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**PLEASE CHECK FOR CHANGE INFORMATION AT THE REAR OF THIS MANUAL.**

# 390AD
# PROGRAMMABLE DIGITIZER
## OPERATORS MANUAL

INSTRUCTION MANUAL

**Tektronix, Inc.**
**P.O. Box 500**
**Beaverton, Oregon 97077**

070-4450-00
Product Group 45

Serial Number ____________

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## INSTRUMENT SERIAL NUMBERS

Each instrument has a serial number on a panel insert, tag, or stamped on the chassis. The first number or letter designates the country of manufacture. The last five digits of the serial number are assigned sequentially and are unique to each instrument. Those manufactured in the United States have six unique digits. The country of manufacture is identified as follows:

| | |
|---|---|
| B000000 | Tektronix, Inc., Beaverton, Oregon, USA |
| 100000 | Tektronix Guernsey, Ltd., Channel Islands |
| 200000 | Tektronix United Kingdom, Ltd., London |
| 300000 | Sony/Tektronix, Japan |
| 700000 | Tektronix Holland, NV, Heerenveen,<br>The Netherlands |

# INSTRUCTIONS FOR COMPLETING THE SOFTWARE/FIRMWARE PERFORMANCE REPORT

I. Please type or print clearly. Use a separate Software/Firmware Performance Report (SFPR) for each problem.

II. SECTION 🅐
Fill in the serial number of the 390AD PROGRAMMABLE DIGITIZER.

III. SECTION 🅑
Use your complete company mailing address. Please include the name and phone number of the person reporting the error. Also, be sure to fill in the name of the person submitting the SFPR.

IV. SECTION 🅒
Check the reason for report and whether the error is reproducible. We cannot properly evaluate the problem if we have difficulty in reproducing the error.

V. SECTION 🅓
Give a complete description of the system configuration on which the problem occurred. Please include related peripherals, interfaces, options, and operating system.

VI. SECTION 🅔
Describe the problem completely. Include any information which might help in evaluating the error with the SFPR. If you have determined a procedure to avoid the error condition, please include this procedure. If this problem prevents you from accomplishing any useful work with the product, please state this fact. Be sure to include with the SFPR any information (programs, listings, hard copies, etc.) which will help us duplicate your problem.

VII. SECTION 🅕
This section is for use by Tektronix Lab Scopes Software Maintenance personnel. DO NOT WRITE IN THIS SPACE.

VIII. Mail **all** copies of the Software/Firmware Performance Report to:

TEKTRONIX, INC.
LAB SCOPES SOFTWARE MAINTENANCE
P.O. BOX 500 DEL. STA. 39-285
BEAVERTON, OREGON 97077

SEND TO:
TEKTRONIX, INC.
LAB SCOPES SOFTWARE MAINTENANCE
P.O. BOX 500 DEL. STA. 39-285
BEAVERTON, OREGON 97077

# 390AD PROGRAMMABLE DIGITIZER SOFTWARE/FIRMWARE PERFORMANCE REPORT

Ⓐ

**390AD Programmable Digitizer Serial #** ____________

**390AD ID Query Output Line (See Operators Manual for detail about ID Query)** ____________

Ⓑ

COMPANY NAME: ____________
USER: ____________
ADDRESS: ____________
CITY: ____________ STATE: ____________ ZIP: ____________
PHONE: ____________ EXTENSION: ____________

FORM SUBMITTED BY: ____________ DATE: ____________

Ⓒ

REASON FOR REPORT:
☐ Software/Firmware Error
☐ Documentation Error
☐ Suggested Enhancement

IS THE ERROR REPRODUCIBLE?
☐ Yes ☐ No
☐ Intermittent

Ⓓ

SYSTEM DESCRIPTION: (Hardware, software, firmware and host related to the problem)

Ⓔ

DESCRIPTION OF PROBLEM:

LIST ENCLOSURES:

INTERNAL USE ONLY
**(DO NOT WRITE BELOW THIS LINE)**

Ⓕ

ACTION TAKEN:

RESPONDER: DATE OF RESPONSE:

DATE RECEIVED ____________
SFPR # ____________

SFPR LOG

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# OPERATORS SAFETY SUMMARY

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

## TERMS

### IN THIS MANUAL

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

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

### AS MARKED ON EQUIPMENT

CAUTION indicates a personal injury hazard not immediately accessible as one reads the marking, or a hazard to property including the equipment itself.

DANGER indicates a personal injury hazard immediately accessible as one reads the marking.

## SYMBOLS

### IN THIS MANUAL

| | |
|---|---|
| ⊘ | Static Sensitive Devices. |
| ⚠ | This symbol indicates where applicable cautionary or other information is to be found. |

### AS MARKED ON EQUIPMENT

| | |
|---|---|
| ⚡ | DANGER—High voltage. |
| ⏚ | Protective ground (earth) terminal. |
| ⚠ | ATTENTION—refer to manual. |

## WARNINGS

### POWER SOURCE

This product is intended to operate from a power source that will not apply more than 250 volts rms between the supply conductors or between either supply conductor and ground. A protective ground connection by way of the grounding conductor in the power cord is essential for safe operation.

### USE THE PROPER POWER CORD

Use only the power cord and connector specified for your product. Use only a power cord that is in good condition.

For detailed information on power cords, refer to Section 1 General Information.

Refer cord and connector changes to qualified service personnel.

### GROUNDING THE PRODUCT

This product is grounded through the grounding conductor of the power cord. To avoid electrical shock, plug the power cord into a properly wired receptacle before connecting to the product input or output terminals. A protective ground connection by way of the grounding conductor in the power cord is essential for safe operation.

### DANGER ARISING FROM LOSS OF GROUND

Upon loss of the protective-ground connection, all accessible conductive parts (including knobs and controls that may appear to be insulating), can render an electric shock.

### USE THE PROPER FUSE

To avoid fire hazard, use only the fuse specified in the parts list for your product, and which is identical in type, voltage rating, and current rating.

