

ARTISAN®
TECHNOLOGY GROUP

Your **definitive** source for quality pre-owned equipment.

Artisan Technology Group
(217) 352-9330 | sales@artisantg.com | artisantg.com

Full-service, independent repair center
with experienced engineers and technicians on staff.

We buy your excess, underutilized, and idle equipment
along with credit for buybacks and trade-ins.

Custom engineering
so your equipment works exactly as you specify.

- Critical and expedited services
- In stock / Ready-to-ship
- Leasing / Rentals / Demos
- ITAR-certified secure asset solutions

Expert team | Trust guarantee | 100% satisfaction

All trademarks, brand names, and brands appearing herein are the property of their respective owners.

Visit our website - *Click HERE*

WAVETEK

OPERATOR'S MANUAL

Model 1375
Arbitrary Waveform Generator

For Model 1375 Maintenance Information, refer to separate Maintenance Manual, P/N 1006-00-0611-01.

© 1996 Wavetek Ltd.

This document contains information proprietary to Wavetek and is provided solely for instrument operation and maintenance. The information in this document may not be duplicated in any manner without the prior approval in writing from Wavetek.

Wavetek Ltd.
Hurricane Way,
Norwich Airport Industrial Estate
Norwich
Norfolk NR6 6JB
UK

Tel: 44 1603 404 824
Fax: 44 1603 483 670

Manual Revision: 12/90
Manual Part Number 1006-00-0611

CONTENTS

OPERATOR'S MANUAL
MODEL 1375

SECTION 1 GENERAL DESCRIPTION

1.1	MODEL 1375	1-1
1.2	STANDARD FEATURES	1-1
1.2.1	Modes of Operation	1-1
1.2.2	Resolution	1-1
1.2.3	Frequency	1-2
1.2.4	Amplitude and Offset	1-2
1.2.5	Inputs	1-2
1.2.6	Outputs	1-2
1.2.7	Data Sources	1-2
1.2.8	Editing	1-2
1.3	SPECIFICATIONS	1-2
1.3.1	Modes of Operation	1-2
1.3.2	Waveform Resolution	1-2
1.3.3	Trace Output Characteristics	1-3
1.3.4	Output Frequency	1-3
1.3.5	Amplitude	1-3
1.3.6	Offset	1-3
1.3.7	Clocks	1-3
1.3.8	Triggers	1-3
1.3.9	Marker Outputs	1-4
1.3.10	Filtering	1-4
1.3.11	Pre-defined Waveshapes	1-4
1.3.12	Memory	1-4
1.3.13	VXI Interface	1-4
1.3.14	Physical	1-4
1.3.15	Options	1-5

SECTION 2 INITIAL PREPARATION

2.1	RECEIVING INSPECTION	2-1
2.1.1	Unpacking Instructions	2-1
2.1.2	Returning Equipment	2-1
2.2	LOGICAL ADDRESS SELECTION	2-1
2.3	DATA TRANSFER BUS ARBITRATION	2-1
2.4	INSTALLATION	2-4
2.5	ELECTRICAL CHECK OUT	2-4
2.5.1	Instrument Operation Tests	2-4
2.5.2	Operation Verification procedure	2-6

CE

This product complies with the requirements of the following European Community Directives:
89/336/EEC (Electromagnetic Compatibility) and **73/23/EEC (Low Voltage)**
as amended by **93/68/EEC (CE Marking)**.

However, noisy or intense electromagnetic fields in the vicinity of the equipment can disturb the measurement circuit. Users should exercise caution and use appropriate connection and cabling configurations to avoid misleading results when making precision measurements in the presence of electromagnetic interference.

SECTION 3 OPERATION

3.1	INTRODUCTION	3-1
3.2	CONNECTORS AND INDICATORS	3-1
3.2.1	Front Panel	3-1
3.2.2	Rear Panel	3-2
3.3	POWER-UP AND *RST DEFAULTS.	3-2
3.4	CREATING ARBITRARY WAVEFORMS	3-3
3.5	SCPI (STANDARD COMMANDS FOR PROGRAMMABLE INSTRUMENTS) PROGRAMMING FORMAT	3-4
3.6	PROGRAMMING ERRORS	3-5
3.7	MODEL 1375 PROGRAMMING TUTORIAL	3-5
3.7.1	Basic Commands	3-6
3.7.2	Trigger Programming	3-7
3.7.3	Backplane Triggering	3-7
3.7.4	Agated Programming	3-8
3.7.5	Sgated Programming	3-8
3.7.6	Burst Programming	3-8
3.7.7	Reference Oscillator	3-9
3.7.8	Operator Defined Trace	3-9
3.7.9	Trace Subsystem Queries	3-10
3.7.10	Remaining Trace Subsystem Commands	3-11
3.7.11	Triggered Sequence Programming	3-12
3.7.12	Marker Programming	3-13
3-7-13	Marker Triggering	3-13
3.7.13.1	Marker Position Backplane Triggering	3-14
3.7.13.2	Marker Sync Backplane Triggering	3-14
3.8	OUTPUT SUBSYSTEM	3-17
3.8.1	Output Trace ON/OFF State	3-18
3.8.2	Output Filter ON/OFF State	3-19
3.8.3	Output Trigger to Backplane	3-20
3.8.3.1	Trigger Output Line and Source	3-21
3.8.3.2	Trigger Output Line ON/OFF State	3-22
3.8.4	Output Clock to Backplane	3-23
3.8.4.1	Clock Output Line and Source	3-24
3.8.4.2	Clock Output Line ON/OFF State	3-25
3.9	MODE SUBSYSTEM	3-27
3.10	SOURCE SUBSYSTEM	3-31
3.10.1	Source Voltage	3-32
3.10.1.1	Source Amplitude	3-33
3.10.1.2	Source Offset	3-34
3.10.2	Source Frequency	3-35
3.10.2.1	CW (Arb Output Frequency)	3-36
3.10.2.2	Raster (Memory Scan Frequency)	3-37
3.10.3	Source Reference Oscillator	3-38
3.10.4	Source Triggered Sequence	3-40
3.10.5	Source Burst	3-41
3.11	TRIGGER SUBSYSTEM	3-43
3.11.1	Trigger Source	3-44
3.11.2	Trigger Frequency	3-45
3.12	TRACE SUBSYSTEM	3-47
3.12.1	Trace Definition	3-49
3.12.2	Data Input	3-53
3.12.2.1	Factory Pre-defined, User defined, and Block Entry	3-53
3.12.2.2	Line entry	3-59
3.12.3	Trace Mode	3-61
3.12.4	Trace Points	3-63

3.12.5 Trace or Block Limits 3-65
3.12.6 Trace Select 3-67
3.12.7 Trace Catalog Query 3-68
3.12.8 Memory Free Query 3-68
3.12.9 Directory Query 3-68
3.12.10 Trace Status (Memory Diagnostic Report) 3-69
3.12.11 Trace Delete 3-71
3.13 MARKER SUBSYSTEM 3-73
3.13.1 Marker ON/OFF State 3-74
3.13.2 Marker Position 3-75
3.13.2.1 Points (insert) 3-75
3.13.2.2 Points (All Off) 3-75
3.13.3 Marker Sync 3-76
3.14 SYSTEM SUBSYSTEM 3-77
3.15 STATUS SUBSYSTEM 3-79

SECTION 4 COMMON COMMANDS

4.1 **COMMON COMMANDS** 4-1
4.1.1 ***CLS** Clear Status 4-1
4.1.2 ***ESE** Standard Event Status Enable 4-1
4.1.3 ***ESE?** Standard Event Status Enable Query 4-1
4.1.4 ***ESR?** Standard Event Status Register Query 4.2
4.1.5 ***IDN?** Identification Query 4-2
4.1.6 ***OPC** Operation Complete 4-2
4.1.7 ***OPC?** Operation Complete Query 4-2
4.1.8 ***RST** Reset 4-3
4.1.9 ***SRE** Service Request Enable 4-3
4.1.10 ***SRE?** Service Request Enable Query 4-3
4.1.11 ***STB?** Read Status Byte Query 4-3
4.1.12 ***TRG** Trigger 4-4
4.1.13 ***TST?** Self-Test query 4-4
4.1.14 ***WAI** Wait -to-Continue 4-4

APPENDIX

A MODEL 1375 COMMAND TREE A-1
B MODEL 1375 COMMAND and PARAMETER LIST B-1
C SCPI BEGINNERS GUIDE C-1
D ARB SYSTEM ERROR MESSAGES D-1
E SAMPLE PROGRAMS E-1
E1.1 Square Wave (Continuous pre-defined shape) E-1
E1.2 Sine Wave (Triggered pre-defined shape) E-2
E1.3 8-point Sine Wave (Arbitrary block transfer) E-3
F SCPI CONFORMANCE F-1
G LOW LEVEL INTERFACE COMMANDS G-1

LIST of ILLUSTRATIONS

OPERATOR'S MANUAL
MODEL 1375

FIGURE	TITLE	PAGE
1-1	Wavetek Model 1375 Arbitrary Waveform Generator	1-1
2-1	Set the Logical Address	2-2
2-2	Bus Arbitration Level Jumpers	2-3
2-3	Self Test Status Word	2-4
2-4	Decimal to Binary Status Word Conversion Example	2-5
3-1	Connectors and Indicators	3-1
3-2	RAM Diagram	3-3
3-3	Waveform Plotting	3-4
3-4	Trace Limit Plotting	3-11
3-5	Trace Line Plotting	3-12
3-6	Arb Trigger Output to VXI Backplane	3-20
3-7	Arb Clock Output to VXI Backplane	3-23
3-8	Clock/Trigger Input/Output Block Diagram	3-26
3-9	Trigger and Signal in the Asynchronous Gated Mode	3-27
3-10	Trigger and Signal in the Synchronous Gated Mode	3-27
3-11	Trigger and Signal in the Triggered Mode	3-28
3-12	Trigger and Signal in the Burst mode	3-28
3-13	Trigger and Signal in the Triggered Sequence Mode	3-29
3-14	Point Value vs Amplitude	3-32
3-15	CW Block Diagram	3-35
3-16	Raster Block Diagram	3-35
3-17	Input Clock Selections	3-38
3-18	Input Trigger Selections	3-43
3-19	Initialized Memory after Power-up	3-50
3-20	Copying a Pre-defined Trace into Default Memory Size	3-50
3-21	Allocating Memory Space for New Traces	3-51
3-22	Copying an Existing Trace in its Entirety	3-52
3-23	Copying a Pre-defined Trace into an Allocated Memory Size	3-54
3-24	Copying an Existing Trace into a Non-equal Allocated Memory Size	3-55
3-25	Copying a Trace into a Larger Allocated Destination	3-56
3-26	Copying a Trace into a Smaller Allocated Destination	3-56
3-27	A Block of Data Transferred into Memory	3-57
3-28	Using the Line Command to Alter a Trace	3-59
3-29	Using the Line Command to Create a Trace	3-60
3-30	Reducing the Trace Size	3-63
3-31	Incresing the Trace Size	3-64
3-32	Rearranging Memory	3-64
3-33	Changing the Trace Start and Stop points	3-65
3-34	Changing the Block Start and Stop Points	3-66
3-35	Memory Diagnostic Summary Word	3-69
3-36	Delete the First Trace in Memory	3-71
3-37	Delete any Trace in Memory	3-72
3-38	Delete All Traces in Memory	3-72
3-39	Trigger, Sync, Marker, and Arb Output Timing	3-73
3-40	Sync when Using ZCROs	3-76
3-41	Sync when Using BBITs	3-76

LIST of TABLES

TABLE	TITLE	PAGE
2-1	Self Test Format	2-5
2-2	Self Test Equipment and Tools	2-6
3-1	Power-up Defaults	3-2
3-2	Model 1375 Programming Tutorial	3-5
3-3	Basic Commands	3-7
3-4	Trace Query Response	3-10
3-5	Marker Programming Examples	3-13
3-6	Memory Diagnostic Word Description	3-70

SAFETY FIRST



PROTECT YOURSELF. Follow these precautions:

- Don't touch the outputs of the instrument or any exposed test wire carrying the output signals. This instrument can generate hazardous voltages and currents

- Don't bypass the power cord's ground lead with two-wire extension cords or plug adapters.

- Don't disconnect the green and yellow safety-earth-ground wire that connects the ground lug of the power receptacle to the chassis ground terminal

(marked with ⏚ or ⚠)

- Don't hold your eyes extremely close to an RF output for a long time. The normally nonhazardous low-power RF energy generated by the instrument could possibly cause eye injury.

- Don't plug in the power cord until directed to by the installation instructions.

- Don't repair the instrument unless you are a qualified electronics technician and know how to work with hazardous voltages.

- Pay attention to the **WARNING** statements. They point out situations that can cause injury or death.

- Pay attention to the CAUTION statements. They point out situations that can cause equipment damage.

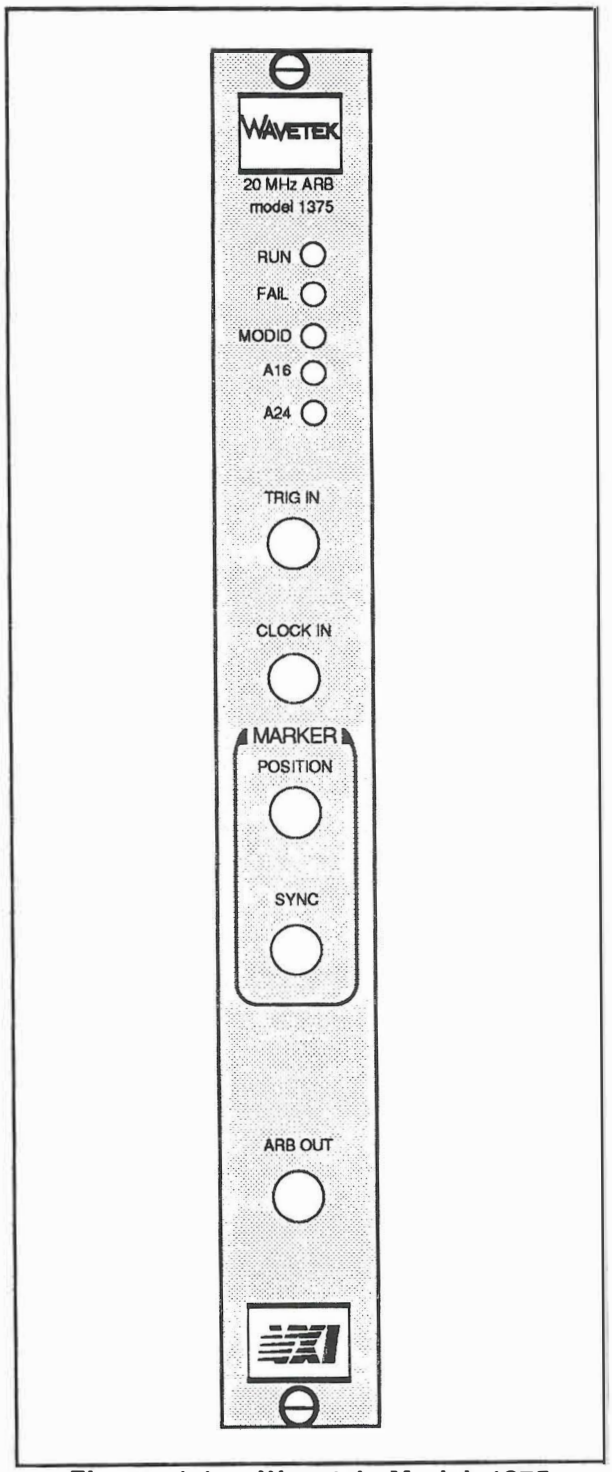


Figure 1-1. Wavetek Model 1375 Arbitrary Waveform Generator

SECTION 1

GENERAL DESCRIPTION

1.1 MODEL 1375

The Arbitrary waveform generator has a variety of applications in scientific research, test and measurement, industrial facilities, and in commercial use, limited only by the users imagination. Using the Arb, waveshapes can be created which simulate a wide range of natural events. Waveshapes can be created based on known data then altered to research a variety of possible malfunctions or improvements. Used in conjunction with other VXI modules, the Model 1375 Arb becomes part of a system that uniquely simulates an event which can be measured by other instruments.

1.2 STANDARD FEATURES

The Model 1375 Arb adheres to the Standard Commands for Programmable Instruments (SCPI) remote programming format Version 1.0, April 1990 (refer to the SCPI manual for further information). SCPI is a new industry standard language for remote instrument programming. The Wavetek Model 1375 Arbitrary Waveform Generator is a single slot C size ,VXI module.

1.2.1 Modes of Operation

The Arb has six operating modes: a Continuous mode, two Gated modes, a Triggered mode, a Burst mode, and a Triggered Sequence mode. The Triggered Sequence mode operates on 8192 point blocks, the others operate on the selected waveform.

1.2.2 Resolution

The Model 1375 has a minimum of 8 and a maximum of 32,768 locations (32K) of addressable waveform points (a 128K option is available). The vertical resolution of each point is 12 bits (4096 values). Single waveforms may be assigned any size between 8 points and the maximum memory remaining.

1.2.3 Frequency

The output signal has a frequency range from 100 mHz to 2.5 MHz. The frequency accuracy is dependent on the clock reference used. The default clock uses the VXI Resource Manager 10 MHz clock, CLK10.

1.2.4 Amplitude and Offset

The output amplitude ranges from 5mVp to 5Vp into 50Ω with a resolution of 3-1/2 digits and a default of 1Vp. A dc offset between -5V and +5V may be selected with a resolution of 3-1/2 digits and a default of 0V. Amplitude and Offset are coupled, limiting the output voltage to 5Vp.

1.2.5 Inputs

The Model 1375 Arb has two TTL signal inputs on the front panel, clock and trigger. The external clock frequency may range from DC to 20 MHz, the external trigger may range from 1mHz to 2MHz. Additionally, four clock and four trigger inputs can be accessed through the VXI backplane TTLTRG lines. The clock and trigger input lines from the backplane are limited by the VXI specifications to a maximum of 12.5 MHz.

1.2.6 Outputs

The Model 1375 Arb has three output signals on the front panel: the arbitrary waveshape that has been created, the Marker Sync and the Marker Position. The Arb also provides both a clock and a trigger output to the selected VXI TTLTRG lines. The source of both the clock and trigger output provided to the backplane is selectable.

1.2.7 Data Sources

The Arb has a variety of ways to create a waveform. External binary data may be down loaded from a host. Internal "standard waveform" algorithms in ROM will create exactly one cycle of the waveform (random and dc, obviously, are not cyclical). Previous user created waveshapes residing in memory may be copied. Waveforms can be built from entered line segments.

1.2.8 Editing

The Model 1375 has several editing features. After filling the allocated memory with data defining the waveform, the user may select the entire waveform or only a portion to be "played back" (Trace-Limit command). Any selected portion may be used for creating a new waveshape (Trace-Data command). An existing trace may be overwritten with new data (Trace-Data command). Any trace may be expanded or reduced by copying it into a different size memory; the integrity of the shape is maintained (Trace-Data command). Wave-shape segments may be copied end to end creating new shapes (Trace-Data command). A trace may be re-sized (Trace-Points command). A line segment can be created (Trace-Line command). Any waveform in the directory can be selected for "play back" (Trace-Select command). Traces may be deleted individually or globally (Trace-Delete command).

1.3 SPECIFICATIONS

1.3.1 Modes

Continuous:
Waveform is continuously generated.

Triggered:
One cycle of waveform generated for each trigger.

Asynchronous gated:
Waveform generated only when trigger is high.

Synchronous gated:
Waveform generated only when trigger is high, completes existing cycle after trigger goes low.

Burst:
Waveform repeats between 1 and 10,000,000 times.

Triggered Sequence:
Waveforms generated using 1, 2, 3, or 4 sequentially triggered 8192 point blocks (16 blocks with option 01).

Maximum trigger frequency is 2MHz.

Block switching time: <200 nS in CW mode or 2 clock cycles in Raster Mode.

1.3.2 Waveform Resolution

Horizontal:
32K points, 128K points with option 01.

Vertical:
12 bits.

1.3.3 Trace Output Characteristics

Settling Time:
40 nS to 0.1%.

Square Transition:
<35 ns, 10% to 90% at 5Vp.

Square Aberrations:
Overshoot/ringing
0.501 Vp to 5Vp, <6% + 40 mV
0.0501 Vp to 0.5 Vp, <6% + 4mV
0.00501 Vp to 0.05 Vp, <6% + 1mV

Sine Distortion:
(400 mVpp < V< 10Vpp, 4MHz filter on)
F_O< 20 kHz, harmonics < -60 dBc (< 0.2% THD)
20 kHz <F_O< 100 kHz, harmonics < -50 dBc (< 0.7% THD)
100 kHz <F_O< 2.5 MHz harmonics,-40 dBc.

Intermodulation Products (Spurs):
4MHz filter on
<1MHz, -50dBc, limited by 50µVpp.
≥1MHz, -60dBc, limited by 50≥Vpp.

1.3.4 Output Frequency

Range:
100 mHz to 2.5 MHz.

Resolution:
10 mHz at output frequencies > 100 Hz; 1mHz at output frequencies <100 Hz.

Accuracy:
Provided by the selected clock source.
Internal source, provided by VXIbus CLK10 .
Frequency accuracy is equal to the selected source accuracy specification + 10 nHz.

1.3.5 Amplitude

Range:
5mVp to 5Vp into 50Ω, coupled to offset.
Default: 1Vp.

Resolution:
3 1/2 digits.

Accuracy:
±(1.0% + 5mV) at 0.505 Vp to 5.000 Vp.
±(1.0% + 0.5 mV) at 0.0505 Vp to .5000 Vp.
±(1.0% + 0.05 mV) at 5.00 mVp to 50.00 mVp.

Flatness:
Sine response relative to 1kHz sine, filter on.
±2% from 40 Hz to 50 kHz.
±5% from 50 kHz to 1MHz.
±10% from 1MHz to 2.5 MHz.

Monotonicity:
0.2% (9 bits).

1.3.6 Offset

Range:
±5V into 50Ω, coupled to amplitude.

Resolution:
3 1/2 digits.

Accuracy:
±(1.5% + 0.5 mVdc) at 0mVdc to ±50.0 mVdc.
±(1.5% + 5mVdc) at ±50.1 to ±500.0 mVdc.
±(1.5% + 25 mVdc) at ±0.501 to ±5.0 Vdc.

1.3.7 Clocks

CW Mode:
20 MHZ when Internal clock selected.
Accuracy provided by the selected source.
Internal selection accuracy (VXI CLK10) ±100 PPM (0.01%).

Raster Mode:
Range from 1mHz to 20 MHz, user selectable.
Resolution 4 digits limited by 1mHz.
Accuracy provided by the selected source.
Internal selection accuracy (VXI CLK10) ±100 PPM (0.01%).

External Input:
TTL input at front panel BNC.
Selectable by programming.
Range from DC to 20 MHz.
Input impedance is 5kΩ, 33pF shunt.
Protected to ±20 Vdc.

VXI Backplane:
Four odd TTLTRG lines (TTLTRG1, 3, 5, 7).
Selectable by programming, one as an output and/or one as an input.
Maximum backplane frequency 12.5 MHz.

1.3.8 Triggers

Internal:
Range from 1mHz to 2MHz.
Output pulse width to backplane is >100ns.
Resolution can be set in 100ns increments.
Accuracy is provided by the VXIbus CLK10.

External input:
TTL input at front panel BNC.
Maximum Arb trigger frequency is 2MHz.
Minimum required pulse width: 50ns.
Protected to ±20 Vdc.
Slope: Positive.

VXI Backplane:
Four even TTLTRG lines (TTLTRG0, 2, 4, 6). Selectable by programming, One as an output and/or one as an input.
Maximum backplane frequency 12.5 MHz.
Slope (input/output): Negative.

Programmed:
***TRG** may be used as a trigger.

Trigger to Trace delay:
maximum 1 clock + (<100ns).

1.3.9 Marker Outputs

Sync:
TTL output into 50Ω, synchronous with waveform. Protected against short circuit to ground. Rise and Fall time <20 ns into 50Ω.

ZERO CROSSING DETECTOR.
Sync is a TTL high when waveform is above 2048 (0V).

BEGINNING BITS
Sync is a TTL high for 1 to n clock cycles at first trace memory location in use (mode sensitive width, 50 ns minimum).

Position:
TTL output into 50Ω, short circuit protected.
User definable marker state for each point.
Rise and Fall time <20 ns into 50Ω.

Accuracy
Low level <0.4V into > 10KΩ.
High level > 2.5V and < 4.0V into >10KΩ.
Low level <0.2V into 50Ω.
High level >2.0V and <2.5V into 50Ω.
Rise and fall time <20 ns into 50Ω

1.3.10 Filtering

Programmable insertion, 4MHz, 6 pole, 0.5 dB flatness to 2.5 MHz.

1.3.11 Pre-defined Waveshapes

Sinusoid:
One cycle of a sine wave.

Square:
One cycle of a square wave.

Triangle:
One cycle of a triangle wave.

Positive Ramp:
A positive ramp from 1 to 4095.

Negative Ramp:
A negative ramp from 4095 to 1.

Positive Haversine:
Two cycles of an inverted cosine, the most negative point is 2048 (0V).

Negative Haversine:
Two cycles of a cosine, the most positive point is 2048 (0V).

Random:
Random point values.

DC:
The point value 2048, output range ±5V

SINC (sinx/x):
A SINC pulse spanning ±16π radians.

1.3.12 Memory

Standard 32,768 words of volatile RAM.
Optional 131,072 words of volatile RAM.

1.3.13 VXI Interface

VXIbus P1 and P2 connector.
A16/A24/A32 bus master capability.
Full A16/A24/A32 register access.
All A16 registers provided.
Message based, 1K input buffer

1.3.14 Physical

Weight:
<1.6kg (3.4 lb)

Power:
<32W.
+5V at 2.5A peak.
+12V at 0.15A peak.
-12V at 0.15A peak.
+24V at 0.2A peak.
-24V at 0.2A peak.
-5.2V at 0.35A peak.
-2V at 0.1A peak.

Dimensions:
Single slot, "C" size VXI module.

Specifications temperature:
Calibrated at 23° C ±3° C.

Operating Temperature
0°C to +50°C.

1.3.15 Option

01 128K memory.

SECTION 2

INITIAL PREPARATION

2.1 RECEIVING INSPECTION

Check the shipment at the time of delivery and inspect each box for damage. Describe any box damage and list any shortages on the delivery invoice.

2.1.1 Unpacking Instructions

1. **Unpack the boxes**. Unpack the boxes in a clean and dry environment. Save all the packing in case the instrument has to be returned for repair.
2. **Inspect the shipment for damage**. Inspect the equipment carefully for any signs of mechanical damage regardless of the condition of the shipping boxes.
3. **If necessary, file a claim**. In the case of mechanical damage, call the shipper immediately and start the claim process.
4. **Call Wavetek**. Call Wavetek's Customer Service representative (619-279-2200) to inform them that the shipment arrived damaged. Please be prepared to provide a detailed damage report.

2.1.2 Returning Equipment

Follow these steps when you return equipment to Wavetek:

1. **Save the packing material**. Always return equipment in its original packing material and boxes. If you use inadequate material, you'll have to pay to repair any shipping damage as carriers won't pay claims on incorrectly packed equipment.
2. **Call Wavetek Customer Service and ask for a return authorization.** The Wavetek Customer Service representative (619-279-2200) will ask for your name, telephone number, company name, equipment type, and a description of the problem.
3. **Pack and ship the equipment.**

2.2 LOGICAL ADDRESS SELECTION

The VXIbus logical address for the Arb can be set using the eight position DIP switch accessible on the side panel (refer to figure 2-1). The address is used by the Commander to communicate with the Arb. All 256 addresses can be set, however, two addresses are unique. Address "0" is reserved for the VXI Resource Manager. Address 255 permits the Resource Manager to dynamically configure the logical address (soft address). The Arb uses active low logic at the switch. The switch must be turned OFF to generate a logical 1. Switch position 1 is the least significant bit. The Arb is shipped with address 255, all 1's. An example of address "3" and address "255" are shown in figure 2-1.

2.3 DATA TRANSFER BUS ARBITRATION

The Model 1375 has VMEbus Mastership capability. This means the Arb, when enabled, sends Responses and Events as signals to its Commander (the Arb does not have the capability to interrupt the Commander).

Because the Arb is configured as a level 3 requestor at the factory, the level 3 Bus Request and Grant lines are used (BR3*, BG3IN*, and BG3OUT*). The other Bus Grant lines are daisy-chained by jumpers. The VMEbus specifications describe three priority schemes: Prioritized, Round-robin, and Single level. Prioritized arbitration assigns the bus according to a fixed priority scheme where each of four bus request lines has a priority from highest (BR3*) to lowest (BR0*). Round-robin arbitration assigns the bus on a rotating priority basis. Single level arbitration only accepts requests on BR3*.

If a different Arb requestor level is required, the jumpers must be changed. The following instructions and figure 2-2 will aid in reconfiguring the Arb to the new level. Refer to the VMEbus specification for more information on '*data transfer bus arbitration*'.

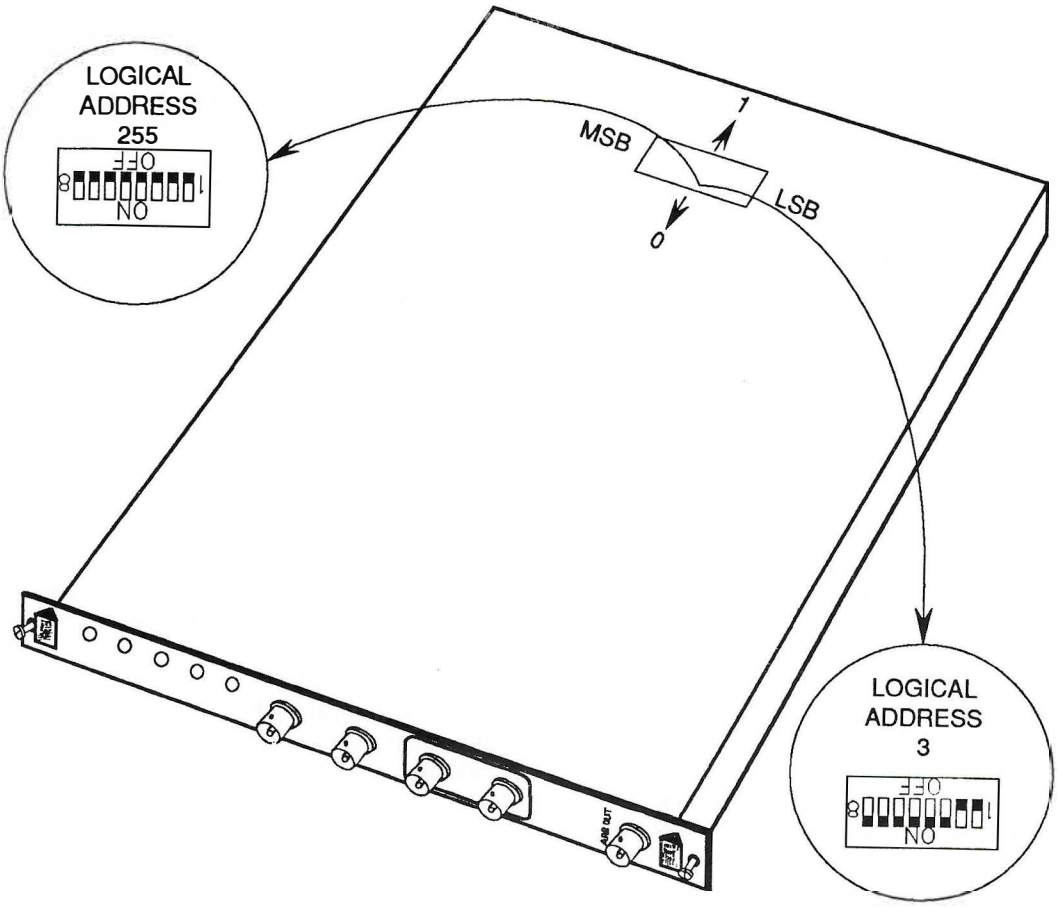


Figure 2-1. Set the Logical Address

CAUTION

The Arb contains CMOS devices which are sensitive to static electricity. When performing the bus arbitration level change, static electricity discharge straps should be worn.

1. Remove the four flat head screws on the Arb left side panel, remove the panel.

2. Remove the four pan head screws holding the VXI Interface card to the main Arb board.

3. Slowly and gently lift the VXI Interface card up from the Arb board. Considerable force may be required as there are four connectors between the two boards with a total of 136 pins. Do not use a metallic prying tool.

4. Change the data transfer bus arbitration jumpers to the desired level. Refer to figure 2-2.

5. Carefully re-install the VXI Interface card onto the Arb board. Re-install the four pan head screws, the side panel and the four flat head screws.

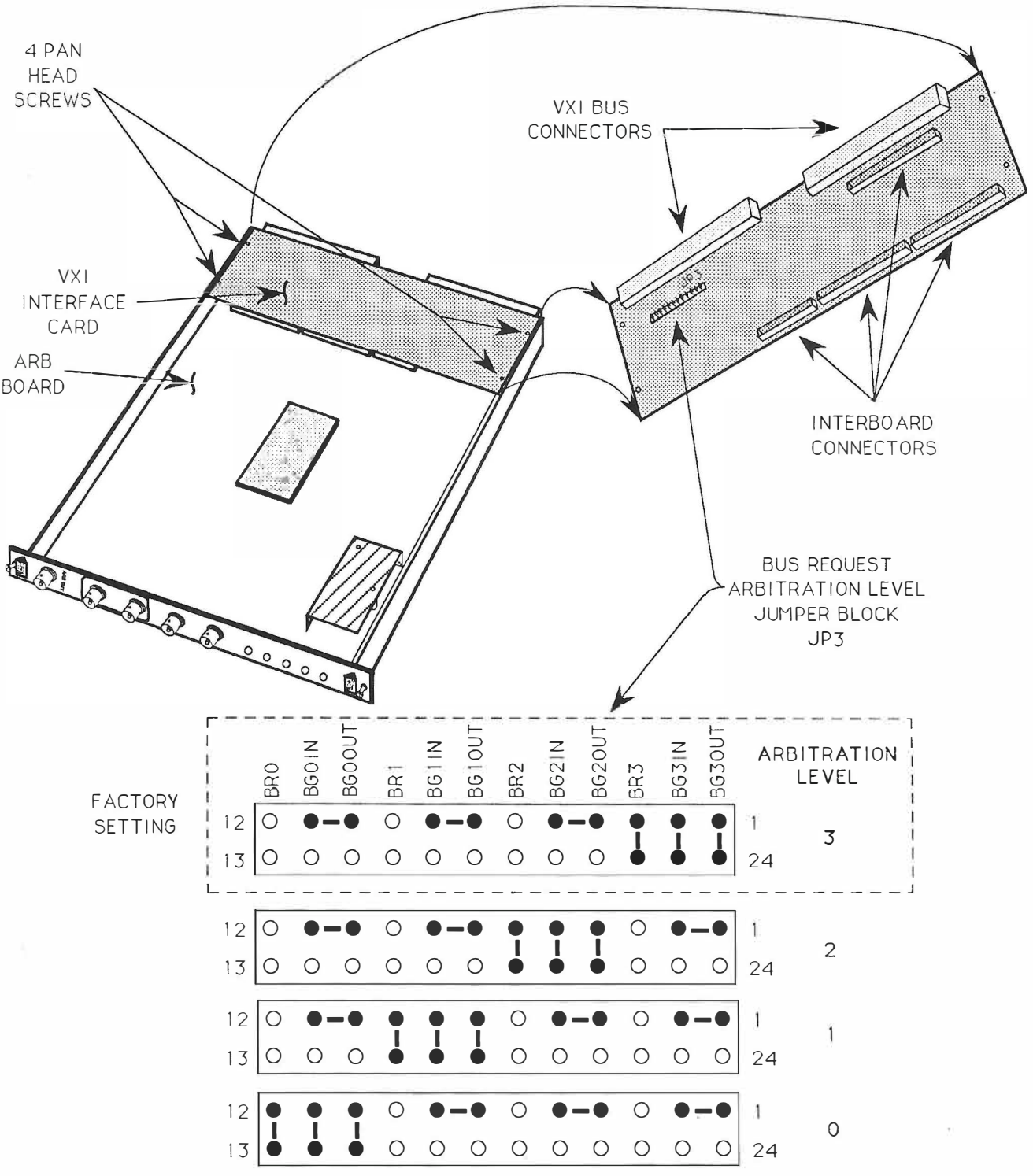


Figure 2-2. Bus Arbitration Level Jumpers

2.4 INSTALLATION

The instrument must be installed in a VXI mainframe in any slot except slot 0 (zero), which is reserved for the Resource Manager. When inserting the instrument into the mainframe, it should be gently rocked back and forth to seat the connectors into the backplane receptacles. The ejectors will be at right angles to the front panel when the instrument is properly seated into the backplane. Secure the instrument into the chassis with the two captive screws above and below the ejectors.

