Test Template 3-12
- Using Template Compare 3-13

Testing Results 3-14
- Setting Test Type 3-14
- Setting Test Limits 3-14
- Running a Test 3-15
- Getting Test Results 3-15
- Using Template Compare 3-16

Sequencing 3-17
- Using Stored Settings 3-18
- Running a Test Sequence 3-19
- Getting Test Results 3-19

Errors 3-20
- Including an Error Interrupt Handler Routine 3-20

Section 4. Advanced Operation

Introduction 4-1
Acquisition Control 4-1
- Triggering Options 4-1
- Cross Channel Triggers 4-2
- VXI Triggers 4-2
- Free Run Triggers 4-4
- High Frequency Reject 4-4
- Exporting Backplane Triggers 4-5
- Timing Out an Acquisition 4-6

Waveform Processing During Acquisition 4-7
Waveform Data Storage and Transfer 4-10
- Using Waveform Storage Locations 4-10

Waveform Data 4-11
- RIB Waveform Transfer 4-11
- RPB Waveform Transfer 4-11
- ASCII Waveform Transfer 4-12
- Transferring a Subset of the Waveform Data 4-13
- Scaling the Data Points 4-14
- Out of Range Signals 4-14
- Template Waveforms 4-14
- Waveform Downloads 4-15

What is Pulse Analysis? 4-17
- Sample Waveform 4-18
- Maximum, Minimum, and Peak-to-Peak Voltages 4-18
- Top, Base, and Amplitude 4-20
- Calculating the 10%, 50%, and 90% points (Proximal, Mesial, and Distal) 4-21
- Reference Parameter Calculations 4-22
- Time Parameters, Rise and Fall 4-23
- Time Parameters, Width, Period, Frequency, and Duty Cycle 4-24
- Width and Period 4-24
- Extended Parameters — RMS, Area, Mean, and Energy 4-25
- Gain and Phase 4-25
- Gain and Phase Example 4-25

Selecting Waveforms with WINDOW 4-26

Peak-to-Peak Ripple Measurement . . . 4-26
Modifying Extended Mode Calculations . . . 4-27
Base and Top Determination . . . 4-28
Setting Base and Top to MinMax . . . 4-30
Changing Reference Levels . . . 4-31
Testing . . . 4-32
Saving the expected result . . . 4-32
Sequencing . . . 4-32
Infinite Loop Testing . . . 4-32
Getting Detailed Test Results . . . 4-33
Performance Enhancements . . . 4-33
Single Acquisition with Multiple Measurements . . . 4-33
Fast Data Access . . . 4-34

Section 5. Command Notation and Formats

Introduction 5-1
Command Notation 5-1
ASCII Code 5-2
Number Base 5-2
Decimal Numeric Data Format 5-2
General Command Format 5-2
Header Arguments 5-2
Command Headers 5-3
Compound Headers 5-3
Query Commands 5-4
Argument Delimiter 5-4
Command Unit Separators 5-5
IEEE 488.2 Standard Commands 5-5

Section 6. Command Dictionary

Introduction 6-1
Alphabetical Command Listing 6-2
Functional Command Listing 6-4
Acquisition Sequence Setup Commands 6-4
Acquisition Sequence Control Commands 6-5
Acquired Data Access Commands 6-5
Post Acquisition Data Manipulation Commands 6-6
Low Level Shared Memory Commands 6-8
Error and Event Reporting Commands 6-8
Instrument Maintenance Command 6-8
Miscellaneous Commands 6-8
IEEE-488.2 Support Commands 6-9
Commands for Instrument Identification 6-9
Commands for Synchronization 6-9
Commands for Error & Event Reporting 6-9
Power-Up Default Control Settings . . . 6-10
Command Dictionary Layout . . . 6-11

Channel Commands . . . 6-11
CHx:ACQUIRE:LOC . . . 6-12
CHx:ACQUIRE:MODE . . . 6-13
CHx:ACQUIRE:NUM . . . 6-14
CHx:AUTO . . . 6-15
CHx:COMPARE:HIGH . . . 6-16
CHx:COMPARE:LOC . . . 6-17
CHx:COMPARE:LOWiCHx:COMPARE:LOW command . . . 6-18
CHx:COMPARE:NOMINAL . . . 6-19
CHx:COMPARE:TYPE . . . 6-20
CHx:COMPARE:TYPE (continued) . . . 6-21
CHx:CONNECT:TRIGGEROUT . . . 6-22
CHx:COUPLING . . . 6-23
CHx:OFFSET . . . 6-24
CHx:PRETRIGGER . . . 6-25
CHx:RANGE . . . 6-26
CHx:RECALL . . . 6-27
CHx:RESULT?, CHx:RESULT:LONG? . . . 6-28
CHx:SAMPLE:INTERVAL . . . 6-29
CHx:SAMPLE:WINDOW . . . 6-30

CHx:SAVE . . . 6-31
CHx:START . . . 6-32
CHx:STATS? . . . 6-33
CHx:STATUS? . . . 6-34
CHx:STEP:COUNT? . . . 6-35
CHx:STEP:EXIT . . . 6-36
CHx:STEP:MODE . . . 6-37
CHx:STEP:NUMLOOP . . . 6-38
CHx:STOP . . . 6-39
CHx:TRIGGER:EXT:COUPLING . . . 6-40
CHx:TRIGGER:HFR . . . 6-41
CHx:TRIGGER:LEVEL . . . 6-42
CHx:TRIGGER:SLOPE . . . 6-43
CHx:TRIGGER:SOURCE . . . 6-44
CHx:WAIT? . . . 6-45
CH1? . . . 6-46
CH2? . . . 6-47

Instrument Commands . . . 6-49
ADD . . . 6-51
AMPLITUDE? . . . 6-52
AREA? . . . 6-53
BASE? . . . 6-54
BMODE . . . 6-55
BOVER? . . . 6-56
BTLINES . . . 6-57
CURVE . . . 6-58
DATA:COUNT . . . 6-59
DATA:ENCDG . . . 6-60
DATA:LOC . . . 6-61
DATA:START . . . 6-62
DESE, DESE? . . . 6-63
DUTY? . . . 6-64
ENERGY? . . . 6-65
EVENT? . . . 6-66
EVMSG? . . . 6-67
EXTMODE . . . 6-68
FALL? . . . 6-69
FDCBASE? . . . 6-70
FDCLOAD, FDCLOAD? . . . 6-71
FDCSIZE? . . . 6-72
FREQUENCY? . . . 6-73
GAIN? . . . 6-74
ID? . . . 6-75
INIT . . . 6-76
MARGINS . . . 6-77
MAX? . . . 6-78
MEAN? . . . 6-79
MID? . . . 6-80
MIN? . . . 6-81
PERIOD? . . . 6-82
PHASE? . . . 6-83
PK2PK? . . . 6-84
REFCRS? . . . 6-85
REFLINES . . . 6-86
REF:LOC . . . 6-87
REFUNITS . . . 6-88
REFVALUES? . . . 6-89
RISE? . . . 6-90
RMS? . . . 6-91
SET? . . . 6-92
SUB . . . 6-93
TMODE . . . 6-94
TOP? . . . 6-95
TOVER? . . . 6-96
TST? . . . 6-97
WFMCMP? . . . 6-98
WFMPRE? . . . 6-99
WIDTH? . . . 6-100
WINDOW . . . 6-101

System Commands 6-103
*ESE,*ESE? 6-104
*ESR? 6-105
*IDN? 6-106
*OPC,*OPC? 6-107
*RCL 6-108
*SAV 6-109
*SRE,*SRE? 6-110
*STB? 6-111
*TST? 6-112
*WAI 6-113

Section 7. Errors, Warnings, and Events

Error and Event Reporting 7-1
An Overview of the Event Reporting Mechanism 7-1
Status Byte Register and Service Request Enable Register 7-4
Event Status Register 7-5
Using the Status/Event Reporting System Commands 7-6
Example Interrupt Generation 7-7
Event Queue Length 7-7
Errors, Warnings, and Events 7-8
Explanation of VX4250 event codes 7-9

WARNING

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

SERVICE SAFETY SUMMARY

DO NOT SERVICE ALONE
USE CARE WHEN SERVICING WITH POWER ON
USE CARE WITH COVERS REMOVED
DO NOT SERVICE WITH INPUTS CONNECTED

Section 8. Maintenance

Introduction 8-1
Static-Sensitive Components 8-1
Assembling and Disassembling the VX4250 8-2
Tools Required 8-2
Disassembly Instructions 8-2
Assembly Instructions 8-3
Hardware Required 8-3
Assembly Steps 8-3
Cable Dress Diagram 8-5
Preventative Maintenance 8-6
Troubleshooting 8-6
Introduction 8-6
Troubleshooting Aids 8-6
Troubleshooting Equipment 8-6
Troubleshooting Techniques 8-7

Section 9. Checks and Adjustments

Introduction 9-1
Static-Sensitive Components 9-1
VX4250 Calibration 9-1
Test Equipment Required for Calibration 9-2
1. VERIFY POWER SUPPLY VOLTAGES 9-4
2. VERIFY REFERENCE VOLTAGES 9-4
3. VERIFY FAST RAMP REFERENCE VOLTAGE 9-4
4. VERIFY SLOW RAMP REFERENCE VOLTAGE 9-5
5. VERIFY CURRENT SOURCE REFERENCE VOLTAGE 9-5
6. ADJUST POSITION (OFFSET) REFERENCE 9-5
7. ADJUST TRIGGER LEVEL REFERENCE 9-5
8. ADJUST CH 1 & CH 2 POSITION DAC REFERENCE 9-6
9. ADJUST CH 1 & CH 2 ADC REFERENCE 9-6
10. ADJUST CH 1 & CH 2 STATIC POSITION 9-7
11. ADJUST CH 1 & CH 2 DC BALANCE 9-7
12. ADJUST CH 1 & CH 2 DYNAMIC POSITION (OFFSET) 9-9
13. ADJUST CH 1 & CH 2 INTERNAL TRIGGER LEVEL OPERATING POINT . 9-10
14. ADJUST CH 1 & CH 2 EXTERNAL TRIGGER LEVEL OPERATING POINT . 9-10
15. ADJUST CH 1 & CH 2 LF GAIN COMPENSATION 9-11
16. ADJUST CH 1 & CH 2 BUFFER GAIN 9-12
17. ADJUST CH 1 & CH 2 INTERNAL DYNAMIC TRIGGER OFFSET 9-13
18. ADJUST CH & CH 2 EXTERNAL DYNAMIC TRIGGER OFFSET 9-14
19. ADJUST CH 1 & CH 2 ATTENUATOR COMPENSATION 9-15
20. ADJUST CH 1 & CH 2 EQUIVALENT TIME BASES 9-19
21. LATCH ENABLE DELAY 9-21
VX4250 Performance Verification 9-22
Test Equipment Required for Performance Verification: 9-22
1. Check DC Gain Accuracy 9-22
2. Check Bandwidth 9-27
3. Timebase Accuracy 9-28
4. Trigger Sensitivity 9-31

Section 10. Replaceable Parts List of Field Replaceable Units

Introduction 10-1
Replaceable Parts 10-1
Mechanical Parts List 10-2
Electrical Parts List 10-3
Standard Accessories List 10-3
Cross Index: Mfr Code Number to Manufacurer 10-3
VX4250 Exploded View Drawing 10-4

Appendix A. IEEE Standard 488.2 Reference

Command Header Tree Structure A-1
Non-Decimal Numeric Program Data A-2

Appendix B. Pulse Measurement Definitions

Overview B-1
Method of Computation – Magnitude Parameters B-3
Pulse Magnitude Summary B-5
Pulse Analysis Setup Commands B-7
Pulse Measurement Calculation within the VX4250 . . . . . B-7
Common Problems and Errors B-8

Appendix C. VXI Rear-Panel Interface

Introduction C-1
Active Signal States C-1

Appendix D. Fast Data Channel Reference

Overview D-1
FDC Commands D-2
FDC Access D-2

GENERAL SAFETY SUMMARY

Only qualified personnel should perform service procedures. This Service Safety Summary and the General Safety Summary should be read before performing service procedures.

The general safety information in this summary is for operating and servicing personnel. Specific warnings and cautions can be found throughout the manual where they apply, and may not appear in this summary.

TERMS IN THIS MANUAL

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

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

TERMS AS MARKED ON EQUIPMENT

CAUTION indicates a hazard to property, including the equipment itself, and could cause minor personal injury.

WARNING indicates a personal injury hazard not immediately accessible as you read the marking.

DANGER indicates a personal injury hazard immediately accessible as you read the marking.

SYMBOLS AS MARKED ON EQUIPMENT



DANGER–High voltage



Protective ground (earth) terminal



ATTENTION–REFER TO MANUAL

GROUNDING THE PRODUCT

WARNING: This product is grounded through the VXI mainframe chassis. To avoid the possibility of electrical shock, always secure the front panel mounting screws to the mainframe. Assure that the mainframe is adequately grounded before applying power. Refer to grounding information in the mainframe safety documentation.

DANGER ARISING FROM LOSS OF GROUND

Upon loss of the protective-ground connection, all accessible conductive parts (including the front panel and extraction handles which may appear to be insulated) can render an electric shock.

USE PROPER FUSE

To avoid fire hazard use only a fuse of the correct type, voltage rating, and current rating.

REMOVE LOOSE OBJECTS

During disassembly or installation procedures, screws or other small objects may fall to the bottom of the mainframe. To avoid shorting out the power supply, do not power-up the instrument until such objects have been removed.

DO NOT OPERATE WITHOUT COVERS

To avoid personal injury or damage to the product, do not operate this product with the covers or panels removed.

REMOVE FROM OPERATION

If you have reason to believe that the instrument has suffered a component failure, do not operate the instrument until the cause of the failure has been determined and corrected.

DO NOT OPERATE IN EXPLOSIVE ATMOSPHERES

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

SAFETY CERTIFICATION OF MODULES

For modules which are safety certified by Underwriters Laboratories, UL Listing applies only when the module is installed in a UL Listed product.

Section 1
General Information

Introduction

The VX4250 is a dual channel analog waveform tester optimized for high throughput testing applications. The single wide VXI "C" size module combines a high performance acquisition system, powerful internal pass/fail determination, and internally stored test sequence execution. Twenty four built-in measurement functions directly provide parametric answers of common single and two port measurements, often eliminating the need to transfer large waveform data blocks with a system controller. VXI triggering capability allows the VX4250 to coordinate its operation with other instrumentation in the system.

Description

The VX4250 instrument is a programmable VXI component. All user communication is done via Word Serial Protocol and Fast Data Channel.

Each channel can autonomously test or monitor a signal using template comparison or parametric measurement techniques. The VX4250 is a stored measurement instrument and therefore varying degrees of test signal failure information can be extracted, including the raw acquisition data.

Through the use of stored settings, on board analysis and waveform template comparison, run-time communication is minimized and fast testing is maintained.

Fast access to all user variable information is made available through a Fast Data Channel (FDC) that is directly mapped into VXI address space. This allows the instrument to excel in data intensive and high performance applications.

Three important attributes make the VX4250 a high performance test system component:

- **Flexible Measurements.** Accommodates a wide variety of test signal amplitudes and frequencies with averaging and enveloping.
- **Autonomous testing capability.** Determines pass or fail in the instrument.
- **Fast runtime communications.** Through the use of locally stored data and direct access via FDC.

Figure 1-1 shows a block diagram of the instrument hardware.

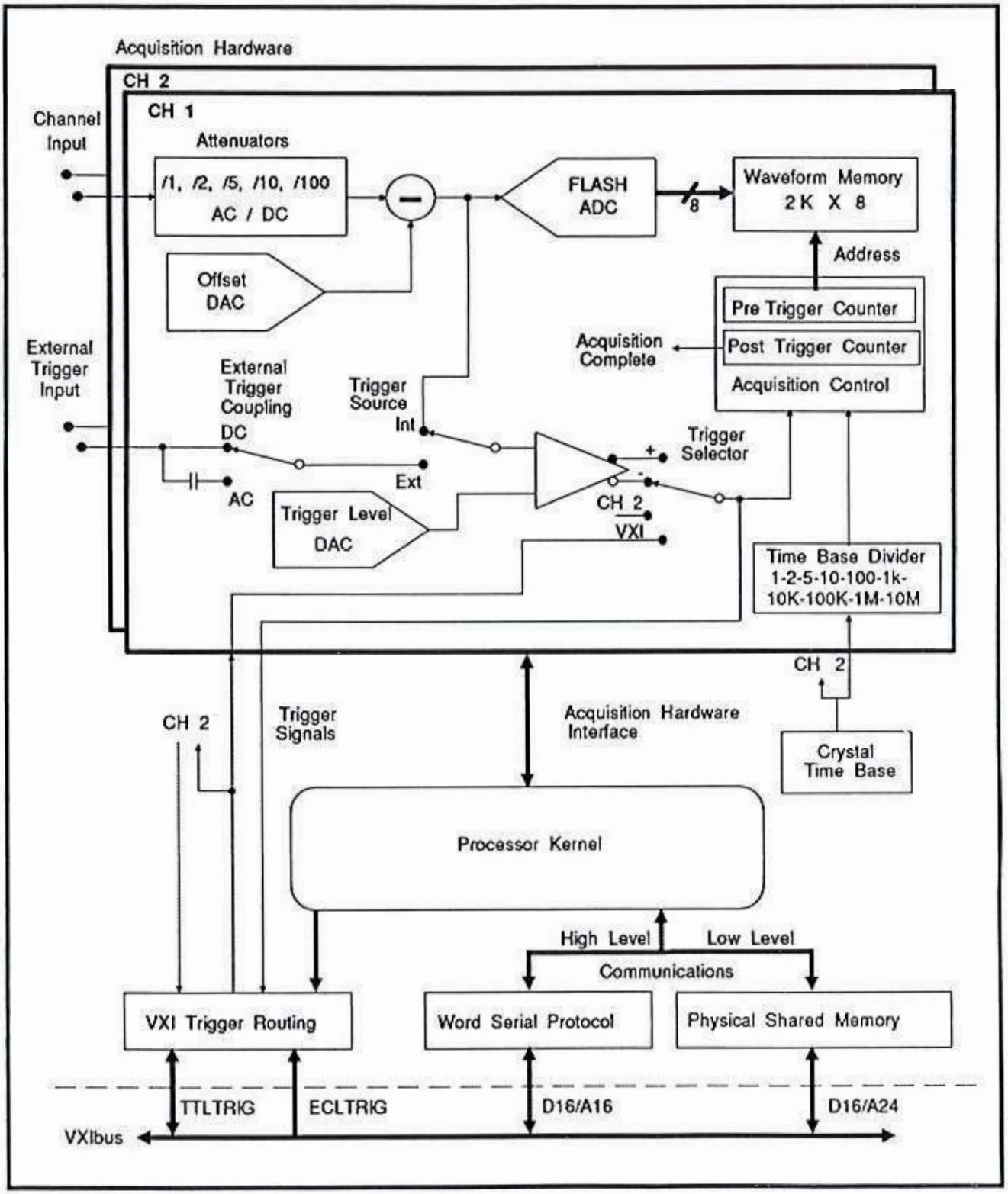


Figure 1-1. VX4250 Instrument Block Diagram.

Flexible Measurements

Acquisition

The VX4250 is a stored measurement instrument. At regular time intervals, the amplitude of the analog input signal is converted into a digital value and then stored in a waveform memory. This process is referred to as "acquisition".

A single acquisition results in a waveform that digitally represents time sequential samples taken at regular time intervals until the acquisition memory is full. Each sample is stored as a numerical value which correlates to the actual voltage amplitude of the input signal at the instant the sample was taken.

Sample interval and sample window are two different methods of specifying the speed at which samples are acquired. The "sample interval" is the time interval between individual samples. The "sample window" is the total amount of time or window, over which data will be captured. The sample window is equal to the sample interval multiplied by the physical number of storage locations in the waveform memory.

Sample Window = Sample Interval x Waveform Memory Size

For example, if the instrument is set to acquire with a one microsecond sample interval and it has 2044 locations in its waveform memory, it can store data that represents 2.044 milliseconds of time, as shown in Figure 1-2.