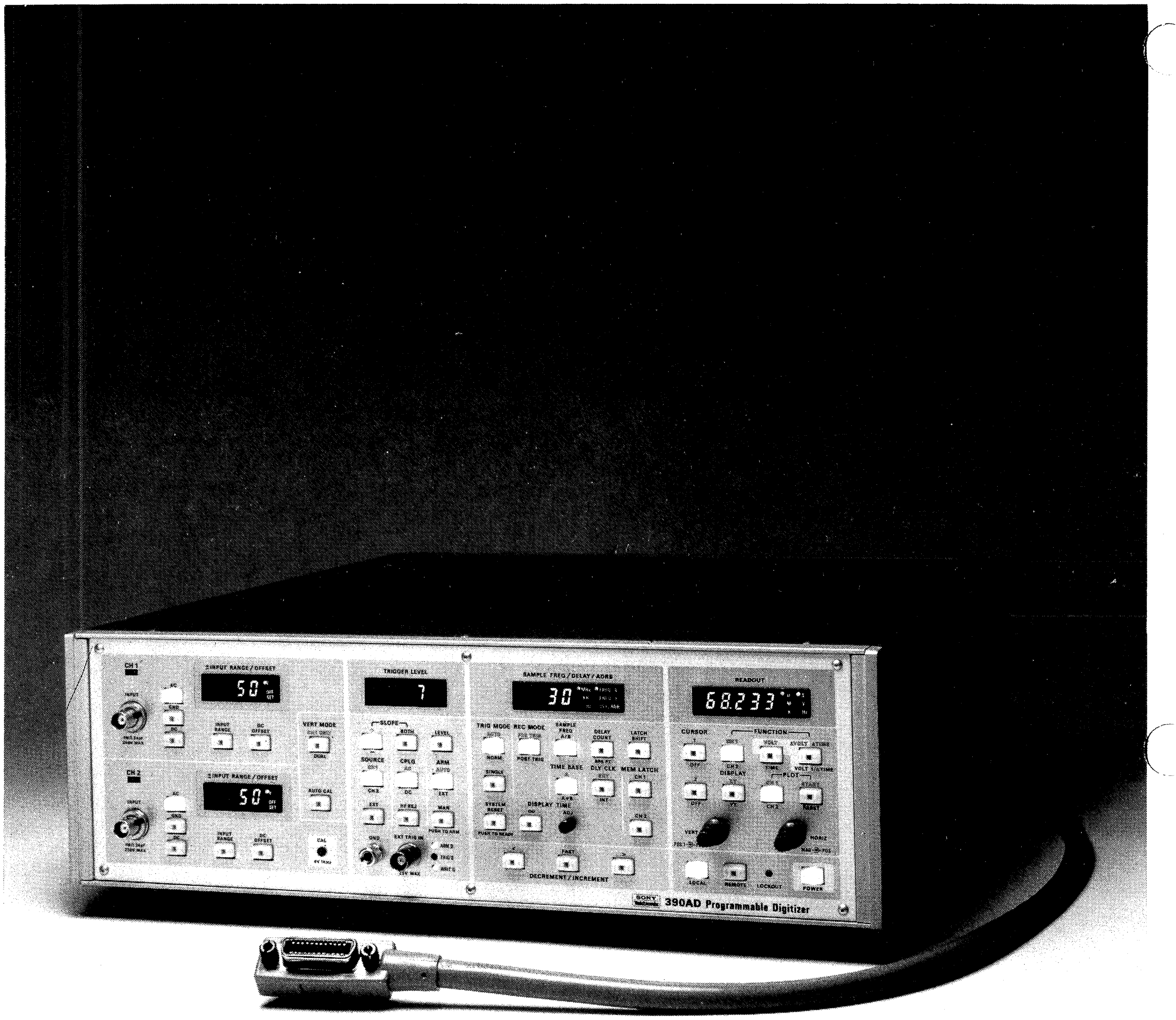
Refer fuse replacement to qualified service personnel.

## DO NOT OPERATE IN EXPLOSIVE ATMOSPHERES

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

## DO NOT REMOVE COVERS OR PANELS

To avoid personal injury, do not remove the product covers or panels. Do not operate the product without the covers and panels properly installed.



4450-1

390AD Programmable Digitizer

# GENERAL INFORMATION

This section contains a basic content description of both the Operators and Service Manuals, a description of the 390AD information on instrument installation, packaging for shipment, and specifications. The Specification portion consists of three tables: Electrical, Environmental, and Physical Characteristics.

This section also contains a Standard Accessories list and a full-page instrument dimensional drawing.

## OPERATORS MANUAL

The Operators Manual has the following four sections:

Section 1—General Information contains instrument description, electrical specifications, environmental characteristics, standard and recommended accessories, installation information, and packaging for shipment instructions.

Section 2—Operating Instructions contains information about operating and checking the instrument operation.

Section 3—Programming contains details of programming the 390AD.

Section 4—Instrument Options contains a description of available options and gives the location of the incorporated information about those options.

## SERVICE MANUAL

**WARNING**

*THE SERVICE MANUAL CONTAINS INSTRUCTIONS FOR USE BY QUALIFIED SERVICE PERSONNEL ONLY. TO AVOID PERSONAL INJURY, DO NOT PERFORM ANY SERVICING UNLESS YOU ARE QUALIFIED TO DO SO.*

The Service Manual which is available separately by ordering Tektronix Part 070-4452-00, has the following nine sections:

Section 1—General Information contains instrument description, electrical specifications, environmental characteristics, standard and recommended accessories, installation, and packaging for shipment instructions.

Section 2—Operating Information contains information about front- and rear-panel controls, connectors, and indicators, internal switches and selectors, and other information relative to operating and checking instrument operation.

Section 3—Theory of Operation contains general and specific circuit analysis that may be useful for servicing or operating the instrument.

Section 4—Maintenance describes routine and corrective maintenance procedures with detailed instructions for replacing assemblies, subassemblies, and individual parts.

Section 5—Checks and Adjustment contains procedures to check the performance and electrical characteristics of the instrument. Procedures also include methods for adjusting the instrument to meet specifications.

Section 6—Instrument Options contains a description of available options and tells where to find information about those options.

Section 7—Replaceable Electrical Parts contains information necessary to order replaceable parts and assemblies.

Section 8—Diagrams and Circuit Board Illustrations includes detailed circuit schematics, locations of assembled boards within the instrument, voltage and waveform information, circuit board component locators, and locations of adjustments to aid in performing the Adjustment and Performance Check part of the Calibration procedure.

Section 9—Replaceable Mechanical Parts includes information necessary to order replaceable mechanical parts and shows exploded views which identify assemblies.

# DESCRIPTION

The 390AD is a high-performance, fully-programmable waveform digitizer with two-channel input, 10-bit voltage resolution, maximum sampling rate of 60 MHz, and bandwidth of dc to 15 MHz.