2.5 ELECTRICAL CHECK OUT

The electrical check out is composed of the automatic power-up trace memory validation test, the operator initiated Self-test, ***TST?**, and the operation verification procedure. The ***TST?** must be initiated to verify the pass/fail status of the trace memory test.

2.5.1 Instrument Operation Tests

Two separate tests are required to verify proper operation of the instrument. One test verifies only the trace memory, while the second verifies the remaining Arb circuitry.

The trace memory test destroys all data in memory, it is performed only during power-up as part of the initialization routine. The test results (a value between 0 and 65,535) are available to the operator through the `TRAC:STAT?` query. If the instrument passes, 0 (or 1 if option 01 is installed) is returned. Any number greater than 1 indicates a faulty RAM module, which is not field repairable. If a faulty module is indicated, use the factory address and telephone number located on the title page of this manual to contact the Wavetek Customer Service Department *prior to factory shipment*. If the unit is under warranty, return the entire instrument to the factory. If the unit is no longer within warranty, the module may be removed and shipped to the factory.

The remaining Arb circuitry is tested by sending `*TST?`. When the instrument receives this query, all traces and hardware settings are saved and output relays are opened. The circuitry is then tested in the order shown in table 2-1, and the results returned. A returned value of 0 indicates all tests passed. Upon a failure, the program will terminate and return the error value (-32767 to +32768). After the indicated problem is corrected, `*TST?` should again be sent.

By using the information located in figure 2-3 and table 2-1, the operator is able to decode the returned error value into a 16-bit binary number. Refer also to figure 2-4 to decode an example returned value of 2565. To decode the example value, first subtract the highest ERROR WORD BIT WEIGHT possible (2048) that does not exceed the number returned (2565) and note the BIT RETURNED (11). From the remainder, (517) again subtract the highest ERROR WORD BIT WEIGHT possible (512). Note the BIT RETURNED (9). This process is continued until the remainder is zero. In this example, subtract ERROR WORD BIT WEIGHTS 4 and 1, corresponding to RETURNED BITS 2 and 0. Refer now to table 2-1. Note the "Test Number" and "Error Code" columns. RETURNED BITS 0 through 7 (from figure 2-3) identify Error Codes, and RETURNED BITS 8 through 15 identify Test Numbers. To identify the Test Number, add the TEST NUMBER BIT WEIGHTS (8 and 2) that correspond to the Test Number BITS RETURNED (11 and 9) to yield the Test Number (8 + 2 = 10). Table 2-1 lists six Error Codes for Test Number 10. More than one Error Code for a Test Number may be asserted. The Error Codes asserted in this example are 4 and 1, corresponding to RETURNED BITS 2 and 0. Therefore, Error Codes 4 and 1 of Test Number 10 identify failed operations during the self-test.

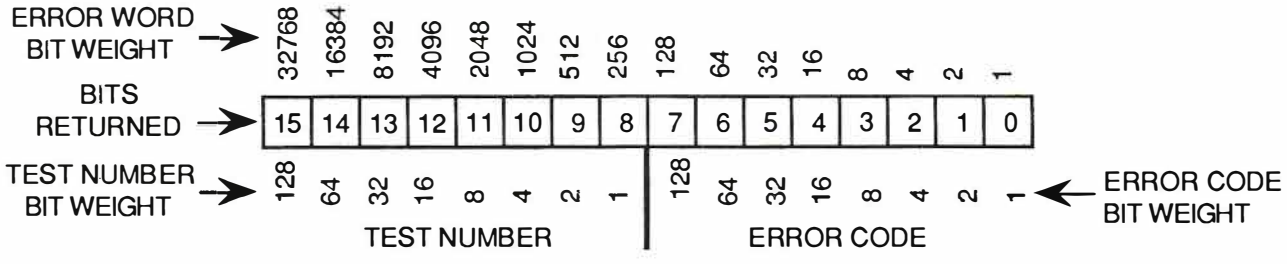


Figure 2-3. Self-test Status Word

Table 2-1. Self-Test Format

Test Number	Error Code	Circuit Indicated/Parameters		Test Boundaries
1	N/A	Trace Memory		Memory test bit 1
2	1	Diagnostic Interface		0V ±0.05V
3	1	DAC -amplitude reference		-1.0V ±5%
4	1	DAC +amplitude reference		2.4V ±20%
	2			0.7V ±20%
5	1	Offset		+5.0V ±5%
	2			-5.0V ±5%
6	1	Pre-amplifier		-1.3V ±10%
	2			1.3V ±10%
7	1	Power amp (Amplitude)		+8.0V ±5%
	2			-8.0V ±5%
	4	Power amp (Offset)		+8.0V ±5%
	8			-8.0V ±5%
8	1	Pre-attenuator:	2:1 Attenuation	+5.0V ±10%
	2		4:1 Attenuation	+2.5V ±10%
	4		8:1 Attenuation	+1.25V ±10%
	8		16:1 Attenuation	+0.625V ±10%
	16		32:1 Attenuation	+0.3125V ±10%
9	1	Filter		+8.0V ±2%
10	1	Output Attenuator:	1:1 Attenuation	+9.0V ±15%
	2		10:1 Attenuation	+0.9V ±15%
	4		100:1 Attenuation	+0.09V ±15%
	8		1:1 Attenuation	-9.0V ±15%
	16		10:1 Attenuation	-0.9V ±15%
	32		100:1 Attenuation	-0.09V ±15%
11	1	Marker	BBIT, 1st bit triggers sync threshold, marker low	1.7V ±10%
	2	Position	BBIT, 1st bit set below sync threshold, marker low	0.0V ±0.5V
	4	and Sync:	BBIT, 1st bit triggers sync threshold, marker high	3.4V ±10%
	8		BBIT, 1st bit below sync trigger threshold, marker high	1.7V ±10%
	16		ZCRO, 1st bit set below zero crossing, marker low	0.0V ±0.5V
	32		ZCRO, 1st bit set above zero crossing, marker low	1.7V ±10%

Number Returned =	2565	
Subtract	2048	= BIT RETURNED 11 = TEST NUMBER BIT WEIGHT 8
Remainder	517	
Subtract	512	= BIT RETURNED 9 = TEST NUMBER BIT WEIGHT 2
Remainder	5	
Subtract	4	= BIT RETURNED 2 = ERROR CODE BIT WEIGHT 4
Remainder	1	
Subtract	1	= BIT RETURNED 0 = ERROR CODE BIT WEIGHT 1
Remainder	0	

Test Number = bit 11 Test Number weight plus bit 9 Test Number weight:

bit 11 weight =	8
bit 9 weight =	2
Test number that failed	10

For this example, Test Number 10, Error Codes 4 (100:1 positive) and 1 (1:1 positive) have failed.

Figure 2-4. Decimal to Binary Status Word Conversion Example

2.5.2 Operation Verification Procedure

The operation verification procedure is to be used only as a receiving inspection or post-repair checkout. The procedure verifies functional operation of this instrument but does not verify calibration. Required tools and test equipment are given in table 2-2.

Table 2-2. Test Equipment and Tools

Equipment	Comments
Oscilloscope	Bandwidth: 100 MHz
Signal Source	Frequency: 1kHz to 2MHz Output: TTL
BNC 50Ω Feed-through (2ea)	Accuracy: 0.5% Power: 2W
BNC Coax Cable (2ea)	RG58U, 3 ft. length

Because each step in the procedure is dependent on the preceding step, start with step 1 and continue through to the end. Do not send any command unless specifically instructed to do so within the procedure.

1) Verify proper LED operation during instrument power-up

LED	Normal Result
Run	On
Fail	Off
MODID	Flashes
A16	On
A24	Off

2) Send: `*tst?`
If response = 0, continue
If response ≠ 0, decode error value (see paragraph 2.5.1)

NOTE

If the test fails on a new or newly factory repaired unit, return it to the factory.

3) Connect a coax cable between the ARB OUT connector and oscilloscope through a 50Ω terminator.
Send: `outp on`
Verify 1Vp, 1kHz sine wave from the ARB OUT connector.

4) Move cable from the ARB OUT connector to the MARKER SYNC connector.
Send: `mark on`
Verify TTL level, 1kHz square wave from the MARKER SYNC connector.

5) Send: `mark:sync bbit`
Verify sets of TTL level, pulses at 1ms intervals.

6) Move cable from the MARKER SYNC connector to the ARB OUT connector.
Send: `trac:def test,tri`
Verify 1Vp, 1kHz triangle wave.

7) Move cable from the the ARB OUT connector to the the MARKER POSITION connector.
Send:
```
mark:pos:poin test,1
mark:pos:poin test,3
mark:pos:poin test,5
```
Verify three TTL level 0.5 µs pulses, each separated by an interval of 0.5 µs.

8) Send: `mark:pos:aoff test`
Verify pulses disappear.

9) Move cable from the MARKER POSITION connector to the ARB OUT connector.
Connect an external 1kHz, TTL level signal to the TRIG IN connector through a 50Ω terminator.
Send:
```
freq 1e4;:mode trig
trig:sour ext
trac:data test,sin
```
Verify a 1Vp, 0.1 ms wide sine wave at 1.0ms intervals.

10) Change the 1kHz external TTL signal to 2MHz
Move the external source cable from the TRIG IN connector to the CLOCK IN connector.
Send:
```
freq 1e3;:mode cont
rosc:sour ext
```
Verify 1Vp, 100 Hz sine wave.

SECTION 3

OPERATION

3.1 INTRODUCTION

This section describes the operation of the Model 1375. It begins with a description of the controls, connectors and indicators, followed by programming information. Programming is broken up into two sections: 1) a tutorial, explaining how to set up the instrument for a variety of applications, followed by; 2) a detailed description of each command.

3.2 CONNECTORS AND INDICATORS

3.2.1 Front Panel

The Arb front panel has five BNC connectors, two inputs (TRIG IN and CLOCK IN) and three outputs (MARKER POSITION, MARKER SYNC and ARB OUT). The front panel connectors and indicators are shown in figure 3-1 and keyed (bold numbers) to the following descriptions.

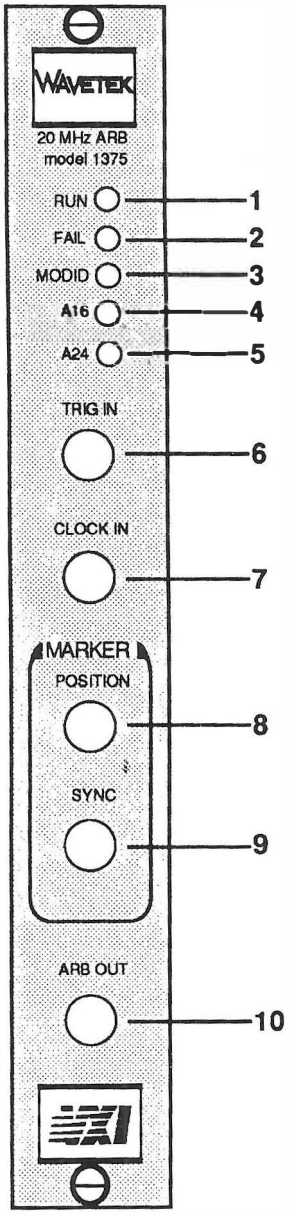


Figure 3-1. Connectors and Indicators

1 **RUN.** LED indicator. ON when the Interface Module microprocessor is operational.

2 **FAIL.** LED indicator. ON if the VXI interface has not been initialized.

3 **MODID.** LED indicator. Flashes at power-up when the mainframe microprocessor identifies the Arb module.

4 **A16.** LED indicator. ON when the A16 registers are being accessed from the VXI bus.

5 **A24.** LED indicator. Not used in the Arb.

6 **TRIG IN.** BNC connector. Accepts TTL level signals in the range of dc to 2MHz for externally triggering the instrument.

7 **CLOCK IN.** BNC connector. Accepts TTL level signals in the range of dc to 20 MHz. Allows the operator to externally clock the instrument.

8 **MARKER POSITION.** BNC output connector. TTL high (when terminated by 50Ω) while each user pre-selected trace point is being addressed.

9 **MARKER SYNC.** BNC output connector. If zero crossing is selected, sync is TTL high (when terminated by 50Ω) while ARB OUT signal is above 0V. If beginning bits is selected, sync is TTL high (when terminated by 50Ω) for at least one clock cycle at the start of each trace.

10 **ARB OUT.** BNC output connector. Arbitrary generator output (main output). Provides factory defined or user defined waveforms, with a frequency range of 1 mHz to 2.5 MHz in cw trace mode, 30.5 nHz to 2.5 MHz in raster trace mode. Amplitude ranges from 5mVp to 5Vp into 50Ω.

3.2.2 Rear Panel Connectors

Two multi-pin rear panel connectors, P1 and P2, connect the Model 1375 to the VXI chassis. These connectors provide power supplies, digital interfacing, and the backplane signal lines used by the Arb to transmit or receive trigger and clock signals.

3.3 POWER-UP AND *RST DEFAULTS

Upon instrument power-up, parameters revert (default) to those listed in table 3-1. A `*rst` command returns all parameters,except those related to trace memory, to their initial power-up state. The instrument may be returned to the power-up state by sending `*rst;:trace:del all`.

Table 3-1. Power-up Defaults

SUBSYSTEM	DEFAULT VALUE
OUTPUT	
Trace Output State	OFF
Clock Output State	OFF
Output Clock Lines	Internal Source
Trigger Output State	OFF
Output Trigger Lines	Internal Source
Filter State	OFF
MODE	Continuous
SOURCE	
Amplitude	1V peak
Offset	0V
CW Frequency	1kHz
Raster Frequency	20 MHz
Reference Oscillator	Internal
Trigger Sequence	1
Burst	1
TRIGGER	
Source	Internal
Frequency	1kHz
TRACE	
Mode	CW
Select	Default Sine Wave
MARKER	
State	OFF
Sync	ZCROs
Points	All off
SYSTEM	
Error Register	0
STATUS	
Query Response	0

3.4 CREATING ARBITRARY WAVEFORMS

Because function generators use analog oscillators to create their output signals, they are limited to producing standard waveforms such as sine waves, triangle waves and square waves, or variations of these waveforms. For example, by varying waveform symmetry, a triangle can be turned into a ramp, or a square into a pulse. However, truly complex waveforms, such as a simulated heartbeat, are beyond the capabilities of such an instrument. An arbitrary waveform generator (Arb) is capable of creating virtually any desired waveform by converting digital information into an analog voltage.

The Model 1375 creates waveforms by sequentially addressing points stored in Random Access Memory (RAM), and converting the resulting digital output into an analog waveform. Figure 3-2 represents the Model 1375 RAM (without option 01). There are four 8k blocks of memory, each with a vertical dimension of 4k. Instruments with option 01 have sixteen 8k blocks of memory, but otherwise operate as described. Figure 3-3 details the first of these 8k (8192 point) blocks. During "playback" of a trace, the horizontal "Address Locations", are sequentially sampled. As each address is identified, the corresponding "Data in RAM" (a number from 0 through 4095) held at that address is returned, then converted to an analog value, with the results seen at the ARB OUT connector. Returning the number 0 represents minimum, 2048 represents the midpoint, and 4095 is maximum. The actual output voltage depends not only on the returned number, but also the programmed amplitude and offset. Figure 3-3 shows a sine wave occupying the entire 8k block. For this particular trace, if address location 2047 is identified, the number 4095 is returned. If the amplitude is set for 1Vp and 0V offset, returning 4095 corresponds to an output amplitude of 1V. Identifying address location 6143 returns 0, which, for this example is -1V.

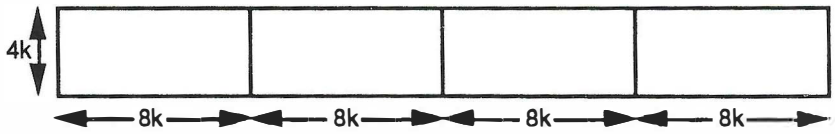


Figure 3-2. RAM Diagram

The address location is determined by clocking a phase accumulator circuit that resembles an adder. As the clock (internal or external) cycles, the count (address location) from the phase accumulator advances, identifying a specific location in RAM. Each phase accumulator advance (the distance between selected address locations) is called a phase increment.

The Arb is capable of producing signals from one of two trace modes, cw or raster. In most cases, the phase increment in cw mode will be greater or less than one. In raster trace mode, each point in the trace is sampled, one per clock, and the address increment is therefore always one. The number of trace points and the clock (raster) frequency are operator selected. Raster frequency has a range of 1mHz to 20 MHz. The ARB OUT frequency is calculated by the Arb from the following equation:

$F_O = F_R / P$

Where: F_O = ARB OUT Frequency
F_R = Raster Frequency
P = Number of trace points

Therefore, with a given number of points in a trace, output frequency is controlled by selecting the raster frequency, which has a default value of 20 MHz.

If cw trace mode is selected, the clock frequency is fixed at 20 MHz and the ARB OUT frequency is programmed by the operator, or defaults to 1kHz. The Arb calculates the phase increment. When the phase increment is less than one, the phase accumulator internally sums the fractions until the next address is reached, at which time the accumulator output advances to that address. While the fractions are being accumulated, the Arb continues to output the value at the previous address location.

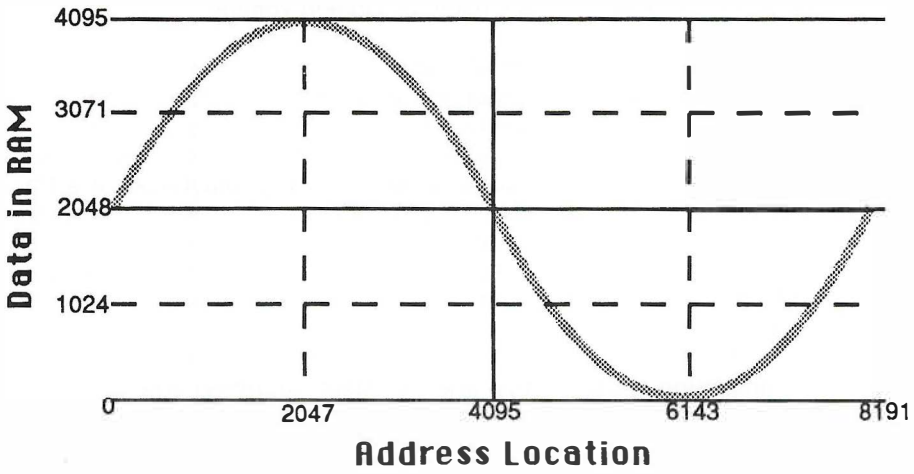


Figure 3-3. Waveform Plotting

When initially powered-up, a default 2048 point sine wave trace resides in the first 8k block, from address 0 to address 2047. Identifying the first defined trace erases the original default sine wave. Adding other traces to memory has no effect on those already residing in RAM. Each trace may have as few as 8, or as many as 32768 points. Several factory pre-defined traces are available for the operator to use. Any trace may be uploaded or downloaded through the VXI interface and controller. These may be very complex waveforms, requiring a computer to identify each trace point.

Since the Model 1375 converts each point into a specific voltage, an enlarged view of the signal at the ARB OUT connector will show discrete amplitude changes instead of a smooth line. This is especially true at higher frequencies, or when the waveform is defined by only a few points. An internal filter may be enabled by the operator to smooth the waveform by suppressing spurs and harmonics that would otherwise be seen at the output.

3.5 SCPI (STANDARD COMMANDS FOR PROGRAMMABLE INSTRUMENTS) PROGRAMING FORMAT

Sending commands to the Model 1375 is very easy, provided the programmer pays strict attention to the SCPI command string format, as shown in this manual. Each required character (including spaces) must be properly placed, or the instrument will ignore the string. When this happens, an error is recorded in memory, but no indication of the programming error is given the operator until the instrument is queried.

For each program string given in this exercise, refer to the command flow chart in Appendix A. Knowledge of how to use this chart is critical for sending commands to the instrument. Notice that on the command flow chart, there is a mixture of upper and lower case characters for most commands, such as marker being shown as MARKer. When programming this command, either **mark** or **marker** may be sent to achieve the same result. Any other form, such as **marke** is invalid and will be ignored by the instrument, placing an error message in memory. One colon (without any spaces) must be placed between any two

commands, and there must be one space between the last command and the variable. For example, to enable an external clock source (using shortform mnemonics), the string is **outp:cloc:sour ext**. Several commands and variables shown in the command flow chart (Appendix A) are housed within [brackets]. These are defaults that may be ignored by the programmer. The following two strings show how, by using the shortform mnemonic, and eliminating words shown within [brackets], the number of characters required to send a string is greatly reduced. Both strings program the ARB OUT amplitude for 5 volts.

```
source:voltage:level:immediate:amplitude  5
volt 5
```

A wide variety of statements, all performing the same programming change, may be sent. The following ten examples are all valid strings that enable the ARB OUT connector.

```
output:state  on          output:state  1
output:stat  on           output:stat  1
outp:state  on            outp:state  1
output  on                output  1
outp  on                  outp  1
```

All characters in a programming string may be in upper case, lower case, or any combination of upper and lower case letters.

As seen in Appendix A, each subsystem contains a hierarchy of commands and parameters that are related to a given instrument function. Some commands in one subsystem require settings be made in another subsystem for proper operation. The subsystem command trees are shown at the beginning of each subsystem discussed later in this section.

For SCPI language specifications, refer to the Standard Commands for Programmable Instruments Manual. An introduction to SCPI can be found in Appendix C, SCPI Beginners Guide.

3.6 PROGRAMMING ERRORS

When sending new programming strings, periodically send error queries (**syst:err?**) to the instrument to verify acceptance of all statements. If there are no errors, the Arb response will be `0,"No Error"`. Appendix D lists error codes that could be returned. A **syst:err?** query must be sent for each error being held in memory by the instrument. As each error is queried, it is cleared from memory.

3.7 MODEL 1375 PROGRAMMING TUTORIAL

Table 3-2 lists the Model 1375 commands explained in the tutorial. Basic, trigger/gated, and reference oscillator command groups are explained using the default 2048 point sine wave. All other command groups must have one or more operator defined traces entered into memory. Operators who are unfamiliar with the Model 1375 should read and enter all programming statements in the tutorial. Experienced operators may "brush-up" on seldom used commands by programming each command group individually. Before starting, install the Model 1375 in a working VXI chassis, containing a slot 0 controller, and turn the power on.

Table 3-2. Model 1375 Programming Tutorial

Command Group	Commands	Paragraph Number	Default Sine Wave Used?
Basic	Amplitude Offset Reset Output Frequency Filter	3.7.1	Yes

Table 3-2. Model 1375 Programming Tutorial (Cont)

Command Group	Commands	Paragraph Number	Default Sine Wave Used?
Trigger	Mode (Trigger) Trigger Source (Internal) Internal Trigger Frequency	3.7.2	Yes
Backplane Triggering	Trigger Source (Backplane)	3.7.3	
Asynchronous Gated	Mode (Asynchronous Gated) Trigger Source (External)	3.7.4	
Synchronous Gated	Mode (Synchronous Gated)	3.7.5	
Burst	Mode (Burst) Burst Count	3.7.6	
Reference Oscillator	Trace Mode (Raster/cw) Raster Frequency Reference Oscillator Source (External/Backplane)	3.7.7	
Operator Defined Trace	Trace Define Trace Data	3.7.8	No
Trace Queries	Trace Catalog? Trace Free? Trace Directory? Trace Status?	3.7.9	
Trace Commands	Trace Select Trace Limit Trace Points Trace Line Trace Delete	3.7.10	
Triggered Sequence	Mode (Triggered Sequence) Trigger Source (Bus) Triggered Sequence Count	3.7.11	
Marker	Marker On Marker Sync Marker Position	3.7.12	
Marker Triggering	Marker Position Backplane Triggering Marker Sync Backplane Triggering	3.7.13	

3.7.1 Basic Commands

Commands addressed in this paragraph:

- Amplitude
- Offset
- Reset
- Output
- Frequency
- Filter

Connect the ARB OUT connector through a 50Ω terminator to an oscilloscope, send the string `*rst;:trac:del:all;:outp 1` and verify the presence of a 1Vp, 1kHz sine wave. Program the commands shown in table 3-3 to modify the default sine wave.

Table 3-3. Basic Commands

Command	String Sent	Observed Result	Comments
Amplitude	`volt 2`	Amplitude increases from 1Vp to 2Vp	See paragraph 3.10.1.1
Offset	`volt:offs 3`	Waveform offsets +3 volts	See paragraph 3.10.1.2
Reset	`*rst`	Output signal disabled	Amplitude and offset have been returned to their original settings
Output	`outp 1`	1Vp, 1kHz sine wave	
Frequency	`freq 2e6`	Frequency changes from 1kHz to 2 MHz	See paragraph 3.10.2
Filter	`outp:filt 1`	Filtered output signal	

3.7.2 Trigger Programming

Commands addressed in this paragraph:
- Mode (Trigger)
- Trigger Source (Internal)
- Internal Trigger Frequency

Send `*rst;:trac:del:all;:outp 1` to reset the instrument and enable the ARB OUT connector. In this exercise, the default internal trigger source will be used to trigger the instrument. To program and observe the trigger mode, monitor the ARB OUT connector and send the following string:

```
freq 1e4;:mode trig
```

Verify a 1Vp, 0.1 ms wide sine wave at 1ms intervals (triggered waveform). To change the internal trigger frequency from 1kHz to 500 Hz, send `trig:freq 500`. The intervals have now changed to 2ms.

3.7.3 Backplane Triggering

Command addressed in this paragraph:
- Trigger Source (Backplane)

A trigger signal may be placed on the backplane where it is accessible from any device mounted in the VXI chassis. The instrument is also capable of retrieving a trigger signal from the backplane. Reference oscillator and trigger backplane input lines may only be selected as a pair. In this exercise, the instrument will be programmed to send and receive, the internal trigger signal, through the backplane.

NOTE

*If **not** continuing from the previous paragraph, reset the instrument and enable the ARB OUT connector by programming `*rst;:trac:del:all;:outp 1`, then place the instrument in triggered mode by sending:*

`freq 1e4;:mode trig`.

Verify a 1Vp, 0.1 ms wide sine wave at 1.0 ms intervals (triggered waveform). Now enable backplane triggering by following the procedure outlined below.

If continuing from the previous paragraph, return the internal trigger frequency to 1kHz by sending `trig:freq 1e3`. Program the Arb to select the trigger from VXI bus TTLTRG line 2 by sending `trig:sour ttlt1` (see figure 3-6). Because no trigger signal has yet been placed on this backplane line, the ARB OUT signal will stop at the first trace point, address 0 (zero volts). Now, send the internal

(default) trigger signal to VXI bus TTLTRG line 2 and enable the trigger output by programming `outp:ttlt1 1`. This completes the backplane loop (refer to figure 3-6 and 3-8), and the ARB OUT signal should again be a triggered waveform.

3.7.4 Agated Programming

Command addressed in this paragraph:
Mode (Asynchronous Gated)
Trigger Source (External)

Send `*rst;:trac:del:all;:outp 1` to reset the instrument and enable the ARB OUT connector. Connect an external, 1kHz TTL level square wave to the TRIG IN connector. To program and observe the agated mode, monitor the ARB OUT connector and send the following string:

```
freq 1e4;:mode agat;:trig:sour ext
```

Verify 1Vp, 0.1 ms wide sine waves for a duration of approximately 0.5 ms at 1.0 ms intervals. Vary the trigger frequency slightly to verify the last cycle is may not finish (refer to figure 3-9).

3.7.5 Sgated Programming

Command addressed in this paragraph:
Mode (Synchronous Gated)

NOTE

If continuing from the previous paragraph, do not send any string other than `mode sgat`, *then verify the result.*

Send `*rst;:trac:del:all;:outp 1` to reset the instrument. Connect an external 1kHz, TTL level square wave to the TRIG IN connector. To program and observe the sgated mode, monitor the ARB OUT connector and send `freq 1e4;:mode sgat;trig:sour ext`

Verify 1Vp, 0.1 ms wide complete sine waves for a duration of approximately 0.5 ms at 1.0 ms intervals. Vary the trigger frequency slightly to verify that the last cycle is always completed before returning to zero volts (refer to figure 3-10).

3.7.6 Burst Programming

Command addressed in this paragraph:
Mode (Burst)
Burst Count

NOTE

Send `*rst;:trac:del:all;:outp 1` *to reset the instrument and enable the ARB OUT connector.*

In burst mode, the instrument may be programmed to produce from 1 to 10,000,000 waveform cycles. The number of waveform cycles is the burst count, which has a default value of 1. To program and observe the burst mode, monitor the ARB OUT connector, then send:

```
freq 1e4;:mode burs
```

Verify one, 1Vp 0.1 ms wide sine wave at 1.0 ms intervals. Change the burst count to "7" by sending `burs 7`, then verify an output of seven, 1Vp 0.1 ms wide sine waves at 1.0 ms intervals (refer to figure 3-12).

3.7.7 Reference Oscillator

Commands addressed in this paragraph:
- Trace Mode (Raster/cw)
- Raster Frequency
- Reference Oscillator Source (External/Backplane)

CW/Raster Trace Modes The reference oscillator provides the clock for the phase accumulator. A change in clock frequency creates a corresponding change in the ARB OUT frequency. In cw trace mode, the internal clock frequency is fixed at 20 MHz. However, in raster trace mode, the clock frequency may be selected by the operator to be between 1mHz and 20 MHz. Each point in the trace is clocked once when in raster clock mode. The Arb output frequency in raster mode is calculated from the following equation:

$F_O = F_R/P$

Where: F_O = ARB OUT Frequency
F_R = Raster Frequency
P = Number of trace points

The default raster frequency is 20 MHz, and the default waveform has 2048 points. Therefore, from the previous equation, the default ARB OUT frequency in raster trace mode is ~ 9.8 kHz. To prove this, reset the instrument and enable the ARB OUT connector by sending `*rst;:trac:del:all;:outp 1`, then program `trac:mode rast` and measure the ARB OUT frequency. To see how the raster frequency controls the ARB OUT frequency (when in raster trace mode), change the default 20 MHz raster frequency to 10 MHz by sending `freq:rast 1e7` and verify that the ARB OUT frequency is divided in half, from ~ 9.8 kHz to ~ 4.9 kHz. Return the instrument to cw trace mode by sending `trac:mode cw` and verify that the ARB OUT frequency is now 1kHz.

External Reference Oscillator Source In this exercise, the internal 20 MHz clock will be replaced with an external 2MHz clock. This will effectively divide the default, 1kHz output frequency by 10, producing an ARB OUT frequency of 100 Hz. Before starting, reset the instrument and enable the ARB OUT connector by sending `*rst;:trac:del:all;:outp 1`. Inject a 2MHz, TTL level signal into the CLOCK IN connector. Send the string `rosc:sour ext` and verify a 1Vp, 100 Hz sine wave.

Backplane Reference Oscillator Source The reference source may be placed on one of four VXI bus TTLTRG lines where it is accessible from any device mounted in the VXI chassis. The instrument is also capable of retrieving a signal from one of these lines. Reference oscillator and trigger backplane input lines may only be selected as a pair. In this exercise, the instrument will be programmed to send and receive, through the backplane, the 2MHz external signal used as the reference oscillator source in the previous exercise. Program the instrument to select the clock reference from backplane line 2 by sending `rosc:sour cloc2`. Because no clock signal has yet been placed on this backplane line, the ARB OUT signal will stop at the last address selected by the phase accumulator, producing a dc voltage within the amplitude range of the waveform. Now, program the external clock input to be sent to backplane line 2 (and the clock output to be enabled) by sending `outp:cloc2:sour ext;:outp:cloc2 1`. This completes the backplane loop (refer to figure 3-7 and 3-8), and the ARB OUT signal should now be a 1Vp, 100 Hz sine wave.

3.7.8 Operator Defined Trace

Commands addressed in this paragraph:
- Trace Define
- Trace Data

When initially powered on, a 2048 point sine wave is loaded into the Model 1375. For most applications, one or more operator defined waveforms must be substituted for this default waveform. New traces are programmed within the trace subsystem by defining and modifying one trace for each required waveform. The standard instrument (without option 01), contains a total of 32768 (32k) address locations (points) for the operator to program. These are divided into four 8k blocks (8192 points). Each trace may have as few

as 8, or as many as 32768 points. Reset the instrument and enable the output by programming `*rst;:trac:del:all;:outp 1`, then enter an 8192 point triangle named "wave" by sending:

```
trac:def wave,8192;data wave,tri
```

Verify a 1Vp, 1kHz triangle at the ARB OUT connector. When any changes need to be made to the trace, it must be identified within the programming string. For example, to change the waveshape of the newly entered trace (wave) from triangle to sine, send **`trac wave,sin`**. Changing basic commands such as frequency or amplitude has no effect on the trace held in memory, and are therefore programmed as shown in table 3-3. Define two additional traces, a triangle (wave1), and a square (wave2) by programming:

```
trac:def wave1,tri;:trac:def wave2,squ
```

When first defining a trace, if the waveform name is followed by the function rather than the size (as in the previous program string), the waveform defaults to 8k (8192 points).

3.7.9 Trace Subsystem Queries

Commands addressed in this paragraph:

Trace Catalog
Trace Free (Memory available)
Trace Directory
Trace Status (Errors?)

NOTE

If continuing from the previous paragraph, read the following paragraph, but do not send any string other than those listed in table 3-4.

Within the trace subsystem are four query selections, "catalog?", "free?", directory?, and "status?". These selections are described in section 3. If not continuing from the previous paragraph, reset the instrument by sending **`*rst;:trac:del:all`**, enter the following program string, and verify that the responses for each query match those shown in table 3-4.

```
trac:def wave,sin;:trac:def wave1,tri;:trac:def wave2,squ
```

Table 3-4. Trace Query Responses

Query	String Sent	Response	Comments
Catalog	`trac:cat?`	WAVE,WAVE1,WAVE2	Trace names only
Memory Free	`trac:free?`	8192,24576	Memory free, Memory used
Directory	`trac:dir?`	WAVE,8192,0,8191;WAVE1,8192,0,8191; WAVE2,8192,0,8191	Trace name, number of trace points, start and stop addresses
Test Status	`trac:stat?`	0 (1 with expanded memory option)	No memory errors

3.7.10 Remaining Trace Subsystem Commands

Commands addressed in this paragraph:

- Trace Select
- Trace Limit
- Trace Points
- Trace Line
- Trace Delete

When in any mode other than tseq, any of the waveforms located in RAM may be accessed by using the *trace select* command. If not continuing from the previous paragraph, reset the instrument by sending **`*rst;:trac:del:all`** and enter three traces into memory by sending:

```
trac:def  wave,sin;:trac:def  wave1,tri;:trac:def  wave2,squ
```

To select and view the triangle wave, send the command **`trac:sel wave1;:outp 1`**.

The *trace limit* command allows the operator to view only a specific portion of a waveform without making permanent changes to the trace. The beginning and ending trace addresses of the area to be viewed (see figure 3-4) are required to identify the trace limits. Note that for the factory defined triangle trace occupying an entire 8k block, address locations "0" and "8191" are minimum data values in RAM, and address "4095" is maximum. Send **`trac:lim wave1,3095,5095`** to eliminate all but the positive peak of the triangle named "wave1". The trace displayed after sending this command is black in figure 3-4. Now, send **`trac:lim wave1,0,8191`** to again display the entire waveform.