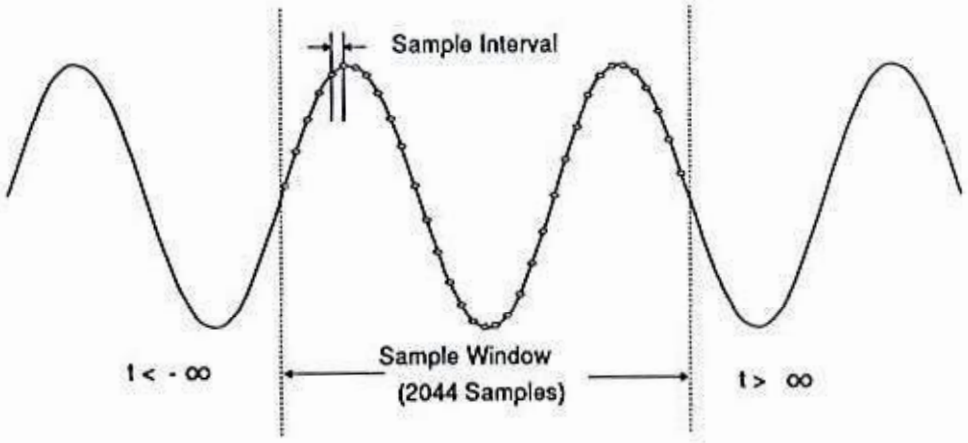


Figure 1-2. Relationship of Sample Window to Sample Interval.

The acquisition process begins when the user gives a command to the instrument to start sampling. Once the process is started, the signal is continuously sampled and put into waveform memory. The waveform memory is a circular buffer which can hold a finite number of samples. Thus, the oldest sample data is always being replaced with the latest data. In order to complete the acquisition, a trigger signal must tell the instrument when to stop the acquisition process (refer to Figure 1-3).

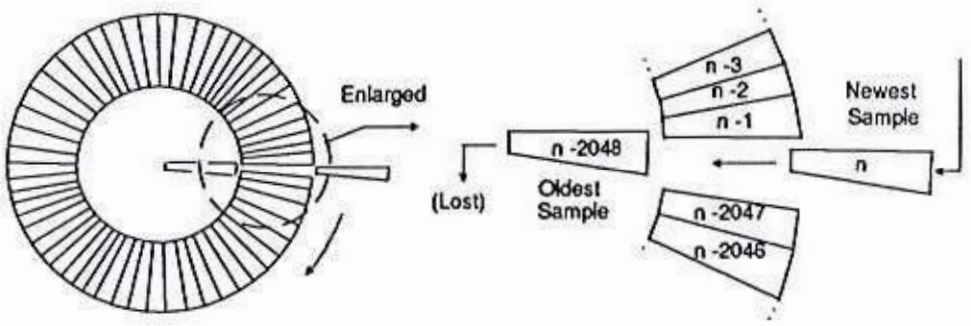


Figure 1-3. Circular Acquisition Buffer.

Because the trigger qualifies the end of acquisition, data which was acquired before the trigger point can be maintained and used. This is called "pretrigger" data. If the acquisition process is stopped at exactly the point of time that the trigger occurred, all of the captured data in the waveform memory will be "pretriggered", that is, a history of the signal before the trigger occurred. The addition of a digital counter to the acquisition system allows the acquisition process to continue taking a predetermined number of samples after the trigger occurs, then stop. The data that is stored after the trigger occurrence is referred to as "posttrigger" data.

By presetting the digital counter, the user can control the ratio of samples that are acquired before and after the trigger point. This control is referred to as the amount of "pretrigger". Figure 1-4 illustrates the relationship of pretrigger to time intervals recorded.

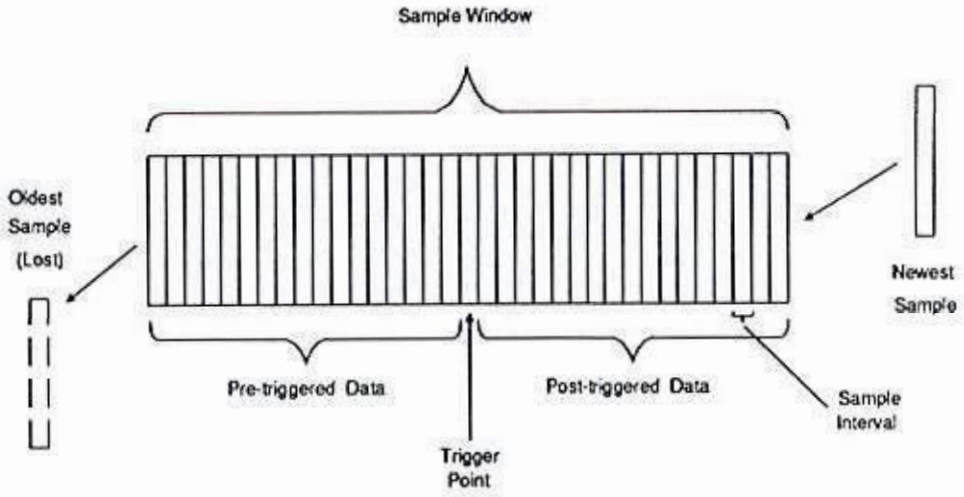


Figure 1-4. Effect of Pretrigger on Sample Window.

All acquisition systems have a finite maximum speed at which they can sample the input signal. To allow more flexibility, the VX4250 employs "equivalent time" sampling to extend the usable range of the instrument. In equivalent time mode, a single sample of the input is taken at a known period of time after the trigger occurs and is stored in waveform memory. By slightly increasing the time after each trigger that the sample is taken and stored, the entire waveform memory can be filled with a record that is an equivalent representation of the input signal over a continuous window of time. Since this record is built from repetitive samples of successive periods of the input signal, equivalent time mode requires a consistent, repetitive input waveform. Also, because the sample is taken after the trigger occurs, pretrigger data is not available in equivalent time mode. The VX4250 uses equivalent time sampling at sample intervals of five ns and faster. At the slower sample intervals, the conventional, successive sampling process is used. This is referred to as "real time" sampling mode.

Figure 1-5 illustrates equivalent time sampling.

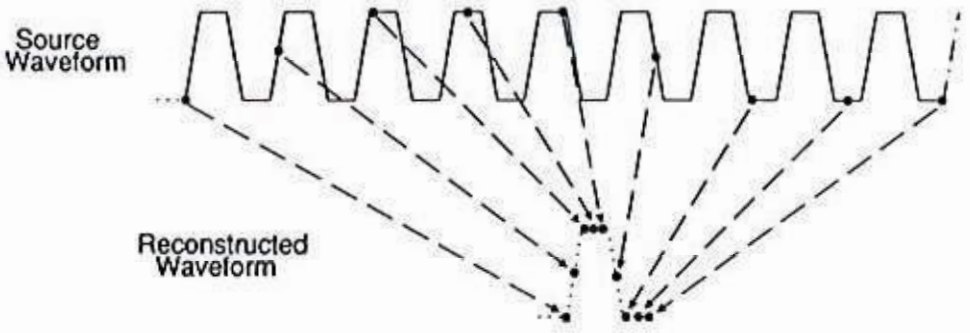


Figure 1-5. Equivalent Time Mode.

Triggering Sources

As explained above, the trigger determines when the acquisition process will stop. This trigger can come from several sources.

Internal trigger is the most straightforward trigger source. In this mode, triggering occurs when the input signal of the channel being sampled passes through a predetermined voltage known as "trigger level", in a predetermined direction known as "trigger slope".

Cross channel trigger operates the same as internal trigger, except the trigger signal originates from the other channel in the instrument. For example, if channel 1 trigger source is set to cross channel (XCH), channel 1 will be triggered when the input signal on channel 2 passes through the "trigger level" in the direction of "trigger slope".

External trigger derives the trigger signal from an independent input connector, EXT TRIG IN. Two of these inputs are provided, one for each channel. Trigger level and trigger slope qualify the signal required to trigger the instrument, the same as internal and cross channel trigger modes. In addition, input coupling of DC or AC can be selected when using external trigger mode. By selecting AC coupling, any DC component present in the external input signal will be ignored by the trigger level comparator circuits in the instrument.

VXI triggering derives the trigger signal from one of the VXI backplane triggers. This allows the acquisition system to be triggered by another instrument in the VXI mainframe. In order to use VXI trigger as a trigger source, the particular backplane trigger line to be monitored must be predetermined. This can be selected from any of the available C size VXI triggers: TTLTRG 0—TTLTRG7, ECLTRG 0 or ECLTRG1. Because these trigger signals are digital in nature, "trigger level" is not used when VXI trigger is selected. Trigger slope selection is still available. When selecting VXI trigger source, the user must select the trigger slope to coincide with the desired edge of the backplane trigger being generated by the other instrument in the VXI mainframe. With TTLTRG lines, the active slope is generally MINUS, while with ECLTRG lines it is generally PLUS.

Input Signal Conditioning

As mentioned earlier, the resulting data in the acquisition memory represents time sequential samples of the input signal. Each sample is stored as a numerical value which correlates to the actual voltage amplitude of the input at the instant in time in which the sample was taken. This voltage amplitude is modified by three parameters which control the input signal path. Control of these input conditioning parameters allow the user to optimize the accuracy and information that can be derived from an acquired waveform.

Range controls the amount of attenuation applied to the input signal. All acquisition systems can resolve the input signal to a fixed amount, usually expressed in number of bits. The maximum resolution is one part in 2n where *n* is number of bits. The VX4250 is an 8 bit system, therefore the input signals can be resolved to a maximum of 1 part in 256 or 0.39% of range. In order to maximize resolution, an input range as small as possible should be selected to capture the entire dynamic range of the signal.

Coupling can be selected as either DC or AC. AC coupling removes any DC component from the input signal. AC coupling should be used whenever the magnitude of the DC component is not of interest in the measurement. A typical application would be measuring the peak-to-peak noise on a DC power supply signal.

Offset allows the nulling of a DC component from a signal while maintaining calibration of the component. The offset signal is subtracted directly from the input signal before the signal is digitized in the acquisition system. Applying an offset approximately equal to the DC component of the input signal will center the signal in the measurement window of the digitizer. Generally this will allow a reduction in the range setting, resulting in more measurement resolution.

Acquisition Modes

The VX4250 can perform single, smoothed, averaged and enveloped acquisitions. The resulting data can be directed to any one of several internal waveform data storage locations.

Smoothing is a mathematical process performed by the VX4250 after data acquisition to remove noise from the data. The process uses a three point running average which progresses through the buffer point by point. The smoothing function operates on data that is acquired in a single acquisition. Because smoothing averages successive data points, it will tend to remove sharp corners from a waveform. This effect is somewhat akin to adding a low pass filter function to signal.

Averaging acquisition mode acquires the input signal for the number of times specified and calculates a waveform. This waveform is built from points which are the statical average of each corresponding sample point in all of the acquisitions. Averaging acquisition mode is useful for filtering out random noise from signals when multiple acquisitions of the signal can be made. Because averaging does not average time successive points, it does not add a low pass filter effect to the signal.

Enveloped acquisition mode acquires the signal for the number of times specified and builds an "envelope". This resulting envelope has two amplitude values for each sample point. These represent the minimum and maximum values for the corresponding sample point during all of the acquisitions.

Autonomous Testing

Figure 1-6 shows how a single measurement can be managed in an automated context within the instrument.

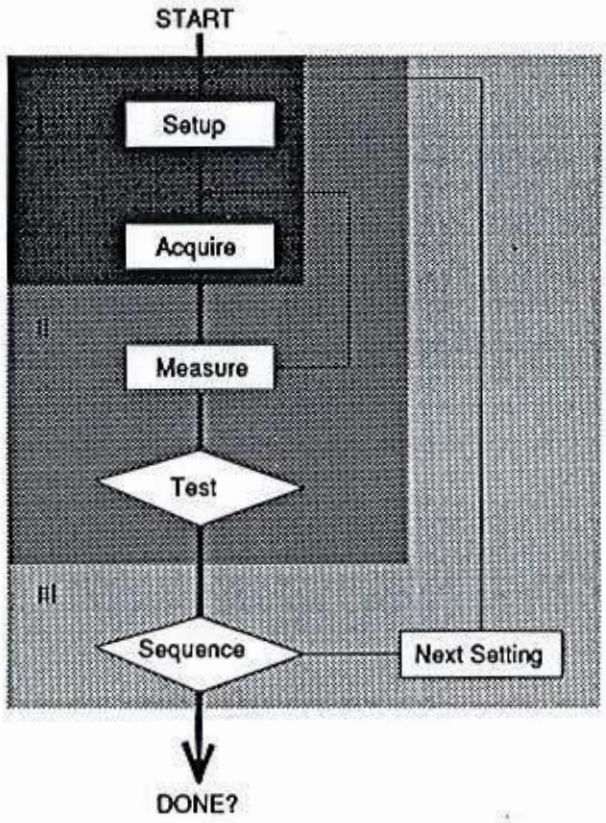


Figure 1-6. VX4250 Functional Layers.

Waveform Testing Modes

The VX4250 can test a waveform using template compare or parametric measurements with predefined high/low windows. Testing a single boundary is possible by setting one of the desired margins to its maximum numeric value.

Template compare testing may be performed using a waveform acquired in any acquisition mode, in conjunction with a previously generated waveform template. This template contains the maximum and minimum value for each sample. The process of template comparison involves a sample by sample comparison of the acquired data with the comparison template. Any excursion beyond the range specified for each sample is trapped and will cause the VX4250 to generate an event message.

Parametric Measurements include max, min, midpoint, average, RMS voltages, rise-time, fall-time, frequency, period, width, duty cycle, and many others. To perform a parametric test, the VX4250 uses the acquired data to compute the measured value, and then compares this value to predetermined high and low values. As in the case of template compare testing, any excursion beyond the limits is considered an event.

Sequencing Modes

The VX4250 may be programmed to autonomously loop on a cycle of "acquire and test". This cycle is termed the CHANNEL SEQUENCE. The user may control the method for terminating the channel sequence. This may include: excursions across the comparison template boundaries or parametric limits, number of loops executed, and infinite looping.

Thus, the channel sequence may be programmed to continuously execute, terminating when a test condition passes or fails to execute for a specific number of times.

The application of this feature allows the instrument to autonomously measure and test analog signals which reduces the workload in the system controller and thus increases system throughput.

Fast Runtime Communications

Stored Settings and Waveforms

To reduce the amount of communications during test program runtime, the VX4250 allows the user to store and recall setups and waveforms from instrument memory.

There are eight (1 - 8) waveform locations for the user to access. Each channel can access any waveform location.

There are also eight (1 - 8) stored settings per channel. The stored setting locations are treated as test steps for the channel sequence. They may be executed individually or together—just as a test program may be single stepped or executed.

Figure 1-7 shows the stored data objects that may be manipulated by the user.

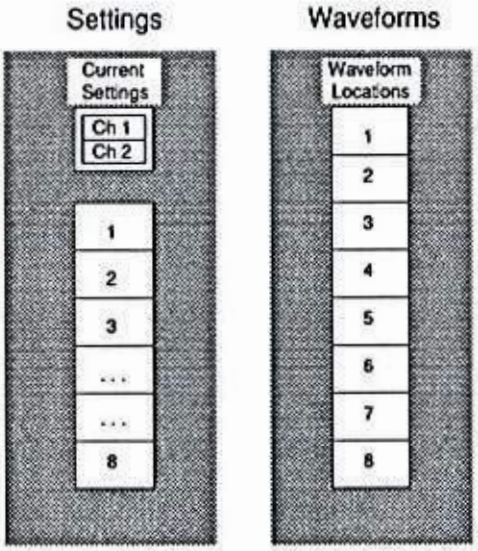


Figure 1-7. VX4250 Stored Information.

Fast Access to Instrument Data

All user generated information may be accessed through a Fast Data Channel (FDC). Thus, the stored settings and waveforms may be quickly swapped to further enhance system throughput.

Figure 1-8 shows how the stored data objects are directly accessible via FDC.

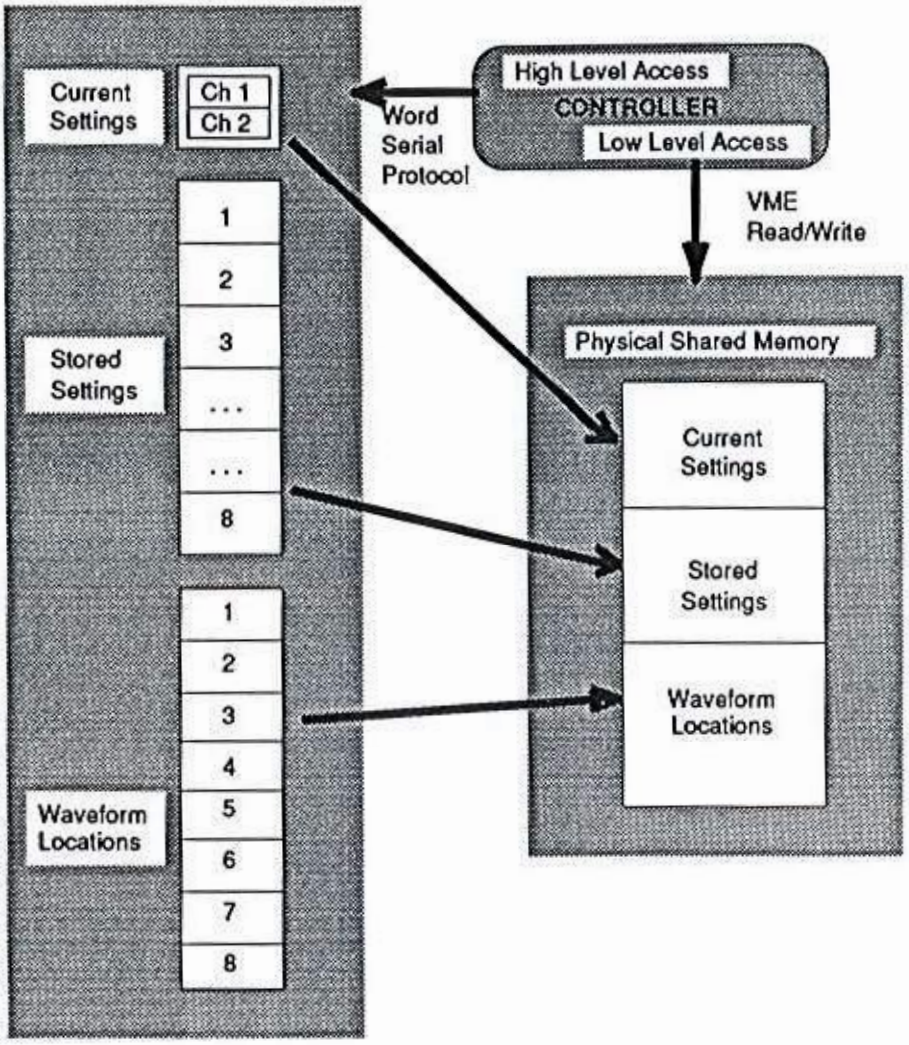


Figure 1-8. VX4250 Stored Information Access.

Standard Accessories

SoftScope™ Software Package

INSTRUMENT SOFTWARE DESCRIPTION FILE for
TekTMS™ Interactive Program Generator

This instruction manual

Specifications

Performance Conditions

The performance requirements for the specifications listed in Table 1-2 are valid only when the instrument is operating under the following conditions:

- The instrument module must have at least a 20 minute warm-up period.
- The instrument module must be in an environment whose limits are specified in Table 1-3.
- The VX4250 has been calibrated within the last 12 months.

The electrical and environmental performance limits, together with their related validation procedure, comprise a complete statement of the performance of a calibrated instrument module.

Table 1-2 presents the specifications for the vertical system, time bases, trigger system, memory, general digitizer, and VXI system of the VX4250.