It can record a high speed, single shot event simultaneously in two channels and give a Y-T or X-Y waveform display on a monitor or other instrument connected to the analog output. If a strip chart recorder or an analog plotter is connected, the waveform can be recorded on a chart. The 390AD is equipped with a GPIB connector (IEEE 488-1978) for waveform processing and automatic measurement using an external controller. Provisions are made to form a triggered daisy chain with additional units of 390AD.

The voltage or time at any point(s) on the stored waveform can be measured by means of cursors and front-panel readout. A trigger point can be set at any desired position, and the pre-trigger function allows recording of events that precede the trigger. The sampling rate can be switched during waveform acquisition. For example, this feature allows the user to obtain precision data through the full use of the internal waveform memory by sampling at a slow rate in the absence of event, and at a higher rate when an event occurs. The roll mode feature makes it possible to observe signals of lower frequency or slower changing events, continuously, as with a strip chart recorder.

The 390AD includes circuits to automatically calibrate the gain and dc drift, which ensures high stability, excellent dynamic accuracy, effective bits, transient response, differential gain and differential phase.

# SPECIFICATIONS

These specifications apply to an ambient temperature from 0°C to +40°C. The instrument requires a warmup of 20 minutes or longer.

**Table 1-1**
**ELECTRICAL CHARACTERISTICS**

| Characteristic | Performance Requirement | Supplemental Information |
|---|---|---|
| **VERTICAL SYSTEM (Channel 1 has the same characteristics as Channel 2)** | | |
| Sensitivity (input range) | ±100 mV to ±50 V full scale (200 mV p-p to 100 V p-p) | 1-2-5 sequence, 9 steps |
| Input RC | 1 MΩ ±2% paralleled by approximately 24 pF | |
| Maximum Input Voltage | | |
| DC coupling | 250 V (dc + peak ac) | |
| AC coupling | 500 V (dc + peak ac) | |
| Bandwidth | Dc to 15 MHz, lower limit for ac coupling: 10 Hz | −3 dB point |
| Input dc Offset Voltage | 0 to ±99% of input range | Selectable in 1% steps, accuracy: within 0.5% |
| Automatic Calibration | | |
| Gain Accuracy | ±0.4% | |
| DC Drift Accuracy | Within ±0.1% | |

Table 1-1 (cont)

| Characteristic | Performance Requirement | Supplemental Information |
|---|---|---|
| **A/D CONVERTER** | | |
| Resolution | 10 bits (1/1024) | |
| Maximum Sampling Frequency | | |
| CH 1 ONLY | 60 MHz | |
| DUAL | 30 MHz | |
| Aperture Jitter | | Nominally 150 ps including clock jitter |
| Dynamic Accuracy | | Including vertical accuracy, at temperature +25°C ±5°C |
| Sampling Frequency | | |
| Up to 30 MHz excepting external CH 1 ONLY | 1 MHz: effective bits[a] 8.5 or more,<br>10 MHz: effective bits 7.5 or more | |
| Internal 60 MHz and external CH 1 ONLY | 1 MHz: effective bits 8.0 or more,<br>10 MHz: effective bits 6.5 or more | |
| **TIME BASE** | | |
| Sampling Frequency | | |
| Internal | | |
| CH 1 ONLY | 5 Hz to 60 MHz | 23 steps, in a 1-2-5 sequence, except for 60 MHz and 30 MHz |
| DUAL | 5 Hz to 30 MHz | 22 steps, in a 1-2-5 sequence, except for 30 MHz |
| External | | |
| CH 1 ONLY | DC to 60 MHz | Minimum clock pulse width 7 ns |
| DUAL | DC to 30 MHz | Minimum clock pulse width 14 ns |
| Internal Clock | 60 MHz ± 10 ppm | Quartz oscillator |
| Waveform Memory Length | | |
| CH 1 ONLY | 4096 words | |
| DUAL | 2048 words/channel | |
| Waveform Memory Time Length | 2047 (or 4095) × (1/sample frequency) | |
| Memory Latch | | Rewriting data into either channel is prohibited. The waveform can be shifted horizontally |

---

**[a] For a discussion of effective bits see "Definition of Effective Bits," which follows Table 1-1.**

Table 1-1 (cont)

<table>
<tr><th>Characteristic</th><th colspan="3">Performance Requirement</th><th>Supplemental Information</th></tr>
<tr><td colspan="5"><b>TRIGGER AND ARM</b></td></tr>
<tr><td>Trigger Source</td><td colspan="3"></td><td>Channel 1, Channel 2, External</td></tr>
<tr><td>Coupling</td><td colspan="3"></td><td>AC, DC, HF REJ</td></tr>
<tr><td>Slope</td><td colspan="3"></td><td>+, − or BOTH (bi-slope)</td></tr>
<tr><td>Level Range</td><td colspan="3"></td><td></td></tr>
<tr><td>Internal</td><td colspan="3">0 to 99% of input range</td><td>Selectable in 1% steps</td></tr>
<tr><td>External</td><td colspan="3">0 to ±4.95 V</td><td>Selectable in 0.05 V steps (1% for 5 V)</td></tr>
<tr><td>External Trigger</td><td colspan="3"></td><td></td></tr>
<tr><td>Maximum Input Voltage</td><td colspan="3">25 V (dc + peak ac)</td><td></td></tr>
<tr><td>Input RC</td><td colspan="3">1 MΩ, paralleled by approximately 40 pF</td><td></td></tr>
<tr><td rowspan="2">Trigger Sensitivity</td><td rowspan="2"><b>Frequency Range</b></td><td colspan="2"><b>Sensitivity</b></td><td rowspan="2"></td></tr>
<tr><td>Internal</td><td>External</td></tr>
<tr><td>DC</td><td>dc to 15 MHz</td><td></td><td></td><td></td></tr>
<tr><td>AC</td><td>25 Hz to 15 MHz</td><td>30 LSB</td><td>300 mV p-p</td><td></td></tr>
<tr><td>HF REJ</td><td>25 Hz to 50 kHz</td><td></td><td></td><td></td></tr>
<tr><td>Trigger Point</td><td colspan="3"></td><td>Intensity-modulated spot on the waveform</td></tr>
<tr><td>Arm</td><td colspan="3"></td><td>Automatic, manual, external</td></tr>
<tr><td colspan="5"><b>RECORDING SYSTEM</b></td></tr>
<tr><td>Trigger Mode</td><td colspan="3"></td><td></td></tr>
<tr><td>Auto</td><td colspan="3"></td><td>Waveform digitized and displayed without trigger input [b]</td></tr>
<tr><td>Normal</td><td colspan="3"></td><td>Waveform digitized and displayed with trigger input [b]</td></tr>
<tr><td>Single</td><td colspan="3"></td><td>Waveform digitized and displayed by first trigger after pressing RESET button</td></tr>
</table>