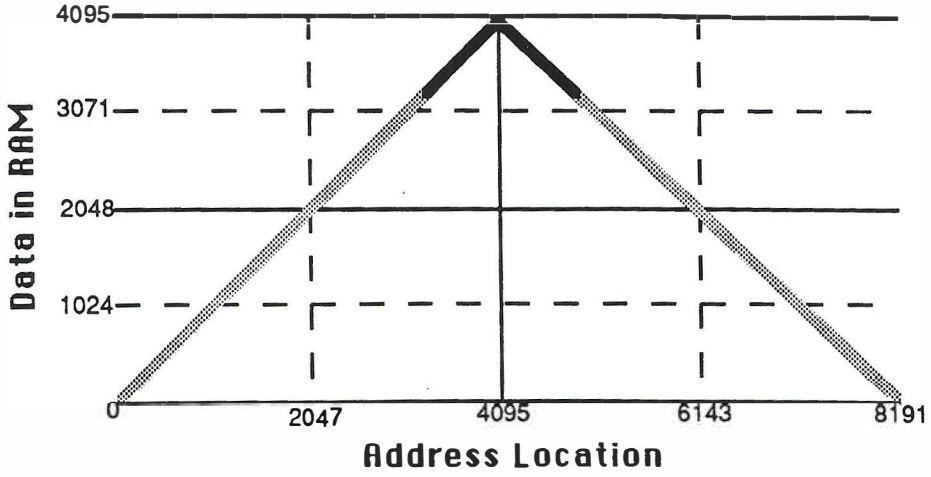


Figure 3-4. Trace Limit Plotting

The *trace points* command changes the amount of space a specific trace occupies in RAM. Each new trace added to RAM begins at the lowest previously unwritten address. There are no unwritten addresses between traces. When the *trace points* command is used, the modified trace is treated as a new trace, and the original location is closed-up. To change the triangle from 8192 points to 4000 points, send **`trac:poin wave1,4000`**. This trace is now the last trace in memory, and the space it formerly occupied has been closed-up. This can be verified by sending the query **`trac:dir?`** (table 3-4).

The *trace line* command allows the operator to **permanently** draw a straight line between any two points in a waveform. The points are identified from X/Y coordinates written into the command string. The horizontal dimension is equal to the trace address of the waveform (see figure 3-5). The vertical dimension is a number from 0 (minimum) through 4095 (maximum), with 2048 as the midpoint (zero). In this exercise, a line will be drawn from the 75% point (3071, vertically) of the sine wave positive excursion

at trace address 700, to the point where the waveform crosses zero (vertical location 2048) on its negative-going excursion (trace address 4095). To draw this line, first select the sine wave for viewing by sending **trac:sel wave**, then send **trac:line wave,700,3071,4095,2048.**

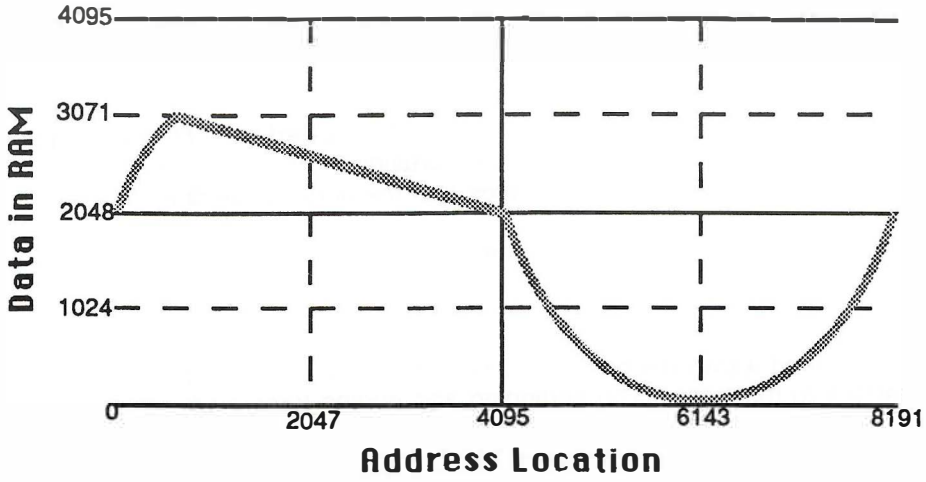


Figure 3-5. Trace Line Plotting

It is possible to delete any trace by using the *trace delete* command. To delete the trace named "wave", send **trac:del wave**. A quick check can be made to verify that this waveform has been erased by sending **trac:cat?**. The response verifies the deletion. Remove the remaining traces from memory by sending **trac:del:all**. Since there are no longer any operator defined traces in RAM, the default sine wave has been returned to the first 2048 address points.

3.7.11 Triggered Sequence Programming

Commands addressed in this paragraph:
- Mode (Triggered Sequence)
- Trigger Source (Bus)
- Triggered Sequence Count

To observe the triggered sequence mode, four items must be programmed. Failure to program any one of these items will prevent the triggered sequence mode from working. These four items are:

1) a minimum of one operator defined, 8192 point trace in RAM
2) a triggered sequence count selected (1, 2, 3, or 4)
3) an appropriate trigger source selected
4) the triggered sequence mode enabled

NOTE

All traces used in the triggered sequence mode must have 8192 points and begin at the first address of an 8k block, or the results will not be predictable.

When in triggered sequence mode, the contents of each 8k block (8192 address locations) of memory is scanned. For this example, there will be three operator defined, 8192 point traces, each occupying an 8k block of memory. Send ***rst;:trac:del:all;:outp 1** to reset the instrument, then enter the three traces by programming;

```
trac:def wave,sin;:trac:def wave1,tri;:trac:def wave2,squ
```

The triggered sequence count selects the number of 8k blocks that will be sequentially selected, beginning with block 1. Since only three of the 8k blocks have been programmed, enter a triggered sequence count of "3" by sending `tseq 3`.

Triggering for this exercise will be done using the *trg command. Program `trig:sour bus`. Select the triggered sequence mode by sending `mode tseq`. To observe the triggered sequence mode, monitor the ARB OUT connector, then sequence through the blocks by sending one `*trg` for each block change.

3.7.12 Marker Programming

Commands addressed in this paragraph:
- Marker On
- Marker Sync
- Marker Position

NOTE

If continuing from the previous paragraph, move the cable from the ARB OUT connector to the MARKER SYNC connector.

Reset the instrument by sending `*rst;:trac:del:all`. Connect the MARKER SYNC through a 50Ω terminator to an oscilloscope. Use table 3-5 to program the marker sync output.

Table 3-5. Marker Programming Examples

Command	String Sent	Observed Result	Comments
Marker Zero Crossing	`mark 1`	TTL Level, 1kHz square wave	See paragraph 3.13.3
Marker Beginning Bits	`mark:sync bbit`	TTL Level, pulse at 1.0 ms intervals	

Enter an 8k triangle named "wave" and enable the ARB OUT connector by sending:

```
trac:def wave,tri;:outp 1
```

Verify a 1Vp, 1kHz triangle at the ARB OUT connector.

Connect the ARB OUT and MARKER POSITION connectors to a dual input/trace oscilloscope, and trigger on the ARB OUT signal. To observe selected address points (in this example points 0 and 4095), send the string `mark:pos:poin wave,0;pos:poin wave,4095`.

Verify that the marker pulses are present at the positive and negative peaks of the ARB OUT waveform.

Address points observed from the MARKER POSITION connector cannot be deselected individually. To simultaneously deselect all marker points, send the string `mark:pos:aoff wave` and verify the pulses disappear.

3.7.13 Marker Triggering

Commands addressed in this paragraph:
- Marker Position Backplane Triggering
- Marker Sync Backplane Triggering

NOTE

Two generators are required to use marker position and marker sync backplane triggering. This exercise will be performed using two Model 1375's.

3.7.13.1 Marker Position Backplane Triggering

To observe marker position triggering, four items must be programmed. Failure to program any one of these items will prevent marker position from triggering. These four items are:

1) the triggering unit must have a minimum of one operator defined trace (any size) in RAM
2) a marker position must be enabled in the triggering unit
3) triggered mode must be selected in the triggered unit
4) both units must have backplane triggering selected

Power down the VXI chassis long enough to install a second Model 1375 in the chassis.

NOTE

If a second Model 1375 is already installed, reset the equipment by sending `*rst;:trac:del:all` *to both instruments.*

Select one Arb to be the trigger source. This will be referred to as "Arb A". The Arb being triggered will be referred to as "Arb B".

Arb A Programming: Define an 8k (8192 point) triangle, and enable the ARB OUT connector by sending `trac:def wave,tri;:outp 1`. Select a marker at the positive peak of the triangle (trace address 4095) by sending `mark:pos:poin wave,4095`. Place the selected marker on VXI bus TTL trigger line 6 by sending `outp:ttlt3:sour mpos;:outp:ttlt3 1`.

Arb B Programming: Define an 8k (8192 point) triangle, and enable the ARB OUT connector by sending `trac:def wave,tri;:outp 1`. Change the ARB OUT frequency to 10 kHz by programming `freq 1e4`. Select triggered mode and VXI bus TTL trigger line 6 as the trigger source by sending `mode trig;:trig:sour ttlt3`.

To verify the results, connect the ARB OUT connectors of both instruments to a dual input/trace oscilloscope, and trigger on the Arb A output. The output from Arb B should be triggered at the positive peak of the Arb A waveform.

3.7.13.2 Marker Sync Backplane Triggering

To observe marker sync triggering, two items must be programmed. Failure to program any one of these items will prevent marker sync triggering from working. These items are:

1) triggered mode must be selected in the triggered unit
2) both units must have backplane triggering selected

Power down the VXI chassis long enough to install a second Model 1375 in the chassis.

NOTE

If a second Model 1375 is already installed, reset the equipment by sending `*rst;:trac:del:all` *to both instruments.*

Select one Arb to be the trigger source. This will be referred to as "Arb A". The Arb being triggered will be referred to as "Arb B".

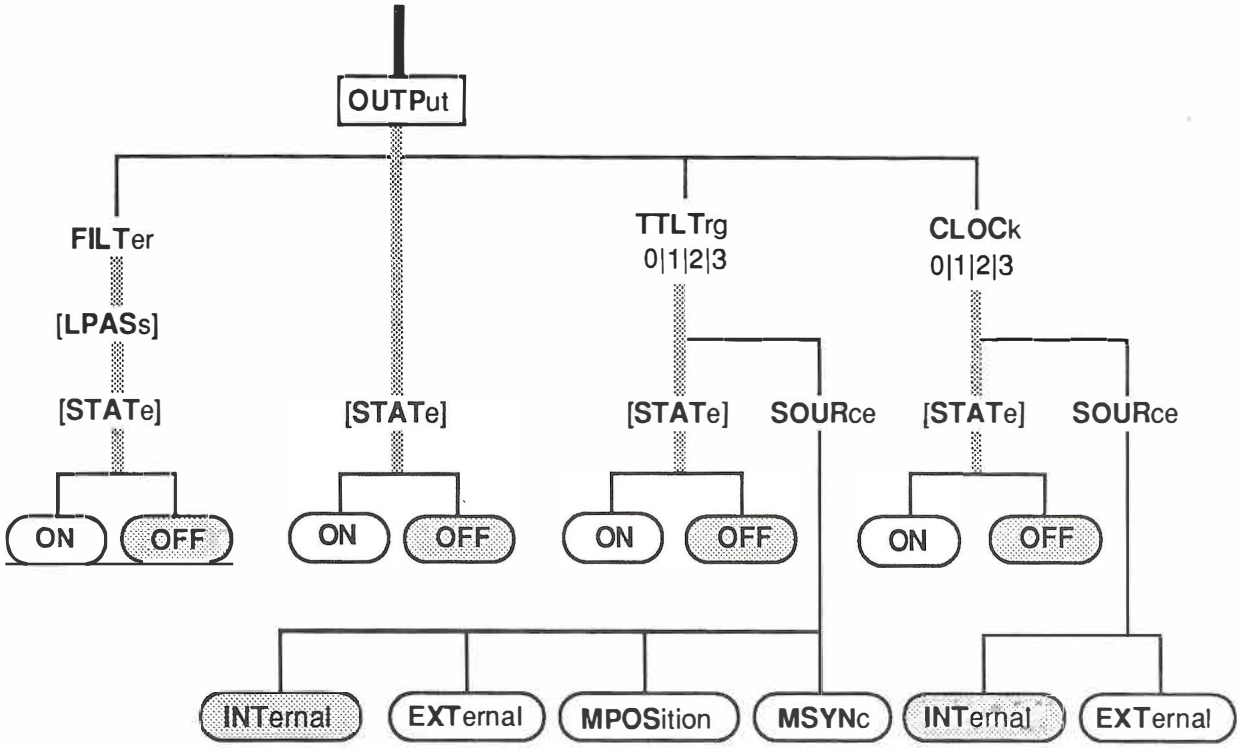
Arb A Programming: Enable the ARB OUT connector by sending `outp 1`. Place the selected marker sync output on VXI bus TTL trigger line 6 by sending:

```
outp:ttlt3:sour  msyn;:outp:ttlt3  1.
```

Arb B Programming: Change the ARB OUT frequency to 10 kHz and enable the ARB OUT connector by sending `freq 1e4;:outp 1`. Select triggered mode and VXI bus TTL trigger line 6 as the trigger source by sending `mode trig;:trig:sour ttlt3`.

To verify the results, connect the ARB OUT connectors of both instruments to a dual input/trace oscilloscope, and trigger on the Arb A output. The output from Arb B should be triggered at the zero crossing point of the Arb A output (refer to point 0 in figure 3-39).

3.8 OUTPUT SUBSYSTEM



The Arb Output subsystem controls the various Arb outputs. Outputs are turned ON and OFF, Trigger and Clock sources from the Arb for use by other modules within the VXI chassis are selected, and the smoothing filter is inserted or removed from the signal path. The complete Arb command tree, including the Output command subsystem tree, can be found in Appendix A.

Upon power-up, all of the Arb output states are OFF. Each output must individually be turned ON. The 4 MHz low pass smoothing filter is OFF (out of the circuit) and must be turned ON when required. The default for the clock and trigger lines is CLOCk0 and TTLTrg0 if the numerical suffix is not used with the command. The clock and trigger lines are the eight VXI backplane bi-directional TTLTRG lines. The clock lines are the odd TTLTRG lines 1, 3, 5, and 7; the trigger lines are the even TTLTRG lines 0, 2, 4, and 6.

Because the implied output "STATe" sub-command is Boolean, its parameter can be in either of two formats; "ON" is the same as "1", "OFF" is the same as "0".

The response to a query about a Boolean state will return only a "1" or "0".

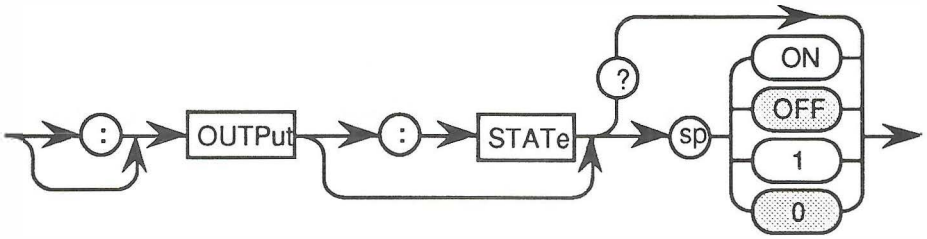
The trigger source used by the Arb is selected in the Trigger subsystem.

The clock source used by the Arb is selected in the Source subsystem.

The **BOLD** upper case characters used in both the command tree and the command lines are the shortform mnemonic. Only the exact shortform or the exact longform may be used. The brackets, [ ], around keywords in the command tree identify optional commands or parameters. These optional keywords may be used in the command line for clarity, but are not required.

3.8.1 Output Trace ON/OFF State

DEFAULT:
STATE: OFF



The OUTPut command permits the trace output to be turned ON or OFF. Example 1 illustrates the use of the optional STATe sub-command. Example 5 illustrates the output state query.

Example 1: Turn the Arb output ON (optional STATe command shown); enter

```
:OUTPut:STATe ON
```

Example 2: Turn the output ON, alternate method; enter

```
:OUTPut 1
```

Example 3: Turn the output OFF; enter

```
:OUTPut OFF
```

Example 4: Turn the output OFF, alternate method; enter

```
:OUTPut 0
```

Example 5: What is the state of the output? Enter

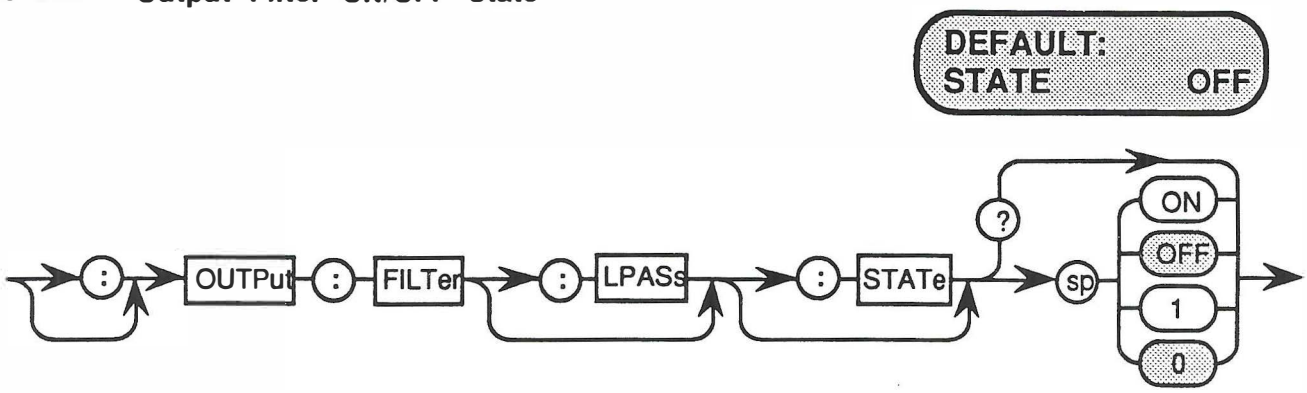
```
:OUTPut?
```

The example response may be:

```
1
```

which indicates the selected trace is at the Output BNC.

3.8.2 Output Filter ON/OFF State



This command inserts the 6-pole 4MHz low pass filter into the trace output path when turned ON. The filter attenuates frequencies above 4MHz. These are predominantly clock pulses that may be on the output line or the higher harmonics of sharp transition waveforms such as the square wave. The filter will also smooth the the Arb waveform when relatively few points are used in its creation. Example 1 illustrates the use of the optional LPASs and STATe sub-commands. Example 5 illustrates the output filter state query.

Example 1: Turn filter ON; enter

```
:OUTPut:FILTer:LPASs:STATe ON
```

Example 2: Turn filter ON, alternate method; enter

```
:OUTPut:FILTer 1
```

Example 3: Turn filter OFF; enter

```
:OUTPut:FILTer OFF
```

Example 4: Turn filter OFF, alternate method; enter

```
:OUTPut:FILTer 0
```

Example 5: What is the state of the output filter? Enter

```
:OUTPut:FILTer?
```

The example response may be:

```
1
```

which indicates the filter is in the trace output path.

3.8.3 Output Trigger to Backplane

The Arb can supply one of four triggers for use as a system (VXI) trigger on one of the four even numbered backplane TTL trigger lines found on P2. The output line and source should be selected before setting the output to ON. If a line suffix number is not used with the command, TTLTrg0 is selected (VXI TTL trigger line 0). Selecting any one line will de-select the other three lines. An illustration of the Arb $TTLTrg_n$ and VXI TTLTRG line relationship is shown, for clarity, as a mechanical switch in figure 3-6. Also, refer to figure 3-8 for an overview of the clock/trigger inputs and outputs.

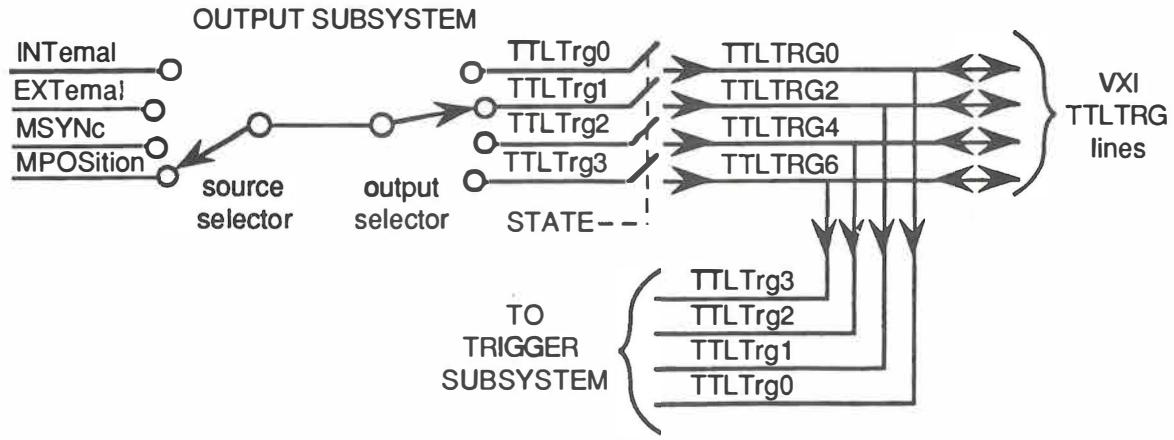


Figure 3-6 Arb Trigger Output to VXI Backplane.

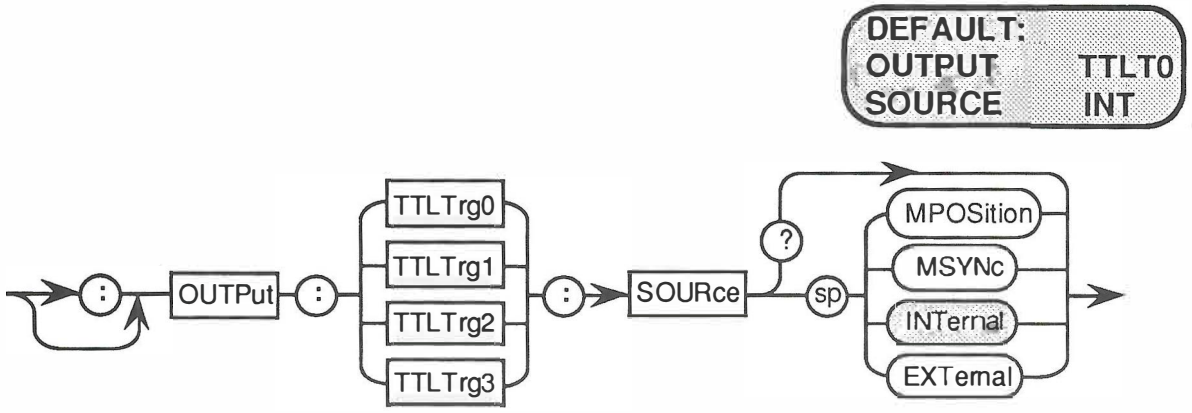
The trigger source selections available are:

Internal	a trigger derived from the Arb clock
External	a trigger derived from the signal applied to the Arb front panel TRIGGER IN BNC
Msync	a trigger derived from Marker Sync selection
Mposition	a trigger derived from the Marker Position selection.

The trigger output selections available are:

TTLTrg0	may only be connected to the VXI TTL TRG0 backplane line
TTLTrg1	may only be connected to the VXI TTL TRG2 backplane line
TTLTrg2	may only be connected to the VXI TTL TRG4 backplane line
TTLTrg3	may only be connected to the VXI TTL TRG6 backplane line.

3.8.3.1 Trigger Output Line and Source



This command path selects which trigger source will be assigned to the selected trigger output line. The power-up default assigns the source of each line to internal. TTLTrg0 (VXI TTLTRG line 0) is selected if a numerical suffix for the line is not used in the command. The output signal, when Internal is selected, is a pulse with a maximum frequency of 2MHz and a width greater than 100 ns. When External is selected, the output signal is the same as the signal applied to the TRIG IN BNC on the front panel (the VXI TTLTRG lines should not have signals greater than 12.5 MHz applied). Both the MPOSition and the MSYNc signals to the TTLTRG lines are the same as the signals seen at the front panel POSITION and SYNC BNC outputs. Example 3 shows the TTLTrg0 default. Example 5 illustrates the output source query for trigger line 2.

Example 1: Select the Internal Trigger for trigger line 1; enter

```
:OUTPut:TTLTrg1:SOURce INTernal
```

Example 2: Apply the External Trigger to TTL trigger line 2; enter

```
:OUTPut:TTLTrg2:SOURce EXTernal
```

Example 3: Set trigger line 0 for the Mposition (showing line 0 default); enter

```
:OUTPut:TTLTrg:SOURce MPOSition
```

Example 4: Apply the Arb Msync to line 3; enter

```
:OUTPut:TTLTrg3:SOURce MSYNc
```

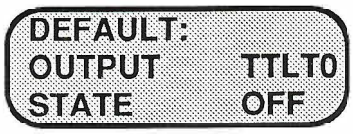
Example 5: What is the trigger source on line 2? Enter

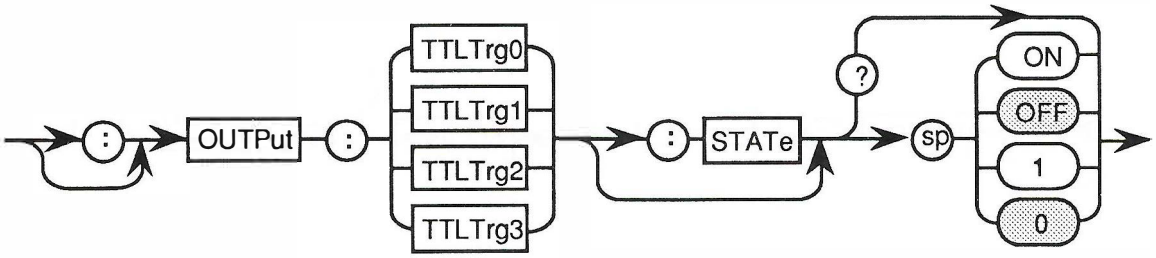
```
:OUTPut:TTLTrg2:SOURce?
```

An example response may be (the short form is always returned):

```
EXT
```

3.8.3.2 Trigger Output Line ON/OFF State





This command sequence will turn the selected trigger output line ON or OFF. Selecting any one line will de-select the other three lines. Example 1 illustrates the use of the optional STATe sub-command. Examples 2 and 4 illustrate the alternate Boolean values. Example 3 illustrates the default to TTLTrg0 if a numerical suffix for the line is not used. Example 5 illustrates the output state query for trigger line 2.

Example 1: Turn trigger line 2 ON; enter

```
:OUTPut:TTLTrg2:STATe ON
```

Example 2: Turn the trigger signal on TTL line 3 to ON; enter

```
:OUTPut:TTLTrg3 1
```

Example 3: Turn the TTL line 0 trigger OFF (showing line 0 default); enter

```
:OUTPut:TTLTrg OFF
```

Example 4: Turn trigger 1 OFF; enter

```
:OUTPut:TTLTrg1 0
```

Example 5: What is the state of trigger line 2 output; enter

```
:OUTPut:TTLTrg2?
```

The example response may be:

0

which indicates the Arb trigger line 2 does not have an output to the backplane.

3.8.4 Output Clock to Backplane

The Arb can supply one of two clocks for use within the chassis on one of four backplane trigger lines (TTLTRG lines 1, 3, 5, and 7) at P2. The output line and source should be selected before setting the output to ON. Clock0 (VXI TTL trigger line 1) is selected if the line number suffix is not used with the command. Selecting any one line will de-select the other three lines. A mechanical switch analog is shown in figure 3-7. Also, refer to figure 3-8 for an overview of the clock/trigger inputs and outputs.

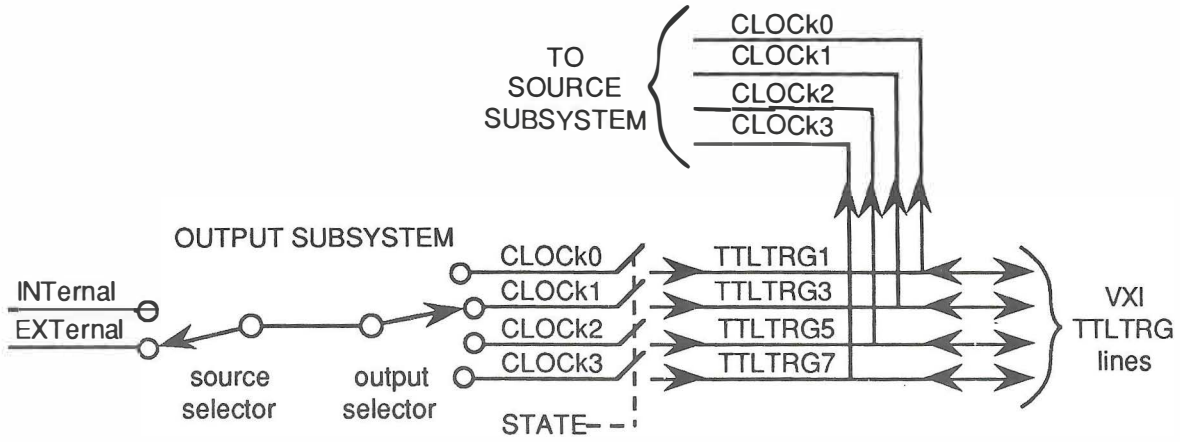


Figure 3-7 Arb Clock Output to VXI Backplane.

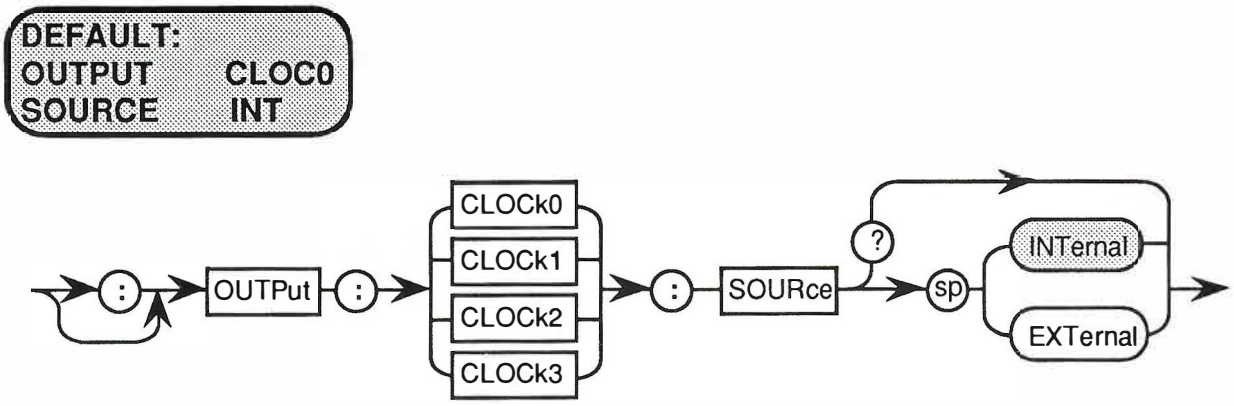
The clock sources available are:

Internal	the internal clock is derived from the VXI CLK10 on the backplane
External	the external clock is from the Arb CLOCK IN BNC.

The clock Output selections available are:

CLOCk0	may only be connected to the VXI TTL TRG1 backplane line
CLOCk1	may only be connected to the VXI TTL TRG3 backplane line
CLOCk2	may only be connected to the VXI TTL TRG5 backplane line
CLOCk3	may only be connected to the VXI TTL TRG7 backplane line.

3.8.4.1 Clock Output Line and Source



This command path selects which clock source will be assigned to the selected output line. The power-up default assigns the source of each line to internal. CLOCk0 is assigned if the line number suffix is not used. The output signal when Internal is selected is a symmetrical square wave of 20 MHz in CW mode and the raster frequency in raster mode (the VXI TTLTRG lines should not have signals greater than 12.5 MHz applied). When External is selected, the output signal is the same as the signal applied to the CLOCK IN BNC on the front panel. Example 3 shows the CLOCk0 default. Example 4 illustrates the source query for clock line 2.

Example 1: Use the Arb Internal clock on line 1; enter

```
:OUTPut:CLOCk1:SOURce INTernal
```

Example 2: Set the External clock to line 3; enter

```
:OUTPut:CLOCk3:SOURce EXTernal
```

Example 3: Set the Internal clock to line 0; enter (showing line 0 default)

```
:OUTPut:CLOCk:SOURce INTernal
```

Example 4: Which clock source is on clock line 2?

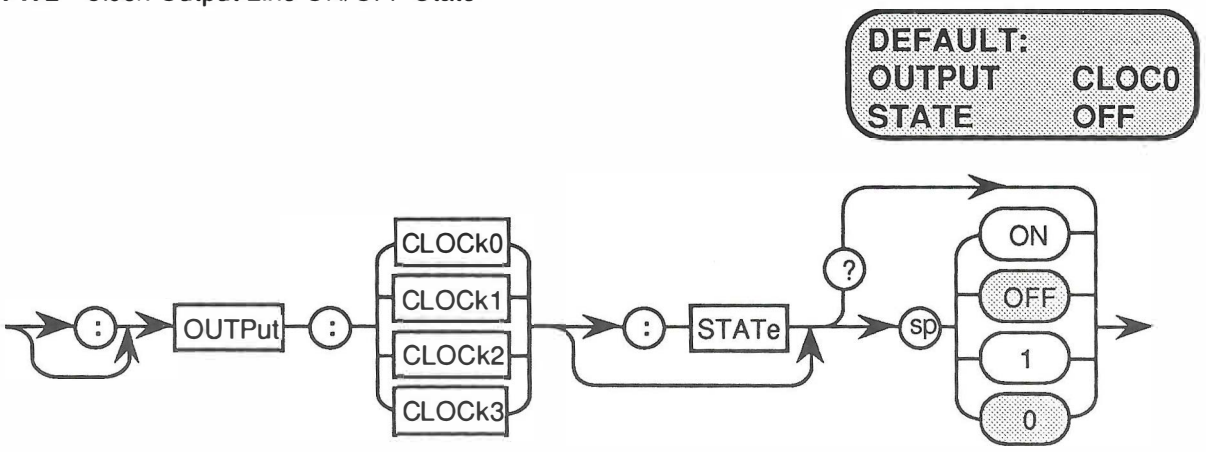
```
:OUTPut:CLOCk2:SOURce?
```

The example response may be (the short form is always returned):

```
INT
```

which indicates the clock derived from the VXI CLK10 is on line 2. If the Arb is set to CW in the SOURce subsystem, the INTernal clock is 20 MHz; if it is set to RASTer, the INTernal clock is the raster frequency.

3.8.4.2 Clock Output Line ON/OFF State



This command sequence will turn the selected clock output line ON or OFF. Selecting any one line will de-select the other three lines. Example 1 illustrates the use of the optional STATe sub-command. Examples 2 and 4 illustrate the alternate Boolean values. Example 3 shows the CLOCk0 default when a clock line suffix is not used. Example 5 illustrates the output clock state query for trigger line 2.

Example 1: Turn the signal on Clock line 1, ON; enter

```
:OUTPut:CLOCk1:STATe ON
```

Example 2: Turn the signal on Clock line 1, ON, alternate method; enter

```
:OUTPut:CLOCk1 1
```

Example 3: Turn clock line 0 OFF; enter (showing the line 0 default)

```
:OUTPut:CLOCk OFF
```

Example 4: Turn clock line 3 OFF; enter

```
:OUTPut:CLOCk3 0
```

Example 5: What is the state of output clock line 2?

```
:OUTPut:CLOCk2?
```

The example response may be:

0

which indicates clock line 2 does not have an output to the backplane.