Table 1-2. Specifications

Characteristic	Performance Requirements	Supplemental Information
Vertical System		
Sensitivity		80, 160, 400, 800 mV 1.6, 4, 8, 16, 40 V Full Scale Each range is bipolar, symmetrical at halfway point, i.e., 4 V range can measure voltages from –2 V to +2 V
DC Gain Accuracy	± (3% of Signal + 0.8% of Range + 2% of Offset + 2 mV)	
Resolution		8 bits (Full Scale / 256)
Bandwidth (– 3 dB)	DC to at least 100 MHz	–3 dB, 7 Hz to at least 100 MHz when AC coupled
Risetime	≤ 3.5 ns	Calculated from Bandwidth Risetime = .35/BW
Coupling		DC or AC
Offset		
Range		–100% of full scale Range to +99.22% of full scale Range
Resolution		Full scale Range / 128
Input Impedance		1 M Ω || 24 pF nominal
Maximum Non-destructive Input Voltage		200 V DC or Peak AC
Time Bases (1 per channel)		
Sample Interval		100 ms – 10 ns (Real Time) 5 ns –100 ps (Equivalent Time) in 1–2.5–5 Sequence
Accuracy		
Real Time	± 0.1%	Based on oscillators of 0.01% accuracy
Equivalent Time	± 3%	
Trigger System		
Sources		CH 1, CH 2, External, VXI TTL or ECL
Slope		+ or –
Coupling		DC or AC selectable on EXTERNAL only. Internal coupling is determined by Vertical Input Coupling
Range		
Internal		–64% to +63.5% of Full Scale Input Range at 0 V offset
External		–6.40 V to 6.35 V
Resolution		
Internal		Full Scale Range / 200
External		50 mV

Table 1-2. Specifications (cont.)

Characteristic	Performance Requirements	Supplemental Information
Trigger System (cont.)		
Sensitivity		
Internal	≤ 12% of Input Range DC—15 MHz ≤ 30% of Input Range 15—40 MHz ≤ 90% of Input Range 40—80 MHz	
External		≤ 1 Vp-p DC—15 MHz ≤ 2 Vp-p 15—40 MHz ≤ 4.5 Vp-p 40—80 MHz
Impedance (External Input)		1 M Ω || 28 pF nominal
Position		
Real Time		Beginning (128th sample) Center (1024th sample) End (1920th sample)
Equivalent Time		Post-trigger only
Typical delay		
Real Time		20 ns or 1 sample, whichever is greater
Equivalent Time (trigger to first data point)		5 ns sample rate: 1.66 µs 2.5 ns sample rate: 821 ns 1 ns sample rate: 315 ns 500 ps sample rate: 227 ns 250 ps sample rate: 139 ns 100 ps sample rate: 85 ns
Uncertainty		± 1 sample
Memory		
Record Length		2044 points per channel
Acquired Waveform Storage Locations		8
General Digitizer		
Acquisition Modes		Single Average (2– 256) Envelope (2 – 256)
Parametric Measurements (Single Port)		Risetime, Falltime, Period Frequency, Width, Duty Cycle, Min, Max, Mid Point, Peak-to-Peak, Amplitude, Proximal, Mesial, Distal, Top, Base, Top Overshoot, Base Overshoot, RMS, Mean, Area, Energy
(Two Port)		Gain, Phase

Table 1-2. Specifications (cont.)

Characteristic	Performance Requirements	Supplemental Information
Comparisions		Template and Parametric HI/LO
Number of Stored Setups		8 per channel
VXI System		
Communications		
Protocol		Word Serial, Fast Data Channel
Interface		Message Based
Triggers, Import		
Digitizer Trigger		TTLTRG 0-7, ECLTRG 0-1
Triggers, Export		
Internal Trigger		TTLTRG 0-7 (This signal is a shaped version of the internal trigger derived from either input channel)
Delay		35 ns typical from trigger occurrence
VXI Interrupts (REQT)		Envelope test fail, Parametric test fail, Acquisition complete, IEEE 488.2 errors and events
Power Requirements		+5 V 3.75 A IPM +12 V 950 mA IPM −12 V 125 mA IPM −5.2 V 40 mA IPM
Cooling Airflow		2.0 liters/second at .75 mm H_20 minimum for a 10° C internal rise

The environmental and mechanical characteristics of the VX4250 are shown in Table 1-3.

Table 1-3. Environmental and Mechanical Specifications

Characteristic	Description
Environmental	
Operating Temperature	0° to 50° C
Non-operating Temperature	–55 ° to 75° C
Humidity (non-condensing)	95% relative humidity, 0° to 30° C 75% relative humidity, to 40° C 45% relative humidity, to 50° C
Electromagnetic Compatibility (EMC)	FCC-A when operated in a certified mainframe with front panel mounting screws installed
Mechanical	
Dimensions	
Height	261.8 mm (10.309")
Width	30.18 mm (1.188")
Depth	367.5 mm (14.469")
Weight	
Net	1.515 Kg (3 Lbs. 5.3 oz.)
Shipping	5.34 Kg (11 lbs. 12 oz.)

Table 1-4 lists the range, offset and trigger limit capabilities of the VX4250.

Table 1-4. Range, Offset, and Trigger Capabilities

Maximum Signal (± Amplitude/2)	OFFSET limits		TRIGGER limits	
	upper	lower	upper	lower
80 mV (± 40 mV)	+79.375 mV	–80 mV	+50.8 mV	–51.2 mV
160 mV (± 80 mV)	+158.75 mV	–160 mV	+101.6 mV	–102.4 mV
400 mV (± 200 mV)	+396.87 mV	–400 mV	+254 mV	–256 mV
800 mV (± 400 mV)	+793.75 mV	–800 mV	+508 mV	–512 mV
1.6 V (± 800 mV)	+1.5875 V	–1.6 V	+1.016 V	–1.024 V
4 V (± 2 V)	+3.9687 V	–4 V	+2.54 V	–2.56 V
8 V (± 4 V)	+7.9375 V	–8 V	+5.08 V	–5.12 V
16 V (± 8 V)	+15.875 V	–16 V	+10.16 V	–10.24 V
40 V (± 20 V)	+39.687 V	–40 V	+25.4 V	–25.6 V

Table 1-5 is a chart showing the timebase capabilities for both the equivalent time (sequential) and real time sampling modes at various sample rates.

Table 1-5. Timebase Capabilities

Sampling MODE	Sample INTERVAL	Sample WINDOW	Pretrigger Samples to Pretrigger TIME			
			0	128	1024	1920
ET Equivalent Time (Sequential)	100 ps	204.4 ns	0*	-na-	-na-	-na-
	250 ps	511 ns	0*	-na-	-na-	-na-
	500 ps	1.022 us	0*	-na-	-na-	-na-
	1 ns	2.044 us	0*	-na-	-na-	-na-
	2.5 ns	5.11 us	0*	-na-	-na-	-na-
	5 ns	10.22 us	0*	-na-	-na-	-na-
RT Real Time	10 ns	20.44 us	-na-	1.28 us	10.24 us	19.2 us
	25 ns	51.1 us	-na-	3.2 us	25.6 us	48 us
	50 ns	102.2 us	-na-	6.4 us	51.2 us	96 us
	100 ns	204.4 us	-na-	12.8 us	102.4 us	192 us
	250 ns	511 us	-na-	32 us	256 us	480 us
	500 ns	1.022 ms	-na-	64 us	512 us	960 us
	1 us	2.044 ms	-na-	128 us	1.024 ms	1.92 ms
	2.5 us	5.11 ms	-na-	320 us	2.56 ms	4.8 ms
	5 us	10.22 ms	-na-	640 us	5.12 ms	9.6 ms
	10 us	20.44 ms	-na-	1.28 ms	10.24 ms	19.2 ms
	25 us	51.1 ms	-na-	3.2 ms	25.6 ms	48 ms
	50 us	102.2 ms	-na-	6.4 ms	51.2 ms	96 ms
	100 us	204.4 ms	-na-	12.8 ms	102.4 ms	192 ms
	250 us	511 ms	-na-	32 ms	256 ms	480 ms
	500 us	1.022 s	-na-	64 ms	512 ms	960 ms
	1 ms	2.044 s	-na-	128 ms	1.024 s	1.92 s
	2.5 ms	5.11 s	-na-	320 ms	2.56 s	4.8 s
	5 ms	10.22 s	-na-	640 ms	5.12 s	9.6 s
	10 ms	20.44 s	-na-	1.28 s	10.24 s	19.2 s
	25 ms	51.1 s	-na-	3.2 s	25.6 s	48 s
	50 ms	102.2 s	-na-	6.4 s	51.2 s	96 s
	100 ms	204.4 s	-na-	12.8 s	102.4 s	192 s

*Some delay occurs between trigger and first sample. Refer to delay specifications in **Trigger System**, Table 1-2. *Specifications* for typical values.

Power-Up Default Control Settings

The following list summarizes the instrument condition after power-up or receiving the `INIT` command.

Note:
Defaults apply to both channel 1 and 2.

RANGE	40
OFFSET	0
COUPLING	DC
SAMPLE:INTERVAL	100E-9
TRIGGER:SOURCE	INT
TRIGGER:EXT:COUPLING	DC
TRIGGER:LEVEL	0
PRETRIGGER	128
ACQUIRE:MODE	Normal
ACQUIRE:NUM	1
ACQUIRE:LOC	(1 for CH1, 2 for CH2)
COMPARE:TYPE	None
COMPARE:LOW	Off
COMPARE:NOMINAL	0
COMPARE:HIGH	Off
COMPARE:LOC	(3 for CH1, 4 for CH2)
STEP:EXIT	Single
STEP:NUMLOOP	1
DATA:LOC	1
DATA:ENCDG	RIB
CONNECT:TRIGGEROUT	OFF

Section 2
Preparation for Use

Module Installation

When the VX4250 is unpacked from its shipping carton, the contents should include these three items:

- One VX4250 Module
- One VX4250 Waveform Tester Module Instruction Manual (this manual)
- One 3 1/2" diskette containing:
  Software front panel for VX4250 for TekTMS™ Interactive Program Generator (located in sleeve of Instruction Manual).
- One 5 1/4" diskette containing:
  Software front panel for VX4250 for TekTMS™ Interactive Program Generator (located in sleeve of Instruction Manual).

All components should be inspected for any damage due to shipping.

The VX4250 module may then be installed into any appropriate C-size or D-size VXI mainframe in any slot other than slot 0. The mainframe should be checked to ensure that it is capable of providing adequate power and cooling for the VX4250. With this ensured, the module's logical address and backplane jumpers can be configured.

Calculating System Power and Cooling Requirements

When a VXI system is integrated, the power available and cooling capacity of the mainframe should meet or exceed the power and cooling requirements of the installed modules. The power requirements can be calculated by adding the required Peak Module Current (IPM) of all the modules in the system for each supply, and then comparing this value with the specified power available from the mainframe. The power requirements for the VX4250 are:

+5 V	3.75 A	IPM
-5.2 V	40 mA	IPM
+12 V	950 mA	IPM
-12 V	125 mA	IPM

The mainframe should also provide minimum cooling to ensure reliable operation of the module. The cooling requirement specification for the VX4250 is:

50° C ambient maximum operating temperature

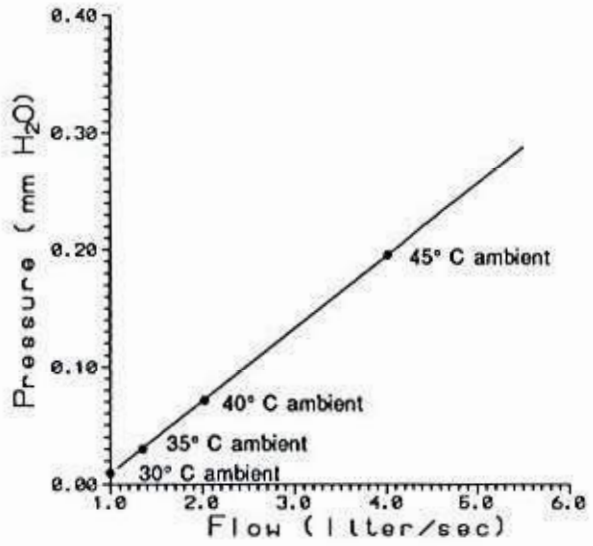


Figure 2-1. VX4250 Airflow Impedance.

To use this information, the maximum expected ambient temperature where the VX4250 will be operating should be known. Find this ambient temperature on Figure 2-1, interpolating between points as needed. This point defines the required airflow to maintain the maximum allowable temperature and the back pressure that the cooling system will experience from this module.

Example of calculating cooli s:

The VX4250 is operated in a sy ir conditioning maintains a worst case temperature of 30° C. The

Point found on Figure 2- m H_20.

Therefore, the airflow needs to b and the module will present .01 mm H_20 backpressure. This poi mpared with the specifications for the mainframe you intend to u h in Figure 2-2 as an example, the operating point calculated is p h of the mainframe slot airflow characteristics.

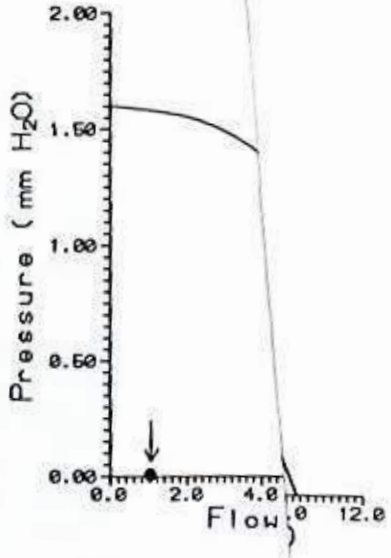


Figure 2-2. Slot Airflow Cl mple.

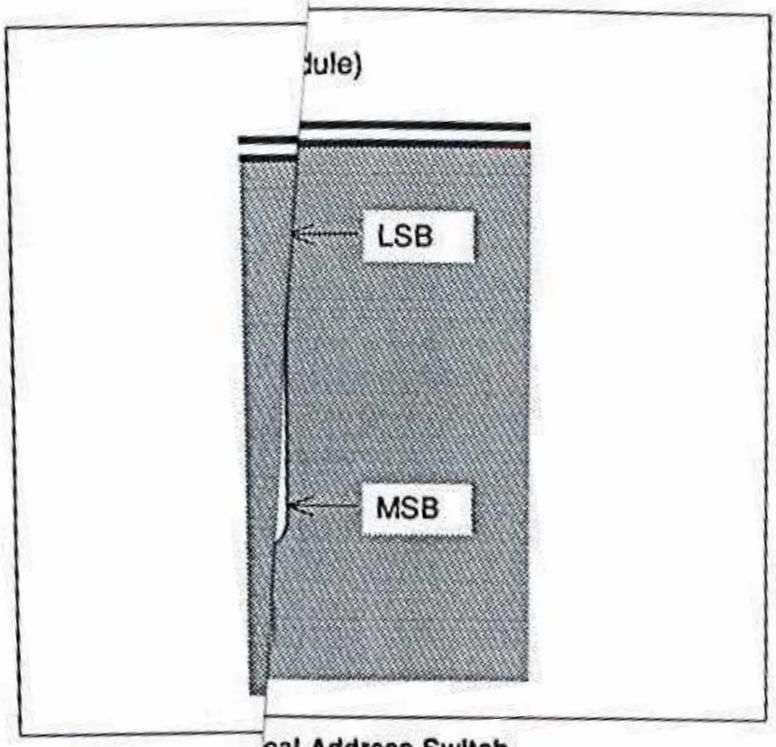
The solid line on the graph represents flow the mainframe can provide in its worst case condition (w e the operating point is below the solid line, it is within the ope e of the mainframe.

Module Configuration

The only operator configura[ble item on] the VX4250 is the Logical Address Switch. Access to the switc[h is through] a cutout in the right side panel of the instrument.

Logical Address Switch

Each VXI module in a syst[em must have a] unique logical address. An 8-bit switch is provided to select the V[XI logical add]ress, as shown in Figure 2-3. The LSB of the switch is toward th[e front panel] and the MSB is toward the bottom. When the switch is in the [open position,] 1 is selected for that bit position. When the switch is in the close[d position,] zero) is selected for that bit position.



cal Address Switch.

The VX4250 suppor[ts Dynamic] to Configuration (DAC). The logical address of a DAC device is [assigned] ned at system power-up. To select Dynamic Auto Configuration[, switch] ns should be set to open (1). When a VXI resource manager [configures] AC devices configures the system, a logical address will be aut[omatically] d to the module.

Configuring the Backplane Jumpers

VXIbus mainframes contain daisy-chain jumpers for the Bus Grant (BG0 — BG3) and Interrupt Acknowledge (IACK) signals. When a VX4250 module is installed in a mainframe slot, the IACK jumper must be configured so that the slot is not bypassed (connected through). Consult the mainframe documentation for the backplane jumper configuration procedure.

WARNING

The mainframe compartment may contain high current. Refer jumper reconfiguration to qualified service personnel.

Installation

Module Installation Using Ejector Handles

The following procedure is for installing the module into a Tektronix mainframe. If the module is being installed in another mainframe, the procedure may need to be modified.

To install the module:

1. Ensure that the power ON/OFF or ON/STANDBY switch on the mainframe is turned to OFF or STANDBY.

2. Insert the module into the mainframe top and bottom module guides for the slot where the module is to be installed and push it partially into the mainframe. Push the module into the mainframe as far as it will go without forcing it. Then press the module completely into the mainframe, seating the P1 and P2 connectors.

3. Ensure that the module is fully seated into its VXI connectors with the front panel flush with the front of the mainframe chassis. Then tighten the top and bottom module retainer screws to secure the module in the mainframe.

Module Removal Using Ejector Handles

The following procedure explains how to remove the VX4250 module from a Tektronix mainframe. If the module is being removed from another mainframe, the procedure may need to be modified.

To remove the module using the ejector handles:

1. Ensure that the power ON/OFF or ON/STANDBY switch on the mainframe is turned to OFF or STANDBY.

2. Loosen the top and bottom module retainer screws. These screws have captive retainers and will not come completely out.

3. Simultaneously push the upper ejector handle fully up and the lower handle fully down to *eject* the module. After the module is ejected, it can be removed from the mainframe.

Power Up Self Test

Once the module has been installed, the mainframe may be powered up. The VX4250 will initially execute its internal diagnostics which should complete in less than five seconds. When the module has successfully completed the diagnostics, the green READY indicator will illuminate.

Section 3
Introduction to Operation and Programming

Getting Started

This initial topics in this section are intended to help you become familiar with the VX4250 Waveform Tester, establish communications with the module, and confidently program and execute simple tests. The rest of the section presents more advanced subjects and many programming examples that can be used to verify system operation.

Front Panel Indicators and Connectors

Familiarity with the VX4250 Front Panel is needed for successful operation.

- READY Indicator—This green LED is illuminated when the instrument has successfully completed its power on self test and is ready to operate.
- ACCESSED Indicator—This yellow LED is illuminated when the instrument is being accessed through Word Serial Protocol.
- CH1 Input Connector—High impedance input for channel 1.
- CH2 Input Connector—High impedance input for channel 2.
- CH1 EXT TRIG Connector—High impedance input for channel 1 external trigger signal when being used.
- CH2 EXT TRIG Connector—High impedance input for channel 2 external trigger signal when being used.

Establishing Word Serial Communications

The first step in using any instrument which does not have front panel controls is to establish two way communications with the instrument. Commands will be sent to the instrument to control it's state and responses will be received from the instrument which show its state or provide data. In VXI, the fundamental high level communications path is referred to as "Word Serial Protocol" (WSP) or simply "Word Serial".

The difficulty in guiding a user through this crucial step is compounded by the variety of different controllers and communications paths. In VXI, the complexity of this task may increase when an interface device is utilized.

In the most general description, the user must verify the operation of the communications paths by sending a simple query to the instrument which will generate a response. The user must then collect the response and verify that it is correct.

The most universal query in VXI is `*IDN?` which requests identification information from the instrument.

This example shows what actual Word Serial communications to the VX4250 look like:

```
Command: *IDN?
Response: TEK,VX4250,0, (Information on firmware version.)
```

It is important to note that whenever the VX4250 is engaging in communications, the yellow indicator on the front panel labeled "ACCESSED" will blink.

The actual syntax used to send and receive these commands will depend on the controller and/or interface device used the VXI system. Refer to documentation supplied with these devices for information on how to send and receive Word Serial messages from a VXI instrument.

Most controllers include a "Talker/Listener" type of utility which facilitates sending and receiving messages with instruments.

Introduction to Instrument Programming

This section describes some fundamental concepts of the instrument command set. All commands and responses are transmitted in ASCII code via the Word Serial Protocol.