[b] **In Auto and Normal, the operation is repeated automatically after display time set previously.**

Table 1-1 (cont)

| Characteristic | Performance Requirement | Supplemental Information |
|---|---|---|
| **RECORDING SYSTEM (cont)** | | |
| Record Mode | | |
| Pre-trigger | | |
| Pre-trigger Range<br>CH 1 ONLY<br>DUAL | 0 to 4092<br>0 to 2046 | In the case of using the internal delay clock, the pre-trigger range is indicated as delay count value. |
| Post Trigger | | |
| Time Base A<br>Delay Count Range | 0 to 9998 | Digitizing starts after delay count set previously. |
| Time Base A+B | | |
| Break Point Range<br>CH 1 ONLY<br>DUAL | 0 to 4092<br>0 to 2046 | Digitizing starts with trigger input, and sample frequency is switched after delay count set previously. |
| Time Base A | | Used for both pre- and post-trigger modes, and waveform taken at a fixed rate. |
| Time Base A + B | | Used for both pre- and post-trigger modes. Sample frequency switched in the course of digitizing waveform. Break point indicated by bright intensity modulation on waveform. In the pre-trigger mode, sample frequency changeable after passing over the pre-trigger area. In the post-trigger mode, sample frequency switched after delay count. Waveform acquisition finished with 2048 (or 4096) samples. |
| **DIGITAL READOUT** | | |
| ΔVOLT | | Voltage difference between two time points on a single channel, or two channels at one and the same time point. Latch shift allows aligning non time-synchronous points. |
| VOLT | | Voltage from ground on each channel. |
| ΔTIME | | Time difference between two points on a single channel. |
| 1/ΔTIME | | Reciprocal of ΔTIME as a means of measuring frequency. |

Table 1-1 (cont)

| Characteristic | Performance Requirement | Supplemental Information |
|---|---|---|
| **INPUT/OUTPUT** | | |
| Display Monitor Outputs | | |
| X | Ramp voltage 1 V p-p output, accuracy: ±5%, duration: CH 1 ONLY 16 ms, DUAL 8 ms/channel | BNC connector on the rear panel. Can be changed to 5 V p-p with internal jumper. |
| Y | 1 V p-p, accuracy: ±5% | BNC connector on the rear panel. Selectable to 5 V p-p by internal jumper. |
| Z | 1 V or 5 V | BNC connector on rear panel. Either 1 V or 5 V can be selected with internal jumped. Polarity changeable. |
| Plot Output | | |
| X, Y | 0 to 5 V, accuracy: ±0.5%, dc offset: ±2% | BNC connector on the rear panel. Plotting rate: 20, 50, and 100 ms/word, auto slow or auto fast selectable with internal jumper. |
| Pen UP/DOWN Output | TTL level | |
| XY Phase Difference | For identical input ranges, 10 MHz: 5° or less, for different input ranges, 2 MHz: 5° or less | Including phase difference in input amplifiers. |
| Calibration Output | Squarewave: 1 kHz, ±10 PPM, 4 V, ±1% | For probe |
| Other Inputs/Outputs | | |
| External Arm Input | TTL level | Positive transition, maximum input voltage, +5.5 V, −0 V |
| External Delay Clock Input | TTL level, maximum 60 MHz, 23 kΩ, 10 pF or less | Maximum input voltage ±10 V |
| External Clock Input | TTL level, maximum 60 MHz, 23 kΩ, 10 pF or less | Delay time: approximately 20 ns<br>Maximum input voltge ±10 V |
| Internal Clock Output | TTL level, maximum 60 MHz, 50 Ω drive possible | Delay time: approximately 10 ns |
| Write End Output | TTL level, 50 Ω drive possible | Positive-going pulse. Connect to External Arm input of another instrument to form a triggered daisy chain. |

Table 1-1 (cont)

| Characteristic | Performance Requirement | Supplemental Information |
|---|---|---|
| **GPIB INTERFACE** | | |
| Interface Function (IEEE 488-1978) | SH1: source handshake function<br>AH1: acceptor handshake funtion<br>T6: talker function<br>L4: listener function<br>SR1: service request full function<br>RL1: remote/local full function<br>PP0: parallel pole function-absent<br>DC1: device clear full function<br>C0: control function-absent<br>DT1: device trigger function | |
| Interface Control Messages | | GTL, LLO, GET, SDC-DCL, SPE-SPD, IFC |
| Programmable Functions | | All settings except for the control of power supply, vertical and horizontal positions, expansion, and display time are programmable. |
| Format | Tektronix standards for Codes and Format V79.1 | Command: ASCII, waveform data transferred through 1 point 2 byte binary/1 point, with upper bytes first |
| **POWER REQUIREMENTS** | | |
| Line Voltage Range | | |
| 115 V | 90 V to 132 V ac | |
| 230 V | 180 V to 250 V ac | |
| Line Frequency | 48 to 440 Hz | |
| Maximum Power Consumption | 200 W | |

## Definition of Effective Bits

In the 390AD, the accuracy of the vertical system (digitizing accuracy) for digitizing high-frequency signals is represented by effective bits. Because the accuracy of high-frequency digitizing cannot be adequately defined by the parameters used in low-frequency digitizing, signal-to-noise ratio (SN) is used as a basis for defining the 390AD HF digitizing accuracy. If the difference between the input signal and the output signal is regarded as noise, the waveform data of the digitizer includes not only the quantizing noise caused inevitably by the A/D conversion, but also noise occurring in all of the analog-signal circuit, non-linearity, aperture jitter, and all other errors. It is possible, therefore, to determine the vertical SN ratio of the 390AD, and express the accuracy definitely by checking the noise components in the waveform data.