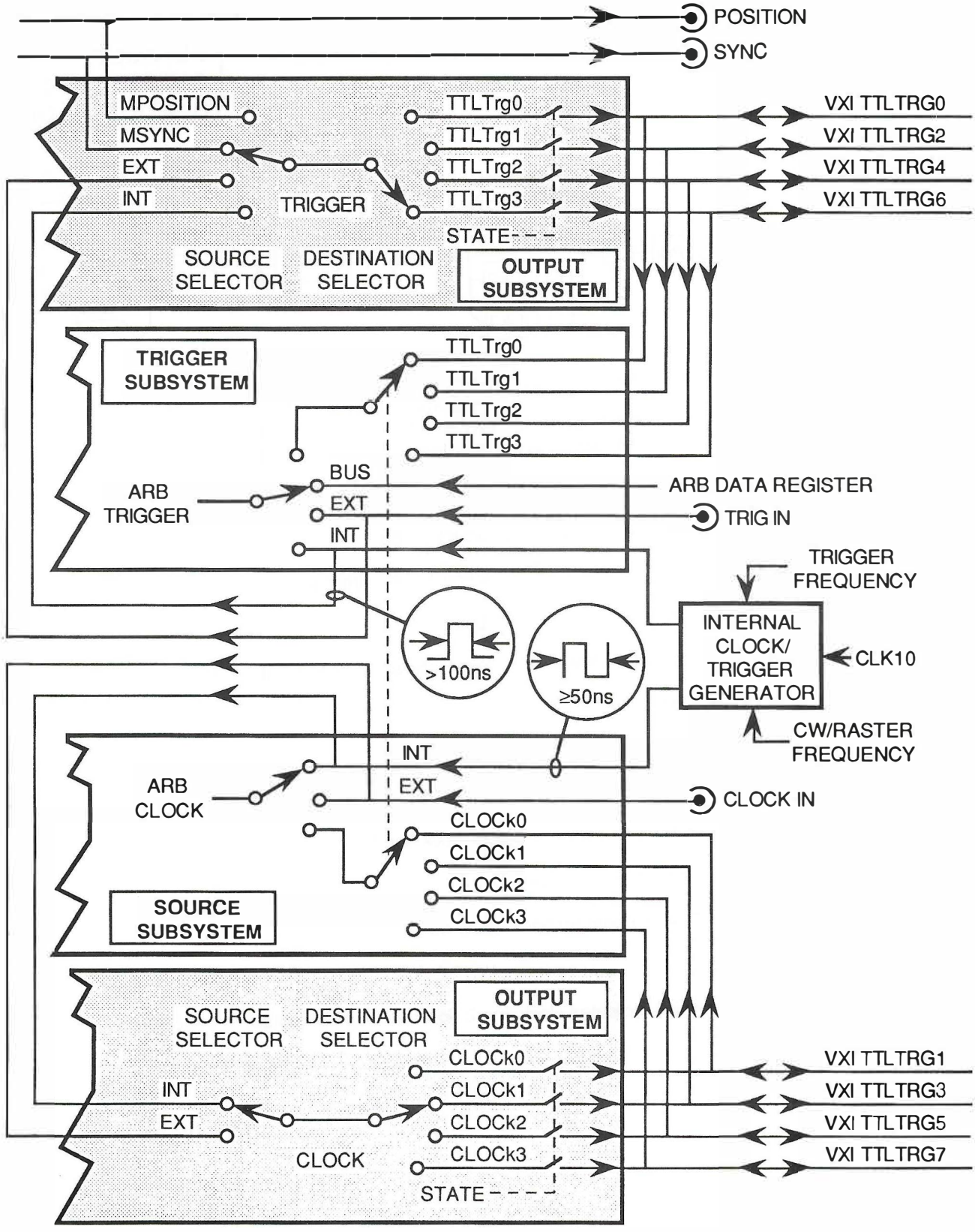
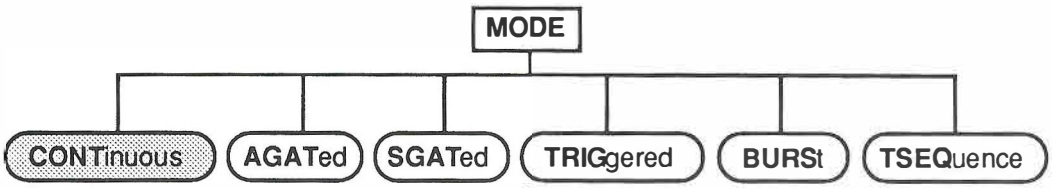


Figure 3-8 Clock/Trigger Input/Output Block Diagram

3.9 MODE SUBSYSTEM



The CONTinuous mode (default) applies no trigger or sync constraints to the output signal; the waveform is generated continuously. The output can be seen at the ARB OUT BNC on the front panel when the output is turned ON. The **BOLD** upper case characters used in both the command tree and the command lines are the shortform mnemonic. Only the exact shortform or the exact longform may be used. The untriggered output value at the ARB OUT BNC is the combined value of the first trace point used and the source amplitude/offset voltage setting. The trace start and stop points may be changed using the LIMit command in the TRACe subsystem.

AGATed
When in the Asynchronous GATed mode, the waveform will be generated as long as the External Trigger is high or all other triggers (INTernal, TTLTrg$_n$, and BUS) are low. The waveform will end where the trigger signal stops and start at the beginning again when the trigger is detected. Refer to figure 3-9.

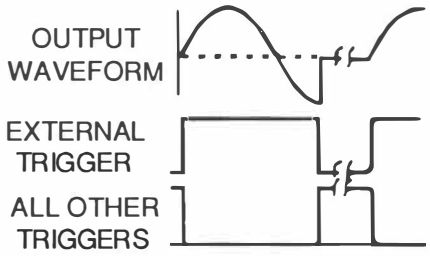


Figure 3-9 Trigger and Signal in the Asynchronous Gated Mode.

SGATed
When Synchronously GATed is selected, the waveform is generated upon the occurrence of the trigger signal. The waveform will finish the cycle it is in after the trigger stops. Refer to figure 3-10.

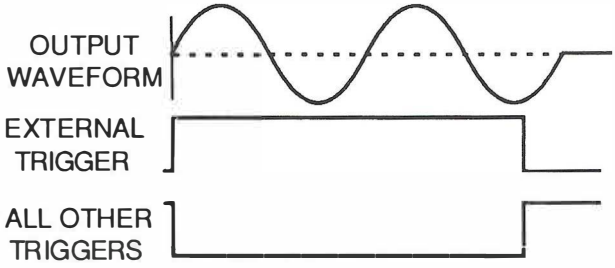


Figure 3-10 Trigger and Signal in the Synchronous Gated Mode.

TRIGgered
When the TRIGgered mode has been selected, the Arb waits for the positive going edge of the External trigger (negative edge of all other triggers) before generating the waveform. The waveform will only be generated once, then the Arb will wait until the next occurrence of the trigger edge. Refer to figure 3-11.

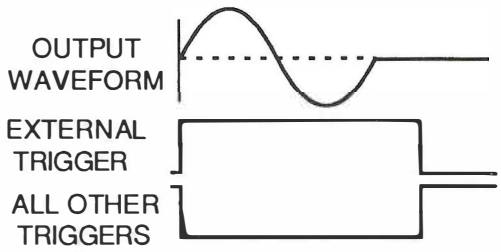


Figure 3-11 Trigger and Signal in the Triggered Mode.

BURSt
When in the BURSt mode, the positive edge of the External trigger (negative edge of all other triggers) will generate the selected waveform the number of times set by the burst quantity. The burst quantity ranges from 1 to 10,000,000 and must be set using the SOURce subsystem. Refer to figure 3-12.

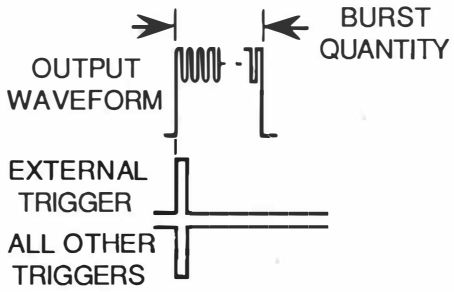


Figure 3-12 Trigger and Signal in the Burst Mode.

TSEQuence
In the Triggered SEQuence mode, the leading edge of the trigger begins the generation of the trace in memory block 1 (each 8192 point memory block used must be filled with only one trace of 8192 points and each end point must fall on the block boundaries). Failure to size block 1 correctly will yield unexpected results. The TRACe:SELect command must select the trace name in block 1. The block 1 trace is generated continuously until the next trigger which begins the generation of the trace in memory block 2 (if more than one block is selected). The start address in each new block is the next sequential address after the last address in the previous block (if a trigger occurs at 3999 in block 1, block 2 starts at 4000). Block 1 initially starts at address "0" unless block limits have been invoked. The new block is continuously cycled until the trigger selects the next block, etc. Upon detection of the trigger while cycling through the last block, the Arb will begin the sequence anew at the next sequential address in block 1. The range of blocks is 1 through 4, (16 with optional memory), set in the SOURce subsystem. The block start and stop points may be changed using the LIMit command in the TRACe subsystem. Refer to figure 3-13.

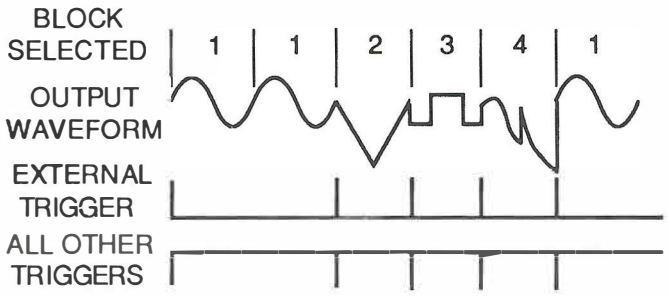
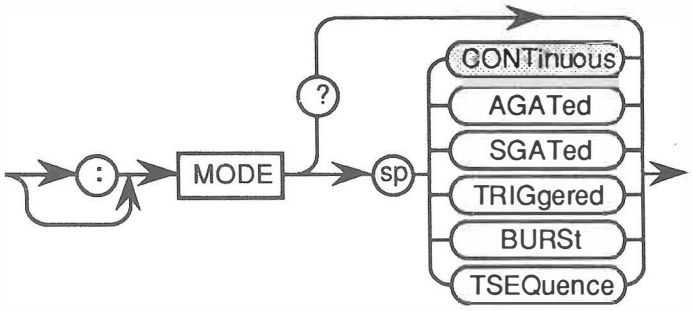


Figure 3-13 Trigger and Signal In the Triggered Sequence Mode.



The Mode Subsystem has no branches, only the parameters shown. Examples are shown below. Example 6 shows the Mode query form.

Example 1: Set the mode to Asynchronous gated; enter

```
:MODE AGATed
```

Example 2: Set the mode to Synchronous gated; enter

```
:MODE SGATed
```

Example 3: Set the mode to Triggered; enter

```
:MODE TRIGgered
```

Example 4: Set the mode to Burst; enter

```
:MODE BURSt
```

Example 5: Set the mode to Triggered Sequence; enter

```
:MODE TSEQuence
```

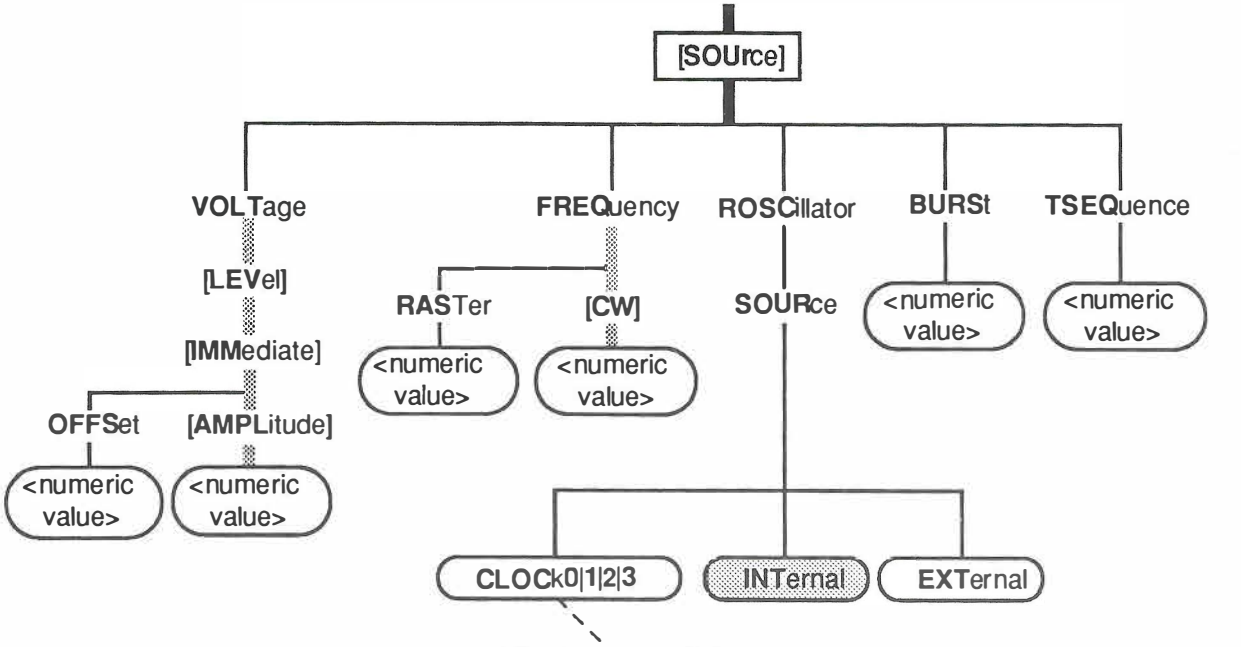
Example 6: What is the mode set for? Enter

```
:MODE?
```

A response to example 6 may be (the short form is always returned):

```
BURS
```

3.10 SOURCE SUBSYSTEM



The Source subsystem is the power-up default. This subsystem selects the source signal characteristics.

The VOLTage sub-command allows control of the waveform AMPLitude and OFFSet level. The waveform AMPLitude is the default.

The FREQuency value entered in the default CW selection is the waveform output frequency. The memory is scanned at a rate internally calculated to yield the output frequency. The FREQuency value entered in RASTer is the rate at which the memory is scanned. The output frequency in RASTer is determined by the ratio of the total number of points for the waveform and the rate at which they are scanned. Also refer to the TRACe:MODE command 3.12.3.

The Reference OSCillator has three possible sources; the internal 20MHz reference (derived from the VXI CLK10), the external CLOCK IN BNC, and the mainframe VXI TTLTRG lines. One of four TTLTRG lines can be selected as a clock source (TTLTRG1, TTLTRG3, TTLTRG5, or TTLTRG7). The Clock suffix selected will also select a like suffix in the Trigger subsystem. The default Reference Oscillator is INTernal.

The BURSt selection requires a burst parameter quantity be entered between 1 and 10,000,000 (only functional when the MODE subsystem is set to BURSt).

The Triggered SEQuence selection requires a block parameter quantity of 1 through 4 (only functional when the MODE subsystem is set to TSEQuence). If the extended memory option is installed, the value may range from 1 through 16.

The **BOLD** upper case characters used in both the command tree and the command lines are the shortform mnemonic. Only the exact shortform or the exact longform may be used. The brackets, [ ], around keywords in the command tree identify optional commands or parameters. These optional keywords may be used in the command line for clarity, but are not required.

3.10.1 Source Voltage

The source voltage is composed of two components, the trace amplitude and the offset. When the VOLTage command is selected, the default path is AMPLitude. OFFSet must be specified. The value for either may be entered using standard notation, scientific notation, or the special number forms of MAXimum, MINimum or DEFault. The amplitude and offset are coupled, limiting the absolute value to 5V for the sum of the two.

The Source Amplitude command sets the absolute value of the maximum amplitude voltage. The amplitude voltage is at maximum when the selected trace point is at its minimum or maximum value. The value of a point in trace memory affects the output amplitude in the manner shown in figure 3-14. Each point in memory contains a value in the range of 0_{10} (000_{16}) to 4095_{10} (FFF_{16}). As trace memory is scanned, these values are converted to analog voltages for output. The Arb is calibrated so that the value 2048_{10} (800_{16}) corresponds to 0V amplitude and the values 1_{10} (001_{16}) and 4095_{10} (FFF_{16}) respectively correspond to the negative and positive full scale amplitude voltages.

Because of the way the Arb is calibrated, the point value 0_{10} (000_{16}) will generate an output voltage slightly more negative than the programmed amplitude. For traces to be symmetrical about 0V, point values should be limited to values between 1_{10} (001_{16}) and 4095_{10} (FFF_{16}).

All factory pre-defined traces of a cyclical nature (SINusoid, SQUare, PRAMp, etc.) are generated such that their most positive point has a value of 4095_{10} (FFF_{16}) and their most negative point has a value of 1_{10} (001_{16}). This makes their amplitude voltages symmetrical about 0V and the absolute value of their peak voltages equal to the programmed amplitude (with offset at 0V).

The Source Offset command sets the value of the offset voltage. The offset voltage is added to the amplitude voltage and is usually used to provide a dc offset. The combined value of the amplitude and the offset voltages cannot exceed |5V|.

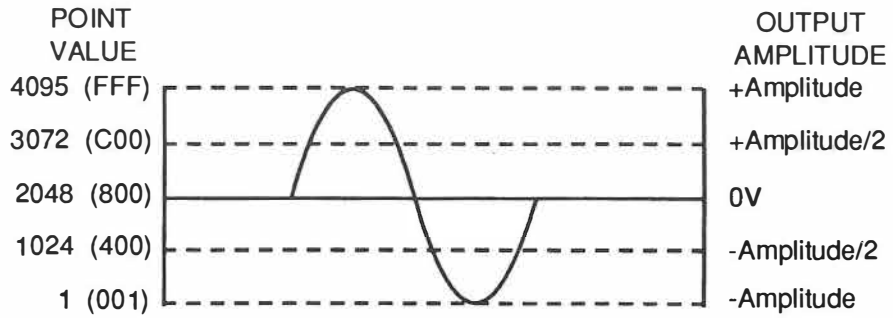
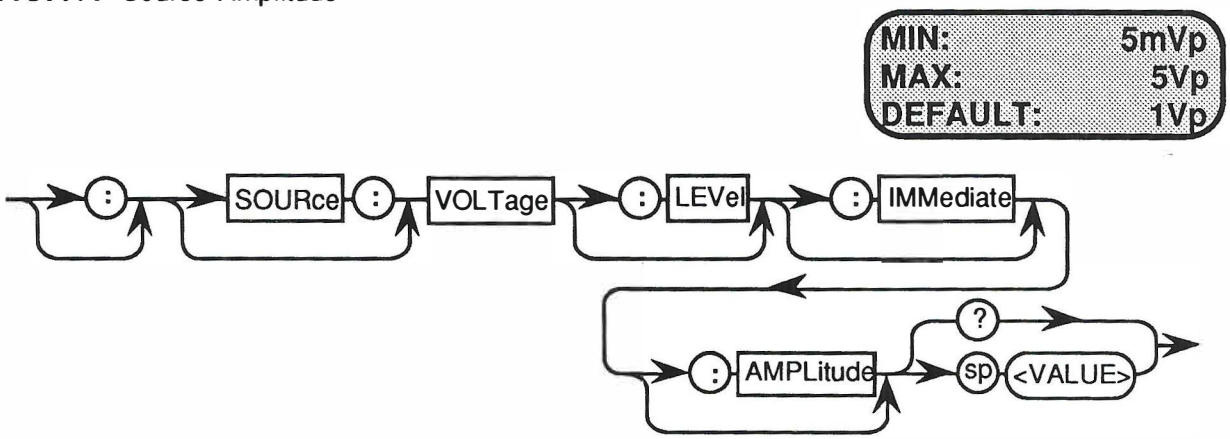


Figure 3-14. Point Values vs Amplitude

3.10.1.1 Source Amplitude



Example 1 shows the command path using the optional SOURce, LEVel, IMMediate, and AMPLitude commands. Example 4 and 5 show queries.

Example 1: Set the output amplitude to 5Vp; enter

```
:SOURce:VOLTage:LEVel:IMMediate:AMPLitude 5
```

Example 2: Set the Amplitude to maximum; enter

```
:VOLTage MAXimum
```

Example 3: Set the Amplitude to 20 mVp; enter

```
:VOLTage 2E-2
```

Example 4: What is the amplitude set for? Enter

```
:VOLTage?
```

An example response may be (fundamental units are returned):

```
3.500
```

The amplitude is set for 3.5 Vp.

Example 5: What is the default amplitude? Enter:

```
:VOLTage? DEFault
```

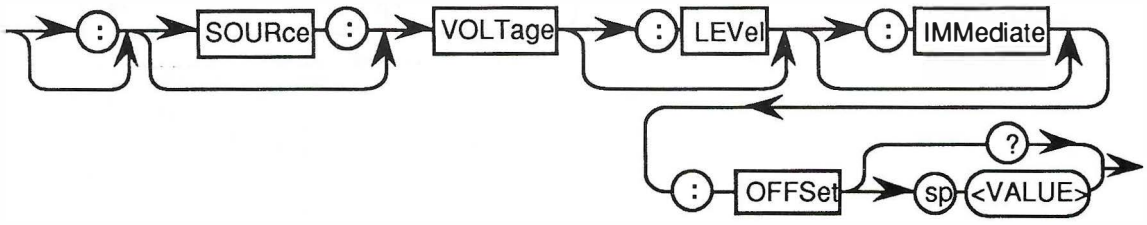
The response will be:

```
1.000
```

The default amplitude is 1Vp.

3.10.1.2 Source Offset

MIN:	-5V
MAX:	+5V
DEFAULT:	0V



Example 1 shows the full path with the optional SOURce, LEVel, and IMMediate commands. Example 5 shows the query for the offset. The positive values are implied. The "+" sign may be entered if desired. The negative sign, "-", must be entered for negative values.

Example 1: Change the offset to +2V; enter

```
:SOURce:VOLTage:LEVel:IMMediate:OFFSet +2
```

Example 2: Set the offset to -3V; enter

```
:VOLTage:OFFSet -3
```

Example 3: Adjust the offset to +0.05V; enter

```
:VOLTage:OFFSet 5E-2
```

Example 4: Change to maximum negative; enter

```
:VOLTage:OFFSet MINimum
```

Example 5: What is the offset voltage? Enter

```
:VOLTage:OFFSet?
```

An example response may be (fundamental units are returned):

```
-.01230
```

Example 6: What is the maximum offset? Enter

```
:VOLTage:OFFSet? MAXimum
```

The response will be:

```
5.000
```

3.10.2 Source Frequency

The SOURce frequency selection (CW or Raster) must coincide with the selection of the CW or Raster mode in the TRACe subsystem (paragraph 3.12.3). When Raster mode is selected, the output frequency must either be computed or the output monitored to determine its value. The CW (Arb output) frequency entered has a range from 100 mHz to 2.5 MHz, while the Raster (memory sampling) frequency has a range from 1mHz to 20 MHz.

The selection of CW permits the direct entry of the Arb output frequency, the memory sampling frequency is internally calculated. The selection of Raster permits the direct control of the Arb memory sampling frequency. CW will permit the Arb to decrease the number of points used for the trace when the requested output frequency prevents all from being included; it permits the Arb to decrease the memory sampling frequency in order to decrease the output frequency. Raster requires the user to directly decrease the number of trace points if the desired output frequency cannot be achieved with the sampling frequency being used, or to change the sampling frequency-or both. Refer to figures 3-15 and 3-16 for a simplified block diagram of the two modes and the function of the frequency value entered. The figures are shown with the Reference Oscillator selection as INTernal.

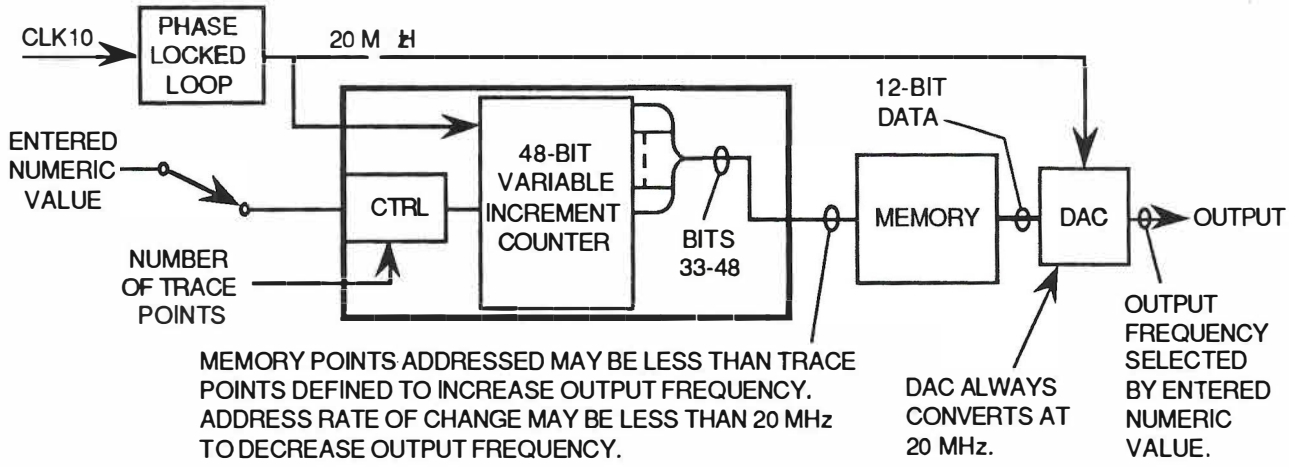


Figure 3-15. CW Block Diagram

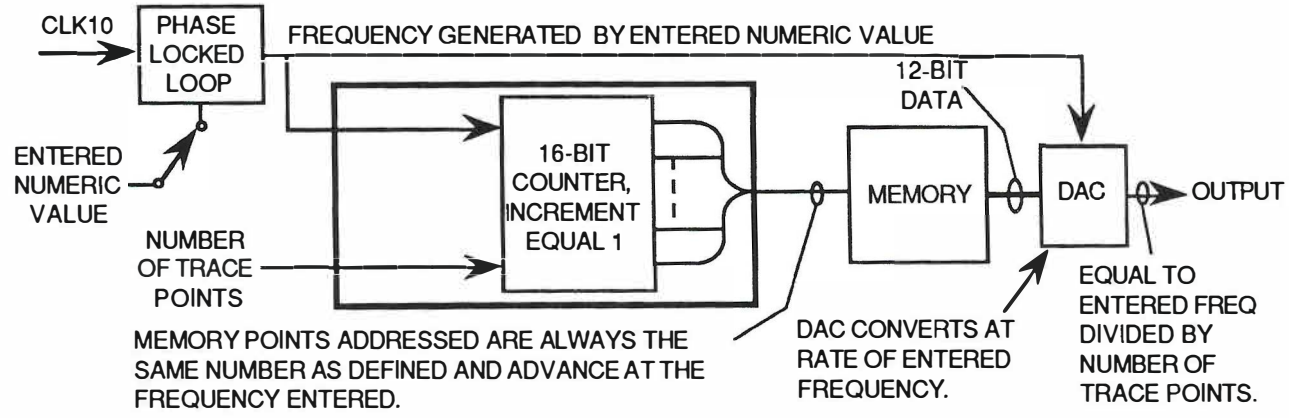
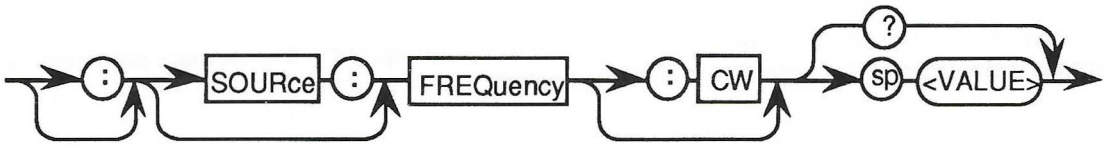


Figure 3-16. Raster Block Diagram.

3.10.2.1 CW (Arb Output Frequency)

RANGE: 100 mHz to 2.5 MHz
DEFAULT: 1KHz



The frequency entered is the trace output frequency. The command is not applied unless the Trace subsystem is also set to the CW Mode. Example 1 has the optional SOURce and CW commands shown, examples 5 and 6 are queries.

Example 1: Set the output frequency to 120 Hz; enter

```
:SOURce:FREQuency:CW 120
```

Example 2: Set the waveform output frequency to 2MHz; enter

```
:FREQuency 2E6
```

Example 3: Set the frequency to 315 mHz; enter

```
:FREQuency 3.15E-1
```

Example 4: Set the output frequency to default; enter

```
:FREQuency DEFault
```

Example 5: What is the waveform output frequency? Enter

```
:FREQuency?
```

An example return may be (fundamental units are returned):

```
2.0000E+4
```

Which indicates the output frequency is set to 20 KHz.

Example 6: What is the minimum frequency? Enter

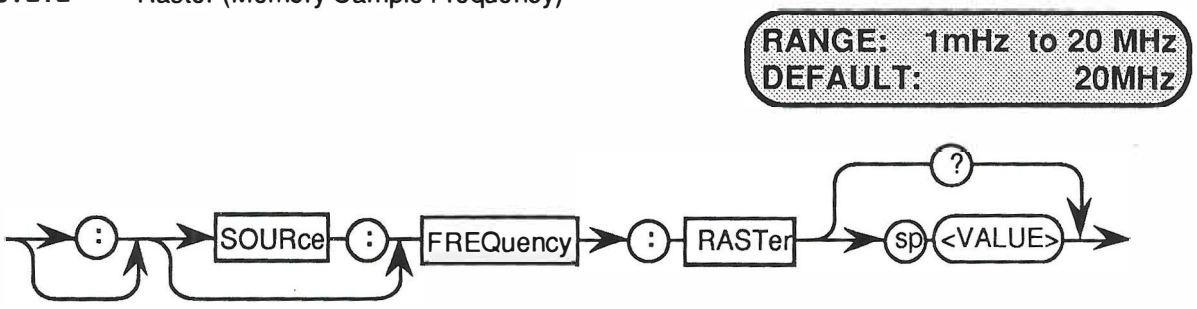
```
:FREQuency? MINimum
```

The return will be:

```
1.000000E-03
```

Which indicates the minimum frequency is 1mHz.

3.10.2.2 Raster (Memory Sample Frequency)



The Raster frequency entered is the memory sampling frequency. The output frequency depends on the number of memory points (between 8 and 32768 [or 131072 with the optional memory]) and the rate at which they are sampled (Raster frequency). The command is not applied unless the Arb Trace subsystem has also been set to the Raster mode. Example 1 shows the optional SOURce command and example 5 shows the query form of the command.

Example 1: Set the Raster sample frequency to 120 Hz; enter

```
:SOURce:FREQuency:RASTer 120
```

Example 2: Set the Raster frequency to 10 MHz; enter

```
:FREQuency:RASTer 1E7
```

Example 3: Set the memory sample frequency to 315 mHz; enter

```
:FREQuency:RASTer 3.15E-1
```

Example 4: Set the Raster frequency to maximum; enter

```
:FREQuency:RASTer MAXimum
```

Example 5: What is the Raster frequency? Enter

```
:FREQuency:RASTer?
```

An example return may be (fundamental units are returned):

1000000

Which indicates the Raster frequency is 1MHz.

Example 6: What is the default Raster frequency? Enter

```
:FREQuency:RASTer? DEFault
```

The response will be:

20000000

Which indicates the default Raster frequency is 20 MHz.

3.10.3 Source Reference Oscillator

DEFAULT:
SOURCE: INTERNAL

When INTernal is selected, the memory sample clock is generated by an internal crystal controlled multiplier/divider referenced to the VXI 10 MHz clock, CLK10. CLK10 has a specified accuracy of ±100 PPM.

For the External setting, the user supplies the memory sample clock at the CLOCK IN BNC on the front panel. The internal multiplier/divider is not used. The clock supplied is used directly. For the CW Frequency setting to be accurate, the External Clock must be 20 MHz.

For the CLOCk0 through CLOCk3 settings, the signals on the odd numbered VXI TTLTRG lines (TTLTRG 1, 3, 5, and 7) are used. The VXI specification limits them to a maximum of 12.5 MHz. Because the internal multiplier/divider is not used, the output frequency in CW mode will not be as expected with a 20 MHz clock. The CLOCk0 through CLOCk3 input lines and the TTLTrg0 through TTLTrg3 input lines are "ganged". For example, when CLOCk0 is selected, TTLTrg0 is also selected, and vice versa. The block diagram illustrating the clock selections is shown in figure 3-17. Also, refer to figure 3-8 for a block diagram of the complete clock/trigger system.

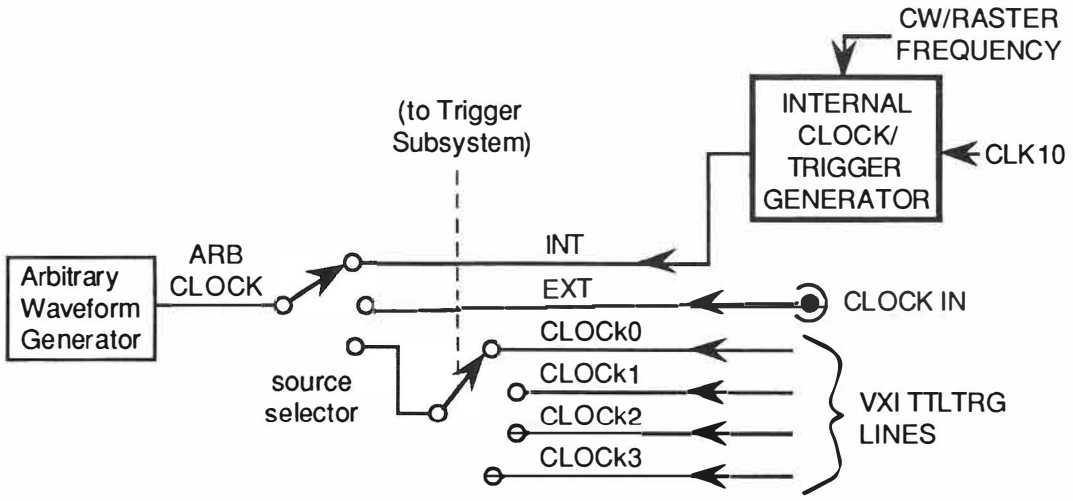
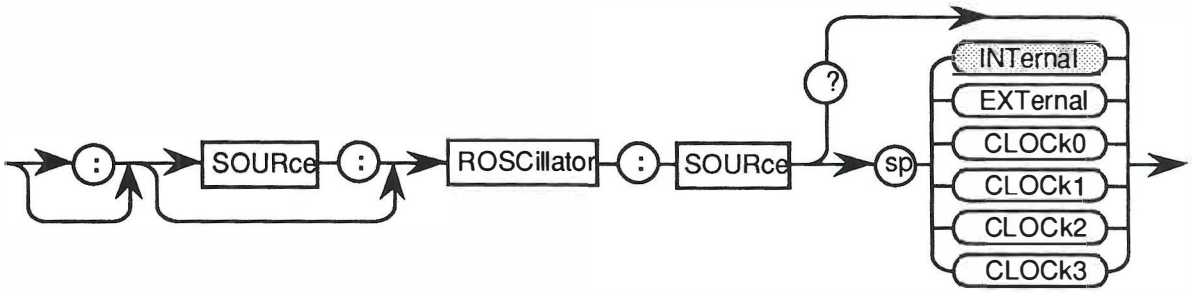


Figure 3-17 Input Clock Selections.

3.10.3 Source Reference Oscillator (cont)



Example 1 shows the optional SOURce command and example 4 shows the query form of the command. CLOCk0 is selected if a suffix is not used.

Example 1: Select the Reference Oscillator to be external; enter

```
:SOURce:ROSCillator:SOURce EXTernal
```

Example 2: Choose the Reference Oscillator on Clock Line 2; enter

```
:ROSCillator:SOURce CLOCk2
```

Example 3: Use Clock line 0 for the Arb clock (using default method); enter

```
:ROSCillator:SOURce CLOCk
```

Example 4: What is the source of the Arb Reference Oscillator? Enter

```
:ROSCillator:SOURce?
```

An example response may be (the short form is always returned):

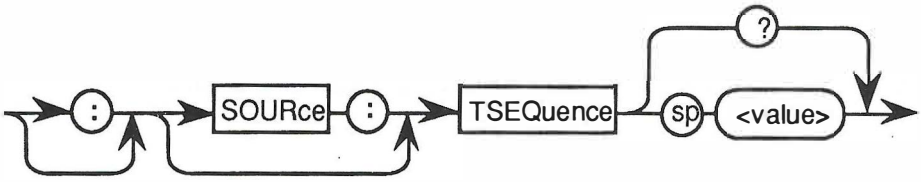
```
CLOC3
```

Which indicates the signal on Clock3 (VXI TTLTRG7) is being used as the clock.

3.10.4 Source Triggered Sequence

RANGE: 1 to 4 (16)
DEFAULT: 1

The value entered defines the number of blocks (8192 points each) used for generating the trace when the MODE subsystem is set to Triggered SEQuence. Upon receiving a trigger, the trace in memory block 1 is sequenced continuously until the next trigger, generating the output waveform. At the next trigger, memory block 2 is read beginning at the next address. Each block must contain only one trace composed of 8192 points. The trace in the new block is generated continuously until the next trigger, etc. There are four blocks in memory numbered 1 through 4 (16 with the optional memory). The start point is always block 1. Because the block sequencing is circular, block 1 will follow the last block programmed. The TRACe:SELect command must select the first first block by using the 8192 point trace name in block 1. If the TRACe:LIMit command (paragraph 3.12.5) has been exercised on a block level, the start and stop points in all blocks will be equally re-defined.



Example 1 shows the optional SOURce command and the last two examples show the query about the number of blocks to be sequenced and the maximum possibility.

Example 1: Set the number of blocks used to 3; enter

```
:SOURce:TSEQuence 3
```

Example 2: Set the blocks used to maximum; enter

```
:TSEQuence MAXimum
```

Example 3: What is the number of blocks used? Enter

```
:TSEQuence?
```

A possible return may be:

```
2
```

Which indicates the first two blocks are selected for sequencing.