Readers who are familiar with other systems digitizers will find most of the commands similar with a few exceptions. These differences result from the architecture of the waveform tester which is optimized for functional test throughput. As the user becomes more familiar with this architecture, they will find the command structure very straightforward and efficient to use. The major considerations in designing the command set were:

- Clear, concise commands that are easily readable in source code.
- Symmetry with easy to remember conventions.
- The support of layered performance test systems concepts.
- Full coverage of the instrument capabilities.
- IEEE 488.2 supported General Command Format

Note:

The text and examples in this section utilize data types and formats which are generated by the majority of controllers. The IEEE 488.2 standard allows considerably more flexibility in the data types and formats permitted as valid input. In order to keep this section concise and readable, details on the options permitted under IEEE 488.2 are given in Appendix A, IEEE Standard 488.2 Reference.

The general command format used in the VX4250 Waveform Tester is:

```
[CHx]:<COMMAND HEADER>[?] [<ARGUMENT>];
```

This command format is used because the acquisition system is comprised of two completely independent acquisition channels.

All commands can be sent in upper or lower case, but responses will always be returned in upper case.

Introduction to Operation

The capabilities of the VX4250 are presented in a layered fashion in this section. Each topic includes programming examples that relate the text to the corresponding operation of the instrument. Each example performs a particular function which is commonly performed in a real application. The topics start with a simple set up and acquisition, then illustrate the use of the more powerful measurement, testing and sequencing capabilities built into the instrument.

It is understood that at this point the reader may not grasp the fine detail of each command syntax. Do not concern yourself with this. Overall, the reader should find it easier to comprehend the overall flow of control without getting bogged down with command format details.

Notes:

In the following examples, the actual commands sent to the VX4250 are printed in THIS TYPEFACE. *Any text which follows the command printed in italic typeface is a comment which explains what the command does. Do not enter any portion of the comment with the command.*

VXI interface devices utilize some method of addressing the particular device in the mainframe which the command is destined for. Because the addressing method used by various interface devices differ, device addressing is not included in the following examples. Refer to the documentation for your interface device for information on how addressing is accomplished. Most VXI talker-listener routines have a mode which sets the default device address and keeps it set until it is specifically changed by the user. The routine then inserts the appropriate addressing automatically.

Initializing and Setting up the Instrument for Acquisition

There are two steps involved in making a measurement or test with the VX4250. First, the channel must be set up correctly to capture the input signal. Once the data is captured and stored, various processes can be used to measure and test the data. Because the VX4250 is a stored measurement instrument, the input signal is only needed for the capture or acquisition step of the process. Hence, multiple measurements and tests can be made even after the input signal is no longer present.

Changes to the parameters which control the acquisition system only take effect when the acquisition is stopped and started. Once the parameters are programmed, the acquisition process can be started.

When the VX4250 completes its power-up self tests, it loads in a set of default parameters. These parameters will allow a valid acquisition to take place by starting the acquisition system.

Starting an Acquisition

A single command will start the acquisition system with the default parameters:

```
CH1:START
```
Starts the channel 1 acquisition process.

When the START command is executed, the acquisition hardware begins sampling the input signal and storing the result in the acquisition memory. This memory is a circular buffer, and will continue to be filled with new data, with the newest data overwriting the oldest. The acquisition process terminates in one of two ways: (1) with a trigger occurrence, or (2) with use of the STOP command.

Often during system debugging, it is desirable to determine if the acquisition process has stopped.

Determining the Status of an Acquisition

A query command is used to determine if the acquisition process is still running (indicating the absence of a trigger).

```
CH1:STATUS?
```
Queries the acquisition status of channel 1.

The VX4250 will reply:

```
WAITING;
```
(If a trigger has not occurred.)

or

```
COMPLETE;
```
If the entire record is captured and the acquisition process is stopped.

Terminating an Acquisition

Changes to parameters which control acquisition only take effect when the acquisition process is not operating. A STOP command will turn off the acquisition process.

```
CH1:STOP
```
Stops the acquisition process on channel 1.

Operational Commands

The START command belongs to a class of commands referred to as "operational" commands. Operational commands initiate a process in the instrument. The normal operation of the instrument may cause the process to complete. In the above example, a trigger would cause the acquisition process initiated with the START command to stop. Because operational commands only initiate a process, they cannot be queried.

Query Commands

The STATUS? command is a query only type command. Query only commands request a response from the instrument and cannot be sent in a non-query form.

Setting up the Signal Path Parameters

To maximize system throughput and measurement accuracy, it is important to set up the VX4250 correctly to capture the signal on the first try.

There are four functional groups of parameters which pertain to the acquisition; signal path, time window, trigger control, and trigger-time relation.

Signal path parameters relate to the amplitude dimension of the captured data. Commands provide control of the dynamic range, amount of offset to be added to the signal, and the coupling of the input.

```
CH1:STOP                 Stops acquisition if it was running.
CH1:RANGE .8             Sets the full scale range to 0.8 V full scale.
CH1:OFFSET -.5           Subtracts – 0.5 V from the input signal.
CH1:COUPLING DC          Sets the input coupling to direct.
CH1:START                Starts the acquisition process.
```

The RANGE command sets the full scale. The RANGE is always centered around the OFFSET value. This example would allow the VX4250 to measure input signals which swing from –0.9 Volt to –0.1 Volt. When OFFSET is programmed to zero, signals with a peak value of plus or minus 1/2 of the RANGE can be measured.

Figure 3-1 shows the dynamic range of this example:

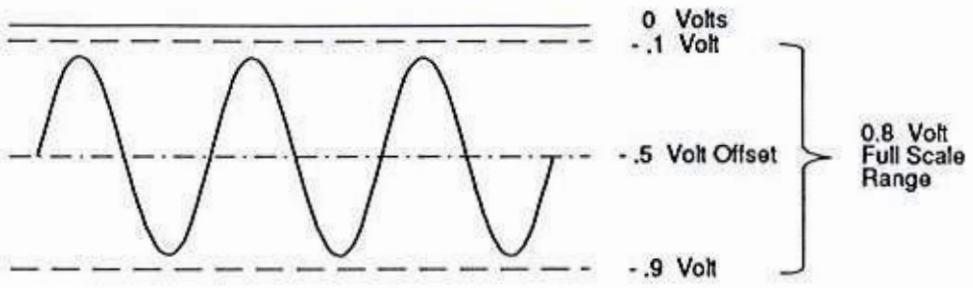


Figure 3-1. Input Dynamic Range.

Settings Commands

The RANGE, OFFSET, and COUPLING commands are examples of "settings" commands. As their name implies, settings commands set a particular parameter in the instrument. Generally, settings commands remain in effect until they are specifically changed by issuing the same command with a different argument. Therefore, only the commands for settings that are to be changed from their present state need be sent. For example, if after taking the acquisition in the previous example, we wished to take another with the offset set to zero, we would only need to enter these commands:

```
CH1:STOP
CH1:OFFSET 0
CH1:START
```

This would set the instrument to acquire with full scale range of 0.8 volts, 0 volts offset, and DC coupling. The RANGE and COUPLING will remain the same as they were in the previous step. Sending the RANGE and COUPLING commands with the same arguments is valid; in fact, some test system programmers send all of the settings at each step. This practice however lowers system throughput, because considerable time is used in sending and processing the superfluous commands.

Unlike operational commands which start a process, settings commands can be queried by sending them to the instrument in the query form. For example, if you send this query to the VX4250 after executing the previous example:

```
CH1:OFFSET?
```

the VX4250 will respond:

```
CH1:OFFSET 0.000E+00;
```

Setting the Time Base

SAMPLE INTERVAL or SAMPLE WINDOW are settings commands which are used to control the acquisition speed. Only one form of the command is used; the other is calculated by the VX4250.

SAMPLE INTERVAL is used when it desirable to control the rate at which samples are taken. For example, to acquire a 100 kHz signal with a minimum of 20 sample points per cycle, use:

```
CH1:SAMPLE:INTERVAL 500E-9
```

This sets the sample interval to 500 ns or 2 MHz which is 20 X 100 kHz.

The argument can be entered in either engineering notation (as above), or in scientific notation:

```
CH1:SAMPLE:INTERVAL 5E-7
```

Both examples give the same result. Queries are always returned in engineering notation. For example:

```
CH1:SAMPLE:INTERVAL?
```

Regardless of the format used to enter the sample interval, this result is returned:

```
CH1:SAMPLE:INTERVAL 500.0E-09;
```

The SAMPLE WINDOW command is used when the total amount of time we wish to capture the input signal is known. For example, to capture one line of a NTSC video signal which has a period of 63.5 µs, we would use:

```
CH1:SAMPLE:WINDOW 63.5E-6
```

If the window specified is not exactly the one available, the VX4250 always uses the next largest sample window, thereby assuring that the entire time of interest will be captured. The query and response after the above example would be:

`CH1:SAMPLE WINDOW 63.5E-6`	*Sets the sample window to capture 63.5 µs.*
`CH1:SAMPLE:WINDOW?`	*Queries the actual window size.*

The VX4250 would reply:

`CH1:SAMPLE WINDOW 102.2E-06;`	*The sample window is 102.2 µs.*

Setting the Trigger Control Parameters

The sampling process is stopped by the occurrence of a trigger. TRIGGER:SOURCE commands determine where the trigger signal will come from. The SLOPE command determines whether the instrument will be triggered on the rising or falling edge of trigger signal. TRIGGER:LEVEL sets the amplitude at which the trigger signal causes a trigger to occur.

If we enter the commands:

```
CH1:TRIGGER:SOURCE INT    Sets trigger source to internal, or the input signal.
CH1:TRIGGER:SLOPE PLUS    Sets triggering to occur on the positive slope.
CH1:TRIGGER:LEVEL -.2     Sets the trigger level to –.2 Volts.
```

The VX4250 would be set to trigger when the input signal crossed -0.2 Volts in the positive (rising) direction.

Trigger coupling for the internal trigger is always the same as the input. When EXT (external) trigger is specified as a source, the coupling is set by a separate command.

If the following commands are sent:

```
CH1:TRIGGER:SOURCE EXT
CH1:TRIGGER:EXT:COUPLING AC
CH1:TRIGGER:SLOPE PLUS
CH1:TRIGGER:LEVEL 3.2
```

The VX4250 would be set to trigger when the AC component of the signal applied to EXT TRIG 1 connector crossed 3.2 Volts in the positive direction. Because the trigger input is set to AC coupling, any DC component in the trigger signal would be ignored.

Note:

The dynamic range of arguments for internal trigger level and offset are dependent on the RANGE argument. When the input RANGE is changed, the VX4250 will attempt to maintain previously programmed values for input OFFSET and internal TRIGGER LEVEL. If either of the arguments are outside of the new available range, the VX4250 will program the parameter to the closest legal value in the range and issue a WARNING message. Table 1-4 at the end of Section 1 lists the range of arguments for TRIGGER LEVEL and input OFFSET in each of the input RANGE settings. Refer to Section 7 for information on Error and Event Reporting.

Controlling the Trigger-time Relationship with Pretrigger.

A powerful feature available in digitizing acquisition systems is the ability to retain a history of the input signal before the occurrence of the trigger. The data which represents this history is referred to as pretriggered. Pretrigger determines how much of the total data record will contain waveform data before the trigger occurrence. This is done by controlling the number of samples that will be taken after the trigger occurrence before the acquisition stops. The VX4250 can be programmed to one of four pretrigger values. The following table relates the pretrigger argument with the ratio of the data record located to pretrigger data.

Table 3-1. Pretrigger argument's relationship to the data record ratio located to pretrigger data.

	ET only	Real Time only		
PRETRIGGER ARGUMENT	0	128	1024	1920
Ratio used for pretrigger	None	1/16	1/2	15/16
Ratio remaining for posttrigger	All	15/16	1/2	1/16

Example:

```
CH1:SAMPLE:WINDOW 102.4E-6
CH1:PRETRIGGER 128
```

This would program the VX4250 to sample data for 102.4 µs. 1/16 of the captured data in the acquisition memory will represent the input signal for 6.4 µs (102.4 X 1/16) before the trigger occurred. Figure 3-2 shows the waveform captured in this example:

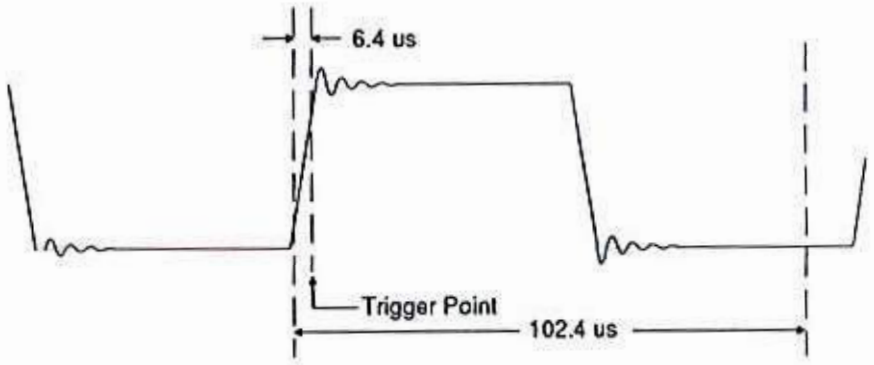


Figure 3-2. Pretrigger Set for 128 Samples.

```
CH1:SAMPLE:INTERVAL 50E-9
CH1:PRETRIGGER 1024
```

In this case, the sample interval is set to 50 ns. 1024 samples will be captured before the trigger occurred. This represents 51.2 µs of time (1024 samples X 50 ns/sample). Figure 3-3 shows the waveform that would be captured in this example:

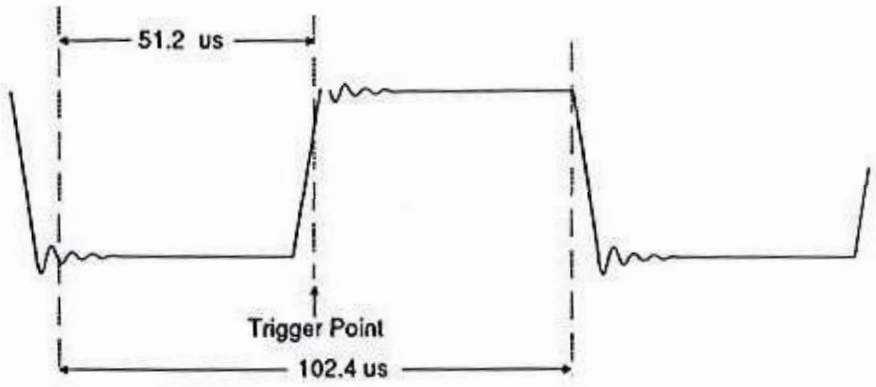


Figure 3-3. Pretrigger Set for 1024 Samples.

Waveform Measurements

Once a waveform has been acquired into the VX4250 memory, several useful parameters can be calculated by the instrument. The results of any of these measurements is a single numeric parameter.

Example:

Suppose you wanted to calculate the maximum and minimum voltage levels of the NTSC signal acquired in a previous example. You would simply send:

```
MAX?
```
This asks the VX4250 for the Maximum value of the waveform.

The VX4250 responds:

```
MAX +600.8E-03;
```
The VX4250 responds, 600.8 mV.

You would then send:

```
MIN?
```
This asks the VX4250 for the minimum value of the waveform.

And the VX4250 responds:

```
MIN -401.2E-03;
```
The VX4250 replies, –401.2 mV.

Notice that the acquisition step was not included in the above example. Using the power up defaults, single port measurement commands always operate on the last waveform acquired through channel 1.

The VX4250 can directly calculate any of the measurements listed in Table 3-2.

Table 3-2. VX4250 Measurement Functions

Magnitude Parameters	Time Parameters	Integrated Parameters	Other Parameters
Top	Rise Time	Mean	Gain*
Base	Fall Time	RMS	Phase*
Maximum	Width	Area	Template
Minimum	Period	Energy	
Top Overshoot	Frequency		
Base Overshoot	Duty Cycle		
Mid-Point			
Peak-to-Peak			
Proximal			
Mesial			
Distal			
Amplitude			

*Gain and Phase are dual port measurements.

These measurements are collectively called "Pulse Measurements". This term originates from the IEEE Standard which defines the measurements. This is somewhat of a misnomer, as the pulse measurements can be made on any waveform shape. See Section 4 and Appendix B for more information on the specifics of the different measurements available.

Generating a Test Template

In order to use the waveform measurement mode known as TEMPLATE test, a template waveform must first exist. The following procedure allows you to generate a test template with only the instrument commands. More sophisticated software tools that run on the system controller are available for more complex template generation.

Example:

Command: `CH1:ACQUIRE:MODE ENVELOPE;`	*Switch to envelope generation.*
Command: `CH1:ACQUIRE:LOC 3;`	*The waveform goes in location 3.*
Command: `CH1:ACQUIRE:NUM 16;`	*Make sixteen acquisitions.*
Command: `CH1:START;WAIT?`	*Generate the envelope.*
Response: `COMPLETE;`	
Command: `MARGINS 3,.5,.-5`	

In the above example, the envelope acquisition mode is used to generate a waveform which contains both high and low boundary information. The template is completed by applying MARGINS, which "stretch" the boundaries up and down, half a volt each direction.

This template in location 3 may now be used with `WFMCMP?` and `CHx:COMPARE:TYPE TEMPLATE`, to make waveform testing PASS/FAIL decisions.

Using Template Compare

Comparing waveforms to templates in the previous section, the use of `ACQUIRE:MODE ENVELOPE` and `MARGINS` to generate a test template was shown. To compare the waveform to the template to see if it fits wholly within the bounds, use these commands:

Example:

Command: `REF:LOC 3;`	*Sets the reference location to 3.*
Command: `WINDOW:LOC 1;`	*Sets the test waveform to location 1.*
Command: `WFMCMP?`	*Perform the compare.*
Response: `0;`	*A response of **0** means zero excursions from the template.*

In the above example, the source waveform to be tested is in location 1 and the template is in location 3. The `WFMCMP?` command is sent to find if the waveforms fits the envelope. The response of "0" indicates that there were no excursions from the envelope. If the number were not zero, for example "34", this would show that there were thirty four occasions where the waveform exceeded the envelope, either on the upper or lower boundary.

Testing Results

Examples here show how to test measurements for PASS/FAIL.

Setting Test Type

Previously, when asked for a measurement, the program returned the measured value. For example, if the MAX? command was given to the instrument, the response was the maximum voltage in the waveform, e.g., +1.56 volts. It is possible to define a test step in the instrument, so that the measurement will be automatically performed and the measured value tested for PASS or FAIL based on acceptable boundaries for the test step.

It is not difficult to set up the instrument to automatically make PASS/FAIL decisions based on the type of measurement and the acceptable range of the measured value.

Example:

```
Command: CH1:COMPARE:TYPE MAX;
```

In the above example, the maximum value of the acquired waveform will be calculated as the test type portion of the test step.

In order to complete the test step definition, limits must be specified—see the next topic, *Setting Test Limits.*

Setting Test Limits

Test limits define the acceptable or PASS window for a measurement.

There are two requirements for defining the test step limits—the definition of (1) the maximum or upper limit and (2) the minimum or lower limit.

With this information, the test step will be complete and when run, will produce PASS/FAIL results.

Examples:

```
Command: CH1:COMPARE:HIGH 1.7;
Command: CH1:COMPARE:LOW 1.2;
```

In the above example, the upper limit is defined to be "1.7" and the lower limit is defined to be "1.2". This means that any measured value falling within that range will be considered as a "PASS". If the measured value exceeds the limits (greater than 1.7 or less than 1.2), then the result would be a "FAIL".

Running a Test

After the test type and limits are defined, the test step may be run:

Example:

```
Command: CH1:STEP:MODE SINGLE;          Do only one test step.
Command: CH1:START;
Command: CH1:STATUS?
Response: COMPLETE;
```

The above example shows how to run the single test STEP. After running this test, the results are accessible with the RESULTS? command. See the next topic, *Getting Test Results.*

Note that the STEP:MODE is set to SINGLE. This tells the instrument that only the current test step will be run. It is possible to save and run up to eight test steps with one START command. See the Sequencing topic later in this section.