The noise occurring in the ideal A/D converter involves theoretical quantizing noise only, which is given, for digitizing a full-scale sinusoidal wave with an N-bit A/D converter, as

$$SN = 6.02N + 1.8 \text{ (dB)}$$

The following table shows the relationship between the number of ideal bits and the SN ratio. The accuracy of an actual digitizer can be defined by using the SN ratio. For instance, if the SN ratio of a 10-bit digitizer for 10 MHz input signal is measured to be 56 dB, which corresponds to a 9-bit ideal A/D converter, the accuracy of this digitizer (as defined by the number of effective bits) is therefore 9 bits.

### TABLE 1-1A

### SIGNAL-TO-NOISE RATIO OF AN IDEAL A/D CONVERTER

| Number of Bits | S/N Ratio |
|---|---|
| 10 | 62 dB |
| 9 | 56 dB |
| 8 | 50 dB |
| 7 | 44 dB |
| 6 | 38 dB |
| 5 | 32 dB |

## Measurement of Effective Bits

Like other expressions of accuracy, the number of effective bits is defined by the difference between input and output. Because it is difficult to evaluate the instantaneous value of an input signal accurately, the input signal is simulated by the computer. The case of using pure sinusoidal waves as input signal is described below.

The input signal is denoted by X(t)

$$X(t) = A \sin (2\pi ft + \theta) + B$$

where A = amplitude, f = frequency, $\theta$ = phase angle, and B = dc level.

The digitized waveform data is denoted by $X_D(n\Delta t)$ with $\Delta t$ representing the sampling interval.

If the waveform data $X_D(n\Delta t)$ is fed into the computer and subjected to the non-linear regression analysis for sinusoidal function, the result $X_F(t)$ is given by

$$X_F(t) = \hat{A} \sin (2\pi \hat{f}t + \hat{\theta}) + \hat{C}.$$

This may be regarded as the input signal.

The result of sampling $X_F(t)$ in the computer is denoted by $X_F(n\Delta t)$. Now, the error signal $r(n\Delta t)$ can be determined as the difference between the output data of the digitizer and the output data of an ideal A/D converter as simulated by the computer.

$$r(n\Delta t) = X_D(n\Delta t) - X_F(n\Delta t)$$

where $X_D(n\Delta t)$ is ideal data and $X_F(n\Delta t)$ is actual data.

If $X_F(t)$ is quantized in the computer by the ideal A/D converter, the result denoted by $X_{FD}(n\Delta t)$ and the difference between the latter and $X_F(n\Delta t)$ gives the quantizing error of the ideal A/D converter.

$$R(n\Delta t) = X_{FD}(n\Delta t) - X_F(n\Delta t)$$

The number of effective bits (Ne) is obtained by subtracting the theoretical quantizing noise from the digitizer error $r(n\Delta t)$

$$Ne = N - \log_2 | RMS(r) / RMS(R) |$$

where N: resolution of the digitizer,

RMS(r): root-mean-square-value for $r(n\Delta t)$

RMS(R): root-mean-square-value for $R(n\Delta t)$

## Table 1-2
## ENVIRONMENTAL CHARACTERISTICS

| Characteristic | Description |
|---|---|
| Temperature | |
| Operating | 0°C to +40°C |
| Non-Operating | −25°C to +70°C |
| Altitude | |
| Operating | 4,570 m |
| Non-Operating | 15,200 m |
| Humidity | 95% or lower |
| Electromagnetic Interference (EMI) | MIL-STD-461B, CE01, CE03, CS02, RE04, RS01, RS03 (Frequency up to 1 GHz) |

## Table 1-3
## PHYSICAL CHARACTERISTICS

| Characteristic | Description |
|---|---|
| Dimensions | 152 (H) × 446 (W) × 540 (D) mm |
| Weight | 15.5 kg |