Example 4: What is the maximum number of blocks? Enter

```
:TSEQuence? MAXimum
```

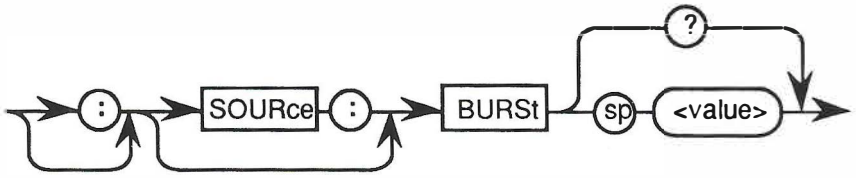
The response will be one of two possibilities, depending upon memory size.

```
4 or 16
```

3.10.5 Source Burst

RANGE: 1 to 10,000,000
DEFAULT : 1

The Burst size quantity determines the number of trace cycles sent to the ARB OUT BNC after the Arb receives a trigger. The burst quantity only applies when in the Burst Mode. The range is from 1 to 10,000,000.



Example 1 shows the optional SOURce command and the last examples show the query forms of the command.

Example 1: Set the waveform burst for a count of 25; enter

```
:SOURce:BURSt 25
```

Example 2: Set the waveform for an output burst of 15,000; enter

```
:BURSt 1.5E4
```

Example 3: Set the output burst for maximum; enter

```
:BURSt MAXimum
```

Example 4: What is the burst value set for? Enter

```
:BURSt?
```

A return may be:

```
10352
```

Which indicates the selected trace will be output 10,352 times upon the occurrence of the trigger.

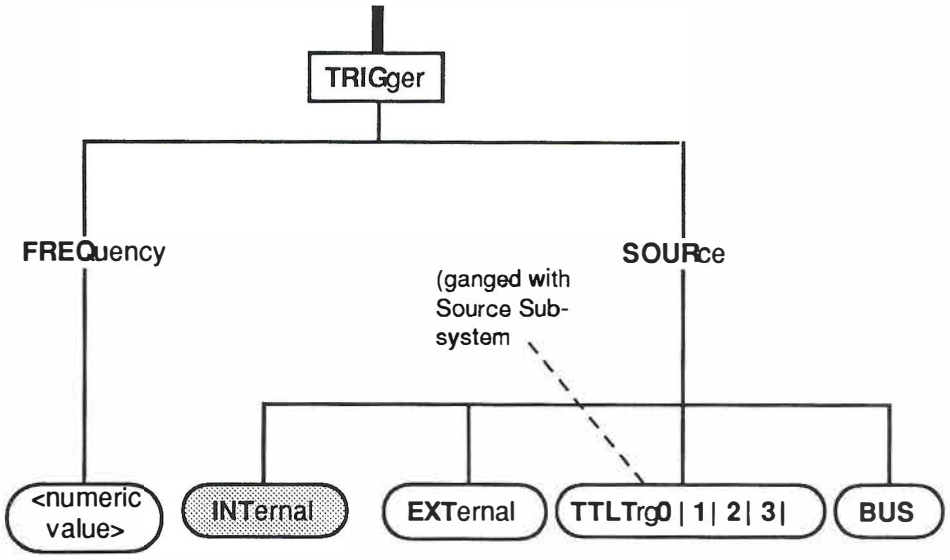
Example 5: What is the default burst value? Enter

```
:BURSt? DEFault
```

The result will be:

```
1
```

3.11 TRIGGER SUBSYSTEM



The Trigger subsystem selects the trigger source and frequency. The trigger default at power-up is Internal and 1kHz. The trigger frequency may be selected when the Internal source is selected. The internal trigger pulse has a minimum width of 100ns.

The EXTernal selection is supplied by the user at the front panel TRIG IN BNC, the BUS is a programmed event from the controller (***TRG**), and the source for the TTLTrg signals is on the P2 connector (TTLTRG lines 0, 2, 4, and 6).

The TTLTrg0 through TTLTrg3 input lines and the CLOCk0 through CLOCk3 input lines are "ganged". For example, when TTLTrg1 is selected, CLOCk1 is also selected, and vice versa. The block diagram illustrating the trigger selections is shown in figure 3-18. Also refer to figure 3-8 for a block diagram of the complete clock/trigger system.

The **BOLD** upper case characters used in both the command tree and the command lines are the shortform mnemonic. Only the exact shortform or the exact longform may be used.

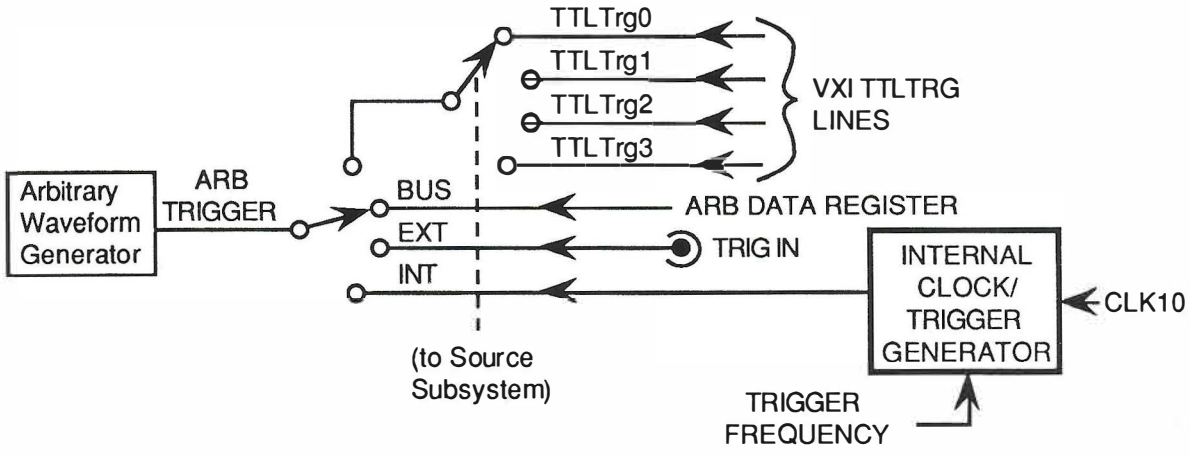
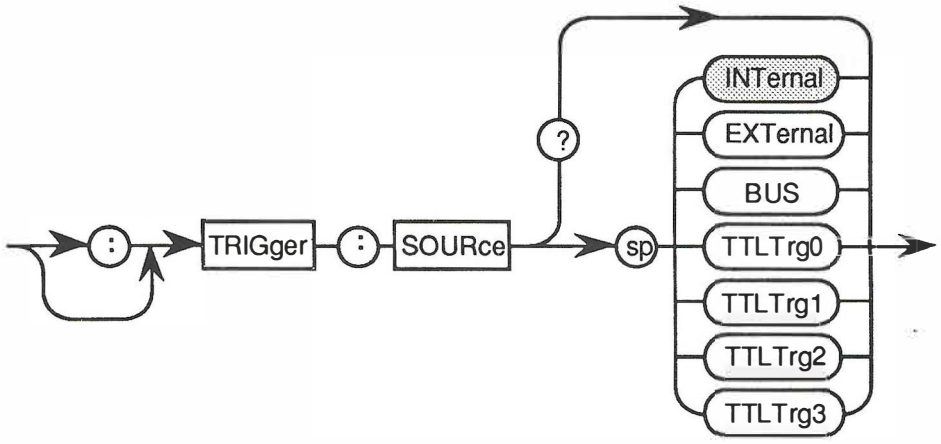


Figure 3-18 Input Trigger Selections.

3.11.1 Trigger Source

DEFAULT:
SOURCE: INTERNAL



This command determines which trigger source will be used to initiate the trace output. The power-up default is internal. If the numeric suffix for the TTL trigger is not used, the default is TTLTrg0. Command example 5 shows the query form of the command.

Example 1: Select the External BNC for the trigger signal; enter

```
:TRIGger:SOURce EXTernal
```

Example 2: Select the TTL trigger #2 for the trigger signal; enter

```
:TRIGger:SOURce TTLTrg2
```

Example 3: Select trigger line TTL0 (showing the line 0 default); enter

```
:TRIGger:SOURce TTLTrg
```

Example 4: Chose the internal trigger; enter

```
:TRIGger:SOURce INTernal
```

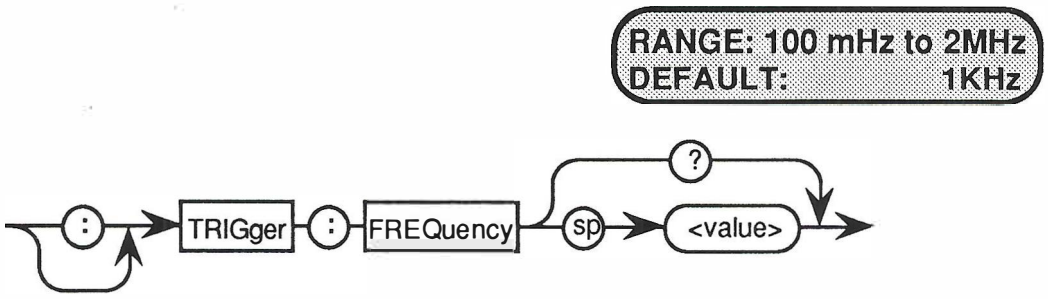
Example 5: What trigger source has been selected? Enter

```
:TRIGger:SOURce?
```

A possible return may be (the short form is always returned):

```
TTLT2
```

3.11.2 Trigger Frequency



The trigger frequency sets the INTernal trigger rate. The frequency value may be entered in standard notation, scientific notation, or Max/Min. Examples 5 and 6 show the query form of the command.

Example 1: Set the Trigger frequency to 5kHz; enter

```
:TRIGger:FREQuency 5000
```

Example 2: Set the Trigger frequency to 1MHz; enter

```
:TRIGger:FREQuency 1.000E6
```

Example 3: Set the Trigger frequency to maximum; enter

```
:TRIGger:FREQuency MAXimum
```

Example 5: What is the trigger frequency setting? Enter

```
:TRIGger:FREQuency?
```

A return may be as follows (fundamental units are returned):

```
1.200000E+03
```

Which indicates the internal trigger frequency is 1200 Hz.

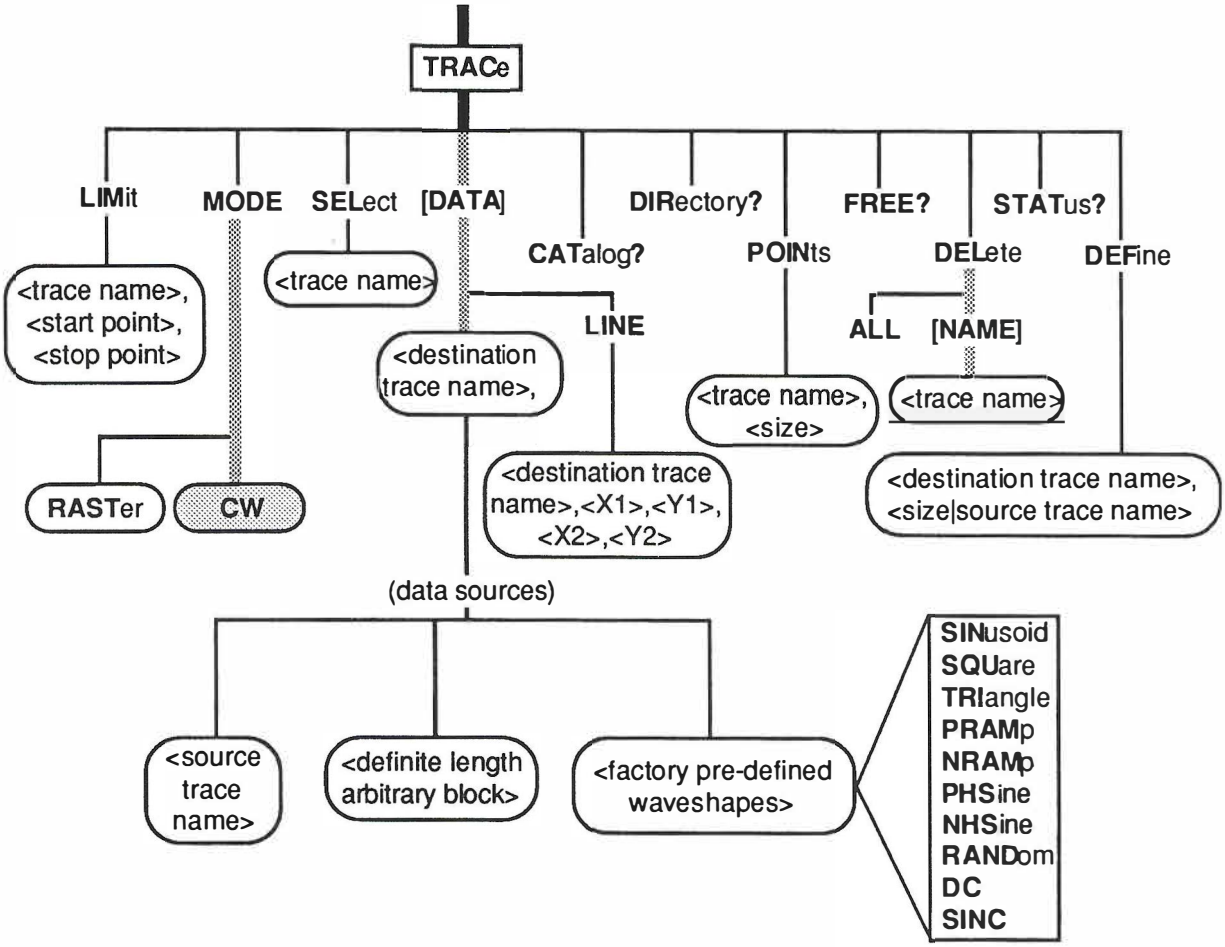
Example 6: What is the maximum trigger value? Enter

```
:TRIGger:FREQuency? MAXimum
```

The return will be

```
2.000000E+06
```

3.12 TRACE SUBSYSTEM



The TRACe subsystem is used to create the trace or waveform. With it, the user can define the trace name, size, data source, and type. The trace is defined with the DEFine sub-command. The trace may be generated using either the CW mode or the Raster mode selected in the TRACe subsystem. Using the LIMit sub-command, the trace "playback" range may be reduced. A trace is selected for output using the SELect sub-command. The four queries show the remaining memory (FREE?), the names of the traces in memory (CATalog? and DIRectory?), and the results of the memory test (STATus?). The number of points allocated to the trace may be changed from the original definition with the POINts sub-command. Data is selected for the trace using the optional DATA sub-command path. Any or all traces may be deleted from memory using the DELete sub-command. When the ***RST** command is issued, the only affect it has on the Trace subsystem is to set the Trace Mode to CW. The following commands are used to operate the Trace subsystem.

The **BOLD** upper case characters used in both the command tree and the command lines are the shortform mnemonic. Only the exact shortform or the exact longform may be used. The brackets, [ ], around keywords in the command tree identify optional commands or parameters. These optional keywords may be used in the command line for clarity, but are not required.

CATalog? This is a query only. The Arb returns a comma separated list of waveform names in trace memory.

[DATA] This command initializes the contents of a trace using a variety of data sources. The factory pre-defined source data sets available are SIN, SQUare, TRIangle, Positive RAMp, Negative RAMp, Positive Haversine (an inverted cosine wave that has its most negative point at 0V), Negative Haversine (a cosine wave that has its most positive point at 0V), RANDom, SINC (sin X ÷ X), and DC. The pre-defined waveshapes are algorithms in firmware and can only be used by first copying them into a user defined trace. Other data sources which may be used for creating a trace are a previously defined trace in memory, the LINE command, and a Definite Length Arbitrary Block transfer. At power-up, a "phantom" sine wave is loaded into the first 2048 locations of memory. Because it is nameless, it can only be used in commands not requiring a name. The range for the DATA command is "0" through "4095".

DEFine A new trace is created with this command. A copy of an existing trace may also be made using this command. The range of trace sizes permitted is from 8 to 32768 points (131072 with optional memory).

DELete Delete a trace from memory. The default NAME sub-command permits the deletion of a specified trace; the ALL sub-command deletes all traces.

DIRectory? A query that returns the names of the traces in memory, their size, and their start and stop points; beginning with the first trace. Traces with the LIMit command applied will show the entire trace size, but only the LIMit start and stop points.

FREE? This query returns the amount of memory free and the amount which is currently in use.

LIMits By redefining the trace (or block) start and stop points, a selected portion of the original can be used in subsequent operations; reversible. The DELete command does not recognize LIMits.

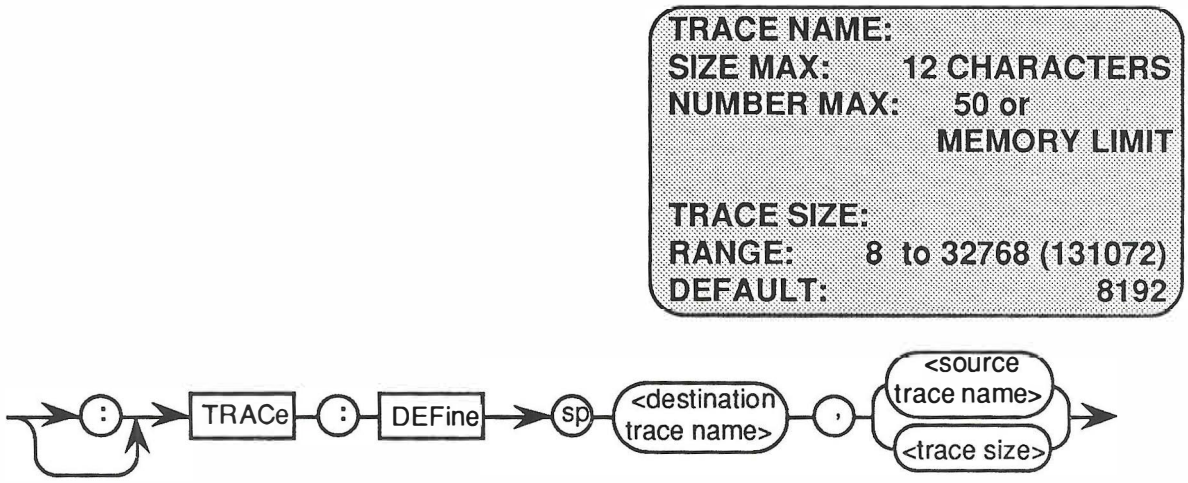
MODE Either CW or RASTer may be selected. If CW is selected, the Arb is initialized to scan memory using the Phase Accumulate method. RASTer initializes the Arb to scan memory as a Raster scan.

POINts A command to change the number of points allocated to a trace; it resizes the trace. Not reversible.

SELect Selects one of the defined traces for output. The Arb will not SELect a trace if it is in the Triggered Sequence (TSEQuence) Mode. Power-up default is the first trace in memory.

STATus? This query provides a review of the memory diagnostic status word resulting from the memory test that occurred at power-up.

3.12.1 Trace Definition



This command allocates memory for the trace. It may also be used to copy a previously defined trace.

Trace names may not have the names of commands nor "BLOCK1" through "BLOCK16", as these are reserved names; they have a maximum length of 12 characters and a preferred length of 4. Trace names must start with with an alpha character and may be composed of either upper or lower case characters. The only other characters permitted are the ten numbers (0-9) and the underscore (_). No short-form of the trace name is permitted. The short-form may be used on the factory pre-defined waveshapes. The Arb directory can hold a maximum of 50 trace names. If the Arb memory is filled or if the directory is filled, new traces can not be defined.

The trace size may range from 8 points to the maximum memory remaining. A newly defined trace will begin immediately after the end of the last defined trace in memory (providing enough memory remains for the defined size).

If the second parameter is the trace size, a new trace is allocated with the specified number of points. All points will be set to 2048 pending the input of data values. If the second parameter is the name of an existing trace, the new trace becomes a copy of the existing trace in all respects, including size and contents.

Upon power-up, an unnamed "phantom" sine wave fills the first 2048 points. The first defined trace will overwrite it. When all traces have been deleted from memory, the unnamed sine wave will again be installed into the first 2048 points. It can be used with commands not requiring a trace name (e.g. `:OUTPut ON`).

There is no query for this command.

After initialization at power-up, the memory can be visualized as a rectangle similar to that shown in the following illustrations. The unnamed "phantom" sine wave is written into the first 2048 points of memory. Its point values range from 1 to 4095 and it is symmetrical about 2048. Refer to figure 3-19.

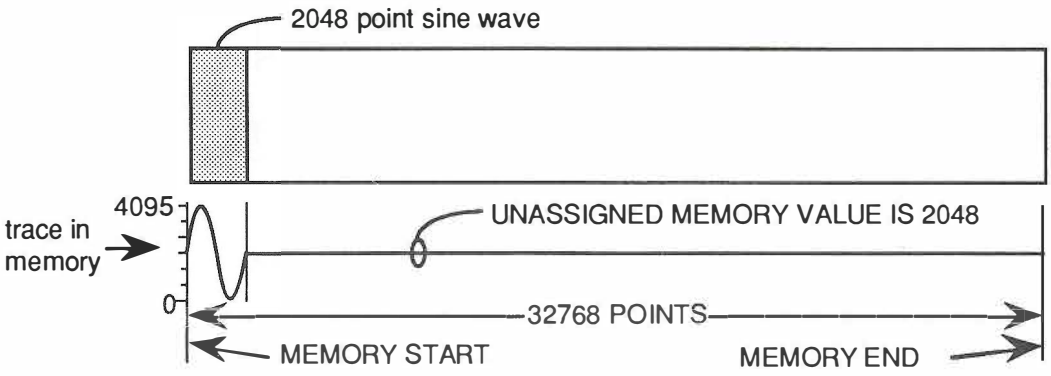


Figure 3-19 Initialized Memory After Power-up.

USING THE FACTORY PRE-DEFINED WAVESHAPES AT THE DEFAULT SIZE

Example 1: Define a new trace named SIN1 as a sine wave; enter

```
:TRACe:DEFine SIN1,SINusoid
```

The default memory size (8192 points) is allocated for the trace named SIN1 and filled with one cycle of a sine wave ranging between 1_{10} (001_{16}) and 4095_{10} (FFF_{16}) and symmetrical about 2048_{10} (800_{16}). The 2048 point phantom sine wave is overwritten with new data. Refer to figure 3-20.

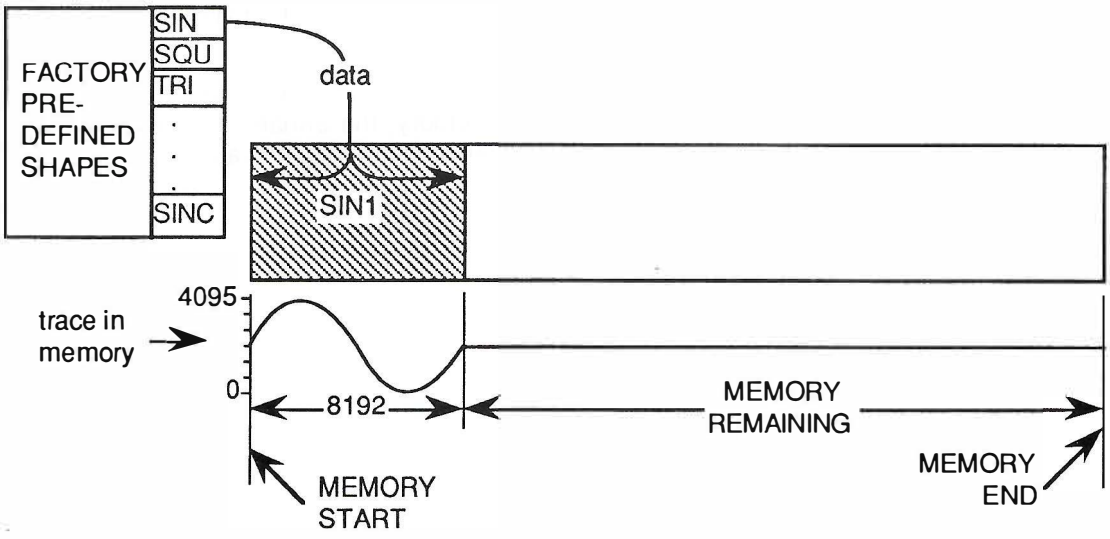


Figure 3-20 Copying a Pre-defined Trace into Default Memory Size.

CREATE NEW TRACES AND ALLOCATE SPACE FOR THEM

Example 2: Define a new trace as Valve3, sized at 4000 points, a new trace named EXP2 at 3000 points, and HEARTBEAT2 with 4000 points.; enter

```
:TRACe:DEFine VALVE3,4000

:TRACe:DEFine EXP2,3000

:TRACe:DEFine HEARTBEAT2,4000
```

Using the semi-colon command separator, the command string would be as follows:

```
:TRACe:DEFine VALVE3,4000;DEFine EXP2,3000;DEFine
HEARTBEAT2,4000
```

The next 4000 points in memory are allocated for the VALVE3 trace, followed by 3000 points for the EXP2 trace, then 4000 points for the HEARTBEAT2 trace. All of the allocated points are presently set at the mid scale default value, 2048_{10} (800_{16}). Refer to figure 3-21.

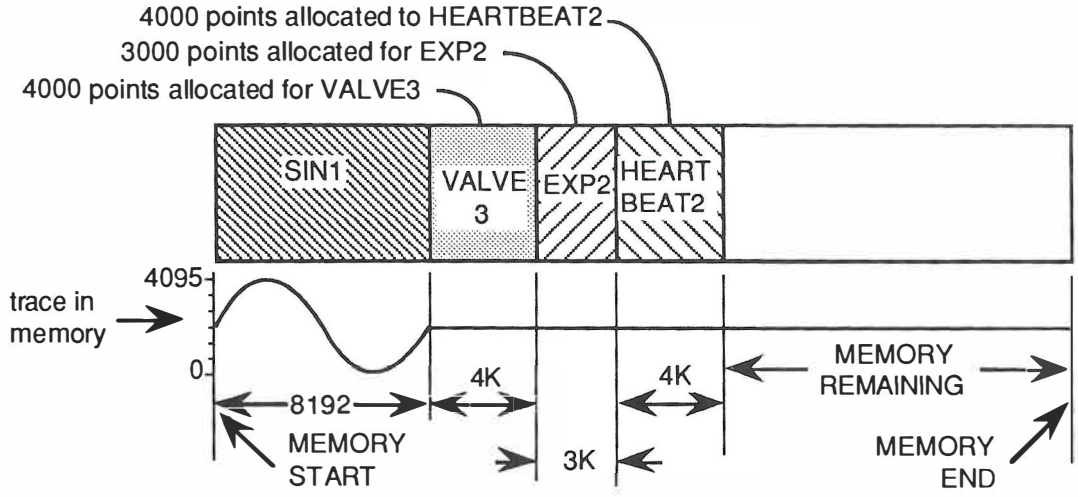


Figure 3-21 Allocating Memory Space for New Traces.

COPY AN EXISTING TRACE TO A NEW TRACE

Example 3: Copy the existing trace SIN1 to the new trace EXP1; enter

```
:TRACe:DEFine EXP1,SIN1
```

EXP1 is set equal to SIN1; one of two copy methods. Refer to figure 3-22. This copy technique and the delete command may be used to rearrange the order of traces in memory. Paragraph 3.12.2.1 shows an example of copying a trace to a memory space of non-equal size.

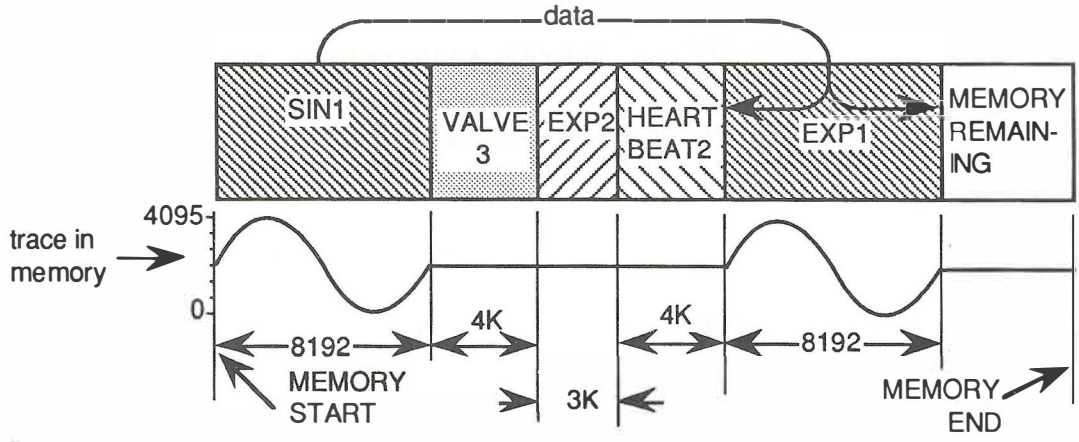


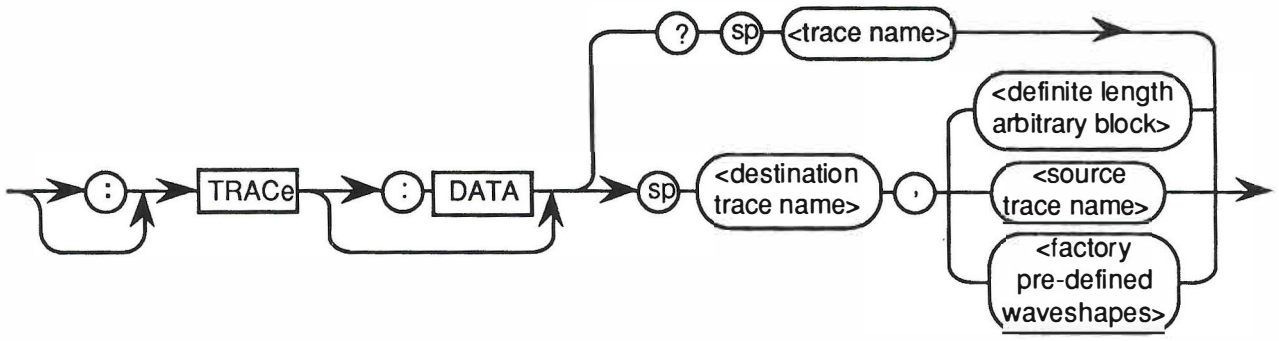
Figure 3-22 Copying an Existing Trace In its Entirety.

3.12.2 Data Input

This command path permits the input of data for the traces defined in paragraph 3.12.1. Each trace data point is defined by 12 bits and may range from 0 to 4095. Each data point requires two 8-bit bytes for its description, high byte first. Refer to paragraph 3.10.1 for a description of memory values vs output amplitude.

Data may be entered by moving the trace values from either a previously defined or a factory pre-defined trace into another trace of equal or unequal size(copying). A block of data may be input from an external source to fill a trace (block transfer). A trace may be initialized to a line segment by entering the co-ordinates of the two end points (Line command).

3.12.2.1 Factory Pre-defined, User Defined, and Block Entry



This data entry path is used to fill the defined trace from a variety of sources. Refer to paragraph 3.12.1 to define a trace and allocate its size.

The parameter, <factory pre-defined waveshapes>, fills the trace using a firmware resident mathematical algorithm to create the data value for each point.

The <source trace name> parameter copies a previously defined trace.

The <definite length arbitrary block> parameter transfers the binary image of a trace from the controller using two 8-bit bytes for each point.

COPY A FACTORY PRE-DEFINED WAVESHAPE

Example 1: Fill the defined trace VALVE3 with a square wave; enter

```
:TRACe:DATA  VALVE3,SQUare
```

One cycle of a square wave will be stored in the 4000 locations of VALVE3 filling the values from 1_{10} (001_{16}) to 4095_{10} (FFF_{16}) symmetrical about 2048_{10} (800_{16}). Refer to figure 3-23.

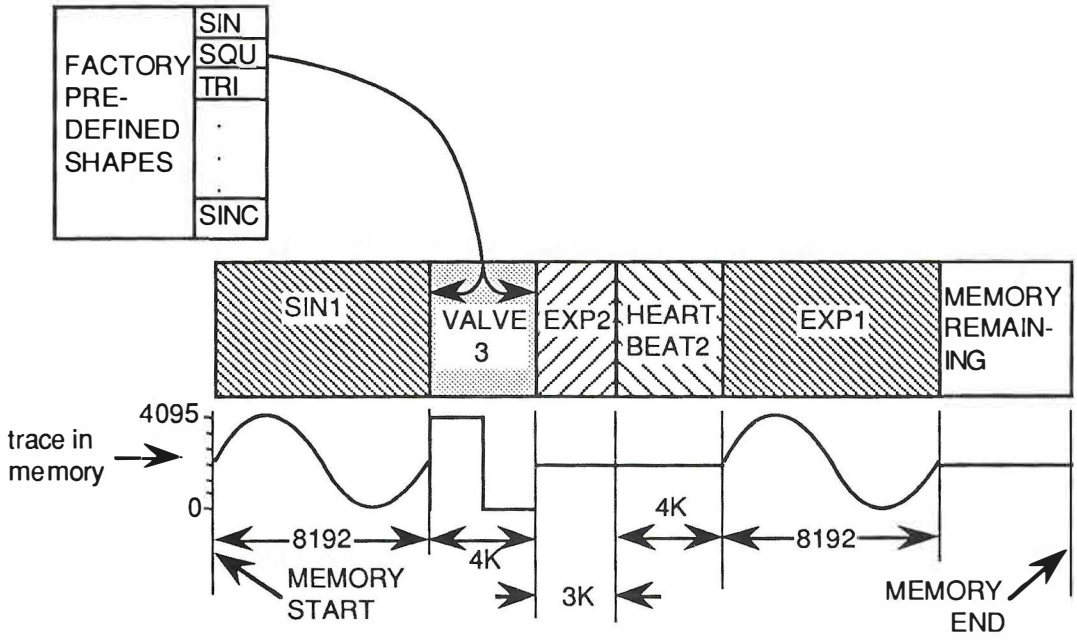


Figure 3-23 Copying a Pre-defined Trace into an Allocated Memory Size.

When a <factory pre-defined waveshape> is used for the trace, it will fill the trace with one cycle of the selected algorithm.

When a trace is assigned the <factory pre-defined waveshape> "DC", all points are set to 2048_{10} (800_{16}). The output value is adjusted using the SOURce:OFFSet command.

When the <factory pre-defined waveshape> "RANDom" is selected, a random generator algorithm "scrambles" the values in the trace. The output voltage is set using the AMPLitude and OFFSet commands in the SOURce subsystem.

When the <factory pre-defined waveshape> SINC is used, the trace is filled with a SINC pulse that starts at negative infinity and ends at positive infinity. The Arb uses the range from -16π radians to $+16\pi$ radians.

COPY A USER DEFINED TRACE

If a previously defined trace has the data set needed for a new trace, it can be copied and will be scaled to fit into the size of the destination trace. Refer to figure 3-24.

When only a selected fraction of an earlier user created trace is needed for the new trace, the LIMit sub-command in paragraph 3.12.5 can be used to select the required portion.

Example 2: Copy the stored trace SIN1 into the trace EXP2; enter

```
:TRACe EXP2,SIN1
```

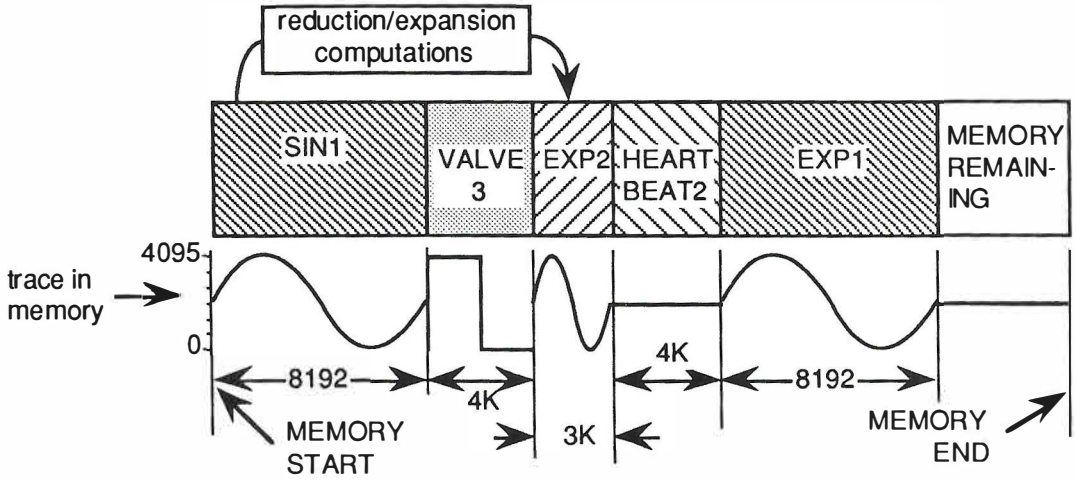


Figure 3-24 Copying an Existing Trace Into a Non-equal Allocated Memory Size.