Getting Test Results

After you run the test step, the results are available with this command:

Example:

```
Command: CH1:RESULT?
Response: PASS, 1.350E+00   (Your measured value may be different.)
```

In the above example, the results from the last test step performed indicate that the test passed and the measured value was 1.350.

Using Template Compare

The previous section showed how to use ACQUIRE:MODE ENVELOPE and MARGINS to generate a test template. The example that follows shows how to use this template for PASS/FAIL testing.

Example:

```
Command: CH1:ACQUIRE:LOC 1
Command: CH1:COMPARE:LOC 3
Command: CH1:COMPARE:TYPE TEMPLATE
Command: CH1:START
Command: CH1:RESULT?
Response: PASS,0;
```

In the above example, the waveform to be tested is acquired into location 1 and the template already exists in location 3. The compare type is set to TEMPLATE. The channel sequence is started and assumed to complete. The results are obtained and show that the test was successful, with zero excursions recorded.

If the test failed, the result would return FAIL, followed by the number of times the waveform exceeded the envelope.

Sequencing

Sequencing provides the ability to setup, acquire, test against limits, and branch based on results. This sequence can be stored and called by executing a single command. Figure 3-4 illustrates the functional layering of the operations available in a channel sequence.

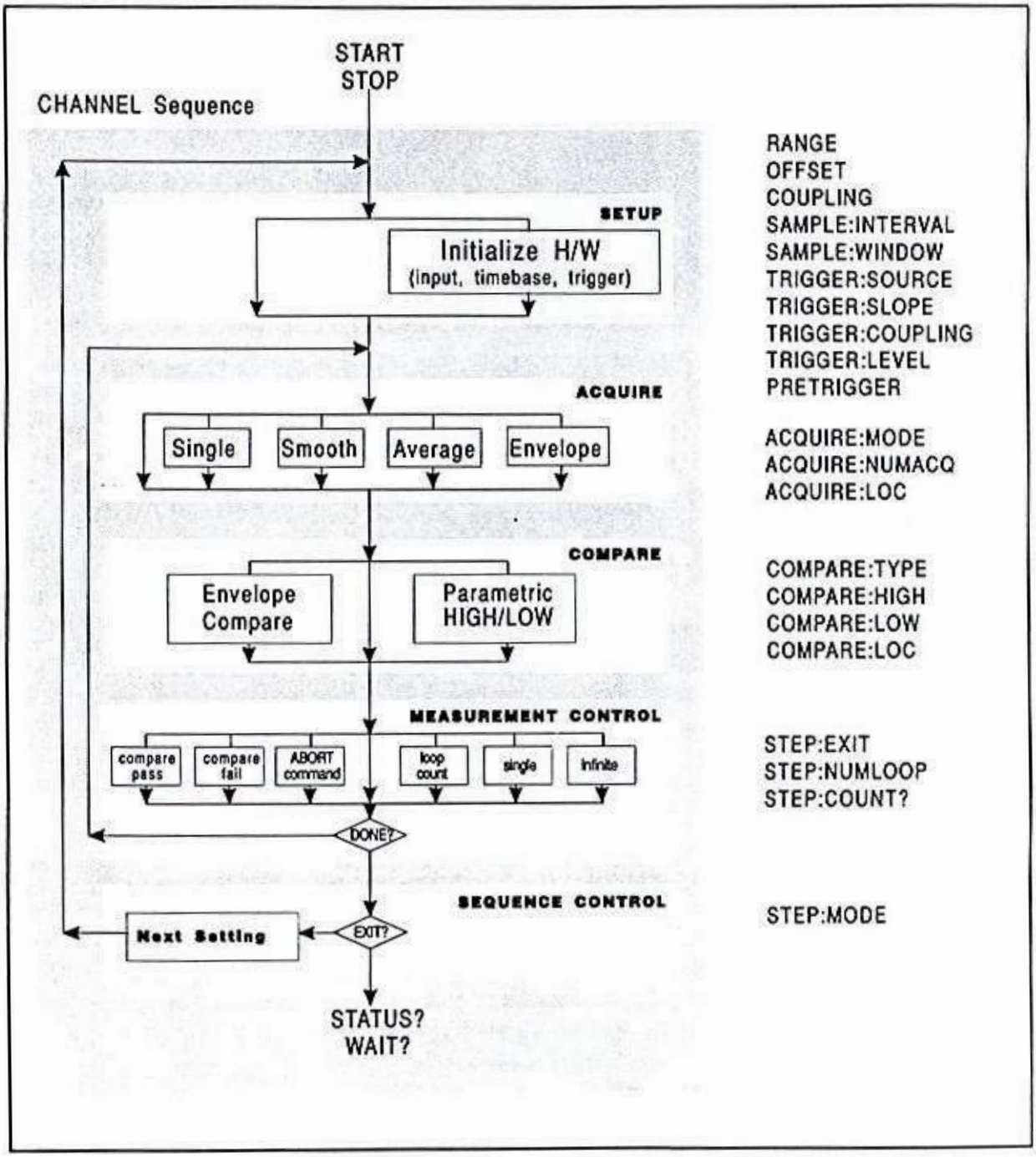


Figure 3-4. Channel Sequence.

The examples below illustrate sequencing in more depth.

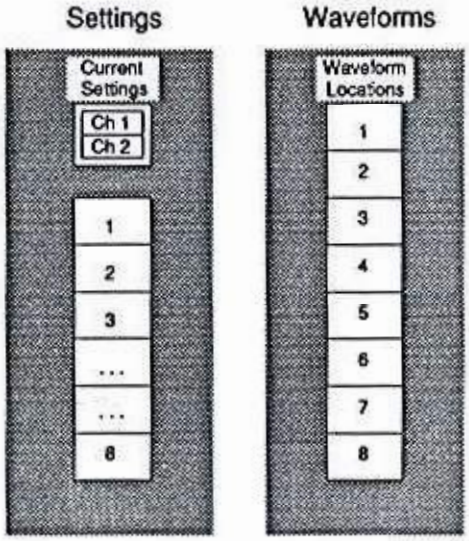


Figure 3-5. Stored Instrument and Waveform Settings.

Using Stored Settings

Once a test has been defined, it is possible to use Instrument Test Step Storage, as shown in Figure 3-5, to save it for later use.

Examples:

Command: `CH1:SAVE 1;`	*Saves CH1 setup as CH1 test #1.*
Command: `CH1:SAVE 2;`	*Saves CH1 setup as CH1 test #2.*
Command: `CH1:SAVE 3;`	*Saves CH1 setup as CH1 test #3.*
Command: `CH1:SAVE 4;`	*Saves CH1 setup as CH1 test #4.*
Command: `CH1:SAVE 5;`	*Saves CH1 setup as CH1 test #5.*
Command: `CH1:SAVE 6;`	*Saves CH1 setup as CH1 test #6.*
Command: `CH1:SAVE 7;`	*Saves CH1 setup as CH1 test #7.*
Command: `CH1:SAVE 8;`	*Saves CH1 setup as CH1 test #8*
Command: `CH1:RECALL 3`	*Restores CH1 setup from CH1 test #3.*

In the above example, the current instrument settings are saved in each of the test step locations. Then, the test step from setting location 3 is recalled into current settings.

The SAVE and RECALL commands will store and load the current settings, including all the information required to make a test, in a local memory location that is only accessible to that channel.

When several tests have been saved, it is possible to recall each one independently and run it, or to run all of them, as the next topic, *Running a Test Sequence*, explains.

Running a Test Sequence

Once a number of tests have been saved, it is possible to run them all, one after the other, with one START command.

Examples:

```
Command: CH1:STEP:MODE RUN;
Command: CH1:START;
Command: CH1:STATUS?;
Response: COMPLETE;
Command: CH1:STEP:MODE SINGLE;
```

When the STEP:MODE is set to RUN, whenever a START command is received, the setup contained in stored setting location #1 is loaded into the hardware and run. When done, stored setting #2 is loaded and executed. This continues until all eight stored settings have been loaded and executed.

If there are stored settings that have not been saved, no test will be run because the default is COMPARE:TYPE NONE.

When the channel sequence is complete, PASS/FAIL information is available from all tests. See the *Getting Test Results* section that follows.

Getting Test Results

Once a test sequence has been run, it is possible to query the results.

Note that results are aligned with the test step. This means result 5 will come from step 5.

Example:

```
Command: CH1:RESULT? 2;          Find the result of step #2.
Response: PASS, 1.000E+00;
```

The RESULT? command will access the information that resulted from the test step being run. The information is in the form of PASS/FAIL and the measured value.

The Parameter that comes after RESULT? specifies which test result is needed.

Errors

All commands and arguments are checked for validity before there are executed. Errors caught at this point are labeled "Command Errors". Whenever a command error is generated, the entire command is ignored and the instrument remains in the state it was prior to receiving the command. If a command error occurs in a command sent with multiple commands in a single message, all remaining commands in the message are flushed and ignored. Any prior commands in the message which are correct will be executed.

It is possible for a command to be valid when entered, but some operation of the instrument creates an invalid state at a later time. When this happens, an "Execution Error" is generated. There are some cases when it is desirable to alert the controller when a certain part of the test program is executing, or a particular event has occurred. The VX4250 has the ability to generate various "Events". The way events are reported is similar to the way errors are reported, but may result from normal operation. Operation complete (*OPC) is an example where the VX4250 would generate an OPC interrupt when a particular operation has completed.

Including an Error Interrupt Handler Routine

Whenever an error or event occurs, the VX4250 sends the controller an interrupt. A good practice in test system programming is to include an error interrupt handler routine. Typically the first thing an error and event interrupt handler will do is query the instrument to determine the cause of the error or event. Specific information on how the VXI error and event interrupt structure operates can be found in Section 7, *Error and Event Handling.*

Once the controller detects that an error or event has occurred, the associated status can be read back from the VX4250 with the EVMSG? command. The response to this command is the message code, followed by a string describing the error or event.

For example, suppose that a misspelled command is sent to the instrument:

```
CH1:RNGE 4          Invalid command, should have been "CH1:RANGE 4".
```

This would immediately generate an interrupt. The user's error handler might send:

```
EVMSG?              Error and event message query.
```

To this query, the VX4250 responds:

```
EVMSG 100, "Command Error, Command not found";
```

The event code 100 corresponds to command errors. When the EVMSG? command is executed, the error or event is removed from the message queue. Up to five errors or events can be stored in the error queue. Errors are reported in the order they are generated. In the following example two errors are generated, then the EVMSG? query is executed twice.

```
CH1:RNGE 4                    Invalid command.
CH1:RANGE 5000                Invalid range argument.
EVMSG?                        First message query sent.
```

The VX4250 replies:

```
EVMSG 100, "Command Error, Command not found";
```

```
EVMSG?                        Second message query sent.
```

The VX4250 replies:

```
EVMSG 220, "Data out of range, Channel input range
limited";
```

If the queue is empty, the program responds with this message:

```
EVMSG?                        Message sent with no errors pending.
```

The VX4250 replies:

```
EVMSG 0, "No events to report";
```

The queue is five deep. When the sixth error or event occurs, an interrupt is generated, but the message is not entered in the queue and will be lost. This usually happens only when an interrupt handler is not employed in the system.

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Section 4
Advanced Operation

Introduction

This section presents a more in depth description of the layered functionality available from the VX4250 Waveform Tester. While the discussion follows the same topics covered in Section 3, several more command options are given which enable the user to optimize the operation of the VX4250 in their application. More information is also given on the internal operation of test and measurement features in the VX4250. This better enables the user to avoid some of the traps commonly encountered when using digitizing acquisition instruments.

The topics covered in this section are categorized in groups relating to the major operations performed by the VX4250: Acquisition, Waveform Storage and Transfer, Measurement, Test, Sequence Control, and Throughput Enhancement.

Acquisition Control

Triggering Options

The VX4250 offers several triggering options for greater flexibility in signal capture. In addition to internal and external triggering (described in Section 3), the VX4250 also incorporates cross channel, VXI backplane, and free run trigger modes. A High Frequency Reject mode allows the user to optionally filter the signal used for internal and external triggering to minimize trigger jitter.

Cross Channel Triggers

When cross channel triggering is selected as a trigger source for a channel, a valid trigger occurrence in the opposite channel triggers that channel. The opposite channel's trigger source, slope and level determine the valid trigger condition.

Example:

```
CH2:TRIGGER:SOURCE INT
CH2:TRIGGER:SLOPE POS
CH2:TRIGGER:LEVEL 1.2
```

These commands set channel 2 to trigger when the signal applied to the input crosses 1.2 volts in the positive direction. This command causes channel 1 to trigger when channel 2 trigger conditions are met.:

```
CH1:TRIGGER:SOURCE XCH
```

Unlike the trigger source selector on a conventional oscilloscope, cross channel (XCH) trigger uses the trigger detector from the alternate channel; hence, all of the alternate channel's trigger controls determine the conditions for valid trigger occurrence. Triggers can be detected from the alternate channel regardless of its acquisition status.

Note:

Selecting XCH as the trigger source for both channels will generate an error.

VXI Triggers

Any of the VXI backplane triggers available in "C" Size modules can be selected as a trigger source for either or both of the channels. These are TTLTRG 0—TTLTRG 7 and ECLTRG 0—ECLTRG 1. Either or both channels can be triggered from the same VXI trigger; however, separate backplane triggers cannot be selected for each channel.

Example:

```
CH1:TRIGGER:SOURCE TTLTRG3
```

This selects TTLTRIGGER line 3 for CH1 trigger.

Trigger level is not applicable to VXI triggers. If a `TRIGGER:LEVEL` command is issued while a VXI trigger is selected, a warning message will be generated by the VX4250.

Trigger slope is selectable for backplane triggers. In order to effectively use backplane triggers, the user must know the active slope of the instrument generating the trigger. Generally, the negative or falling slope is the active slope used in VXI triggering.

The value returned by MAX? and MIN? is the voltage of the maximum and minimum points of the waveform.

Based on the maximum and minimum voltage levels, the peak-to-peak and mid-point values are derived.

The peak-to-peak voltage is the difference between the maximum and minimum voltages; in other words, the maximum voltage swing of the acquired signal. (See Figure 4-6.) The midpoint voltage value is the midpoint between the maximum and minimum voltage levels.

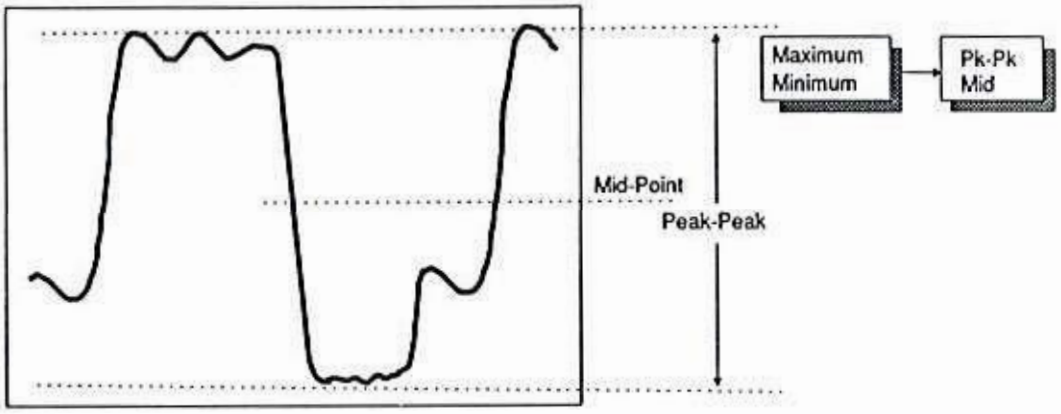


Figure 4-6. Mid-point and Peak-to-Peak Voltages.

Example:

Command:	`PK2PK?`	*Ask the VX4250 for the peak-to-peak voltage.*
Response:	`PK2PK +6.891E+00;`	*The peak-to-peak voltage is 6.891 V.*
Command:	`MID?`	*Ask the VX4250 for the midpoint voltage.*
Response:	`MID +143.0E-03;`	*The midpoint voltage is 143.0 mV.*

Top, Base, and Amplitude

How are Top and Base different than maximum and minimum? There is no single algorithm for determining top and base—the VX4250 has four different base/top determination methods. In most cases, the Top (Base) value is a level the signal attains after any overshoot. For now, let's assume that top and base are at the levels indicated in Figure 4-7.

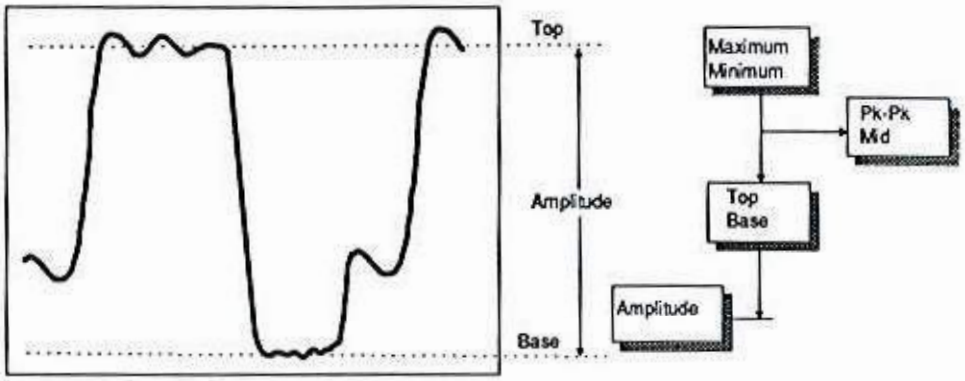


Figure 4-7. Top, Base, and Amplitude.

The example in Figure 4-15, later in this section, shows how a histogram was generated from the waveform in the VX4250's memory. The histogram merely represents the number of times the waveform data "fell into" a particular bin or digitizer level.

The mechanics and implications of using histograms for calculating base and top will be explained latter.

Amplitude is the difference between top and base and is an alternative to the peak-to-peak measurement. Peak-to-peak picks up any noise on the extremes of the signal, which alters the measurement because the noise is included.

Example:

Command:	`TOP?`	*Ask the VX4250 for the top voltage.*
Response:	`TOP +3.312E+00;`	*The voltage at the topline is 3.312 V.*
Command:	`BASE?`	*Ask the VX4250 for the base voltage.*
Response:	`BASE-3.254E+00;`	*The voltage at the baseline is –3.254 V.*
Command:	`AMPLITUDE?`	*Ask the VX4250 for the amplitude.*
Response:	`AMPLITUDE +6.566E+00;`	*Amplitude voltage is 6.566 V.*

Calculating the 10%, 50%, and 90% points (Proximal, Mesial, and Distal)

Most rise and fall measurements are made between the 10% and 90% points on a pulse edge. The 10%, 50%, 90% points will be referred to as reference levels. Note that the reference values are calculated based on the Top and Base values, they are not calculated from the maximum and minimum values.

In some applications, reference levels of 10% and 90% are not desirable. And in some cases, such as ECL circuits, rise and fall times are made between the 20% and 80% points. For the sake of consistent terminology, the IEEE Std. 194-1977 defines the 10%, 50%, and 90% points as proximal, mesial, and distal (see Table 4-5).

Table 4-5. Pulse Reference Level Description

Reference Term	Description
Proximal	Typically the 10% amplitude level
Mesial	Typically the 50% amplitude level
Distal	Typically the 90% amplitude level

Adjusting the value of the reference levels is left until later in this section. For now, we can find the voltage values at the proximal, mesial, and distal points, as shown in Figure 4-8.

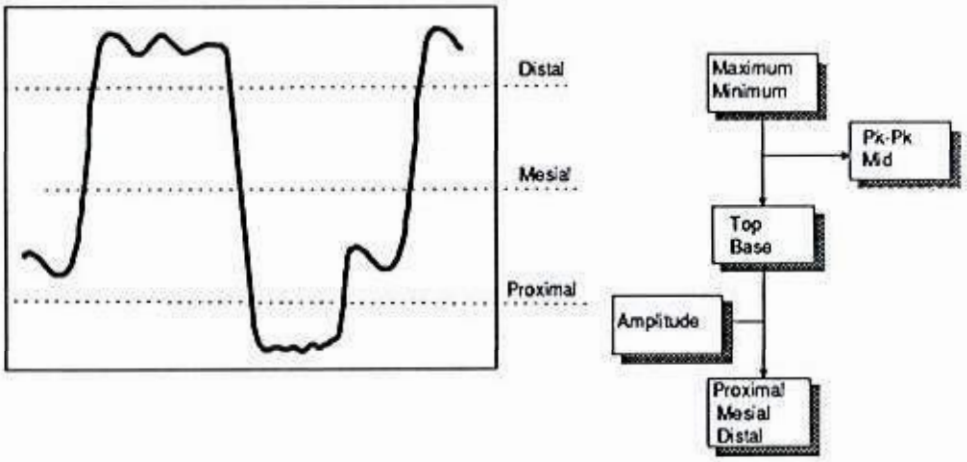


Figure 4-8. Reference Voltages.