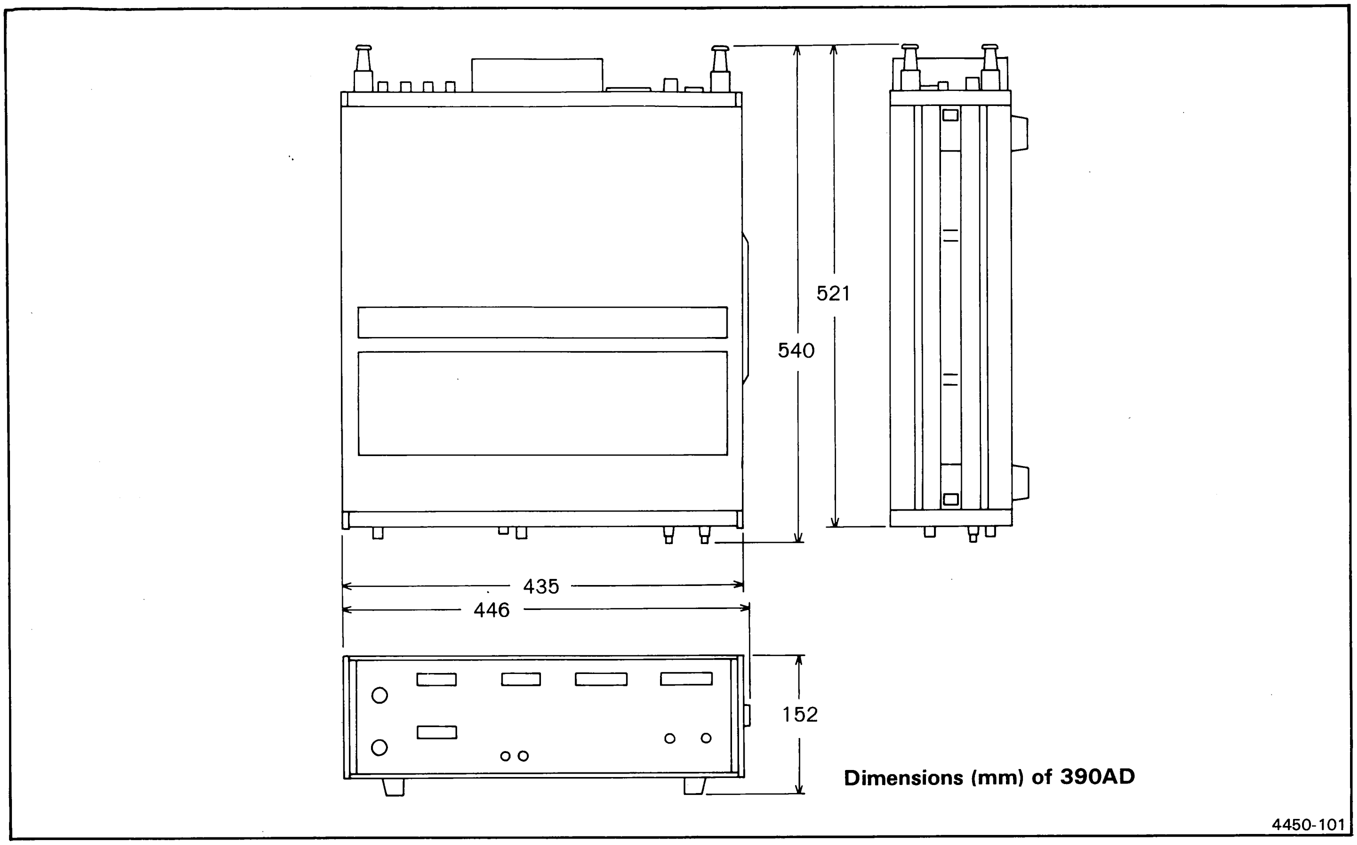

521
540
435
446
152
Dimensions (mm) of 390AD
4450-101

Figure 1-1. Dimensions (mm) of 390AD.

# STANDARD ACCESSORIES

| | |
|---|---|
| 1 each | Operators Manual |
| 1 each | Programming Guide |
| 1 each | GPIB Cable |
| 1 each | Power Cord |
| 2 each | Fuse, 250 V, 4 A |

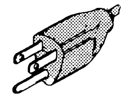
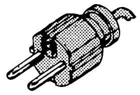
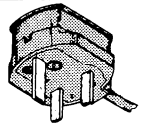
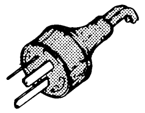
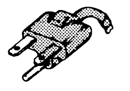
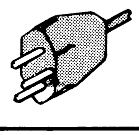
# INSTALLATION

This part concerns the selection of line voltage, connection of other instruments, and setting of internal straps, required before putting the 390AD in operation. WARNING and CAUTION notes that include important information with regard to the protection of the instrument and the safety of operator should be read with particular care.

## CONNECTING AC POWER

The 390AD is to be operated on a single-phase power line, one wire of which is grounded. Because one power line wire is fused to protect from overcurrent, the instrument cannot be operated with live power of which all wires float with respect to ground (such as a three-phase ac power outlet).

The 390AD is furnished with a three-wire power cord, with an earth conductor to ground the equipment body and a three-contact plug. The metallic parts of the instrument are connected to the ground terminal of the power plug via the earth line of the three-line power cord. When the power plug is inserted in a grounded power outlet, the 390AD is grounded. If the earth line is not grounded, the unit is floated to give a potential difference with respect to other instruments. Instruments connected together through signal lines should use grounded power outlets. Figure 1-2 shows the variety of available power cords.

| Plug Configuration | Usage | Nominal Line-Voltage (AC) | Reference Standards | Option # |
|---|---|---|---|---|
|  | North American<br>120V/15A | 120 V | [1]ANSI C73.11<br>[2]NEMA 5-15-P<br>[3]IEC 83 | STANDARD |
|  | Universal Euro<br>240V/10-16A | 240 V | [4]CEE (7), II, IV, VII<br>[3]IEC 83 | A1 |
|  | UK<br>240V13A | 240 V | [5]BS 1363<br>[3]IEC 83 | A2 |
|  | Australian<br>240V/10A | 240 V | [6]AS C112 | A3 |
|  | North American<br>240V/15A | 240 V | [1]ANSI C73.20<br>[2]NEMA 6-15-P<br>[3]IEC 83 | A4 |
|  | Switzerland<br>220V/ 6A | 220 V | [7]SEV | A5 |

[1] ANSI—American National Standards Institute
[2] NEMA—National Electrical Manufacturer's Association
[3] IEC—International Electrotechnical Commission
[4] CEE—International Commission on Rules for the Approval of Electrical Equipment
[5] BS—British Standards Institute
[6] AS—Standards Association of Australia
[7] SEV—Schweizevischer Elektrotechischer Verein

4450-104

Figure 1-2. Power cord and plug identification information.

## CHECKING LINE VOLTAGE

The 390AD will operate on two ranges of input voltage: 115 V and 230 V, 48 to 440 Hz. The former covers 90 to 132 V, and the latter 180 to 250 V. When the instrument is shipped, the voltage selector is set to 115 V. Before connecting the power cord to the power outlet, check the voltage at the outlet to make sure that voltage falls within the voltage range shown by the voltage indicator at the rear panel. Figure 1-3 shows the location of the voltage indicator. If the setting of the line voltage selector does not match the available line voltage, refer the 390AD to qualified service personnel.

**CAUTION**

*Make sure that the reading of the line voltage indicator at the rear of the 390AD matches the line voltage. If the instrument is connected to the 230 V power line while the selector is set to 115 V, not only will the fuse blow, but the instrument may be damaged.*

**Table 1-4**
**AC VOLTAGE RANGES AND FUSE**

| Line Voltage Selector | Voltage Range | Line Fuse |
|---|---|---|
| 115 V, nom. | 90 to 132 V ac | 250 V - 4 A |
| 230 V, nom. | 180 to 250 V ac | |

## CONNECTING OTHER EQUIPMENT

The 390AD may be operated in combination with display monitors, X-Y analog plotters, GPIB controllers, and so on. The connection of these instruments is shown in Figure 1-4.

## HOW TO SET A DISPLAY MONITOR

When a display monitor is used in combination with the 390AD, the internal selection straps of the 390AD and the five position and input sensitivity controls of the display monitor should be set to display the correct waveform. Use the following procedure to make these settings.

### 1. Set the Internal Straps of the 390AD

Refer the 390AD to qualified service personnel.

### 2. Connect the Monitor

Connect the CRT-X, CRT-Y, and CRT-Z outputs on the rear panel of the 390AD to X, Y, and Z inputs of the monitor, respectively, through coaxial cables of 1 m length. If a longer cable is used, the displayed waveform may be deteriorated.