A copy of SIN1 will be stored as EXP2. Because SIN1 is larger than EXP2, it will be scaled down to fit; some points will be discarded (refer to "Scaling Up and Down Simplified" on following page).

SCALING UP AND DOWN SIMPLIFIED

SOURCE SMALLER THAN DESTINATION

When the source is smaller than the destination, a linear interpolation between known points is used to fill the new points using a "connect-the-dots" routine. The destination start and end points are subject to slightly different rules. Because the start point has no earlier points, it is not subject to interpolation and is fixed at the same value as the source. A linear interpolation is performed between the source end point and an imaginary destination end point which has the same value as the start point. This point is used for calculation only and not saved. Illustration 3-25 below shows a simplified example of the process. The black circles are directly copied from the source to the destination in the examples.

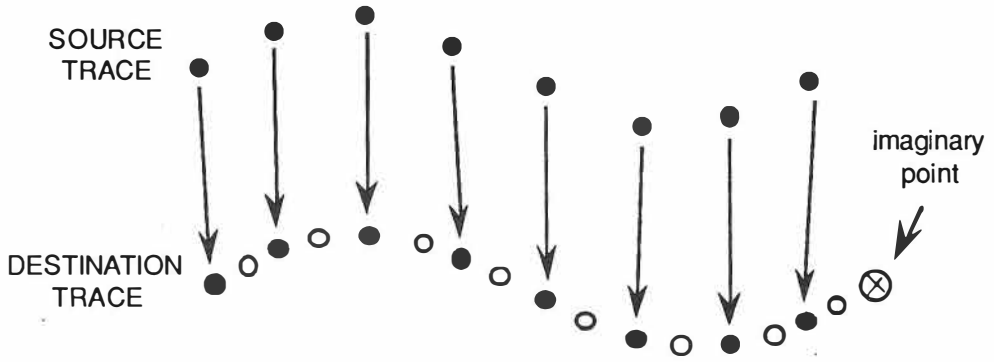


Figure 3-25 Copying a Trace Into Larger Allocated Destination.

SOURCE LARGER THAN DESTINATION

In the algorithm, each point in the destination trace is assigned the value of a point from the source trace, only selected points will be copied. The integrity of the shape is maintained. Refer to figure 3-26.

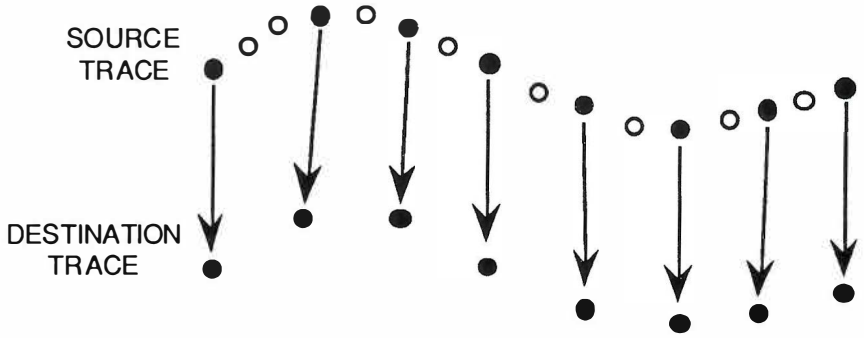


Figure 3-26 Copying a Trace into a Smaller Allocated Destination.

DEFINITE LENGTH ARBITRARY BLOCK

The <definite length arbitrary block> parameter is a format for transferring 8- bit binary data. The format for the <definite length arbitrary block> parameter data is as follows:



The pound sign (#) must precede the <non zero digit>, no white spaces are permitted after it. The single decimal <non-zero digit> defines how many numbers are in the following <digit>; the decimal number(s) <digit> define how many 8-bit data bytes follow; the <8-bit data byte> is each byte required to transfer the block of data from the source. Each Arb trace point is defined by two bytes, high byte is first. Refer to figure 3-27.

Example 4: Set HEARTBEAT2 to the values in byte 0 through byte 7999; enter

```
:TRACe HEARTBEAT2,#48000b0Hb1Lb2Hb3L...b7999L
```

Explanation: 4 after "#" (<non-zero digit>) indicates there are four digits to follow (8000 = <digit>).

8000 (<digit>) means there are 8000 bytes which follow

b_0 through b_{7999} (<8-bit data byte>) are the 8000 bytes in high byte-low byte order for a 4000 point trace.

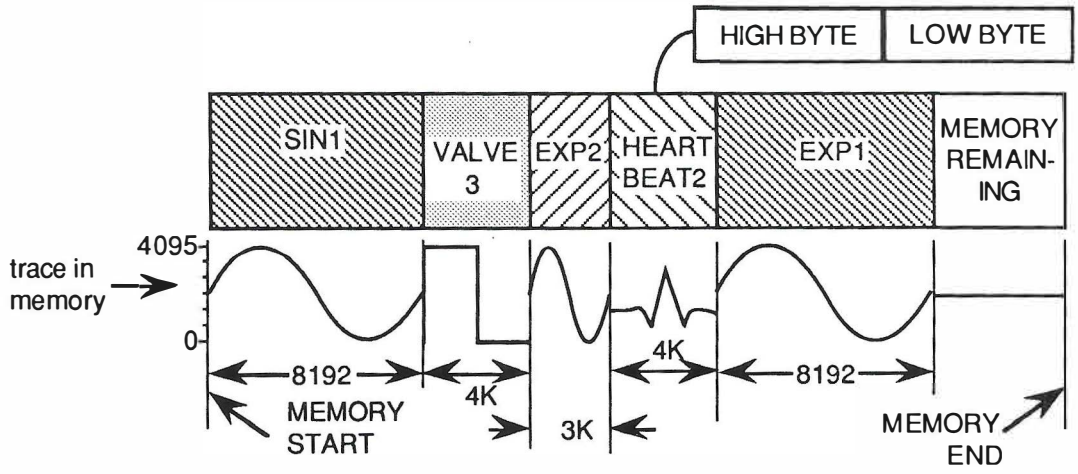


Figure 3-27 A Block of Data transferred Into Memory.

The 8000 bytes may each range from 0 through 255 decimal. The data entry is always in high byte-low byte order. The Arb only uses the 4 least significant bits in the high byte for the trace. An example program in the Basic language which creates and downloads an 8-point sine wave can be found in Appendix E, paragraph E1.3.

Example 5: What are the data values for the trace EXP1? Enter

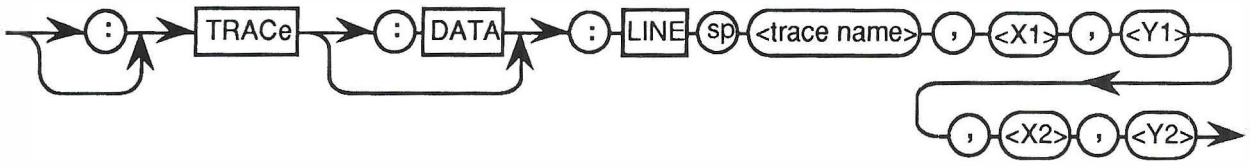
```
:TRACe:DATA? EXP1
```

The return will show all 8192 points that are in EXP1 (16,384 bytes will try to be displayed on the screen). The return format will be the same as Arbitrary Block Data:

$\#516384b_{0H}b_{1L}b_{2H}b_{3L}...b_{16383L}.$

The "non-zero digit", <5>, shows the "digit" contains 5 numbers. The "digit" is composed of the 5 numbers <1-6-3-8-4>. The "digit" is followed by 16,384 bytes arranged in a high byte-low byte order for the 8,192 point trace.

3.12.2.2 Line Entry



The Line sub-command permits the construction of a trace made up of line segments. All of the points between the two end points are set to the values which will lie on the line which connects the ends. The two points may be at any location within the defined trace area; X2 must be larger than X1. Any existing values will be permanently over-written by the line data, however, any memory data outside of the end point boundaries remain unaltered. The Line sub-command does not have a query associated with it. The following examples show several Line commands and the schematic representation in memory. Only the first command line shows the optional DATA command.

Example 1: Over-write the existing data points in EXP2 between 0 and 500 with a line starting at a value of 1024 and ending with a value of 2048. Refer to figure 3-28.

```
:TRACe:DATA:LINE  EXP2,0,1024,500,2048
```

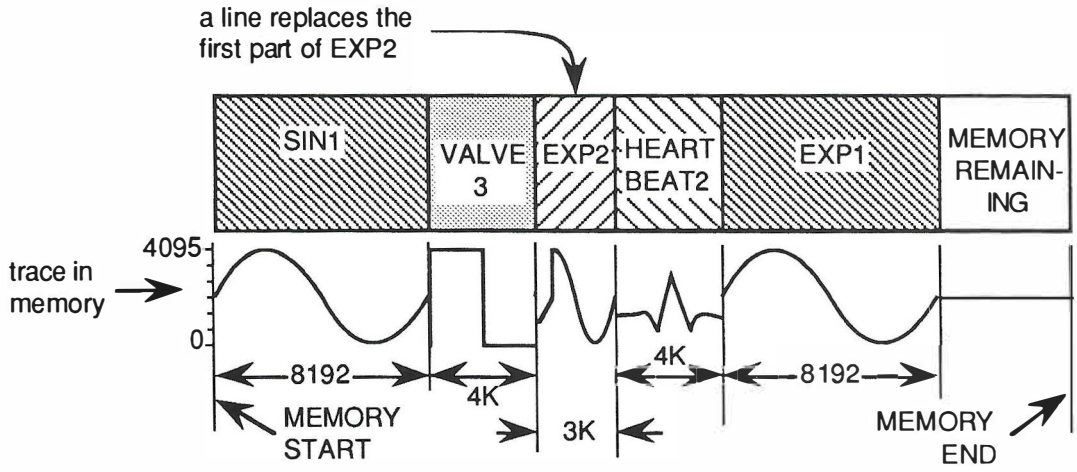


Figure 3-28 Using the Line Command to Alter a Trace.

The following example allocates space for a new trace named LINK using 500 points in memory. LINK is then partly filled with a line defined by the LINE command. It starts at 200, ends at 300 and is horizontal with a value of 1000. The first command creates a new trace with the name LINK and a size of 500 points (refer to paragraph 3.12.1 for TRACe:DEFine); the second command draws a line in the center of the defined area. The memory outside of the end points of the Line command remains at the default value of 2048_{10} (800_{16}). Refer to figure 3-29.

Example 2:

```
:TRACe:DEFine LINK,500

:TRACe:LINE   LINK,200,1000,300,1000
```

Example 2 may also be shown as follows with the semicolon separator between commands:

```
:TRACe:DEFine LINK,500;:TRACe:LINE   LINK,200,1000,300,1000
```

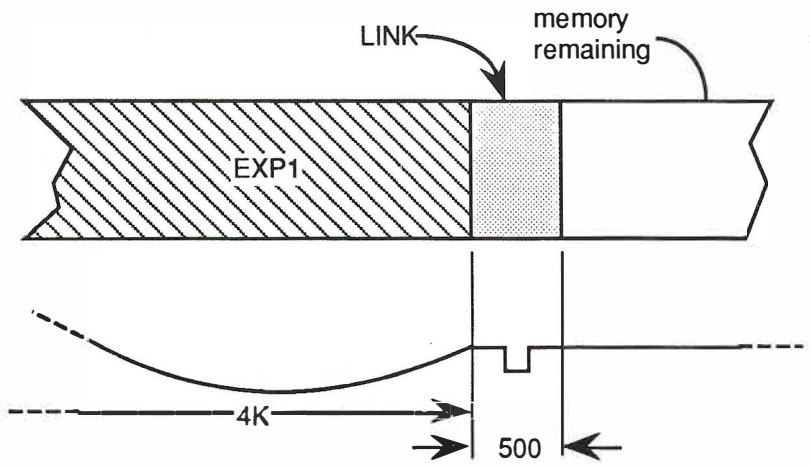
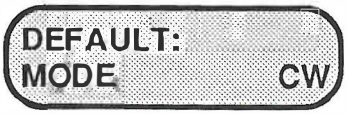
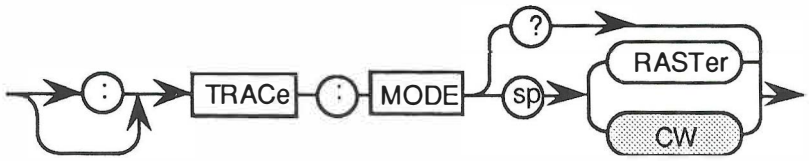


Figure 3-29 Using the Line Command to Create a Trace.

3.12.3 Trace Mode





The MODE sub-command sets the memory scan algorithm to either CW or Raster. Upon power-up and the ***RST** command, the Trace Mode defaults to CW. Refer to paragraph 3.10.2 and figure 3-15 or 3-16 for a discussion of the entered frequency in each mode.

The output in CW Mode is defined as follows:

$F_O = F_C/n$, where F_O = the output frequency selected in the Source subsystem, F_C = the calculated memory sample rate, n = the number of points calculated for the trace

When CW Trace mode is selected, F_C is internally calculated by the Arb; it has a maximum frequency of 20 MHz. The value of "n" calculated by the Arb (minimum value is 8) is derived from the defined size of the trace and the entered CW frequency value. As the entered CW frequency increases, the time allotted to sample all defined trace points decreases. Because the minimum time to sample the memory is fixed by the maximum value of F_C, the value of "n" must decrease to generate the programmed output frequency when all points cannot be sampled in the allotted time (the value of "n" may be reduced to an odd number which can introduce an output "jitter" in sequential runs through the memory). As the entered CW frequency decreases, the memory address rate of change decreases. This permits the Digital to Analog converter (converting at a fixed 20 MHz rate) to convert the same point several times before a new point is made available, therefore increasing the time required to complete one trace memory cycle. The TRACe:LIMit command alters the start and stop points used for the trace ("n").

The output in Raster Mode is defined as follows:

$F_O = F_S/n$, where F_O = the resulting output frequency, F_S = the sample frequency selected in the Source subsystem, n = the defined number of points in the trace

In the Raster mode, the size of "n" is the number of points defined for the trace. The TRACe:LIMit command will redefine "n". Each sequential trace memory point is always sampled and converted at the entered Raster frequency rate. The maximum permitted value for the Raster frequency is 20 MHz. The minimum permitted value for "n" is 8. The maximum output frequency is the same as with CW mode.

Example 1: Set the trace MODE for Raster; enter

```
:TRACe:MODE RASTer
```

Example 2: Set the trace MODE for CW; enter

```
:TRACe:MODE CW
```

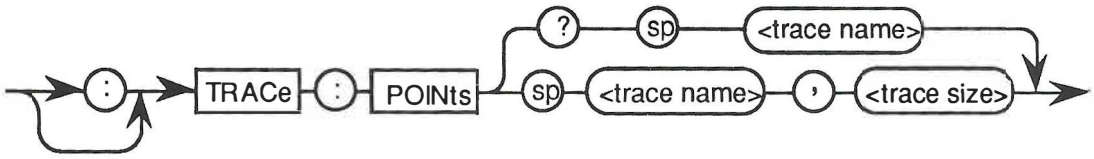
Example 3: What is the Trace MODE? Enter

```
:TRACe:MODE?
```

The return may be (the short form is always returned):

```
RAST
```

3.12.4 Trace Points



This command resizes the trace (refer to paragraph 3.12.2.1 for a description of resizing a trace). The number of points in memory allocated to the trace are changed to the new value. This is not to be confused with the TRACe:LIMit command (paragraph 3.12.5) which reduces the number of points used for generating the trace without changing the number of points in memory. When a trace is resized, it is also relocated to the end of the currently used memory (providing there is enough memory remaining). The original trace ceases to exist. The trace is scaled to fit the new defined size. The memory is restructured so all traces are contiguous and the remaining unused memory is adjusted for the new number of points in use. The query returns the number of points in the trace. Using the previous examples of waveform memory, trace SIN1 was a single sine wave which filled 8192 points in memory. Refer to figures 3-30, 3-31 and 3-32.

Example 1: Resize SIN1 to 4K; enter

```
:TRACe:POINts SIN1,4000
```

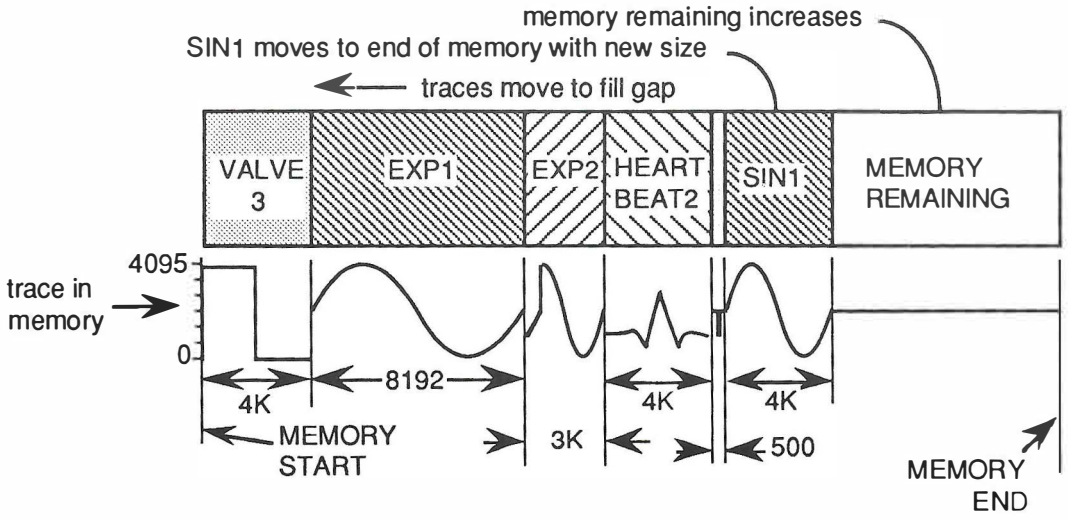


Figure 3-30 Reducing the Trace Size.

Example 2: Resize EXP2 to 6K; enter

```
:TRACe:POINts EXP2,6000
```

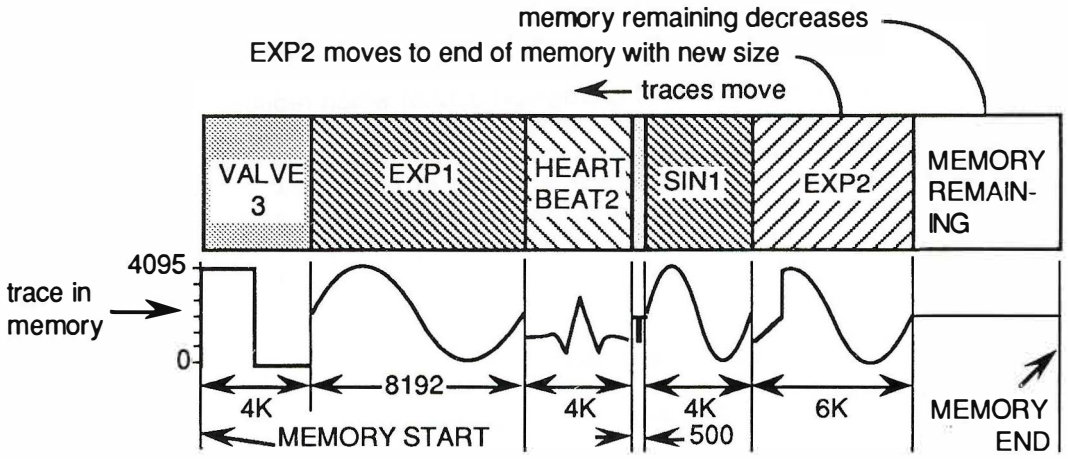


Figure 3-31. Increasing the Trace Size.

Example 3 Move VALVE3 to the end of memory by adding a point; enter

```
:TRACe:POINts VALVE3,4001
```

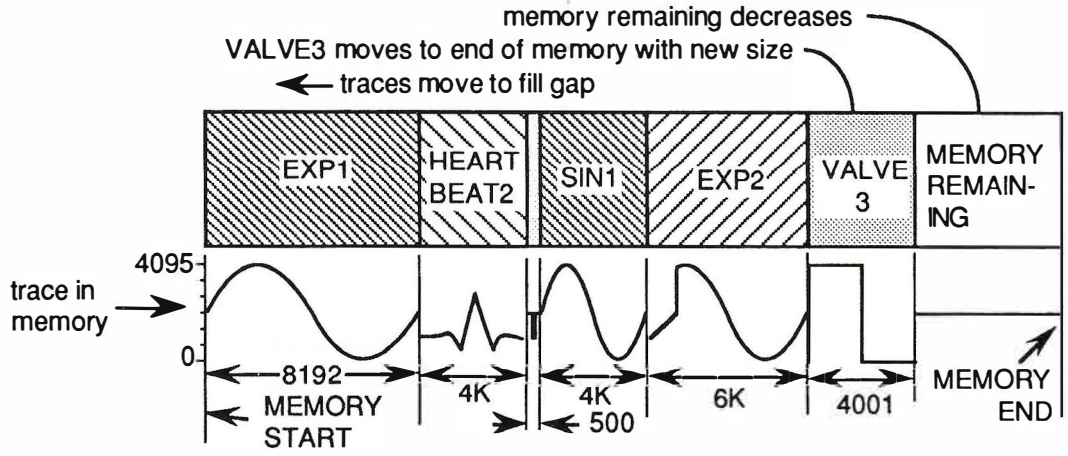


Figure 3-32. Rearranging Memory

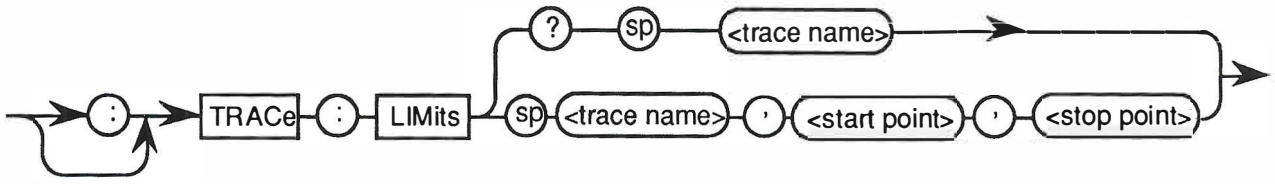
Example 4: How many points in VALVE3? Enter

```
:TRACe:POINts? VALVE3
```

The response is:

```
4001
```

3.12.5 Trace or Block Limits



The LIMit sub-command changes the start and stop points of the trace in memory which are used to generate the waveform. It does not resize the trace, the original start and stop points are recoverable. This effectively reduces the trace to the portion desired. All new operations using the trace will use the new limit values. Refer to figure 3-33. To return to the original start and stop points, the LIMit sub-command is used again with the original points. The Arb will always sample the trace in memory using the last set of limit values entered. The power-up default is the initially defined start and stop points for each trace.

When in the Triggered Sequence (TSEQuence) mode, the Limit sub-command will alter the start and stop points within the 8192 point blocks. Block 1 must be identified with a name (this can be accomplished by DEFining or rearranging the first trace in memory to be 8192 points in size). If the first trace in memory does not span the range from 0 to 8191, the sequenced output will not be as expected (it is recommended all blocks sequenced be constructed of traces 8192 points long and the end points fall on the block boundaries of 0 and 8191). The TRACe:SELect command must be set for the trace that occupies block 1. The last set of limit values entered are the ones used. Only block 1 can have the limits changed. Each block sequenced in the TSEQuence mode will have the same limits applied as block 1.

Example 1: Set the limits for HEARTBEAT2 between 1800 and 2200; enter

```
:TRACe:LIMits HEARTBEAT2,1800,2200
```

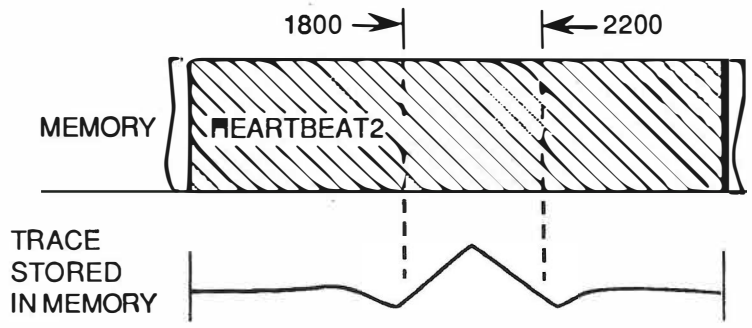


Figure 3-33. Changing the Trace Start and Stop Points.

Until the limits are changed to some other values within the initial size, all new commands using the trace name "HEARTBEAT2" as a source will use the segment between 1800 and 2200.

NOTE

The Delete command does not recognize the limits. It will delete the trace in its entirety.

Using the limit command with the originally defined values (0 and 3999 for HEARTBEAT2) will return the trace to the original start and stop points.

3.12.5 Trace or Block Limits (continued)

Using EXP1 as the first 8192 point block in the memory (Refer to figure 3-30), example 2 shows how the block limits are expressed. The Arb must be in the TSEQuence mode for the Limit command to apply to memory block limits. The block Limit command requires the first trace in memory to be 8192 points. Refer to figure 3-34.

Example 2: Set the 8192 point block named EXP1 for limits between 1K and 4K; enter

```
:TRACe:LIMits EXP1,1000,4000
```

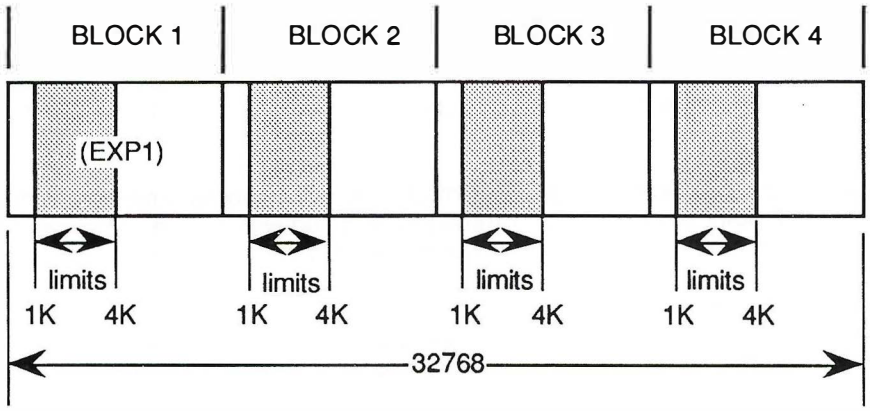


Figure 3-34. Changing the Block Start and Stop Points.

Each block selected for sequencing in the TSEQuence mode will have the same limits that have been selected for the first block, EXP1, regardless of the block contents. There is no difference between the form of the command used for the trace limit and that used for the block limit; all of the other Limit rules apply.

Example 3: What are the limits for the HEARTBEAT2 trace? Enter

```
:TRACe:LIMits? HEARTBEAT2
```

The response (set in example 1) is two values separated by a comma :

```
1800,2200
```

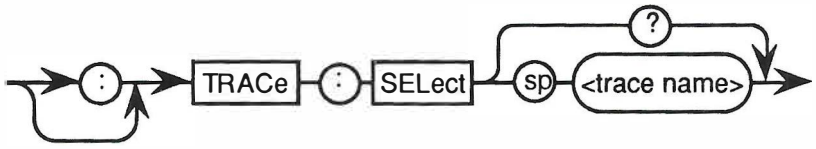
Example 4: What are the limits of EXP1? Enter

```
:TRACe:LIMits? EXP1
```

The response is (set in example 2):

```
1000,4000
```

3.12.6 Trace Select



The SELect sub-command selects one of the traces in memory to be sampled as the output waveform. The selected trace will not be seen at the output if the Arb is in the TSEQuence mode. The Arb power-up default selection is the first trace in memory. ***RST** does not affect the trace selected with this command.

Example 1: Select the trace Heartbeat2 for the output; enter

```
:TRACe:SELect HEARTBEAT2
```

Example 2: Select the SIN1 trace, enter

```
:TRACe:SELect SIN1
```

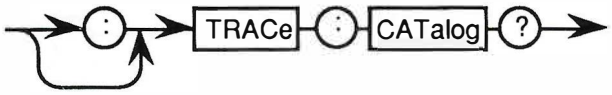
Example 3: What trace has been selected for output? Enter

```
:TRACe:SELect?
```

The response is (set in example 2):

```
SIN1
```

3.12.7 Trace Catalog Query



This query returns a comma separated list of the trace names stored in memory with the first trace in memory listed first. Neither the 2048 point "phantom" sine wave nor any of the factory pre-defined waveshapes will be listed.

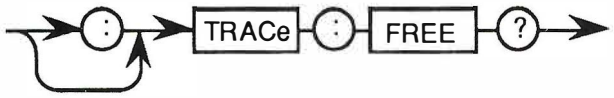
Example: What are the traces stored in memory? Enter

```
:TRACe:CATalog?
```

The response is as follows (from figure 3-29):

```
EXP1,HEARTBEAT2,LINK,SIN1,EXP2,VALVE3
```

3.12.8 Memory Free Query



This query returns the amount of free memory followed by the amount in use

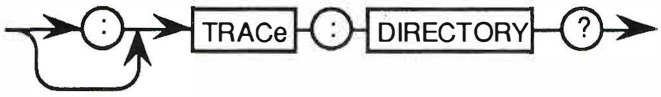
Example: How much memory remains (from figure 3-32)? Enter

```
:TRACe:FREE?
```

The response is as follows (<free>,<used>):

```
6075,26693
```

3.12.9 Directory Query



This query returns the trace names in memory, their sizes and start and stop points; beginning with the first trace in memory. Neither the 2048 point "phantom" sine wave nor any of the factory pre-defined waveshapes will be listed. The format is <name>,<size>,<start>,<stop>;<name>...

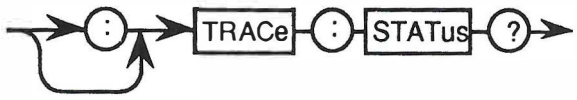
Example: What are the traces in memory and what are their sizes? (from figure 3-32) Enter

```
:TRACe:DIRectory?
```

The response is as follows (example 1, para 3.12.5 set limits on HEARTBEAT2):

```
EXP1,008192,000000,008191;HEARTBEAT2,004000,001800,002200;
LINK,000500,000000,000499;...
```

3.12.10 **Trace Status** (Memory Diagnostic report)



This query will return the memory status summary word. The value is only placed in the summary word at the power-up memory test. The operator initiated Self-Test, ***TST?**, will not test the memory. The value of the return will be between 0_{10} and $65{,}535_{10}$ (0000_{16} and $FFFF_{16}$). The value of "0" (zero) indicates no failure with the standard 32K memory installed. If the 128K optional memory is installed, a value of "1" (one) is returned indicating no failure. A value greater than "1" indicates a failure. Also refer to the ***TST** response in paragraph 2.5 which will simply yield a memory test pass/fail indication.

Example: What is the memory status after power-up?

:TRACe:STATus?

The response will range from 0 through 65535.

Figure 3-35 shows the memory diagnostic summary word bit assignments, Table 3-6 provides a description. These are for reference only, the memory is not considered a repairable component.

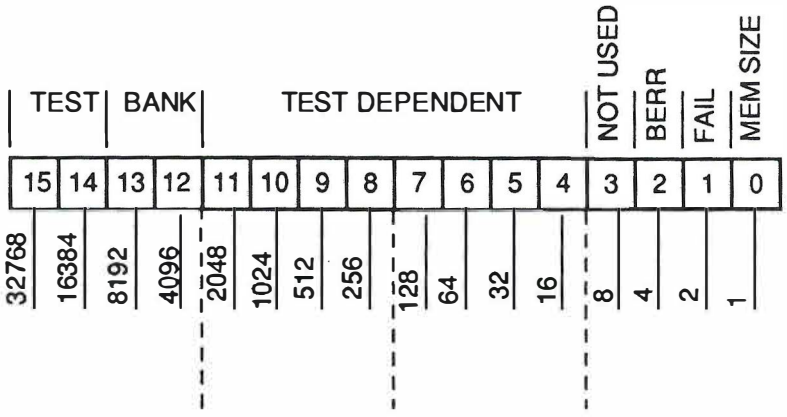


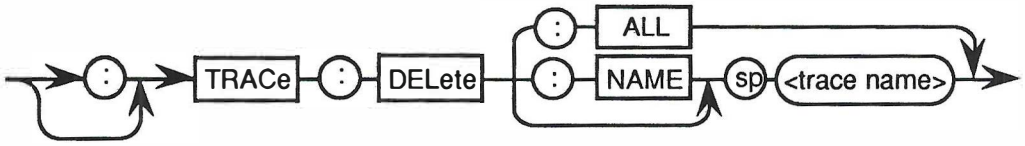
Figure 3-35. Memory Diagnostic Summary Word

3.12.10 **Trace Status** (Memory Diagnostic Report, cont)

Table 3-6. Memory Test Diagnostic Word Description

DIAGNOSTIC BITS	DEFINITION
MEM SIZE	0 32K point trace memory installed 1 128K point trace memory installed
FAIL	0 memory test passed 1 memory test failed
BERR	0 No bus error upon access to Arb hardware 1 Bus error occurred upon access to Arb hardware
Test Dependent bits	Refer to Model 1375 Maintenance Manual
BANK	00 failure detected in RAM bank 0 01 failure detected in RAM bank 1 10 failure detected in RAM bank 2 11 failure detected in RAM bank 3
TEST	00 memory failed sub-test 0 01 memory failed sub-test 1 10 memory failed sub-test 2

3.12.11 Trace Delete



When deleting a trace from memory, the optional "NAME" sub-command may be used; the Arb assumes the "NAME sub-command has been issued unless the "ALL" sub-command is sent. Traces may be deleted in any order. All traces in memory can be deleted using the "ALL" sub-command. When a trace is deleted, the memory it occupied becomes free to accept new trace data. The memory is consolidated so waveform memory is not fragmented. The factory pre-defined waveshapes cannot be deleted. The trace limit sub-command (paragraph 3.12.5) does not apply to the deletion process; the trace is deleted in its entirety regardless of the limit range. The deletion of any or all traces is **permanent**. The "DELete" command is an event, there is no query form of this command. The first example shows the optional NAME sub-command.

Example 1: Delete the trace VALVE3, refer to figure 3-36. Enter

```
:TRACe:DELete:NAME VALVE3
```

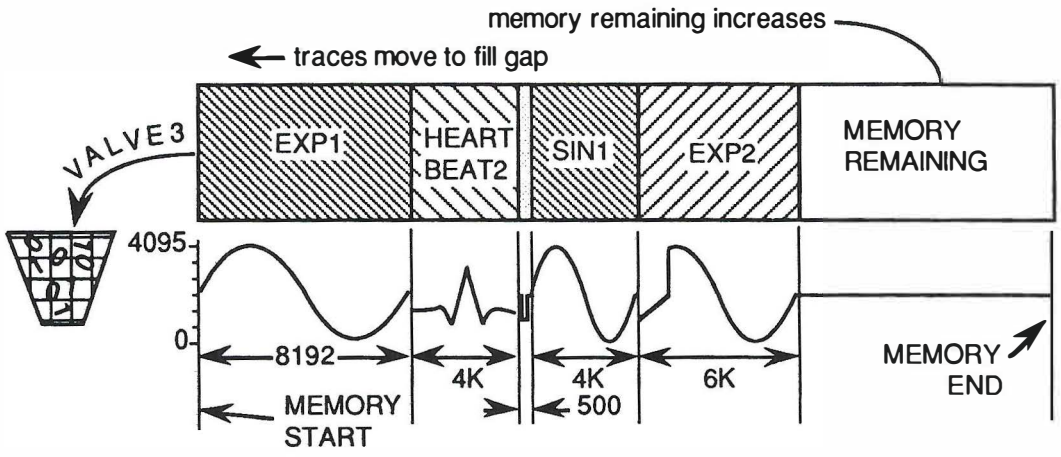


Figure 3-36. Delete the First Trace In Memory.