Example:

```
Command:  PROXIMAL?                    Ask for the proximal voltage.
Response: PROXIMAL  -2.597E+00;        Proximal voltage is –2.597 V.
Command:  MESIAL?                      Ask for the mesial voltage.
Response: MESIAL +29.01E-03;           Mesial voltage is 29.01 mV.
Command:  DISTAL?                      Ask for the proximal voltage.
Response: DISTAL +2.656E+00;           Distal voltage is 2.656 V.
```

Reference Parameter Calculations

What are reference parameters and why are they important? Reference parameters, illustrated in Figure 4-9, are the basis for calculating time related measurements such as rise/fall time, period, etc.

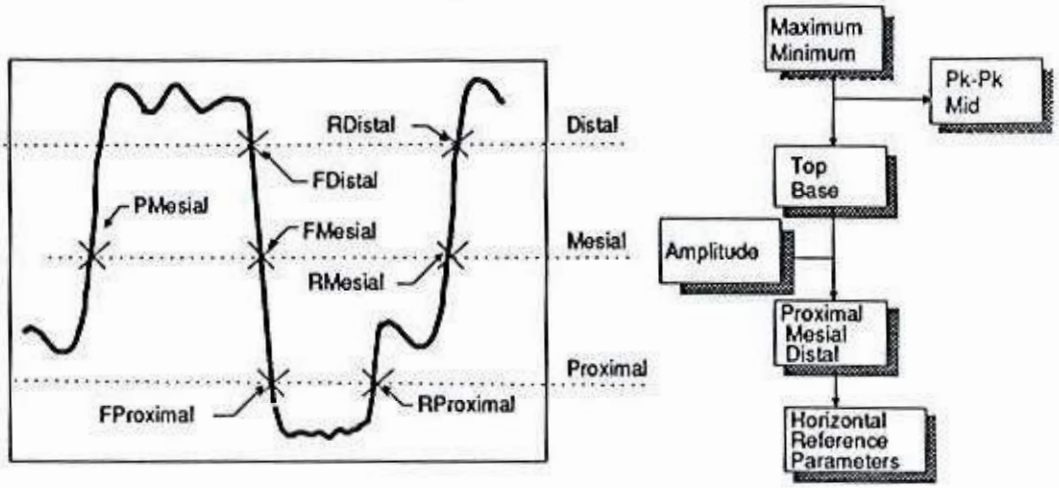


Figure 4-9. Reference Parameters.

The reference parameters and their definitions are listed in Table 4-6:

Table 4-6. Reference Parameter Definitions

Reference Parameter	Definition
FDistal	Location of the Distal value on the falling edge
RDistal	Location of the Distal value on the rising edge
FMesial	Location of the Mesial value on the falling edge
RMesial	Location of the Mesial value on the rising edge
FProximal	Location of the Proximal value on the falling edge
RProximal	Location of the Proximal value on the rising edge
PMesial	Location of a Mesial point used to define a period

The location of these reference parameters is dependent on the value of the proximal, mesial and distal voltages on the vertical axis. Note that reference parameters are expressed in terms of the horizontal axis.

Example:

Command: `REFCRS:FPROXIMAL?` *Where is the falling proximal point?*

Response: `REFCRS:FPROXIMAL +854.2E+00;`

The location of the falling proximal value occurs at the 854.2 point of the waveform. How can a point occur between two samples? The VX4250 pulse analysis firmware uses linear interpolation (see Figure 4-10) when an expected waveform value does not occur on a discrete sample. In the above example, a waveform sample was recorded just after the proximal point (854) and before (855). The VX4250 pulse analysis software interpolated samples 854 and 855. This yields greater accuracy in the pulse timing measurements.

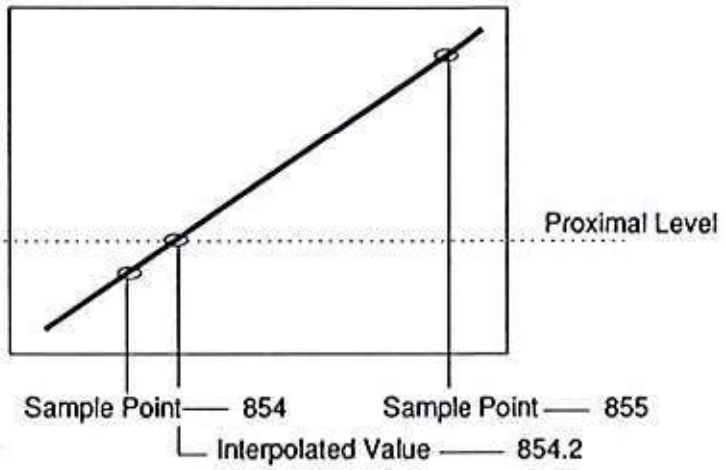


Figure 4-10. Interpolation Between Samples.

Time Parameters, Rise and Fall

After calculating the reference parameters, the rise and fall times are very easily calculated by taking the difference between the associated proximal and distal points (refer to Figure 4-11.)

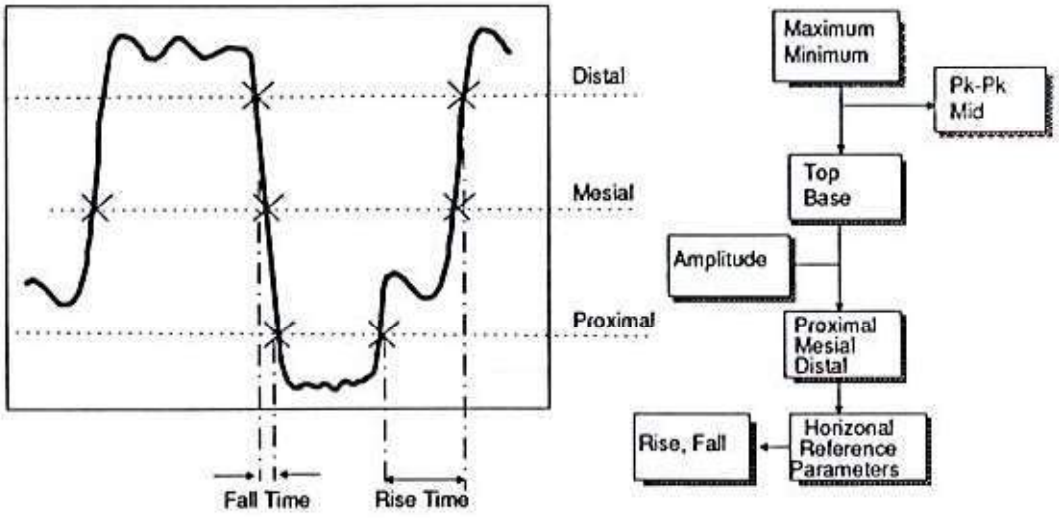


Figure 4-11. Rise and Fall Times.

The example below shows how to query rise and fall times.

Example:

Command:	`RISE?`	*Ask for the rise time.*
Response:	`RISE +3.117E-06;`	*Rise time is 3.117 µs.*
Command:	`FALL?`	*Ask for the fall time.*
Response:	`FALL +1.034E-06;`	*The fall time is 1.034 µs.*

Time Parameters, Width, Period, Frequency, and Duty Cycle

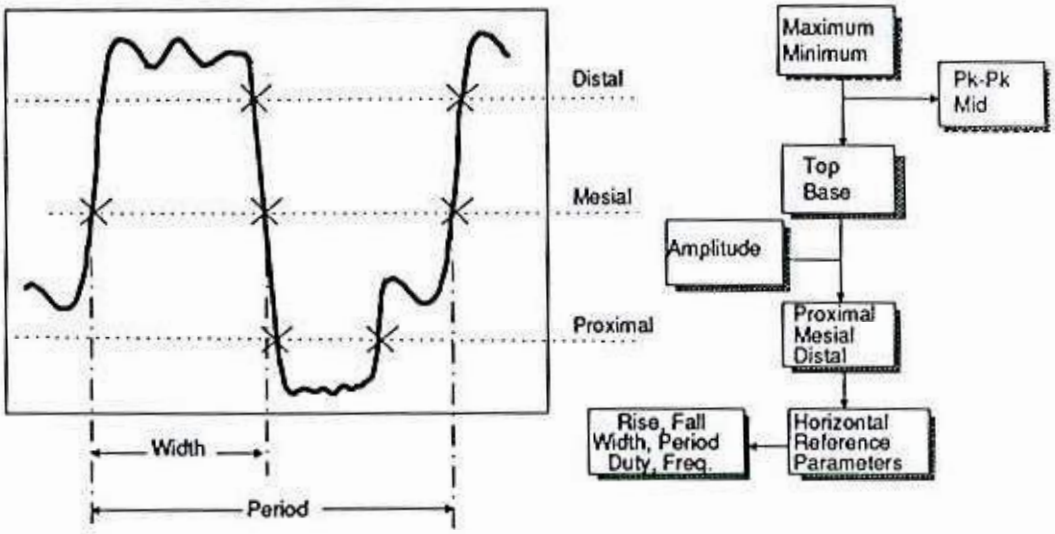


Figure 4-12. Using the Mesial Points for Calculations.

The mesial points are employed to calculate width, period, frequency, and duty cycle.

Width and Period

Period is the time between the first and third mesial points—while frequency is the inverse of period. Width is the time between the first two mesial points.

Duty Cycle is the percentage of time the waveform is greater than the mesial voltage within a given period.

Example:

Command:	`PERIOD?`	*Ask for the period.*
Response:	`PERIOD 11.84E-06;`	*The period is 11.84 µs.*

Extended Parameters — RMS, Area, Mean, and Energy

The extended parameters provide waveform statistics over a single period of the waveform. The formulas and explanations of the extended parameters are discussed in Appendix B, *Pulse Measurement Definitions.*

Example:

Command:	`RMS?`	*Ask for the RMS value of the waveform.*
Response:	`RMS +2.241E+00;`	*The RMS value is 2.214 V.*

Gain and Phase

Nearly all of the pulse analysis functions provide data regarding a single waveform. Two exceptions are Gain and Phase.

Gain is simply the amplitude of the target waveform divided by the peak-to-peak of a reference waveform (see the peak-to-peak measurement earlier in this section).

Phase compares the midpoint crossings of the target and reference waveforms and returns the phase in degrees. Both waveforms must have been acquired at the same sample rate. Phase direction is determined by target waveform relative to reference waveform.

Note:

To obtain accurate phase measurements, it is imperative that both channels are triggered from the same source.

The target waveform is selected by the `WINDOW` command (as described earlier). The reference waveform is selected by the `REF` command.

Gain and Phase Example

This example shows how to measure gain and phase of a target waveform in waveform location 1, compared with a reference waveform in location 7.

Example:

Command:	`WINDOW:LOC 1`	*The target waveform is in location 1.*
Command:	`REF:LOC 7`	*The reference waveform is in location 7.*
Command:	`GAIN?`	*What is the gain of location 1 to location 7?*
Response:	`GAIN +1.141E+00;`	*The gain is 1.141 times location 7.*
Command:	`PHASE?`	*What is the phase of location 1 to location 7?*
Response:	`PHASE +44.14E+00;`	*Location 1 leads location 7 by 44.14 degrees.*

Selecting Waveforms with WINDOW

The WINDOW command is used to select a waveform location and to select a subset of the waveform to be analyzed, as the examples below and Figure 4-13 show.

Example:

Command:	`WINDOW:LOC 1`	*Analysis commands are performed on waveform location 1.*
Command:	`WINDOW:START 122`	*Analysis commands start at the 122nd point in the waveform.*
Command:	`WINDOW:STOP 2022`	*Analysis ends at the 2022nd point in the waveform.*

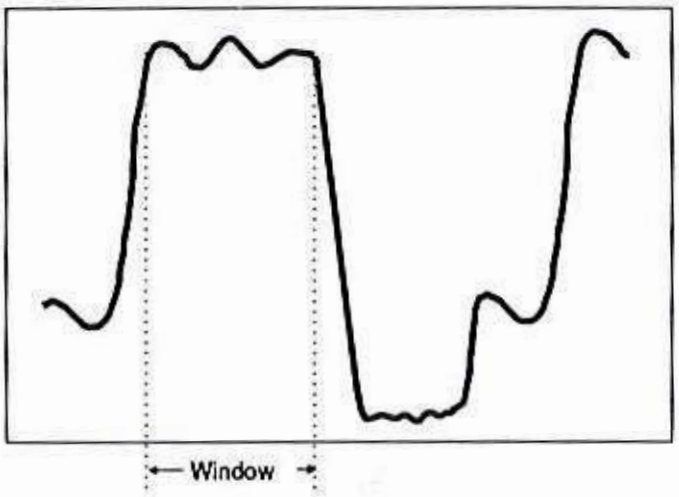


Figure 4-13. Selecting Measurement Window.

The above example shows how to measure the peak-to-peak ripple on the positive level of the waveform.

Peak-to-Peak Ripple Measurement

Example:

Command:	`PK2PK?`	*Ask for the peak-to-peak voltage for the entire waveform.*
Response:	`PK2PK +6.891E+00;`	*The peak-to-peak voltage is 6.891 V.*
Command:	`WINDOW:START 252`	*Start at the 252nd point.*
Command:	`WINDOW:STOP 754`	*Stop at the 754th point .*
Command:	`PK2PK?`	*Ask for the peak-to-peak voltage.*
Response:	`PK2PK 512.2E-03;`	*The peak-to-peak ripple is 512.2 mV.*

Modifying Extended Mode Calculations

The extended mode calculations (RMS, Area, Mean, and Energy) are calculated, by definition, over a period (see Figure 4-14). The EXTMODE command is used to allow the extended mode commands to be calculated over the bounds set by the WINDOW command.

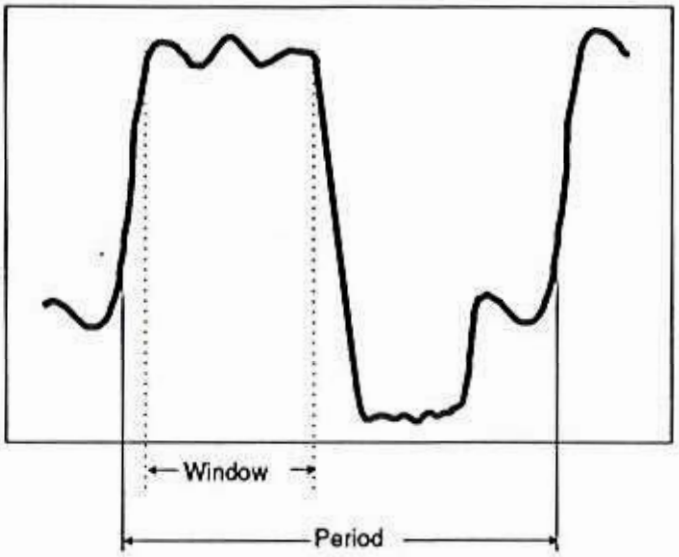


Figure 4-14. Changing Measurement Window.

Here are some sample commands that show how to modify Extended Parameter calculations with EXTMODE.

Example:

Command:	`EXTMODE PERIOD`	*RMS, Area, Mean, and Energy calculated over a period.*
Command:	`RMS?`	*Ask for the RMS value.*
Response:	`RMS +2.241E+00;`	*The RMS value is 2.241E-00.*
Command:	`WINDOW:START 252`	*Start at the 252nd point.*
Command:	`WINDOW:STOP 754`	*Stop at the 754th point.*
Command:	`EXTMODE WINDOW`	*RMS, Area, Mean, and Energy calculated over a window.*
Command:	`RMS?`	*Ask for the RMS value.*
Response:	`RMS +362.2E-03;`	*The RMS value is now 362.2 mV.*

Base and Top Determination

The VX4250 provides three methods for computing Top and Base, as shown in Table 4-7.

Table 4-7. Top/Base Calculation Methods

Method	Description
MinMax	Sets Top=Max, Base=Min
Histogram Mode	Sets Base and Top to the mode of the histogram
Histogram Mean	Sets Base and Top to the mean of the histogram

Most pulse waveforms are suited to using the mode of the histogram. The use of the histogram is illustrated in Figure 4-15.

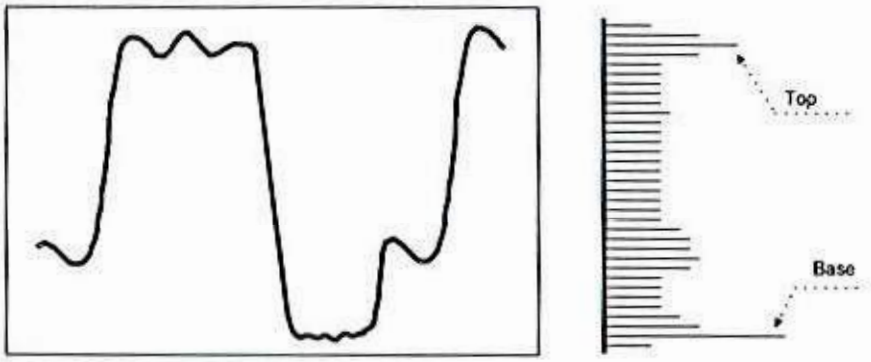


Figure 4-15. Determining Top and Base with Histogram Mode.

In the digitizing process, each waveform sample can be one of 256 bins. A histogram of the digitized waveform can be generated to determine the number of times a sample fell into a particular bin.

When using the mode of the histogram, the bin with the largest number of samples is determined to be the top, or alternately, the base. This method provides immunity to random noise and ringing.

Backplane triggering is a powerful tool available in VXI. It is especially useful in multi-instrument systems used in diagnostic testing. A typical application is a system which tests a digital circuit. A digital tester, such as a Tektronix VX4820, generates a pattern and checks the output of a circuit assembly under test while the VX4250 Waveform Tester is monitoring an internal power supply node. (See Figure 4-1.)

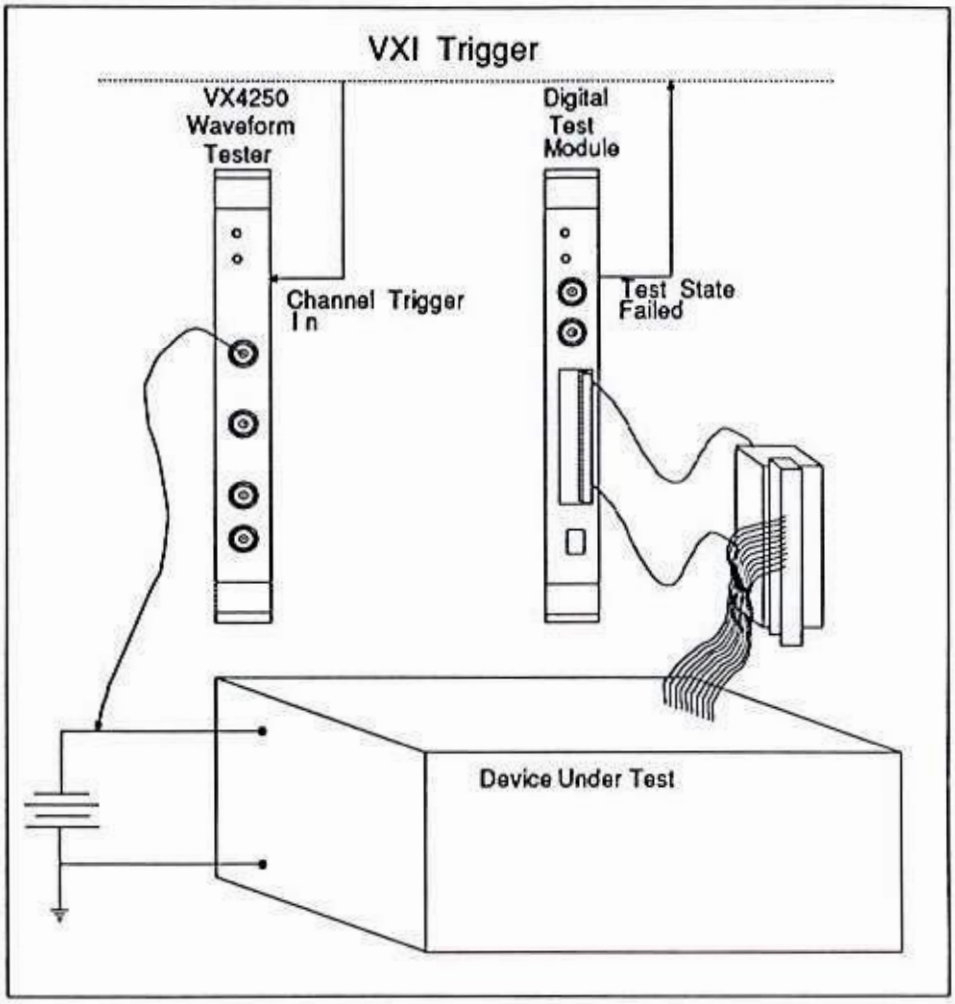


Figure 4-1. VX4820 and VX4250 Test System.