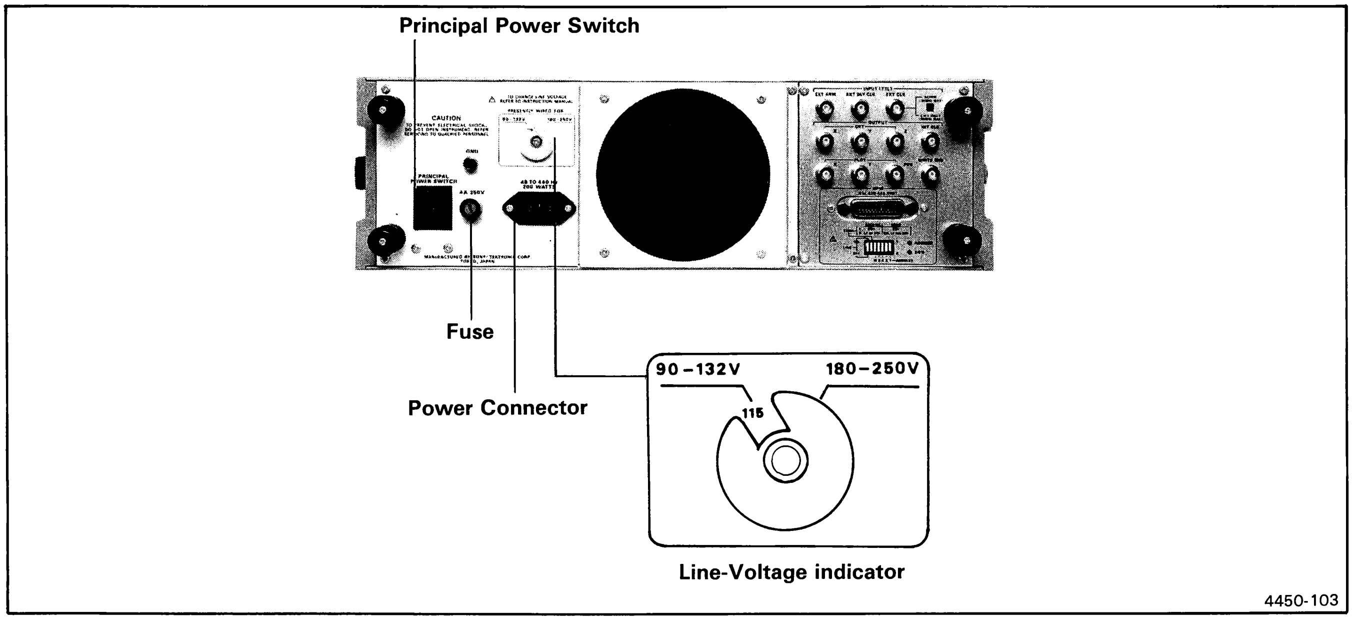


Figure 1-3. Location of line-voltage indicator.

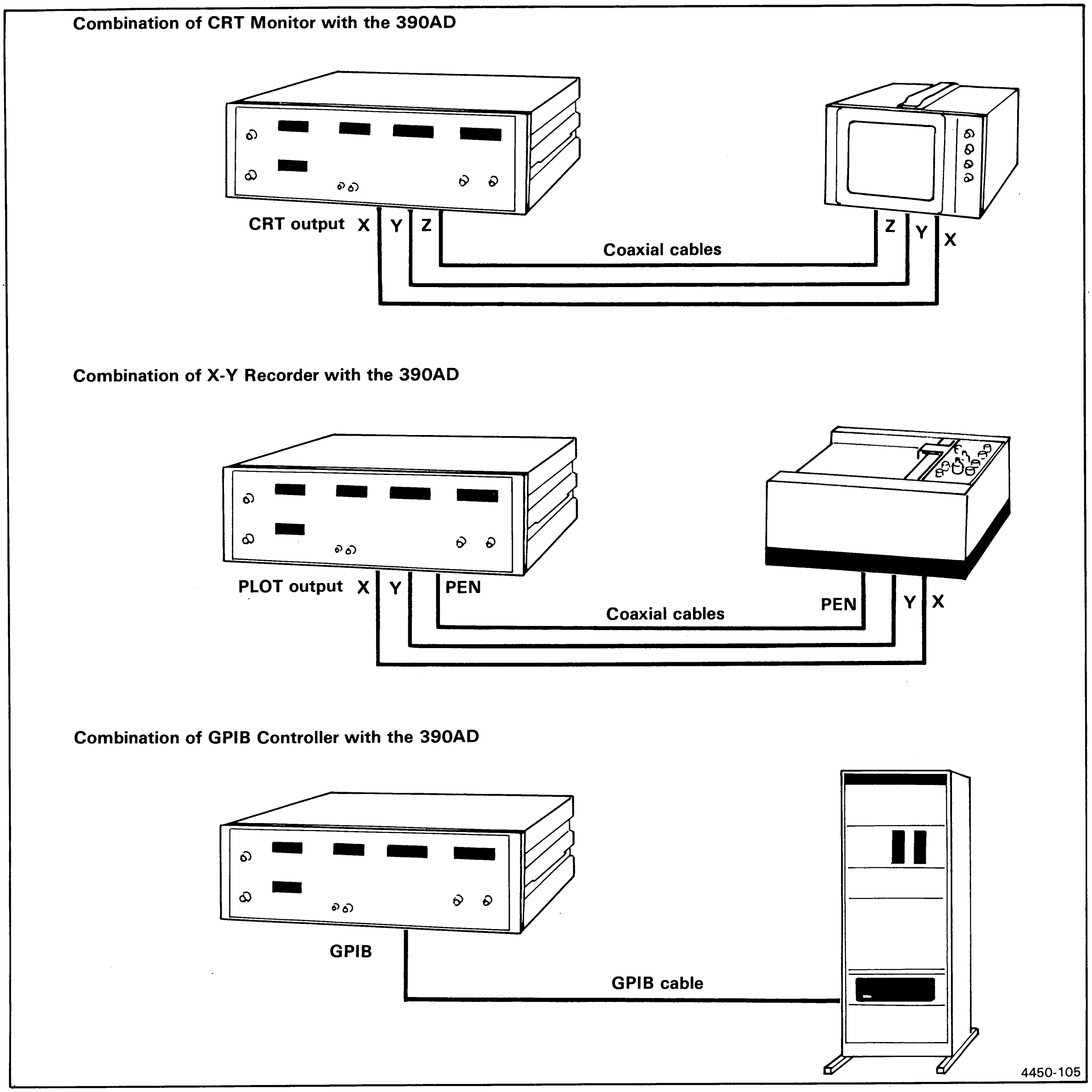

Combination of CRT Monitor with the 390AD
CRT output
X
Y
Z
Coaxial cables
Z
Y
X
Combination of X-Y Recorder with the 390AD
PLOT output
X
Y
PEN
Coaxial cables
PEN
Y
X
Combination of GPIB Controller with the 390AD
GPIB
GPIB cable
4450-105

Figure 1-4. Connecting other instruments to the 390AD.