3.12.11 Trace Delete (continued)

Example 2: Delete LINK (omitting the optional NAME sub-command), refer to figure 3-37. Enter

```
:TRACe:DELete LINK
```

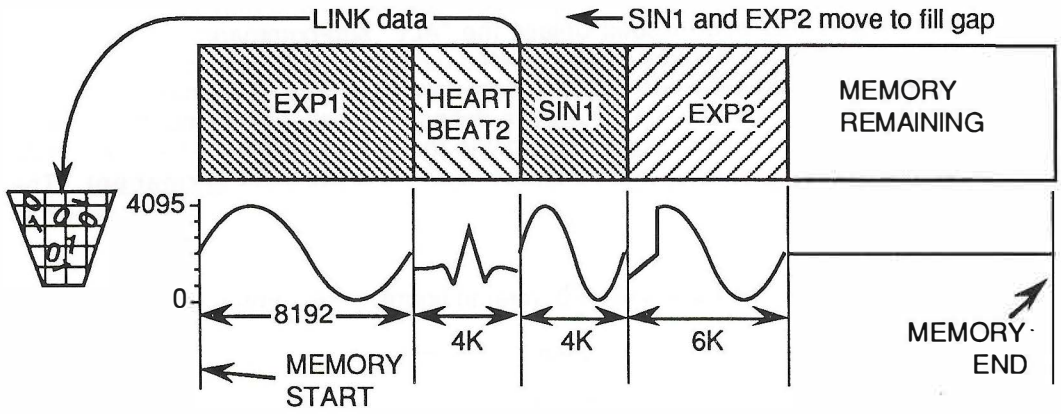


Figure 3-37. Delete any Trace in Memory.

Example 3: Delete all traces in the Arb memory, refer to figure 3-38. Enter

```
:TRACe:DELete:ALL
```

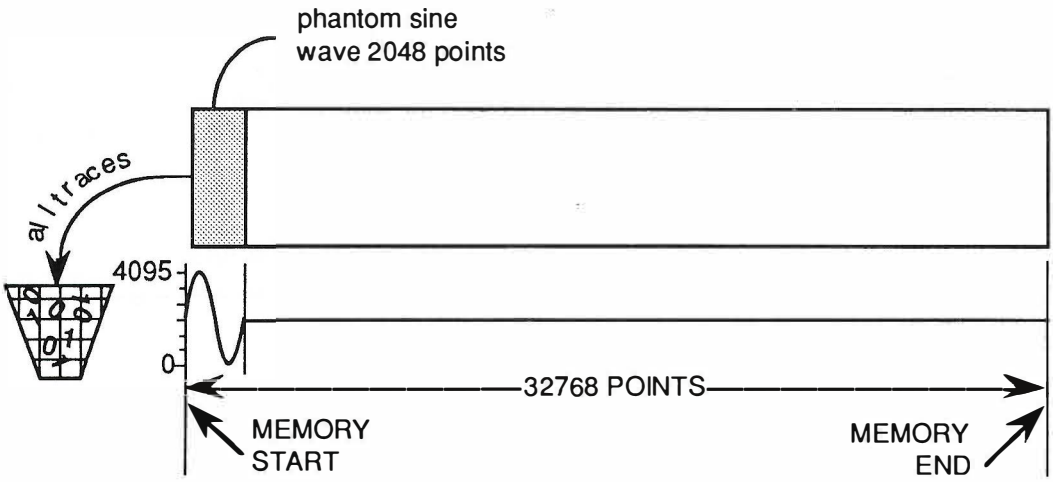
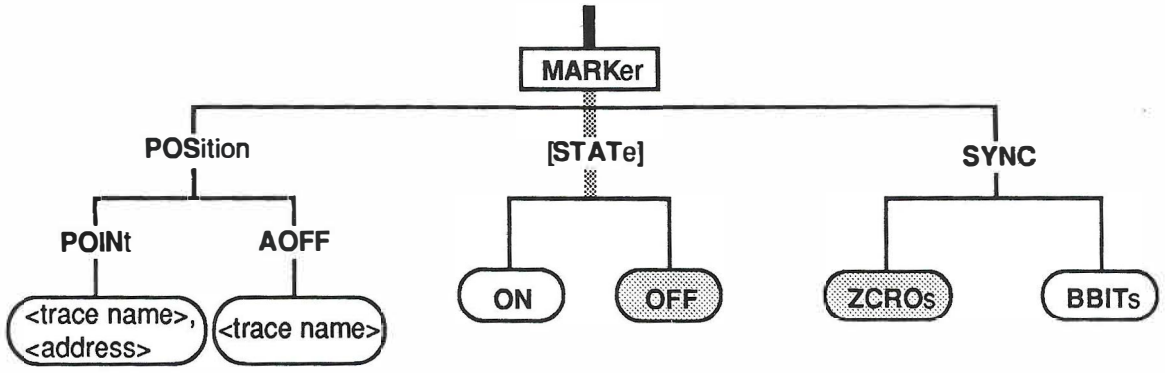


Figure 3-38. Delete All Traces in Memory.

Observe that after all of the traces are deleted, the 2048 point "phantom" sine wave is re-written into memory using the factory pre-defined SIN algorithm.

3.13 MARKER SUBSYSTEM



The Marker default STATe is OFF. Any POINt within the trace may be set to ON or they may all be set OFF (AOFF). The MARKer points are output at the MARKER POSITION BNC on the Arb front panel. Each Marker point selected is high the entire time the trace point is at the Arb output (point zero or the first point selected by the Limit command is at the output pending the trigger arrival). The Marker Position signal is TTL level. Refer to figure 3-39, where only point 0 and only point 1 are set as examples.

The Sync type can be Zero CROssings or Beginning BITs. Both will start approximately 100ns plus one clock cycle after the Arb receives an external trigger, less time with other triggers. Selecting Zero Crossing will produce a Marker Sync when the trace is positive (from 2048 through 4095 vertically). It will always be a logic 0 for the last three points in the trace. The BBITs sync pulse is a minimum of six clock cycles wide in the CW-Triggered Mode, at the trace beginning. In the CW-Continuous Mode, the minimum width is one clock cycle. Raster-Triggered Mode is always 9 clock cycles wide and Raster-Continuous is always four clocks wide. The Marker Sync output is at the MARKER SYNC BNC on the Arb front panel as a TTL level signal. Refer to figure 3-39 for a timing diagram showing the relationship of these signals.

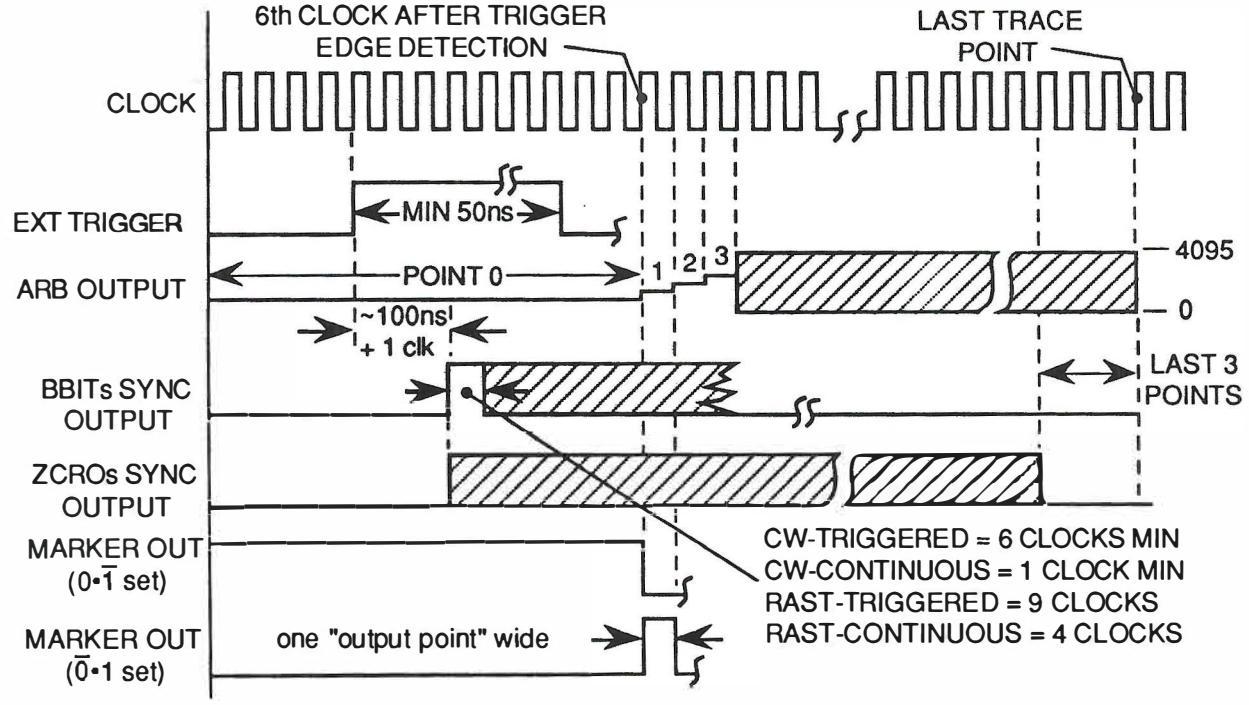
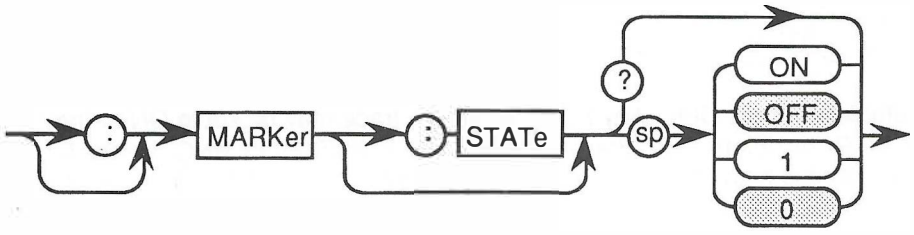


Figure 3-39 Trigger, Sync, Marker and Arb Output Timing.

The **BOLD** upper case characters used in both the command tree and the command lines are the shortform mnemonic. Only the exact shortform or the exact longform may be used. The brackets, [ ], around keywords in the command tree identify optional commands or parameters. These optional keywords may be used in the command line for clarity, but are not required.

3.13.1 Marker ON/OFF State

DEFAULT:
STATE: OFF



The STATe sub-command is optional and is only shown in Example 1. The MARKer STATe parameter is a Boolean value and responds to either ON/OFF or 1/0. Example 5 shows the query form of the command.

Example 1: Turn the Marker ON; enter

```
:MARKer:STATe ON
```

Example 2: Turn the Marker ON, alternative method; enter

```
:MARKer 1
```

Example 3: Turn the Marker OFF; enter

```
:MARKer OFF
```

Example 4: Turn the Marker OFF, alternative method; enter

```
:MARKer 0
```

Example 5: What is the ON/OFF state of the Marker? Enter

```
:MARKer?
```

The response may be (only "1" or "0" will be returned):

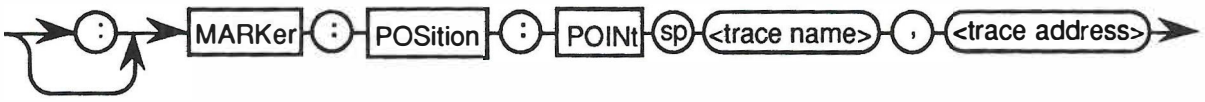
```
0
```

The Marker is turned OFF.

3.13.2 Marker Position

The MARKer POSition has two functions; to turn the marker points ON for the selected positions within the trace or to turn all of the markers OFF. The power-up default is all marker points off.

3.13.2.1 Points (insert)



The Marker Position Point command defines the waveform points which are to have markers set high. The markers can only be set low using the AOFF sub-command. The position address value may be entered in standard or in scientific notation. There is no query form for this command.

Example 1: Set the 1K marker position high for the HEARTBEAT2 trace ; enter

```
:MARKer:POSition:POINt HEARTBEAT2,1E3
```

3.13.2.2 Points (All Off)



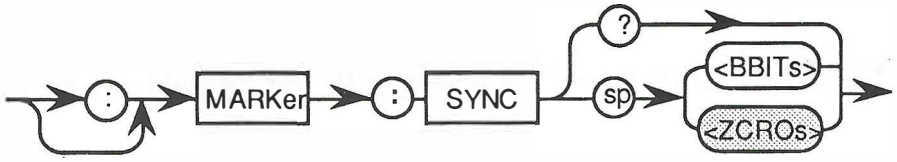
This Command clears all of the marker points for the given trace name. In order for any points to be turned ON, the POSition:POINt command in paragraph 3.13.2.1 must be used. Upon power-up, all points are OFF by default. This command is an event, and therefore has no query form. The trace name shown is for example only, it is assumed the trace has been defined in the Trace Subsystem.

Example: Turn all of the marker points OFF for SIN1; enter

```
:MARKer:POSition:AOFF SIN1
```

3.13.3 Marker Sync

DEFAULT:
SYNC: ZCROs



The Marker SYNC generates an output at the MARKER SYNC BNC on the Arb front panel. When the default ZCROs is selected, the Marker Sync is coincident with the trace area above zero Volts (from 2048 to 4095). The ZCROs sync will always be a logic low for the last three points of the waveform.

The Beginning BITs generate a sync pulse which is a minimum of one clock wide in the Continuous Mode and six clocks wide in the Triggered Mode. Total width is determined by the requested output frequency; the lower frequencies have a wider BBITs pulse. TRACe:LIMit will move the BBITs to the new start point.

Example 1: Set the Marker Sync for Zero Crossing, refer to figure 3-40. Enter

```
:MARKer:SYNC ZCROs
```

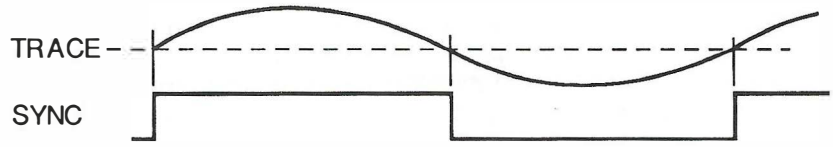


Figure 3-40. Sync when using ZCROs

Example 2: Set the Marker Sync for Beginning BITs, refer to figure 3-41. Enter

```
:MARKer:SYNC BBITs
```

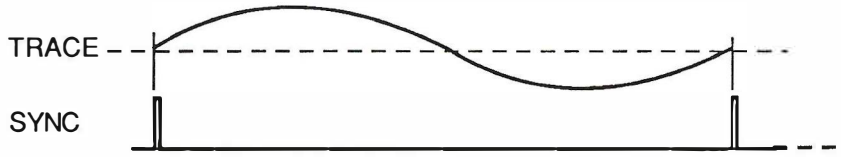


Figure 3-41. Sync when using BBITs

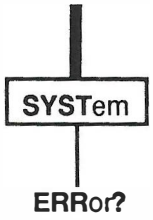
Example 3: What is the Marker Sync set for? Enter

```
:MARKer:SYNC?
```

The return may be:

```
BBIT
```

3.14 SYSTEM SUBSYSTEM



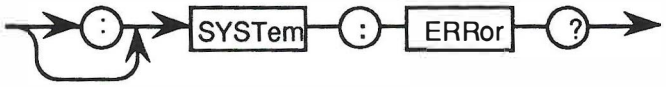
The System subsystem returns the error number and description of the errors in the error queue. The numbers range from -32768 to 32767 with the negative numbers specified by SCPI and the positive numbers Arb dependent. The **BOLD** upper case characters used in both the command tree and the command lines are the shortform mnemonic. Only the exact shortform or the exact longform may be used. When there are no errors, a zero code is returned as follows:

```
0,"No error".
```

The error queue is a first in first out. Only one error is displayed for each query. When all errors have been read from the queue, the zero error code will be returned. If the queue has overflowed, the last error code returned will be:

```
-350,"Queue overflow".
```

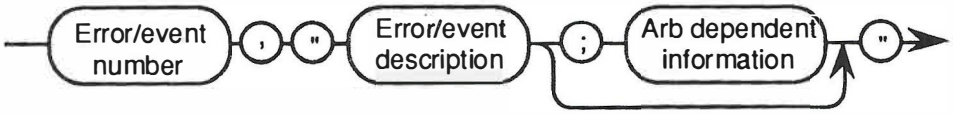
The queue is cleared at power-on, upon reading the last item from the queue, and upon receiving the ***CLS** command. For a list of the Model 1375 error codes, refer to Appendix D.



Example: Show the first error in the queue; enter

```
:SYSTem:ERRor?
```

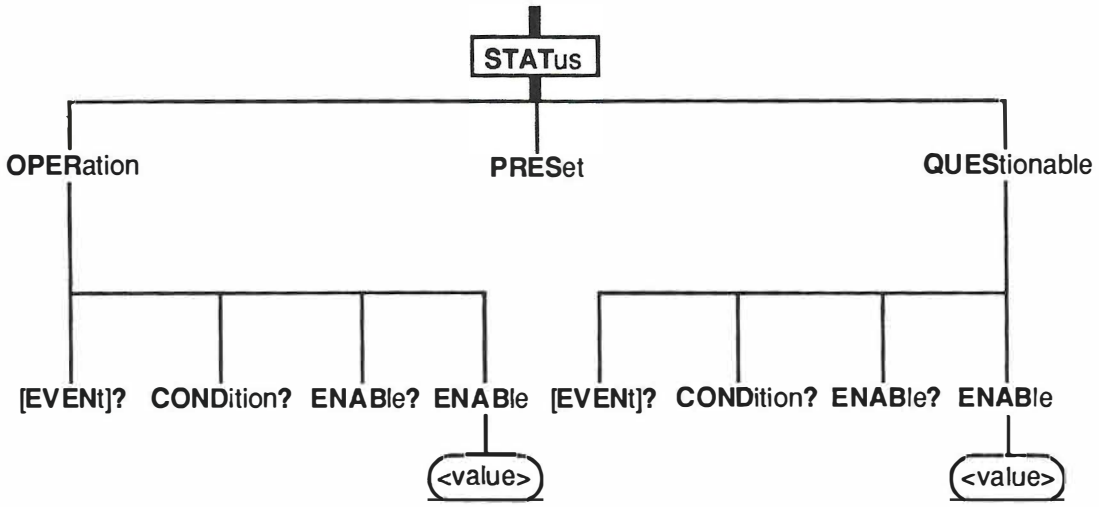
The response to this query will always take the following format:



For example, a return may appear as follows:

```
-112,"Program mnemonic too long"
```

3.15 STATUS SUBSYSTEM



This subsystem contains the Status reporting registers. Neither the Operation nor the Questionable registers are implemented in the Arb. All queries will return a "0" (zero). The ENABle sub-commands for each register will be accepted, but will not perform any function. Preset can be exercised, but will perform no function. The **BOLD** upper case characters used in both the command tree and the command lines are the shortform mnemonic. Only the exact shortform or the exact longform may be used. The brackets, [ ], around keywords in the command tree identify optional commands or parameters. These optional keywords may be used in the command line for clarity, but are not required.

4.1.8 *RST Reset Command (sect. 10.32)

The Reset command performs a device reset. The Reset command is the third level of reset in a three level reset strategy.

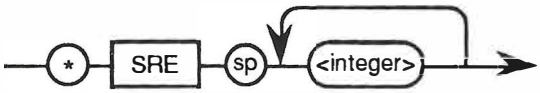


The Reset does the following:

1. Set the device-specific functions to a known state that is independent of the past-use history of the device [all subsystems to default values, parser position remains unchanged, memory is **not** tested).
2. Force the device into the OCIS state (Operation complete Command Idle State).
3. Force the device into the OQIS state (Operation complete Query Idle State).

4.1.9 *SRE Service Request Enable Command (sect. 10.34)

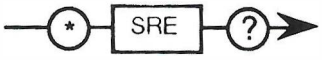
The Service Request Enable command sets the Service Request Enable Register mask bits permitting the programmer to select which messages in the Status Byte Register may cause service requests.



The integer can range between 0 and 255. The mask value of bit 6 will be ignored; it is a fixed logical 0.

4.1.10 *SRE? Service Request Enable Query (sect. 10.35)

The Service Request Enable query allows the programmer to determine the current contents of the Service Request Enable Register.



The response will be the enable value from 0 through 63 or 128 through 191.

4.1.11 *STB? Read Status Byte Query (sect. 10.36)

The Read Status Byte query allows the programmer to read the status byte and Master Summary Status bit.



The response will be a value from 0 through 255.

4.1.12 ***TRG Trigger** Command (sect. 10.37)

This command is the device-specific analog of the IEEE 488.1 defined Group Execute Trigger (GET) interface message, and has exactly the same effect as a GET when received, parsed and executed by the device (the ***TRG** command is only executed when the Arb :TRIGger:SOURce BUS is selected).



4.1.13 ***TST? Self-Test** Query (sect. 10.38)

The Self-Test query causes an internal self-test and places a response into the Output Queue indicating whether or not the device completed the test without any detected errors (refer to paragraph 2.5 for the Arb Self-Test information). This query should be be the first command after power-up. All instrument settings are stored and the outputs are turned off. Upon completion of ***TST?**, the device settings will be restored to the values held prior to the test.



The response will be a value from -32767 through +32767. The summary word is divided into two parts, the high byte is the Test Number and the low byte is the Error Code. Waveform memory is not tested with the ***TST?** query, however the pass/fail result of the power-on memory test (bit 1 of the memory test summary word) is deposited in the self-test summary word as bit 8 and will be returned with the ***TST?** query.

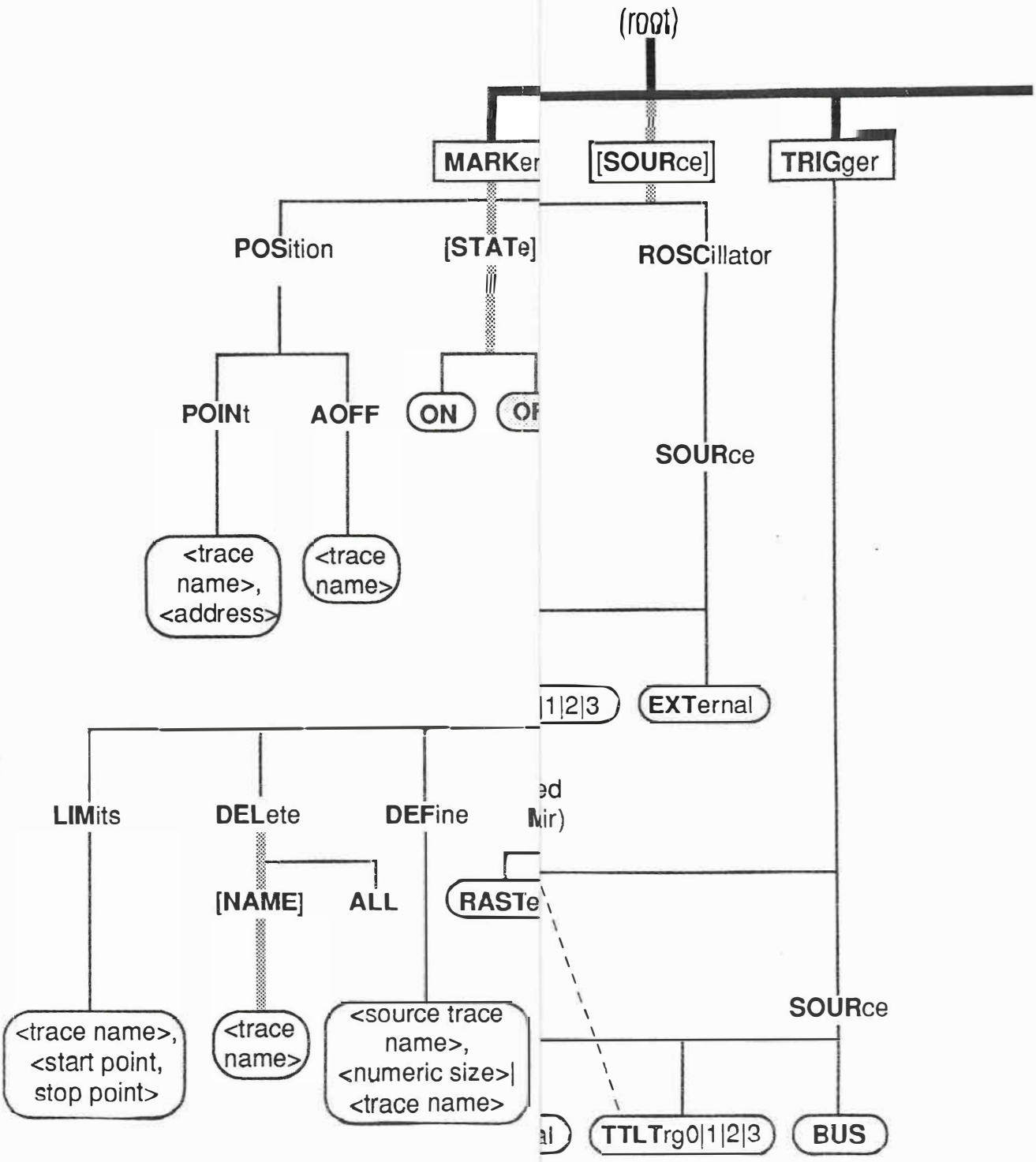
4.1.14 ***WAI Wait-to-Continue** Command (sect. 10.39)

The Wait-to-Continue command will prevent the device from executing any further commands or queries until the No-Operation-Pending flag is TRUE.



APPENDIX A

COMMAND FLOW CHART


(root)
MARKer
[SOURce]
TRIGger
POSition
[STATe]
ROSCillator
POINt
AOFF
ON
SOURce
<trace name>, <address>
<trace name>
EXTernal
LIMits
DELete
DEFine
[NAME]
ALL
RASTer
<trace name>, <start point, stop point>
<trace name>
<source trace name>, <numeric size>| <trace name>
SOURce
TTLTrg0|1|2|3
BUS

APPENDIX B

COMMAND and PARAMETER LIST

AGATed — This is one of six parameters of the Mode subsystem, the Asynchronous Gated mode. When in this mode, the waveform will be generated as long as the selected trigger signal is valid; the signal will stop simultaneously with the trigger going false.

ALL — One of two sub-command options available when deleting waveforms in the Trace subsystem. It will delete all waveforms in memory, **permanently**.

[AMPLitude] — The Arb waveform output level sub-command. Amplitude is the default path for the Voltage sub-command in the Source subsystem. It is an implied command and, therefore, optional on the command line. The amplitude value may range between 5mVp and 5Vp. The power-on default is 1Vp. It is coupled to the Offset sub-command limiting the output value to |5V|.

AOFF — This is a sub-command in the Marker subsystem. It turns all marker points of the selected waveform to OFF. It does not affect the waveform at the ARB OUT BNC.

BBITs — The Beginning Bits is one of two parameters in the Marker subsystem which may be used as a sync signal. This parameter selects the beginning point of the waveform to generate a sync pulse several bits wide.

BURSt — One of the sub-commands in the Source subsystem. This sub-command is used to set the burst value between 1 and 10,000,000. The power-on default value is 1. It only applies when the Mode subsystem parameter is set to Burst.

One of the six parameters in the Mode subsystem. Upon occurrence of the trigger, the selected waveform is generated the number of times set by the burst value.

BUS — One of four trigger source parameters available in the Trigger subsystem; the origin is the common command ***TRG** from the controller on the VXI data bus.

CATalog? — This query in the Trace subsystem sequentially returns a comma separated list of waveform names in memory beginning with the waveform in location one.

CLOCk$_n$ — This sub-command, in the Output subsystem, is used to select one of the two Arb clock sources for connection to the VXI backplane. The state of the clock output to the backplane is also selected under this sub-command. The numerical suffix "n" (0, 1, 2, 3) will select the Arb TTL clock lines 0, 1, 2, or 3. Failure to include the suffix will default to CLOCk0. The Arb clock lines connect to the VXI backplane TTLTRG lines 1, 3, 5, and 7 on P2. CLOCk$_n$ and TTLTrg$_n$ output lines are independent.

One of three parameters which can be selected as the reference oscillator for the Arb in the Source subsystem. The value of "n" (0, 1, 2, or 3) will select a clock signal on the VXI TTLTRG lines 1, 3, 5, or 7 (on P2) as the Arb clock. Failure to include the suffix will default to CLOCk0 (line 1). CLOCk$_n$ and TTLTrg$_n$ inputs are paired, the value of "n" for each is selected simultaneously from either subsystem parameter.

CONDition? — A query under both the OPERation and QUEStionable sub-commands in the unused Status subsystem. It will return a value of 0 (zero).

CONTinuous — One of the six parameters of the Mode subsystem. It continuously generates the selected waveform. It is the power-on default mode.

[CW] — This (implied) sub-command of the Source subsystem will set the Arb output frequency if CW has been selected in the Trace subsystem. The CW range is between 100 mHz and 2.5 MHz. CW is the power-on default selection with the default frequency set to 1kHz.

CW is one of the two parameters for setting the method of waveform generation in the Trace subsystem. It is the Arb power-on default. This is the Phase Accumulate method. As the requested output frequency increases, the number of points read may decrease in order to complete the entire waveform within the allotted time. The memory is scanned at a rate calculated to generate the requested frequency.

[DATA] — This implied (therefore, optional) sub-command is the default path for the Trace subsystem. It is the command path to select a data set for creation of a new waveform.

DEFine — A sub-command in the Trace subsystem. The start point of defining a waveform by giving it a name and the amount of memory it will occupy. This sub-command must be followed by an alphanumeric waveform name and, either the memory size to be allocated to it or the name of an existing waveform in memory to be copied into it.

DELete — A sub-command, under the Trace subsystem, used to delete either a waveform by name or all waveforms from the Arb trace memory. The deletion will **permanently** remove the waveform(s) from memory.

DIRectory? — A query which returns the names of the waveforms in memory, their sizes, and their start and stop points, beginning with the first waveform in memory.

ENABle — A sub-command under both the OPERation and QUEStionable sub-commands in the unused Status subsystem. It has no function.

ENABle? — A query under both the OPERation and QUEStionable sub-commands in the unused Status subsystem. It will return the value of 0 (zero).

ERRor? — A query under the System subsystem which returns any system error codes.

[EVENt]? — A query under both the OPERation and QUEStionable sub-commands in the unused Status subsystem. It will return the value of 0 (zero).

EXTernal — One of four trigger parameters available in the Trigger subsystem. It selects the signal at the Arb front panel TRIG IN BNC to trigger the Arb waveform. The maximum Arb trigger frequency is 2.5MHz.

One of three reference oscillator parameters available in the Source subsystem. It selects the signal at the front panel CLOCK IN BNC as the clock to sequence the Arb functions. The frequency range must be between 1mHz and 20MHz.

One of four possible trigger output parameters in the Output subsystem. It selects the signal at the Arb front panel TRIG IN BNC as a trigger source for one of the four Arb TTL trigger lines. The Arb TTL trigger lines correspond to the VXI TTLTRG lines 0, 2, 4, or 6 on P2. The maximum frequency for the TTLTRG lines is 12.5MHZ.

One of two possible clock output parameters in the Output subsystem. It selects the signal at the Arb front panel CLOCK IN BNC as a clock source for one of the four Arb clock lines. The Arb clock lines correspond to the VXI TTLTRG lines 1, 3, 5, or 7 on P2. The maximum frequency for the TTLTRG lines is 12.5MHZ.

FREE?	A query in the Trace subsystem that returns the amount of memory free and the amount presently in use.
FREQuency	One of the sub-commands in the Source subsystem. It sets either the Arb output frequency when CW is selected (default) or the memory scan frequency when Raster is selected. The Trace subsystem Mode sub-command must be set for the corresponding CW or Raster parameter. A sub-command of the Trigger subsystem which selects the trigger frequency when the source is internal. It must be within the range of 100 mHz and 2MHz.
FILTer	One of the sub-commands in the Output subsystem. This sub-command selects the 4MHz output filter ON/OFF state. When the filter is ON, it is in the path of the waveform to the ARB OUT BNC.
[IMMediate]	An implied (and therefore, optional) sub-command in the Source subsystem used to set either the Arb waveform output amplitude or the waveform offset level.
INTernal	One of four trigger parameters available in the Trigger subsystem. The source is the Arb Phase Locked Loop Clock/Trigger circuit which is referenced to CLK10. One of three reference oscillator parameters available for the Arb clock. The origin is the VXI backplane 10MHz clock signal, CLK10. It is multiplied and divided as necessary Arb Phase Locked Loop Clock/Trigger circuit. One of four possible trigger output parameters in the Output subsystem. It selects the Arb internal trigger as the trigger source for the selected Arb TTL trigger output line. The maximum frequency for the VXI TTLTRG lines is 12.5MHZ. One of two clock output parameters available in the Output subsystem. It selects the Arb internal clock as the clock source for the selected Arb TTL clock output line. The maximum frequency for the VXI TTLTRG lines is 12.5MHZ.
[LEVel]	Level is an implied (and therefore optional) sub-command in the Source subsystem and is part of the amplitude and offset level setting path.
LIMits	This command in the Trace subsystem sets the "playback" size of the selected waveform to less than the originally defined size. The Arb subsequently uses the newly defined limited start/stop points when any command references are made to the waveform. It is reversible. The Limit command may also apply to an 8192 point block of data, changing the normal block start and stop points; it will only be accepted if the Arb is in the Triggered Sequence mode and the first block has a name.
LINE	This sub-command in the Trace subsystem permits the entry of two "X"-"Y" data points defining a line.
[LPASs]	An implied (therefore optional) sub-command of the Output subsystem which describes the filter pass band (Low-pass). It is on the command path that defines the filter ON/OFF state.
MARKer	An Arb subsystem that sets the origin, location and state of the waveform markers. The default state is OFF and the default Sync is Zero Crossing detection.
MODE	An Arb subsystem. The Mode subsystem sets one of six operating modes for the Arb. The Continuous mode is the power-on default. The sub-command in the Trace subsystem which sets the method of waveform generation to either CW or Raster. CW is the power-on default.

MPOSition — The parameter in the Output subsystem which selects the Arb Marker Position as an output on a selected Arb TTL trigger line. The maximum frequency for the VXI TTLTRG lines is 12.5MHZ.

MSYNc — One of the parameters in the Output subsystem. When selected, it applies the Marker Sync signal chosen in the Marker subsystem to the selected Arb TTLTrg line. The maximum frequency for the VXI TTLTRG lines is 12.5MHZ.

[NAME] — An implied sub-command (therefore optional) used to name the waveform to be deleted from memory in the Trace subsystem. The named waveform will be **permanently** deleted.

NHSine — Negative Haversine. One of several factory pre-defined waveshape parameters accessed through the Trace subsystem. Like the others, it is an algorithm and occupies no waveform memory.

NRAMp — Negative Ramp. One of several factory pre-defined waveshape parameters accessed through the Trace subsystem. Like the others, it is an algorithm and occupies no waveform memory.

OFF — One of two possible State parameters in the Output and Marker subsystems. Used for setting the output state of the named sub-command within the indicated subsystem to OFF. OFF is a Boolean parameter and may also be expressed as "0" (zero). It is the power-on default for each State sub-command.

OFFSet — This sub-command in the Source subsystem is used to adjust the Arb waveform offset voltage. The range is between -5V and +5V. The power-on default is 0 (zero) volts. It is coupled to the Amplitude sub-command limiting the output value to |5V|.

ON — One of two possible State parameters in the Output and Marker subsystems. Used for setting the output state of the named sub-command within the indicated subsystem to ON. ON is a Boolean parameter and may also be expressed as "1" (one).

OPERation — A sub-command in the unused Status subsystem. It is not active.

OUTPut — One of the Arb subsystems. It sets the ON/OFF State of the various Arb output signals, the ON/OFF State of the output filter, and selects the source of both the TTL trigger output to the VXI backplane and the TTL clock output to the VXI backplane.

PHSine — Positive Haversine. One of several factory pre-defined waveshape parameters accessed through the Trace subsystem. Like the others, it is an algorithm and occupies no waveform memory.

POINt — This sub-command of the Marker subsystem defines the point on the named waveform at which a marker is desired. When the location is defined, the Arb MARKER SYNC output signal on the front panel is at a high level until the next waveform point which does not have a marker defined.

POINts — A sub-command of the Trace subsystem which resizes the memory allocation of the named trace and relocates it to the end of memory. The original trace will be deleted. Resizing downward will shrink the trace in memory; resizing upward (if space available in memory) will stretch the trace.

POSition — A sub-command under the Marker subsystem which selects either individual marker points to be set high or all to be set low for the named waveform.

PRAMp — Positive Ramp. One of several factory pre-defined waveshape parameters accessed through the Trace subsystem. Like the others, it is an algorithm and occupies no waveform memory.

PRESet — A sub-command in the unused Status subsystem. It is not active.

QUEStionable — A sub-command in the unused Status subsystem. It is not active.

RANDom — Random signal generator. One of several factory pre-defined waveshape parameters accessed through the Trace subsystem. Like the others, it is an algorithm and occupies no waveform memory.