The VX4820 has the ability to generate a TTLTRG when it detects an incorrect digital pattern coming from the unit under test. This TTLTRG can be used to trigger the VX4250 Waveform Tester which was monitoring the power supply. By using a template compare, the VX4250 can check to see if the power supply experienced a noise hit which caused the operational failure in the unit under test. A difficulty in testing state machines is that failures may take several clock cycles to propagate to the output before they are detected. With pretrigger, the VX4250 can capture the status of the power supply signal prior to the detection of the failure.

Free Run Triggers

Specifying free run trigger mode effectively disables triggering. In free run mode, the circular buffer is continuously being overwritten with new data. Once the acquisition is started, it can be stopped only by issuing the STOP command.

Example:

`CH1:TRIGGER:SOURCE FREERUN`	*This command selects FREERUN trigger mode for channel 1.*
`CH1:START`	*This command starts the acquisition process on channel 1.*

Channel 1 will now continuously acquire.

The free run mode is useful if a signal needs to be captured that has no discernable trigger level (such as a DC level). This mode is also useful for system checkout, when uncertain trigger levels exist. Be aware that acquisitions in this mode are asynchonous and may not produce the same results each time.

High Frequency Reject

When any acquisition system is triggered on a signal which has a slow rise or fall time relative to the sample rate, the effect of trigger jitter becomes more evident. When multiple acquisitions of a periodic waveform are being performed, such as when the input is averaged, excessive trigger jitter results in unstable waveforms. Trigger jitter is caused by the acquisition system triggering on noise that is superimposed on the input signal, as shown in Figure 4-2. The result is a time shift of the point at which triggering occurred. As the edge used for triggering becomes slower relative to the sample rate, the number of samples in which the trigger can occur increases. To minimize the effect of trigger jitter, always use the fastest edge available for triggering.

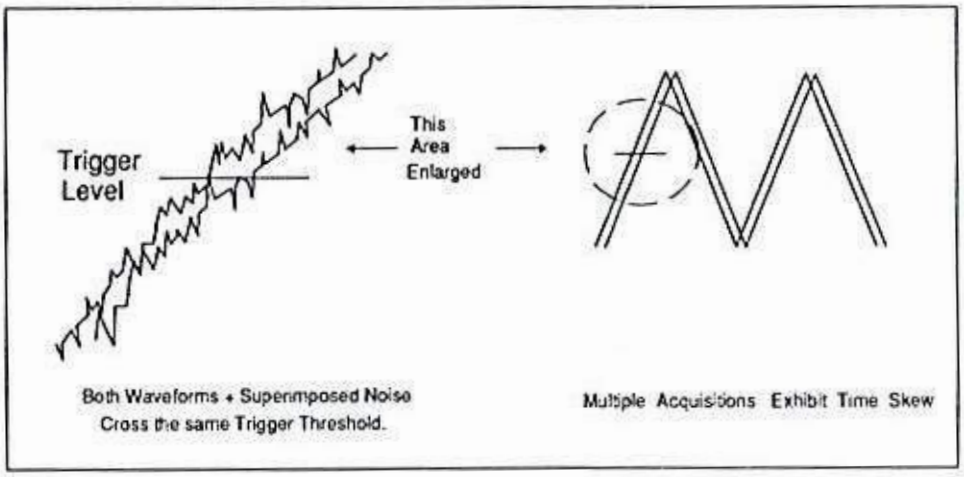


Figure 4-2. Cause of Trigger Jitter.

Sometimes it is necessary to trigger on a slow rising or falling edge. To minimize the jitter in these situations, the VX4250 incorporates a High Frequency Reject (HFR) mode. When HFR is enabled, the signal used for internal and external triggering is filtered to reduce response time of the trigger circuit. This reduces the tendency to trigger on the high frequency noise components in the trigger signal.

Example:

```
CH1:TRIGGER:HFR ON      Turns channel 1 High Frequency Reject filter on.
```

High Frequency Reject generally improves the stability of any low frequency waveform, and this usually improves the fidelity of averaged waveforms. While HFR mode is on, trigger sensitivity of signals over 1 MHz will be substantially reduced. High Frequency Reject does not affect the trigger level or slope and HFR mode has no effect on VXI backplane triggering.

Exporting Backplane Triggers

To allow enhanced system coordination, the VX4250 has the ability to generate a VXI backplane trigger whenever a predetermined channel is triggered. Either channel 1 or 2, but not both, can source the trigger. Any one of the TTLTrigger lines 0-7 can be selected.

Example:

```
CH1:CONNECT:TRIGGEROUT TTLTRG5
```

This command routes channel 1 trigger to VXI backplane TTL trigger 5.

The channel trigger can be used in systems when it is desirable to synchronize other instrumentation to asynchronous events. Once a channel is triggered, the time required to complete the acquisition process is deterministic.

The VXI trigger exporting circuitry contains two timing circuits. One converts the negative portion of the "low" portion of the trigger to a pulse which is low approximately 62.5 ns. This prevents the VX4250 from locking out the trigger line when a static level appears on the internal trigger signal. The second timer limits the maximum repetition rate of the TTLTRG signal to 5 MHz. When input signals generate channel triggers faster than this, the timer will ignore those triggers.

Timing Out an Acquisition

Often a test system programs the VX4250 to acquire and then measure or test a waveform. Normally, the waveform tester will then report the results. If the acquisition process is started and a trigger never occurs, such as when the unit under test does not generate the signal, the VX4250 continues to acquire, waiting indefinitely for a trigger. To prevent the system from locking up in these conditions, a timeout mechanism is provided. The WAIT? command combines the action of the STATUS? command with a timeout mechanism and a command hold off for the next command. Functionally, WAIT? is an operational command that holds off the execution of following commands until acquisition is complete or the timeout value is reached. When either condition is met, WAIT? then forces a STATUS? response. The WAIT? command follows the START command.

Example:

```
CH1:START;:CH1:WAIT? 500;:FREQUENCY?
```

In this example, the channel 1 acquisition process is started, then a 500 millisecond timer is started. The frequency measurement is held off until the acquisition process is complete or timed out. A typical response from the above example would be:

```
COMPLETE;FREQUENCY 3.127E+06;
```

Two conditions result in a timeout. If the timeout occurred without a trigger occurrence, the response to the example query above would be:

```
WAITING;
```

If a trigger occurred but the post trigger acquisitions were still taking place when the timeout occurred, the result to the example query above would be:

```
RUNNING;
```

This usually happens only when slow sample rates are selected. Once a timeout occurs, the remaining commands are executed. If a WAITING response is generated, any measurement or test command will be performed on the data stored from the *previous* acquisition. When a RUNNING response is generated, the next command may operate on a composite of both the old and new waveform data. For example, if a device under test is dead and not generating an output, the result of the above example might be:

```
WAITING;FREQUENCY 4.691E+06;
```

Whenever the response does not start with COMPLETE, the test program should treat the results as invalid, and process the error condition appropriately.

Waveform Processing During Acquisition

The VX4250 provides various methods of processing a waveform during the acquisition process. This processing can reduce the noise in acquired waveforms, or build envelops. The method of processing performed is selected through the use of the ACQUIRE:MODE command. The power on default is off—no processing modes used.

Smoothing and Averaging. Smoothing and averaging enhance waveform measurement accuracy by removing some of the noise in the resulting waveform. In averaging mode, several acquisitions take place. A resulting waveform is calculated by taking the statistical average of each point in the waveform record. The calculations for each sample point are independent. Hence, the process used in averaging affects only the amplitude component of the waveform, and does not alter the time relationship between samples. Averaging requires multiple acquisitions of a reoccurring waveform. The number of acquisitions to be averaged is defined with a separate command, ACQUIRE:NUM. This number must be a power of 2, (2,4,8,16...) with a range of 2—256. If the argument is not a power of two, the VX4250 rounds it to the closest valid argument and issues a warning.

Examples:

```
CH1:STOP
CH1:ACQUIRE:NUM 8                 Sets the number of acquisitions to be
                                  processed to 8.
CH1:ACQUIRE:MODE AVERAGE          Invokes waveform averaging mode.
CH1:START
```

Increasing the number of acquisitions reduces the amount of noise; however, the tradeoff is the amount of time the acquisition process requires. This general relationship is shown in Figure 4-3; however, certain periodic noise components may not follow the relationship. Whenever it is necessary to optimize system performance for both accuracy and throughput, it is best to experiment with the real signals in the actual environment.

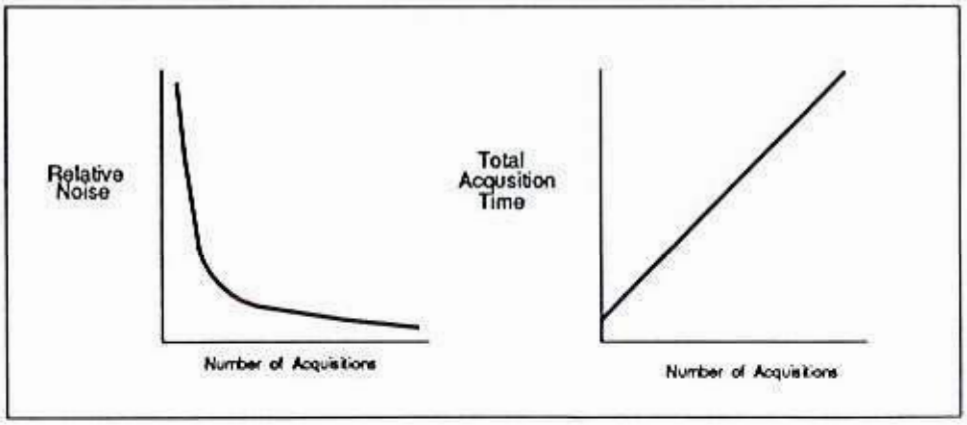


Figure 4-3. Two graphs of noise versus number of averages, time versus number of averages.

Because averaging does not affect the time axis of the waveform, the time relationship of the signals in all of the acquisitions must be consistent. To assure time correlation in the multiple acquisitions, a consistent trigger is required. Excessive noise in the trigger signal will result in time jitter in the acquired waveforms. This effect is more noticeable when the trigger is obtained from a slow rising (or falling) slope. As stated earlier, use the fastest edge available in the signal used to trigger the VX4250 whenever possible.

Smoothing is a different process that can be employed to reduce the noise in an acquired signal. Unlike averaging, smoothing uses only one acquisition of the input waveform. Hence, it works on nonrepetitive signals. The smoothing algorithm is based on a three point running average which starts at the beginning of the waveform and travels to the end. This is the actual algorithm:

$$S_{(i)} = \frac{W(i)}{2} + \frac{W(i+1) + W(i-1)}{4}$$

Where: S is the resulting smoothed waveform element
W is the unprocessed waveform element and
i is the sample point index

Essentially, this is a weighted three point interpolation. Because the algorithm does utilize time, it has the effect of adding a low pass filter to the input signal. Smoothing can be run multiple times, with the result of each pass being used as the source for the next run. The ACQUIRE:NUM command determines the number of times the program runs smoothing. Because the low pass effect is accumulative, running smoothing a large number of times will distort the waveform. Generally, one or two passes offers the maximum benefit without noticeable degradation of the true waveform.

Envelope mode. This mode performs the opposite function of averaging. Like averaging, envelope mode utilizes multiple acquisitions of a repetitive input signal. The resulting waveform contains two amplitude values for each sample location. These values represent the minimum and maximum excursion of the corresponding sample point during all of the acquisitions. Enveloping is useful for looking at maximum noise on a signal, and amplitude variations over time. The number of acquisitions used to build the envelope are set with the ACQUIRE:NUM command. The valid arguments are any integer between 2 and 256.

Example:

```
CH1:STOP
CH1:ACQUIRE:NUM 11
CH1:ACQUIRE:MODE ENVELOPE
CH1:START
```

Executing these commands enables the VX4250 to acquire the input signal 11 times and build an envelope of the maximum and minimum values from all 11 acquisitions. As with average mode, each acquisition requires its own trigger occurrence.

These waveform processing commands, like all acquisition control commands, remain in effect until they are changed or turned off. Once activated, multiple waveforms can be acquired and processed only by issuing additional START commands.

Example:

```
CH1:STOP
CH1:RANGE .8
CH1:SAMPLE:INTERVAL 100E-6
CH1:COUPLING DC
CH1:TRIGGER:SOURCE INT
CH1:TRIGGER:SLOPE PLUS
CH1:TRIGGER:LEVEL -.2
CH1:ACQUIRE:NUM 16
CH1:ACQUIRE:MODE AVERAGE
CH1:START
```

Channel 1 of the VX4250 will now start acquisition with a full scale range of 800 millivolts, at 100 µs per sample, with the input directly coupled. 16 acquisitions will be averaged to produce the resulting waveform. Each acquisition is triggered when the input signal crosses through –200 millivolts in the positive direction. When last of the 16 acquisitions is complete, the acquire status changes to COMPLETE. Issuing the command:

```
CH1:START
```

Will repeat the same process with all of the same conditions. The new result will overwrite the first result, making this example not practical. A parametric measurement step could be added after the START command to extract a parameter such as peak-to-peak volts from the resulting waveform. If maintaining the entire waveform is desired, each result from executing the process could be directed to a different waveform storage location.

Waveform Data Storage and Transfer

Using Waveform Storage Locations

The VX4250 contains eight waveform storage locations. These can be used for storing acquired waveforms, storage for comparison templates, or storage of waveform data loaded from an external source. All operations which handle waveform data can be addressed to use any of the data locations. The location address is specified by compound header commands followed with an argument in the range of 1—8. The location addressing commands are:

`CHx:ACQUIRE:LOC`	*Location for acquisition destination.*
`DATA:LOC`	*Location for sending and receiving waveform data location.*
`WINDOW:LOC`	*Location for data source for parametric measurements.*
`COMPARE:LOC`	*Location of comparison template.*

Location commands, like any other instrument settings commands, stay in effect until they are changed by reissuing the same command with a different argument.

Examples:

`CH1:ACQUIRE:LOC 5`	*Store waveform from channel 1 in location 5.*
`CH2:ACQUIRE:LOC 4`	*Store waveform from channel 2 in location 4.*
`CH1:START`	*Start acquisition on channel 1.*
`CH2:START`	*Start acquisition on channel 2.*

After the channels finish their acquisitions, the VX4250 can be queried for parametric measurements as follows:

`WINDOW:LOC 4`	*Perform the following measurement(s) on data in location 4.*
`PK2PK?`	*Calculate peak-to-peak voltage on data in location 4.*
`WINDOW:LOC 5`	*Perform the following measurement(s) on data in location 5.*
`FREQ?`	*Calculate the frequency of the waveform data stored in location 5.*
`AMPLITUDE?`	*Calculate the amplitude of the waveform data stored in location 5.*

At power up and after an `INIT` command is executed, all of the location commands are set to their default values. The default location is 1 for all commands except `ACQUIRE:LOC`, which defaults to location 1 for channel 1 and location 2 for channel 2. Because the defaults are valid for all operations, users who do not need multiple waveform storage locations can ignore the commands. However, the use of internally stored comparisons will substantially improve the throughput of test systems which use template comparison heavily.

Waveform Data

Waveform data can be accessed through word serial protocol (WSP) or fast data channel (FDC). This section describes waveform access through WSP. For information regarding waveform access through FDC, see Appendix D, *Fast Data Channel Reference*.

Waveform data is transferred through the WSP via the CURVE command. CURVE? causes the VX4250 to send data to the local controller, while CURVE allows the VX4250 to read waveform data from the local controller.

Waveform data can be transferred in one of three formats, and in all three formats, the waveform data is presented as one of 256 values. This corresponds to 8-bit binary data. A method for converting this 8-bit data to a voltage level is explained later in this section.

RIB Waveform Transfer

RIB is a binary waveform format. Waveform data ranges from –128 to 127; that is, –128 is the most negative value, while 127 is the most positive. The advantage of RIB is that the center of the range is at 0.

Example:

```
DATA:ENCDG RIB          Set waveform transfer format to RIB.
CURVE?                  Ask for waveform data.
```

RPB Waveform Transfer

RPB is a positive binary format with the center value being 128. RPB binary values range from 0 to 255.

Example:

```
DATA:ENCDG RPB          Set waveform transfer format to RPB.
CURVE?                  Ask for waveform data.
```

Table 4-1 shows an example of waveform data being transferred in binary format.

Table 4-1. Binary Waveform Transfer Example

Byte	ASCII	Decimal Digit	Hex Digit	Comment
1	C	67	43	Waveform header CURVE
2	U	85	55	
3	R	82	52	
4	V	86	56	
5	E	69	45	
6	< SP>	32	20	
7	#	35	23	Arbitrary block program data
8	2	50	32	Number of bytes in byte count
9	6	54	36	Number of bytes in the waveform
10	9	57	39	transfer is 69 bytes
11	<	60	3C	First byte of waveform data
12	@	64	40	Second byte of waveform data
13	D	68	44	Third byte of waveform data
.	.	.	.	
.	.	.	.	
.	.	.	.	

ASCII Waveform Transfer

Since binary data does not always result in a printable character, an ASCII waveform transfer may be used for debugging purposes, as the example in Table 4-2 shows. ASCII waveform transfers are positive integers that range from 0 to 255. The data is separated by commas.

Example:

```
DATA:ENCDG ASCII          Set waveform transfer format to ASCII.
CURVE?                    Ask for waveform data.
```

Table 4-2. ASCII Waveform Transfer Example

Byte	ASCII	Decimal Digit	Hex Digit	Comment
1	C	67	43	Waveform header CURVE
2	U	85	55	
3	R	82	52	
4	V	86	56	
5	E	69	45	
6	< SP>	32	20	
7	8	56	38	First waveform data point is 85
8	5	53	35	
9	,	44	2C	Comma separated data
10	1	49	31	Second waveform data point is 132
11	3	51	33	
12	2	50	32	
13	,	44	2C	Comma separated data
.	.	.	.	
.	.	.	.	
.	.	.	.	

Transferring a Subset of the Waveform Data

A subset of the 2044 point waveform record can be extracted using the DATA command. In the following example, 128 points are transferred starting at point 1028.

Example:

```
DATA:COUNT 128          Start waveform transfer at the 128th point.
DATA:START 1028         Transfer starts at the 1028th point.
```

The DATA:COUNT command specifies the number of sample points to be transferred. The DATA:START command sets the first point of the waveform transfer to the 1028th point.

Scaling the Data Points

In some applications, it is desirable to convert these 8-bit digitizer values into voltages. In order to convert to voltages, we must examine the waveform preamble information. The waveform preamble is read with the WFMPRE? command. Of the various fields in the waveform preamble, the most important are the YMULT and YZERO values. The YZERO is the DC offset of the waveform in volts, while YMULT is the volts-per-bit value. YMULT is simply the full-scale range divided by 256.