RASTer — Raster is one of the sub-commands in the Source subsystem. It sets the memory scan frequency when the Mode sub-command in the Trace subsystem is set to the Raster parameter. The range is between 1mHz and 20 MHz. The power-on default is 20 MHz.

Raster is one of the two parameters in the Trace subsystem used for setting the method of waveform generation. The Raster scan method always reads each defined memory location of the selected waveform for an amplitude value, at the frequency entered in the Source subsystem.

ROSCillator — This sub-command of the Source subsystem is used to select one of the three reference oscillator sources to be used as the Arb clock. The default is INTernal.

SELect — A sub-command in the Trace subsystem. It selects the named waveform for output. The power-on default is the first trace in memory.

SGATed — This is one of six parameters of the MODE subsystem. The Synchronously Gated mode initiates the output of the waveform upon the occurrence of the selected trigger signal. The waveform will be generated continuously as long as the trigger signal exists. The waveform will finish the cycle it is in when the trigger signal becomes false.

SINC — One of several factory pre-defined waveshape parameters accessed through the Trace subsystem. Like the others, it is an algorithm and occupies no waveform memory. It covers the span from -16π radians to $+16\pi$ radians and is defined as:

$$\frac{\mathrm{Sin}X}{X}$$

SINusoid — One of several factory pre-defined waveshape parameters accessed through the Trace subsystem. Like the others, it is an algorithm and occupies no waveform memory.

[SOURce] — One of the Arb subsystems. It is the default subsystem at power-up. It is used to define the Arb waveform output levels and frequency; Burst and Triggered Sequence values; and the Reference Oscillator source.

SOURce — The source sub-command is used to define a signal source in several subsystems. In the Source subsystem it is used to select the Reference Oscillator source. In the Trigger subsystem it selects the trigger source. The Output subsystem has two Source sub-commands. One selects the clock source and the other selects the trigger source, each for output to the VXI backplane.

SQUare — One of several factory pre-defined waveshape parameters accessed through the Trace subsystem. Like the others, it is an algorithm and occupies no waveform memory.

[STATe] The ON/OFF value defining each of the output conditions found in the Arb. The State sub-command is an implied command and is optional in each command line. Because State is a Boolean command, "ON" or "1" have the same definition and "OFF" or "0" have the same definition. The Output subsystem has four State sub-commands, one each for the clock output to the VXI backplane, the TTL trigger output to the VXI backplane, the waveform output to the front panel BNC, and the state of the filter in the waveform output path.

The Marker subsystem has one State sub-command which turns the marker ON or OFF.

STATus A SCPI mandated subsystem. In place but unused in the Arb. It will accept commands without an effect and, when queried, will return a value of 0 (zero).

STATus? A query in the Trace subsystem which returns the value of the memory test summary word.

SYNC A sub-command in the Marker subsystem used to select either the Zero Crossing or the Beginning Bit type of sync signal.

SYSTem An Arb subsystem. Used for displaying the contents of the error register.

TRACe One of the Arb subsystems. It is used to create a waveform. This subsystem permits the manipulation of data, the selection of a data source, the method of waveform generation, and queries about waveform memory. The factory pre-defined waveshapes are accessed through the Trace subsystem. The ***RST** command only affects the MODE sub-command in this subsystem.

TRIangle One of several factory pre-defined waveshape parameters accessed through the Trace subsystem. Like the others, it is an algorithm and occupies no waveform memory.

TRIGger One of the Arb subsystems. This subsystem selects the trigger source and, when INTernal is selected, sets its frequency.

TRIGgered One of the parameters for the Mode subsystem. In the Triggered mode, the Arb waits, at the first trace point used, for a trigger. The waveform will be generated only once for each occurrence of the trigger.

TSEQuence One of the sub-commands in the Source subsystem. Triggered Sequence sets the value for the number of 8192 point blocks to be "played back" when the Mode subsystem is set to Tsequence. The sequence will always start with block 1. The value may range from 1 through 4 (through 16 with extended memory). The power-on default is 1, which reads only the first block. The LIMit command may be used to set new start and stop values within the block.

One of the parameters for the Mode subsystem. The Triggered Sequence selection generates the waveform by reading 8192 point blocks of memory. Upon receiving the trigger signal, the first block of memory is read continuously. At the next trigger signal, the next sequential block is read continuously beginning where the last one ended, etc. The sequence is circular, the first block is read after a trigger is received in the last block used.

TTLTrg$_n$

This sub-command is in the Output subsystem. It is used to select one of the four Arb triggers for connection as a source to the VXI backplane. The ON/OFF state of the trigger output to the backplane is also selected under this sub-command. The numerical suffix "n" (0, 1, 2, 3) will select the Arb TTL trigger lines 0, 1, 2, or 3. Failure to include the suffix will default to TTLTrg0. The Arb trigger lines connect to the VXI backplane TTLTRG lines 0, 2, 4, and 6 on P2. The maximum frequency for the TTLTRG lines is 12.5MHZ. TTLTrg$_n$ and CLOCk$_n$ output lines are independent.

One of the four parameters used to select a trigger source in the Trigger subsystem. The value of "n" (0, 1, 2, or 3) will select a trigger from one of the Arb trigger lines TTLTrg0 through TTLTrg3 (VXI TTLTRG lines 0, 2, 4, or 6 on P2). Failure to include the suffix will default to TTLTrg0. The source of the trigger on the VXI line is another module in the mainframe. TTLTrg$_n$ and CLOCk$_n$ inputs are paired, the value of "n" for each is selected simultaneously from either subsystem parameter. The maximum frequency for the TTLTRG lines is 12.5MHZ.

VOLTage

A sub-command in the Source subsystem. Voltage selects either Amplitude or Offset for a level adjustment. The maximum absolute value is |5V|.

ZCROs

One of two parameters in the Marker subsystem used for generating sync. When Zero Crossings is selected, a sync signal is coincident with the selected Arb waveform that is above the zero voltage level (2048 through 4095). This sync signal is the power-on default.

APPENDIX C

SCPI Beginner's Guide

INTRODUCTION

SCPI (Standard Commands for Programmable Instruments) traces its lineage to IEEE 488.1 and IEEE 488.2. Although the IEEE 488.2 standard addressed some instrument measurements, it principally dealt with common commands and syntax or data formats. Please refer to the IEEE 488.2 and SCPI reference manuals for more information.

The IEEE 488.1 relates to the physical connection between the instrument and its remote control unit; how the data is transmitted between the two; and the method used to determine master and slave.

The IEEE 488.2 encompassed and built upon IEEE 488.1 by adding syntax and data requirements for the communication path. In addition, it also defined the commands which were to be common to any and all units, and the query format for data retrieval from the remote instrument.

With SCPI, a variety of modular instruments have a universal language, even though they have different functions and manufacturers. SCPI added the fine detail of instrument set-up by establishing a hierarchy of standard command formats and subsystem routing, reducing multiple ways to control similar functions. An example of vertical consistency (same instrument type) would be multimeters from different manufacturers implementing the command to measure a value of DC voltage in the same manner using the *Measure sub-system*. An example of horizontal consistency (different instrument types) would be different instruments using the same command to trigger a function using the *Trigger subsystem*. Refer to figure C-1. Queries of the instrument by the controller result in well defined status response and measurement data. By building on the IEEE 488.2, all of the earlier commands that it had defined have become a part of SCPI and, to the limit that an instrument can be operated by them, they are valid.

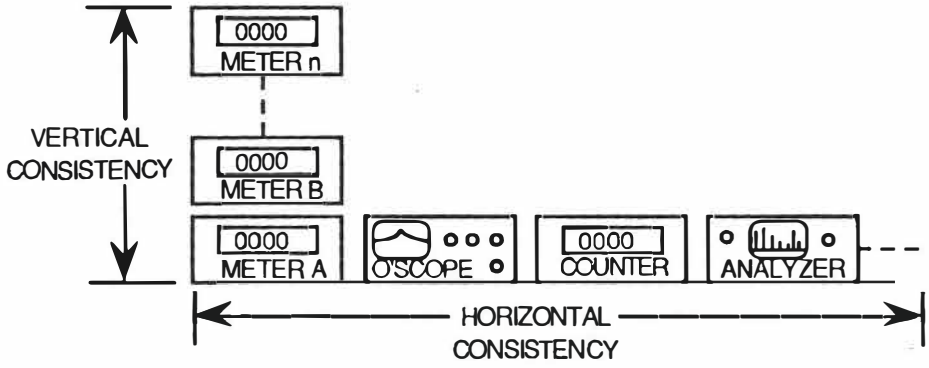


Figure C-1. Command consistency

The user need not be concerned about the interface commands, the common commands or the syntax and data structures, they are IEEE 488.1 and IEEE 488.2 definitions and have not changed; they are encompassed within SCPI. Not all instruments use all commands, but all instruments use the same command format. Using the language rules and the hierarchical nature of the command structure, new commands, parameters, and subsystems can be developed from the existing primitive elements and commands as new instruments are introduced.

The hierarchy of subsystem commands in SCPI is called a **Command Tree** (sometimes also called a **Command Flow Chart**). The SCPI Command Tree is up-side-down, the Root is at the top with branches extending downward, ending with the parameter required for the branch function. Refer to figure C-2. There is only one route to travel to reach the destination keyword or parameter on the selected branch. More than one command may have the same keyword, but on different branches. These commands usually perform a similar function in the respective branches, however, each can only be reached by traversing a unique path.

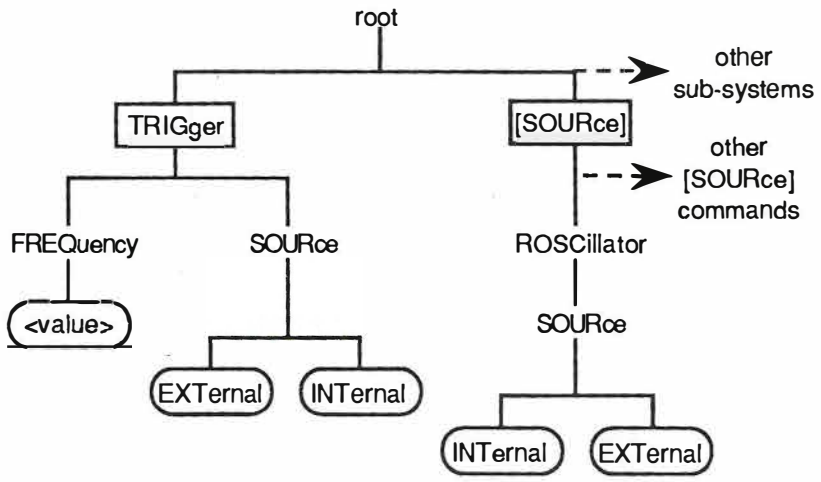


Figure C-2. Same keywords In different subsystems

The command hierarchy can also be represented by a **Command Table** and by **Syntax Diagrams**. An example of each method is illustrated.

PARAMETERS

The parameter specifies the finest detail that is required in a branch. Most parameters have a defined default value at power-up or ***RST**. Parameter defaults are specified in the manual for each instrument. There are three major types of parameters: *Character* (Discrete), *Decimal Numeric*, and *Boolean*.

Character parameters are a one word character label, usually one of a number choices, that defines a characteristic (e.g. ZCROs - the abbreviation for Zero Crossings). Failure to include a numerical suffix with a *Character* parameter requiring one, will result in issuing a command with the lowest value suffix (e.g. the command TTLTrg without any suffix will default to TTLTrg0).

Decimal Numeric has an extended set that may be implemented,. *Decimal Numeric* may not be used as a subset (e.g. 1 of n lines), but may be used as a value definition (e.g. start value = 10). Subsets are implemented by using a suffix with a discrete (e.g. Line2). *Decimal Numeric* also covers the "label" type of parameter, the signal name (e.g. SIN1). The extended numeric set covers the special numbers MAXimum and MINimum which are required and DEFault which is optional.

Boolean parameters can have one of two values, usually ON or OFF. *Boolean* values can also be represented by "1" or "0" on the command line. Queries requesting a *Boolean* value will always return either "1" or a "0".

A SCPI convention shows parameters in text and on the Command Tree with angle brackets (<>) if they are values or names to be entered by the user. Parameters with a character (discrete) keyword or Boolean parameters do not use the angle brackets. A Wavetek convention shows parameters in the command tree enclosed within an oval "box". The default parameters that are selected at power-up or ***RST** are shown in shaded oval "boxes".

QUERIES

Any command that sets a value, can be queried about the current value of the setting. The query form of the command ends with a question mark (?). Some commands are defined as queries only and can be identified by the question mark used after them in the command tree. Some commands are events only and do not have a query form. These can usually be identified by their action nature such as DELete or IMMediate. The values of the special numbers of MAXimum, MINimum, and DEFault may also be queried.

SCPI PUNCTUATION and SYNTAX

Keywords can be abbreviated or used in full. SCPI requires the exact abbreviation or the exact full spelling only; capital or lower case letters have equal weight. The long form of the keyword may be either a single word or a phrase which has been abbreviated to a single word. The SCPI convention is to use the entire keyword in any text or instructions with the accepted abbreviation shown in capital letters. In addition, Wavetek makes the capital portion **bold** to show the minimum command requirements at a glance, and sets it off by using a different typeface. For example,

FREQuency

Common commands must start with an asterisk (*). SCPI commands start with an optional colon (:). Each time a colon is inserted in the command line, the "pointer" is instructed to move down the branch which has the keyword immediately following. A semi-colon separates a string of commands on one line. If a colon does not follow the semi-colon, the "pointer" remains at the same level. A colon following the semi-colon will set the "pointer" back to the root. The commands do not become effective until a "Program Message Terminator" is received at the end of the command line. An incorrect command line will generate an error message.

CONDENSED RULES:

- Power-on and Reset
  After power is applied, the command "pointer" is set to the root and all parameters to default values (***RST** does not set the Trace memory to default values).

- Command line termination
  When the command line is terminated with a Program Message Terminator, the "pointer" is set to the root level.

- Colon
  The optional leading colon in a command line indicates the keyword immediately following is at the root level (a subsystem).

  A colon between command keywords indicates the pointer is to step down one level to the immediately following keyword.

- Semi-colon
  The semi-colon separates commands within the same message without changing levels.

- Whitespace (space bar or tab)
  Whitespace must be used to separate commands from parameters. Whitespace must not be used within a command keyword. Otherwise, SCPI usually ignores the whitespace.

- Comma
  When a command requires a series of parameters, they must be separated by commas.

•Question Mark

The question mark is placed after the program header creating a query. A parameter may be placed after the question mark where appropriate (for example, ...LIMits? <trace name>). Some event commands do not have a query form (for example, DELete). Some commands are queries only (for example FREE?).

•Common Commands

Common commands (***RST**, ***TRG**, etc.) are acted upon the same way regardless of which subsystem or into which level of the SCPI test program they are written. After execution of the common command, the SCPI command "pointer" will return to the point where it was interrupted (the exception is ***CLS**, the "pointer" is set back to the root). The ***RST** command will reset all subsystems to the default values except the Trace memory; it does not set the "pointer" back to the root.

TEXT SYMBOLS

•Square brackets

Commands or portions of parameters that are optional are enclosed by square brackets ([ ]).

•Angle brackets

Angle brackets (< >)enclose parameters that are to be entered by the user, usually either numeric label (names) or numeric data (levels, values).

•Vertical line

The vertical line (|) represents an "exclusive OR", one of the values shown must be used.

TRACE NAMES (numeric label data)

The following restrictions govern parameter names (user waveform names):

1. They cannot exceed 12 characters in length, preferred length is 4.
2. They must not have any embedded whitespace.
3. They must start with an alphabetic character. They cannot start with a numeric, a whitespace, or an underscore.
4. All alphanumeric characters may be used, both capitol and lower case. The underscore (_) may also be used.
5. There is no abbreviation for the users trace name, it must be used as defined.

The command hierarchy can be represented in three ways; the **COMMAND TREE**, the **COMMAND TABLE**, or the **COMMAND SYNTAX DIAGRAM**. All three are illustrated on the following pages. Refer to figure C-3, the Command Tree.

COMMAND TREE

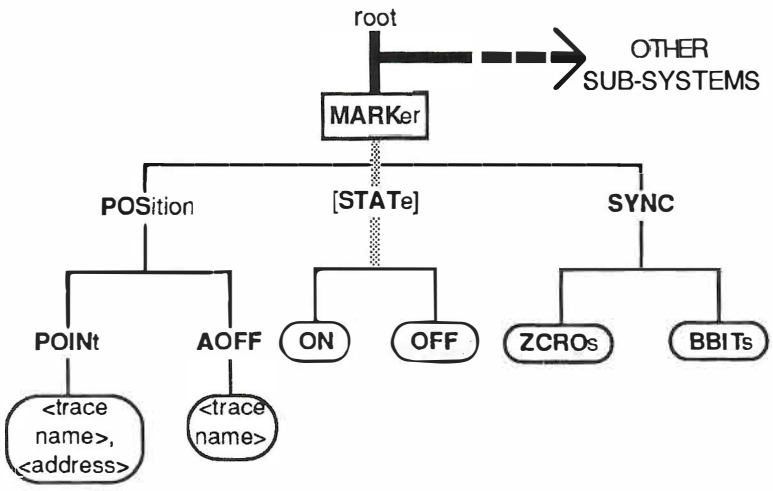


Figure C-3. Marker Subsystem Command Tree

Example command lines for this subsystem follow. Assume a trace name and size have been entered and a trace name is currently selected. Only the entered trace name is acted upon by the commands except in the case of global commands like DELete:ALL or MODE, etc. The longform of the keywords are given with the approved (or Wavetek selected) abbreviations in capitals. Items in **bold**, with the exception of optional commands, are minimum requirements.

The first character on the command line is the colon (:). This places the "pointer" at the "root" and just above all subsystems. The leading colon is optional if the command pointer is already at the "root". The following example shows the development of the command line by "walking" down the tree. Select the MARKer subsystem by entering:

```
:MARKer
```

There are three branches in the Marker subsystem, select SYNC by entering it after MARKer:

```
:MARKer:SYNC
```

Sync has two discrete type parameters. Select one, ZCROs. Enter a <space>, then ZCROs, then a <program message terminator> (<PMT>). The <PMT> is not normally shown in command lines, but is shown below for reference. The PMT will enter the command string into the controller.

```
:MARKer:SYNC ZCROs <PMT>
```

If, after setting markers at various locations in the waveform, the markers are in unacceptable locations, turn them All Off using the AOFF sub-command (AOFF has no abbreviations).

```
:MARKer:POSition:AOFF <trace name>
```

Now, set the marker(s) to the position(s) desired. This command sets only one marker position (high) at a time; if more than one is desired, repeat the command for each position. There must NOT be any whitespace between the comma and either parameter. The <address> is a numeric value.

```
:MARKer:POSition:POINt <trace name>,<address>
```

The desired marker selections have been completed. Now, turn the marker ON. This command can use one of several formats, the complete command follows:

```
:MARKer:STATe ON
```

Because the STATe command is optional (the square brackets, [ ], in the command tree show this) it is not necessary to be entered on the command line:

```
:MARKer ON
```

Because the ON parameter is Boolean, it can be replaced by "1", if desired:

```
:MARKer:STATe 1
```

Both of the options have been exercised in the following command line. The syntax selected for the command depends upon the user.

```
:MARKer 1
```

Not including the query, the commands could have been entered in a string of four commands on one program line, using the semi-colon and colon, as follows:

```
:MARKer:SYNC ZCROs;POSition:AOFF <trace name>;POINt <trace
name>,<address>;:Marker 1
```

Enter a request for the marker state (this does not change the state).

```
:MARKer:STATe?   or   :MARKer?
```

Because the marker has been turned ON, the Boolean response will be:

```
1
```

The command tree can also be presented as a table. The hypothetical instrument command tree portion of figure C-3 is shown below as table C-1. The symbols used with the tree are also used with the table.

The angle brackets (< >) indicate the parameter is entered by the user. Lower case text between the angle brackets show the parameter that is expected. ON/OFF are Boolean parameters. Discrete parameters often appear as command keywords in the command table, but must not be confused; a whitespace is still required before them on the command line. All parameters have manufacturer specified default values which will exist at power-up or ***RST**. Numerical values entered, which are out of range for the branch, will not be acted upon and will return an error when the SYSTem:ERRor? query is sent.

The square brackets ([ ]) are optional commands that are not required in the command line, but may be used for documentation clarity. Some parameters or portions of parameters may be optional and will be shown with square brackets around them.

Table C-1. MARKER COMMAND TABLE

COMMAND	PARAMETERS	PARAMETER TYPE
:MARKer		
POSition		
POINt	*<name>*	numeric (label)
	<address>	numeric
AOFF	*<name>*	numeric (label)
[STATe]	*state (optional)*	Boolean
SYNC	*sync detector type*	discrete

Under the "Command" heading in the table, the subsystem command is not indented. Each sub-command is indented showing the level of subordination. The Parameter column indicates the parameter expected for the command. The Parameter Type column shows the type of parameter for the sub-command

COMMAND SYNTAX DIAGRAMS
(railroad diagrams)

The command list can also be presented as a syntax diagram. The hypothetical instrument command tree in figure C-3 is shown on the following pages as railroad diagrams. Some symbols used with the tree are also used with the diagram.

Railroad diagrams (so called because they look like railroad layouts from above) are another way to present the command flow. There is a railroad diagram for each command in a subsystem. As with the command tree and the command table, railroad diagrams have some unique symbols.



The rectangular box contains command and subsystem keywords with their abbreviation in capital letters.



The oval "boxes" contain parameters; shaded boxes are default. The angle brackets (< >) contain user entered parameters.



The circle encloses punctuation ("sp" implies whitespace).

The arrow shows the command direction flow. The flow is usually from left to right, but the command may contain loops flowing in other directions.

Figure C-4 shows how the sync is selected, the query form, and the parameters available using the "railroad" syntax diagram format. The bypass around the leading colon indicates it is optional in the command line. The default parameter is shown by the shading. At each place the line splits, a decision must be made which path will be followed. The command is completed when the exit arrow has been reached.

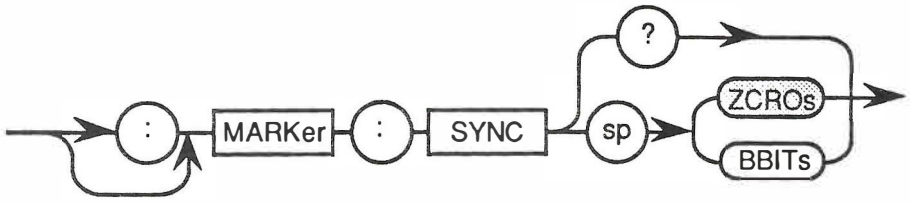


Figure C-4. Sync selection

Figure C-5 shows the All Off command. There is no query form of the command, AOFF is an event.

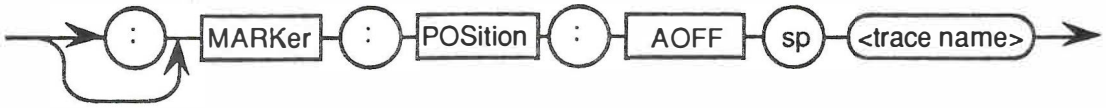


Figure C-5. All markers OFF command

Figure C-6 shows the command for setting the point address.

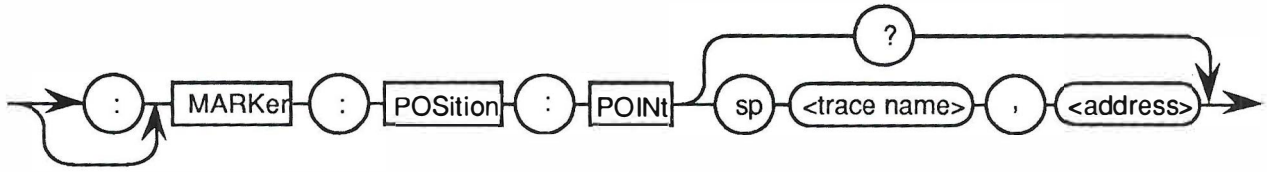


Figure C-6. Set the marker point address

Figure C-7 shows the bypass around the optional STATe command. The entire Boolean parameter compliment is in the diagram with both OFF and "0" shown as default. The OFF parameter is equal to "0", and ON is equal to "1"; equal parameters are interchangeable in the command line.

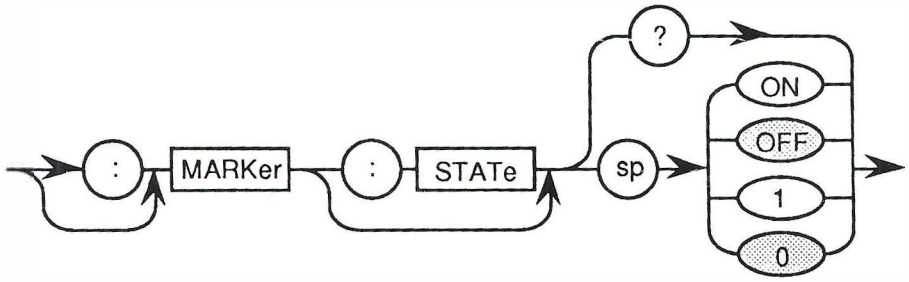


Figure C-7. Set the marker state.

The query to show the output state will only return the Boolean values of "1" or "0".

APPENDIX D

ARB SYSTEM ERROR MESSAGES

32767	"Invalid error number"
0	"No error"
-100	"Command error"
-101	"Invalid character"
-102	"Syntax error"
-103	"Invalid separator"
-104	"Data type error"
-105	"GET not allowed"
-108	"Parameter not allowed"
-109	"Missing parameter"
-110	"Command header error"
-111	"Header separator error"
-112	"Program mnemonic too long"
-113	"Undefined header"
-114	"Header suffix out of range"
-120	"Numeric data error"
-121	"Invalid character in number"
-123	"Exponent too large"
-124	"Too many digits"
-128	"Numeric data not allowed"
-130	"Suffix error"
-131	"Invalid suffix"
-134	"Suffix too long"
-140	"Character data error"
-141	"Invalid character data"
-144	"Character data too long"
-148	"Character data not allowed"
-150	"String data error"
-151	"Invalid string data"
-158	"String data not allowed"
-160	"Block data error"
-161	"Invalid block data"
-168	"Block data not allowed"
-170	"Expression error"
-171	"Invalid expression"
-178	"Expression data not allowed"
-180	"Macro error"
-181	"Invalid outside macro definition"
-183	"Invalid inside macro definition"
-184	"Macro parameter error"
-200	"Execution error"
-201	"Invalid while in local"
-202	"Settings lost due to rtl"
-210	"Trigger error"
-211	"Trigger ignored"
-212	"Arm ignored"
-213	"Init ignored"
-214	"Trigger deadlock"
-215	"Arm deadlock"
-220	"Parameter error"
-221	"setting conflict"
-222	"Data out of range"
-223	"Too much data"
-224	"Illegal parameter value"
-230	"Data corrupt or stale"
-231	"Data questionable"
-240	"Hardware error"
-241	"Hardware missing"
-250	"Mass storage error"
-251	"Missing mass storage"
-252	"Missing media"
-253	"Corrupt media"
-254	"Media full"
-255	"Directory full"
-256	"File name not found"
-257	"file name error"
-258	"Media protected"
-260	"Expression error"
-261	"Math error in expression"
-270	"Macro error"
-271	"Macro syntax error"
-272	"Macro execution error"
-273	"Illegal macro label"
-274	"Macro parameter error"
-275	"Macro definition too long"
-276	"Macro recursion error"
-277	"Macro redefinition not allowed"
-278	"Macro header not found"
-280	"Program error"
-281	"Cannot create program"
-282	"Illegal program name"
-283	"Illegal variable name"
-284	"Program currently running"
-285	"Program syntax error"
-286	"Program runtime error"
-300	"Device specific error"
-310	"System error"
-311	"Memory error"
-312	"PUD Memory lost"
-313	"Calibration memory lost"

-314 "Save/recall memory lost"
-315 "Configuration memory lost"
-330 "Self-test failed"
-350 "Queue overflow"
-400 "Query error"
-410 "Query interrupted"
-420 "Query unterminated"
-430 "Query deadlocked"
-440 "Query unterminated after indefinite response"

APPENDIX E

SAMPLE PROGRAMS

The following programs use the WaveTest Basic language. Any language that is acceptable to the users controller will work. The first two programs use the factory pre-defined waveforms to create the defined trace. The complete command keywords are used, with the approved abbreviation in capitals.

E1.1

SQUARE WAVE;
512 Points, 100 KHz, 10 Vpp,
Continuous

```
10    ! This program creates a 512 point square wave, WAVE1; 100 KHz; 10 Vp-p.
20    Print @ 90130:":TRACe:DEFine WAVE1,512"
30    Print @ 90130:":TRACe:DATA WAVE1,SQUare"
40    Print @ 90130:":TRACe:SELect WAVE1"
50    Print @ 90130:":SOURce:FREQuency:CW 100E3"
60    Print @ 90130:":SOURce:VOLTage:LEVel:IMMediate:AMPLitude 5"
70    Print @ 90130:":OUTPut:STATe ON"
80    End
```

The number "90130" is the combination VXI system and Arb logical address using the WaveTest option basic. The VXI port address is "9", the Arb address is "130", "0" is a place holder. This uses the formula @9xxxx for VXI instrument addresses between 1 and 255.

In line 20 the trace name and size is defined as WAVE1 at 512 points using the Trace subsystem.

Line 30 selects the data source for WAVE1 as the pre-defined shape SQUare, using the trace subsystem. The optional DATA command is used in this line for documentation clarity (the command would have set the factory pre-defined shape if sent as ":TRACe WAVE1,SQUare").

In line 40, using the trace subsystem, trace WAVE1 is selected for output.

Line 50 uses the optional SOURce and CW commands for documentation clarity. They were not needed for the command to function properly (":FREQuency 100E3" would have set the frequency).

Line 60 uses shows the optional SOURce, LEVel, IMMediate, and AMPlitude commands for documentation clarity (":VOLTage 5" would have set the amplitude). Unless another subsystem is selected after the leading colon in the command line, the default is the Source subsystem. The FREQuency sub-command is assumed by the Arb to be in the Source subsystem as no other subsystem was entered on the command line. Line 50 sets the frequency to 100 KHz, line 60 sets the amplitude to 5V peak.

Line 70 turns the output relay ON. The Boolean STATe command in the Output subsystem is optional and shown for documentation clarity (":OUTPut ON" or ":OUTPut 1" would have turned the output on).

```
230     Low_byte$ = CHR$(Low_byte)

240     Data_block$ = Data_block$ & High_byte$

250     Data_block$ = Data_block$ & Low_byte

260     NEXT I
```

Lines 270 through 290
are the output to the Arb.
The new trace is named WAVE3.

```
270     Print@90130:":OUTPut:STATe ON"

280     Print@90130:":TRACe:DEFine WAVE3,8"

290     Print@90130:":TRACe:DATA WAVE3,";Header_block$;Data_block$

300     End
```

Lines 240 and 250 assemble the high byte/low byte in the correct order.

Line 280 allocates eight points in memory be reserved for trace WAVE3.

The "Header_block$" in line 290 creates the "#216" required for the 16 data bytes required for an eight point trace. "Data_block$" is the 16 bytes, in high byte/low byte order, needed to create the eight point sine wave trace (refer to paragraph 3.12.2.1 DEFINITE LENGTH ARBITRARY BLOCK).

Lines 10 through 100 can be replaced with an algorithm selected by the user to create a different waveform or change the number of points, etc.

APPENDIX F

SCPI CONFORMANCE

SCPI Conformance Information

This instrument conforms to **SCPI** version 1.0 published April 1990

Syntax of all **SCPI** confirmed commands implemented by the Wavetek Model 1375 Arbitrary Waveform Generator. Commands in *italic* are not part of the SCPI definition.

[:SOURce]	
:FREQuency	
[:CW]	<numeric value>
:RASTer	*<numeric value>*
:VOLTage	
[:LEVel]	
[:IMMediate]	
[:AMPLitude]	<numeric value>
:OFFSet	<numeric value>
:TSEQuence	*<numeric value>*
:BURSt	*<numeric value>*
:ROSCillator	
:SOURce	INTernal | EXTernal | *CLOCk0 | CLOCk1 | CLOCk2 | CLOCk3*
:MODE	*CONTinuous | AGATed | SGATed | TRIGgered | BURSt | TSEQuence*
:OUTPut	
[:STATe]	<ON | OFF>
:FILTer	
[:LPASs]	
[:STATe]	<ON | OFF>
:CLOCk0 | CLOCk1 | CLOCk2 | CLOCk3	
:SOURce	*INTernal | EXTernal*
[:STATe]	*ON | OFF*
:TTLTrg0 | TTLTrg1 | TTLTrg2 | TTLTrg3	
:SOURce	MPOSition | MSYNc | EXTernal | INTernal
[:STATe]	<ON | OFF>

:TRACe	
:DEFine	<trace name>,<size> | <trace name>]
[:DATA]	<destination trace name>,<source trace name> | <definite length arbitrary block data> | *<factory pre-defined waveshape>*
:LINE	*<destination trace name>, <X1>, <Y1>, ,<X2>, <Y2>*
:SELect	*<trace name>*
:DELete	
[:NAME]	<trace name>
:ALL	
:LIMits	*<trace name>, <start point>, <stop point>*
:MODE	*CW|RASTer*
:FREE?	
:CATalog?	
:DIRectory?	
STATus?	
POINts	<trace name>,<numeric value>
:MARKer	
[:STATe]	<ON | OFF>
:POSition	
:POINt	*<trace name>,<address>*
:AOFF	*<trace name>*
:TRIGger	
:SOURce	BUS | TTLTrg0 | TTLTrg1 | TTLTrg2 | TTLTrg3 | EXTernal | INTernal
:FREQuency	*<numeric value>*

SCPI Mandated Commands

:SYSTem	
:ERRor?	
:STATus	
:OPERation	
[:EVENt]?	
:CONDition?	
:ENABle	
:ENABle?	
:QUEStionable	
[:EVENt]?	
:CONDition?	
:ENABle	
:ENABle?	
:PRESet	

IEEE Mandated Common Commands

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

Other IEEE 488.2 Common Commands

*TRG	Trigger Command

Low Level Interface Commands

ANOP	Abort Normal Operation
BNOP	Begin Normal Operation
CLE	Clear
ENOP	End Normal Operation
ICOM	Identify Commander
RPE	Read Protocol Error
RPR	Read Protocol
RSTB	Read Status Byte

APPENDIX G

LOW LEVEL INTERFACE COMMANDS

The Arb responds to the following low level VXIbus interface commands. These are issued by its commander. Refer to the VXIbus specification for further information.

ANOP Abort Normal Operation
This command causes the Arb to cease its normal operation as fast as possible. It resets the *ready* bit in the Status register to 0. The unit is reconfigured to the default state; the power-up memory test is NOT performed. It has the same effect as ***RST** and ***CLS**.

BNOP Begin Normal Operation:
This commands the Arb to begin normal operation. The *ready* bit in the Status register is set to 1 and the device is ready to receive data.

CLE Clear
Upon receiving the clear command, the Arb removes all output data in the VXI Data Low register. The Arb will discard all data due for output from operations currently in progress and become ready to receive a new command; the input and output queues are cleared. The *read ready* bit in the Response register will be reset to 0. The *Err** bit of the Response register will be de-asserted and any pending *read protocol error* command responses will be canceled.

ENOP End Normal Operation
The Arb ends its normal operation in an orderly manner without any time limit constraints. Incoming signals are no longer processed. The *ready* bit of the status register is reset to 0. The current Arb configuration is maintained.

ICOM Identify Commander
The Commander uses this command to tell the Arb its logical address.

RPE Read Protocol Error
The VXIbus commander uses this command to query the cause of the last protocol error.

RPR Read Protocol
The VXIbus commander uses this command to find out what protocols in addition to the Word Serial protocol that the Arb supports. The Arb supports I, I4, EG, and RG.

RSTB Read Status Byte
This command is used by the Commander to read the status byte from the Arb.

Artisan Technology Group is an independent supplier of quality pre-owned equipment

Gold-standard solutions

Extend the life of your critical industrial, commercial, and military systems with our superior service and support.

We buy equipment

Planning to upgrade your current equipment? Have surplus equipment taking up shelf space? We'll give it a new home.

Learn more!

Visit us at **artisantg.com** for more info on price quotes, drivers, technical specifications, manuals, and documentation.

Artisan Scientific Corporation dba Artisan Technology Group is not an affiliate, representative, or authorized distributor for any manufacturer listed herein.

We're here to make your life easier. How can we help you today?

(217) 352-9330 | sales@artisantg.com | artisantg.com

ARTISAN® TECHNOLOGY GROUP