In order to scale RIB (two's complement, binary data), remember that 0 is in the center of the scale. Therefore,

Voltage = Digitizer Level X YMULT - YZERO

Waveforms in RPB (positive integer, binary data), require that the offset value of 128 be subtracted from the digitizer level, because the center value of an RPB waveform is 128.

Voltage – (Digitizer Level – 128) X YMULT - YZERO

Out of Range Signals

The conversion system used in the VX4250 does not provide overrange indication. Input signals which exceed the limits of the operating range in either direction will result in maximum or minimum count in the output data. Because there is no differentiation of overrange from full scale conditions, users should treat the two full scale data values as overrange indications in their applications programs.

Template Waveforms

Template waveforms are simply two waveforms in one. That is, each waveform sample contains a maximum and minimum excursion at that point. Normal waveforms are represented as 8-bits per point. Template waveforms are represented as 16-bits per point. In the waveform preamble, the BYTNR (byte per point) field is 2 for templates and 1 for normal waveforms.

The first byte of the 2-byte sample represents the most positive excursion of the waveform, while the second byte represents the most negative excursion of the waveform at that particular point. Table 4-3 shows template waveform data being transferred into binary format.

Table 4-3. Template Waveform Transfer Example

Byte	ASCII	Decimal Digit	Hex Digit	Comment
1	C	67	43	Waveform header CURVE
2	U	85	55	
3	R	82	52	
4	V	86	56	
5	E	69	45	
6	< SP>	32	20	
7	#	35	23	Arbitrary block program data
8	2	50	32	Number of bytes in the byte count
9	7	55	37	70 bytes in the waveform transfer, or
10	0	48	30	35 samples (2-bytes per sample)
11	~	126	7E	Most positive value for first sample
12	!	33	21	Most negative value for first sample
13	}	125	7D	Most positive value for second sample
14	"	34	22	Most negative value for second sample
.	.	.	.	
.	.	.	.	
.	.	.	.	

Waveform Downloads

The VX4250 provides a WSP facility for downloading waveforms into waveform memory. The most common example is to download a waveform template for template comparison purposes.

In order to successfully download waveforms, we need to examine the waveform transfer format and waveform scaling information.

As described previously, the waveform data transfer format is as follows:

```
CURVE #CB..B<DATA><DATA><DATA>...
```

Where C is the number of characters in the byte count, B..B is the byte count, and <DATA> is the waveform data. For example, the header for a 2044 byte waveform transfer is:

```
CURVE #42044...
```

Waveform data can be downloaded to any waveform location. Selecting the waveform location for downloading is accomplished in the same way it is for uploading.

Example:

```
DATA:LOC 4          Transfer data to/from waveform location 4.
```

Waveform data can be sent in RIB or RPB format. ASCII waveform downloads are not allowed.

When downloading waveform data, it is important to be aware of the waveform preamble information; specifically, the BYTNR field.

The BYTNR field of the waveform preamble tells the VX4250 the number of bytes in a waveform sample. In particular, a template waveform will contain two bytes per sample—therefore, BYTNR should be set to 2.

Example:

```
WFMPRE:BYTNR 2      Two bytes per sample, template waveform.
```

What is Pulse Analysis?

After acquiring a waveform into the VX4250's memory, some useful parameters can be extracted from the data using the set of pulse analysis functions provided with the VX4250. The VX4250 pulse analysis functions are detailed in Table 4-4.

Table 4-4. Pulse Measurement Functions

Magnitude Parameters	Time Parameters	Integrated Parameters	Two Port Parameters
Top	Rise Time	Mean	Gain
Base	Fall Time	RMS	Phase
Maximum	Width	Area	
Minimum	Period	Energy	
Top Overshoot	Frequency		
Base Overshoot	Duty Cycle		
Midpoint			
Peak-to-Peak			
Proximal			
Mesial			
Distal			
Amplitude			

These pulse analysis functions provide some of the common waveform measurements. The pulse parameters are calculated on waveforms stored in the VX4250's memory. This reduces the need to transfer entire waveforms to an external computer for analysis. PASS/FAIL decisions based on the pulse functions can be made on the VX4250 with minimum intervention from an external controller.

Successfully using these functions requires some knowledge of waveform acquisition (as described in the previous section) and a basic understanding of how the pulse analysis functions work.

The following sections provide a basic framework for performing pulse analysis. The pulse analysis functions will be discussed individually first, followed by topics that explain how to customize the measurements for your individual application.

Sample Waveform

For the following examples, the waveform shown in Figure 4-4 will be used. A graticule has been added for reference purposes.

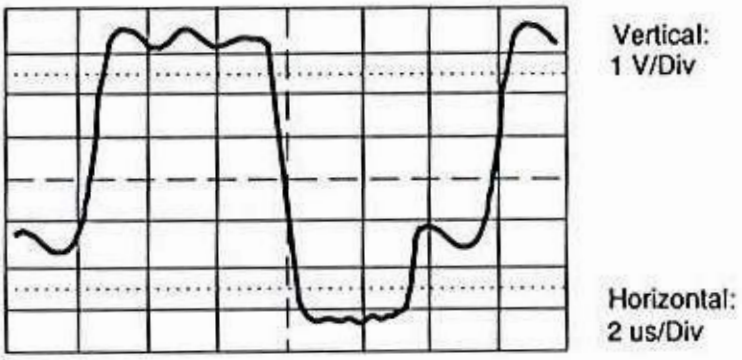


Figure 4-4. Sample Waveform.

Maximum, Minimum, and Peak-to-Peak Voltages

The simplest waveform measurement parameters are maximum and minimum voltages, as shown in Figure 4-5. The VX4250 pulse measurement routines scan the waveform for the largest and smallest sample in the waveform record.

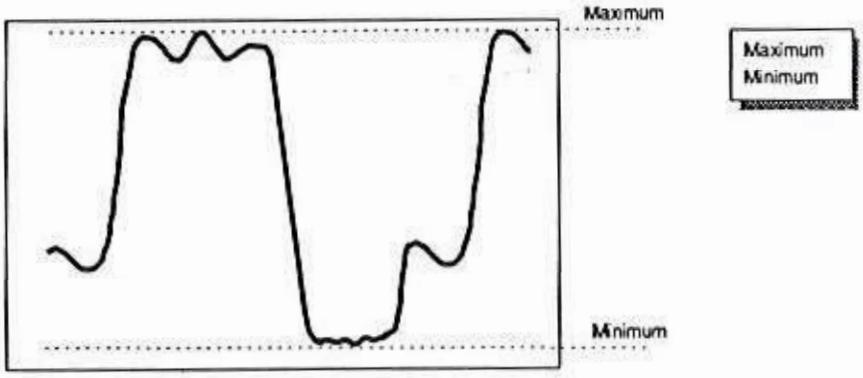


Figure 4-5. Maximum and Minimum Voltages.

Example:

Command:	`MAX?`	*Ask the VX4250 for the maximum value of a waveform.*
Response:	`MAX +3.517E-00;`	*The maximum value is 3.517 V.*
Command:	`MIN?`	*Ask the VX4250 for the minimum value of a waveform.*
Response:	`MIN-3.374E-00;`	*The minimum value is –3.374 V.*

In the waveform shown in Figure 4-16, the top is placed between the two pulse levels. This may or may not be desirable based on your application. However, use of the histogram mode in this case may cause the top (base) to skip between two different levels on multiple acquisitions.

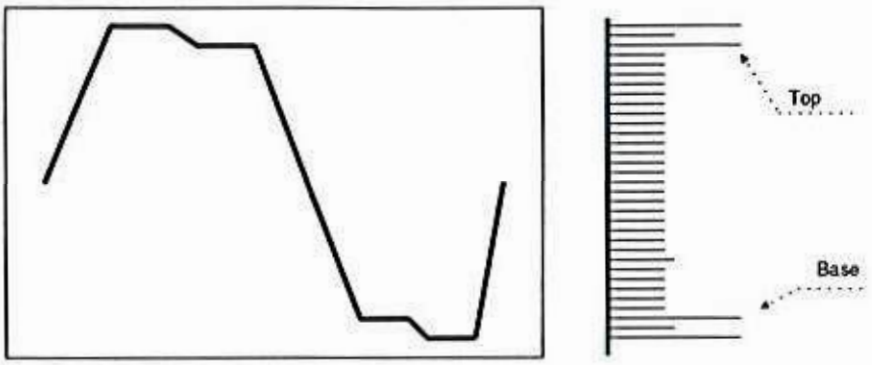


Figure 4-16. Determining Top and Base with Histogram Mode.

An alternative to using the mode of the histogram is to develop a weighted mean of the histogram. That is, each element of the histogram is weighted based on the number of "hits" at that element. The histogram mean method would be useful for the waveform shown in Figure 4-16.

In some cases, the histogram mean would not be a desirable top-base method. As Figure 4-17 shows, the base and top have been moved too far into the middle of the waveform. This waveform could be handled better using the histogram mode method.

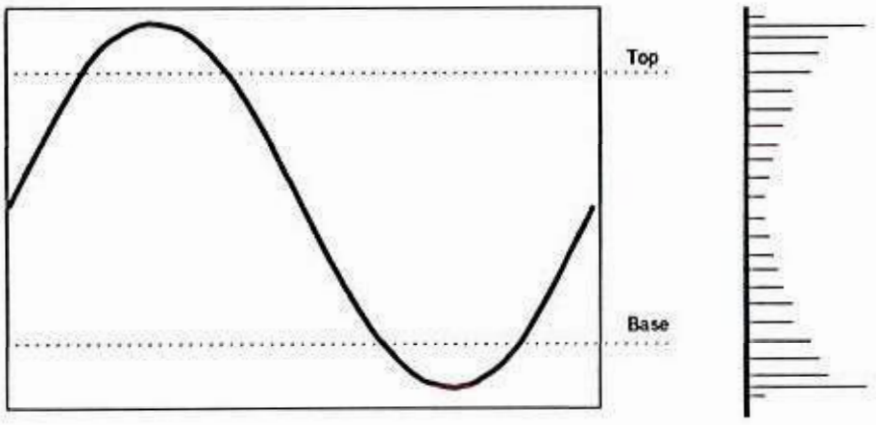


Figure 4-17. Histogram Mean Yielding Undesirable Results.

Note that the top and base values are brought closer to the middle of the waveform due to the distribution of the samples.

Some waveforms have top and base values that are not easily recognizable by use of a histogram. The triangle waveform in Figure 4-18 is such an example.

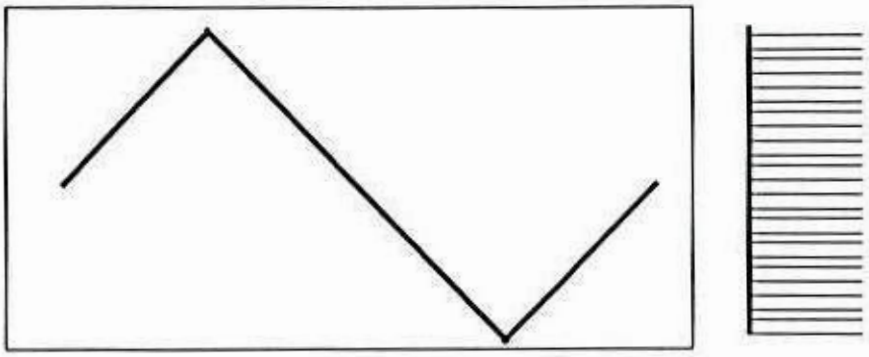


Figure 4-18. Use of the Histogram Mode.

Setting Base and Top to MinMax

Notice that the histogram distribution is even for the entire amplitude. In this case the base/top values will be random. The better base/top determination mode would be MinMax.

Example:

`BMODE:MINMAX`	*Sets base determination method to MinMax.*
`TMODE:MINMAX`	*Sets top determination method to MinMax.*

Every waveform is different, and each application has its own requirements. The top/base determination methods have been provided so that the user can choose the method that best suits the application. There are no absolutes when choosing a top/base method. For most applications, the histogram mode method will be best. However, the user is encouraged to experiment.

Changing Reference Levels

The VX4250 contains provisions that allow modification of reference levels, as shown in Figure 4-19. This allows the flexibility to make rise/fall measurements between the 20% and 80% points, or anywhere else. The only restriction is that the reference levels are as follows: proximal < mesial < distal < 100%.

Example:

```
REFLINES:PROXIMAL 0.2      Proximal level is 20% of the amplitude.
REFLINES:DISTAL 0.95       Distal level is 95% of the amplitude.
```

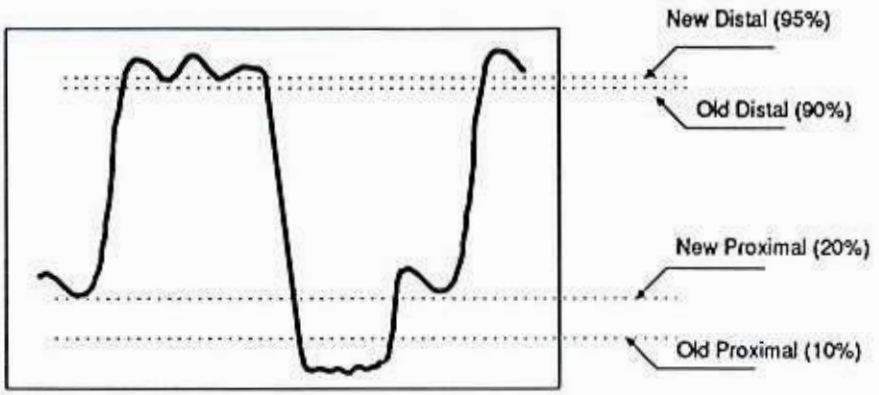


Figure 4-19. Changing Reference Parameter Levels.

Testing

Saving the expected result

To compliment the COMPARE:HIGH and COMPARE:LOW parameters, it may be useful to save the expected value with COMPARE:NOMINAL. This parameter is *not* used in the decision-making process; it is available to document the test more completely.

Example:

```
CH1:COMPARE:HIGH 1.2
CH1:COMPARE:LOW 0.9
CH1:COMPARE:NOMINAL 1.0
```

Saving the nominal value with the high and low bounds, documents the margins allowed. For example, if COMPARE:HIGH is 1.2 and COMPARE:LOW is .9, the nominal value of 1.0 may record asymmetric margins of +20% and –10% respectively.

Sequencing

Infinite Loop Testing

Once a test sequence of multiple tests has been defined, it is possible to run all tests just once, or run all tests continuously.

Example:

```
CH1:STEP:MODE LOOP
CH1:START;
```

In loop mode, only one `START` command need be issued. The only way to end this infinite loop is to issue the `STOP` command. When the channel is running in LOOP mode, the results may be continuously queried to obtain the latest complete measurement. This mode of operation may be useful for monitoring the signal parameters in realtime, by just using the RESULT? mechanism.

Getting Detailed Test Results

Once a test sequence has been run, it is possible to query the results. For instance, to query the results of test step #2, enter the command shown in the example that follows.

Example:

```
Command: CH1:RESULT:LONG? 2;        Find result of step #2.
Response: MAX,PASS,1.000E+00,1.500E+00,500E-03,NORMAL;
```

The RESULT? command will access the information that resulted from the test step being run. The information is in the form of: MEASUREMENT TYPE, PASS/FAIL, the measured value, the upper bound, the lower bound and the acquisition mode.

The parameter that comes after RESULT? specifies which test step result is needed.

Performance Enhancements

Several methods are available to reduce runtime test times. These include single acquisition with multiple measurements and fast data access, which are explained here.

Single Acquisition with Multiple Measurements

When many waveform parameters need to be tested, while running in STEP:MODE RUN or LOOP, the total test time may be reduced by making a single acquisition and many tests. The method for doing this is setting CHx:ACQUIRE:MODE OFF before SAVING the step. The example that follows shows how to enter the commands to save, for instance, test step #2. This eliminates the task of acquiring a new waveform and proceeds directly to the analysis.

Example:

```
CH1:ACQUIRE:MODE OFF
CH1:SAVE 2
```

When the above test step #2 is encountered in the channel sequence, no new acquisition takes place. Measurement and testing will immediately follow, performed on the data already present in the specified data location.

Fast Data Access

This feature offers a solution to the problem of moving large control and data blocks quickly, in and out of the instrument through the physical shared memory.

The commands to accomplish this are not elaborate. They are *simple* and *fast*. The commands are sent over Word Serial Protocol and return information regarding the location and size of the physical memory containing the data. With this information, the physical memory may be directly accessed by the controller. Briefly:

1. The controller asks the instrument where the base address of its shared memory resides with "FDCBASE?"

2. If the FDCSIZE? arguments are sent, then the response indicates the size of the data block in shared memory.

3. The controller with (a) base address and (b) size, extracts the data and stores it.

Example:

Command:	FDCBASE?	
Response:	#H200000;	*Note hexadecimal response*
Command:	FDCSIZE?	
Response:	65528;	*Note decimal response*

The code segments below show how to use these commands to read/write through EPCONNECT.

```
read_data( unsigned long fdc_base, unsigned short fdc_size, char *buffer )
{

        ep_set_acc_mode( A24ND | BM_MBO );
        ep_from_vme( BM_FASTCOPY | BM_W16, fdc_base, buffer, fdc_size );
}

write_data( unsigned long fdc_base, unsigned short fdc_size, char *buffer )
{

        ep_set_acc_mode( A24ND | BM_MBO );
        ep_to_vme( BM_FASTCOPY | BM_W16, buffer, fdc_base, fdc_size );
}
```

In the above example, the VME A24 address and size of the shared memory region is found. This infomation is used to read and write *all* of the shared memory information which includes all waveform locations and stored setups for both channels. Refer to Appendix D, *Fast Data Channel Reference* for more detailed information on data buffer content and format.

Section 5
Command Notation and Formats

Introduction

This section contains introductory information about the notation and format conventions used in the command descriptions for the VX4250. The actual command descriptions are covered in the next section of this manual, Section 6, *Command Dictionary*. Commands use the formats and conventions established by ANSI/IEEE Standard 488.2–1987, IEEE Standard Codes, Formats, Protocols, and Common Commands. The format description given here covers the style used by most programmers and virtually all controllers. The IEEE Standard 488.2 allows considerably more flexibility in command structures than what follows in this section. More information on the command format options available can be found in Appendix 20A of the IEEE 488.2 Reference Manual.

Command Notation

Command format descriptions and descriptive tables use the following standard notation.

These characters are used for descriptions, and do not appear in the command syntax.

< >	Delimits a required, defined element to be provided by the user.
[ ]	Delimits an optional element.
[ ]...	Delimits an optional element that may be omitted, or repeated one or more times.
{ }	Delimits a group of elements from which one must be selected.
|	Delimits the individual elements in a group form which one must be selected.

These delimiters *do* appear as shown in the command syntax.

: (colon)	Compound command header separator used to delimit compound command headers.
, (comma)	Data separator used to delimit multiple command arguments.

ASCII Code

In general, all elements for commands are transmitted in 7-bit ASCII code. However, 8-bit words are used when arguments are transmitted in binary Arbitrary Block Data format.

Number Base

Unless otherwise noted, all numbers are assumed to be decimal (base 10).

Decimal Numeric Data Format

All decimal command arguments can be entered in any format: integer, floating point, or exponential notation (referred to in IEEE 488.2 as NR1, NR2, and NR3 respectively). Depending upon the command, the query response will always be in one of two forms, INTEGER or REAL. INTEGER format (referred to as NR1 in IEEE Standard 488.2) may be signed or unsigned. Arguments denoted as REAL, (referred to as NR3 in IEEE Standard 488.2), will be returned in Engineering notation; i.e., 43.27E-06. The format will have a four digit mantissa, followed by a two digit exponent which is a multiple of three.

General Command Format

In the following examples, this command format will be broken down to illustrate the significance of the various pieces.

Header Arguments

```
[CHx]:<COMMAND HEADER>[?] [<ARGUMENT>];
```

The header argument CH1 or CH2 is required at the beginning of commands which control acquisition and measurement in order to direct the command to the appropriate channel. Because the acquisition systems are totally independent, commands can be sent to change the settings of one channel while the other channel is making an acquisition.

EXAMPLES:

```
CH2:STOP
```

This command causes the acquisition process on channel 2 to stop.

```
CH1:RANGE 8
```

This command sets the full scale range of channel 1 to 8 volts.

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