### 3. Power ON

Set the PRINCIPAL POWER SWITCH (on the rear panel of the 390AD) to ON, and press the POWER switch on the front panel for one to two seconds to energize the instrument.

Turn on the monitor.

### 4. Setting Horizontal Gain and Position of Display Monitor

Display a sweep on the monitor by grounding the 390AD inputs. Set the 390AD HORIZ MAG to minimum (fully counterclockwise), adjust the monitor horizontal (or X) gain for a full-scale sweep. Mechanically center the 390AD HORIZ POS, set the monitor horizontal position control to center the sweep on the monitor.

## 5. Set the Vertical Gain and Position Controls of Display Monitor

Connect a 10 kHz 5 volt peak-to-peak sine wave signal to the Channel 1 input. Set the 390AD input range to 2 V. Adjust the monitor vertical (Y) GAIN control so that the clipped waveform reaches from the bottom to the top of the graticule. This sets the vertical display. See Figure 1-5A.

If Channel 1 and Channel 2 are to be used separately, adjust the monitor vertical (Y) GAIN control so that the clipped waveform occupies half of the graticule space. See Figure 1-5B. Verify that the 390AD vertical position controls and the monitor vertical position controls are at approximately mid-range.

With these settings, the size and position of the horizontal waveform can be set with the 390AD VERT POS and HORIZ POS and MAG controls.

## 6. Set the Intensity of Display Monitor

If the intensity is variable as in the case of the TEKTRONIX 624 Monitor, adjust the monitor as follows:

a. Display both CH 1 and CH 2 waveforms on the monitor.

b. Press the 390AD front panel VOLT FUNCTION button.

c. In this case, the intensity of the CH 2 waveform becomes slightly dimmer than that of CH 1. The Z Gain of the 624 Monitor is not externally adjustable. To set the Z Gain, refer the 624 to qualified service personnel.

In addition to displaying the acquired waveform, the monitor also displays the scales.

Figure 1-5A shows scale readings for the full-scale display of the waveform on the monitor screen with Gnd level set at the center of the vertical scale.

Figure 1-5B shows scale readings for a four-division display of two waveforms (CH 1 and CH 2) with Gnd levels set at the 2nd and 6th divisions of the vertical scale.

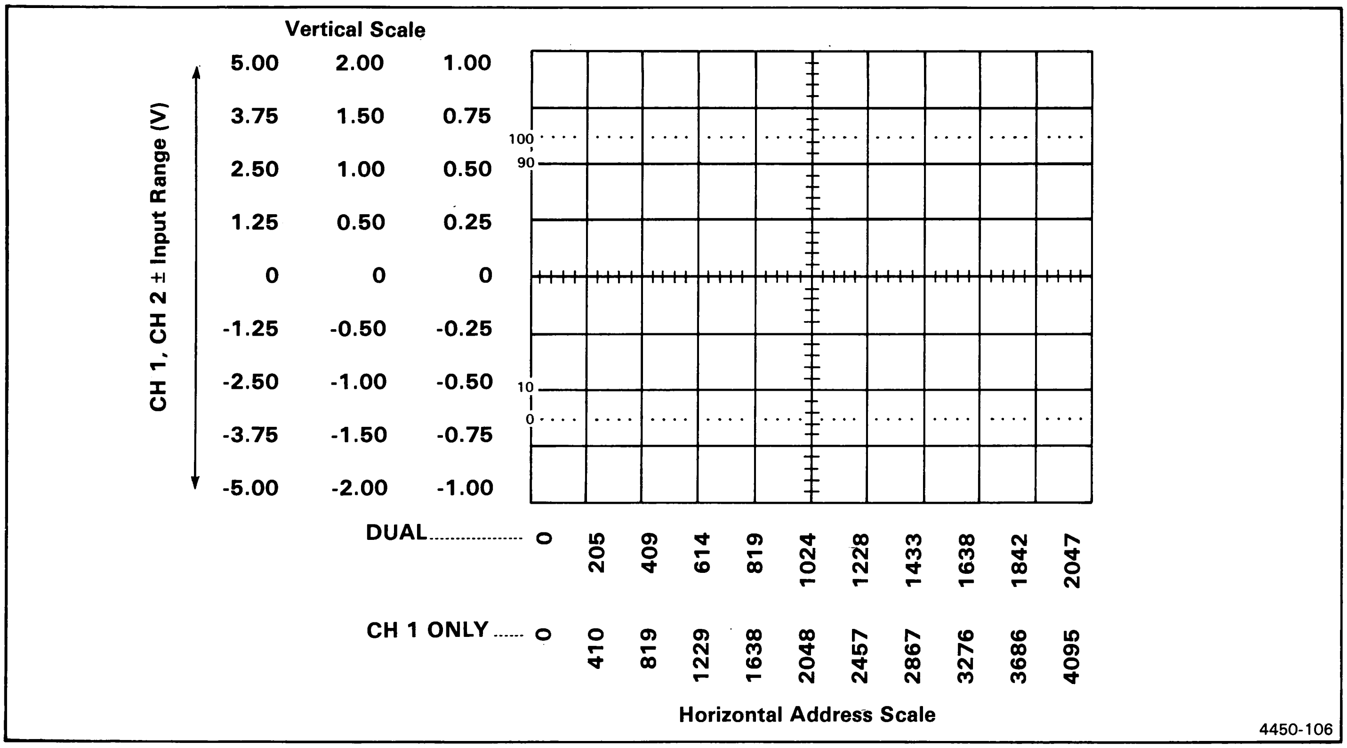

Vertical Scale
CH 1, CH 2 ± Input Range (V)
5.00 2.00 1.00
3.75 1.50 0.75
2.50 1.00 0.50
1.25 0.50 0.25
0 0 0
-1.25 -0.50 -0.25
-2.50 -1.00 -0.50
-3.75 -1.50 -0.75
-5.00 -2.00 -1.00
100
90
10
0
DUAL .................. 0 205 409 614 819 1024 1228 1433 1638 1842 2047
CH 1 ONLY ....... 0 410 819 1229 1638 2048 2457 2867 3276 3686 4095
Horizontal Address Scale
4450-106

Figure 1-5A. Scale readings on monitor with full-scale set for 8 divisions.

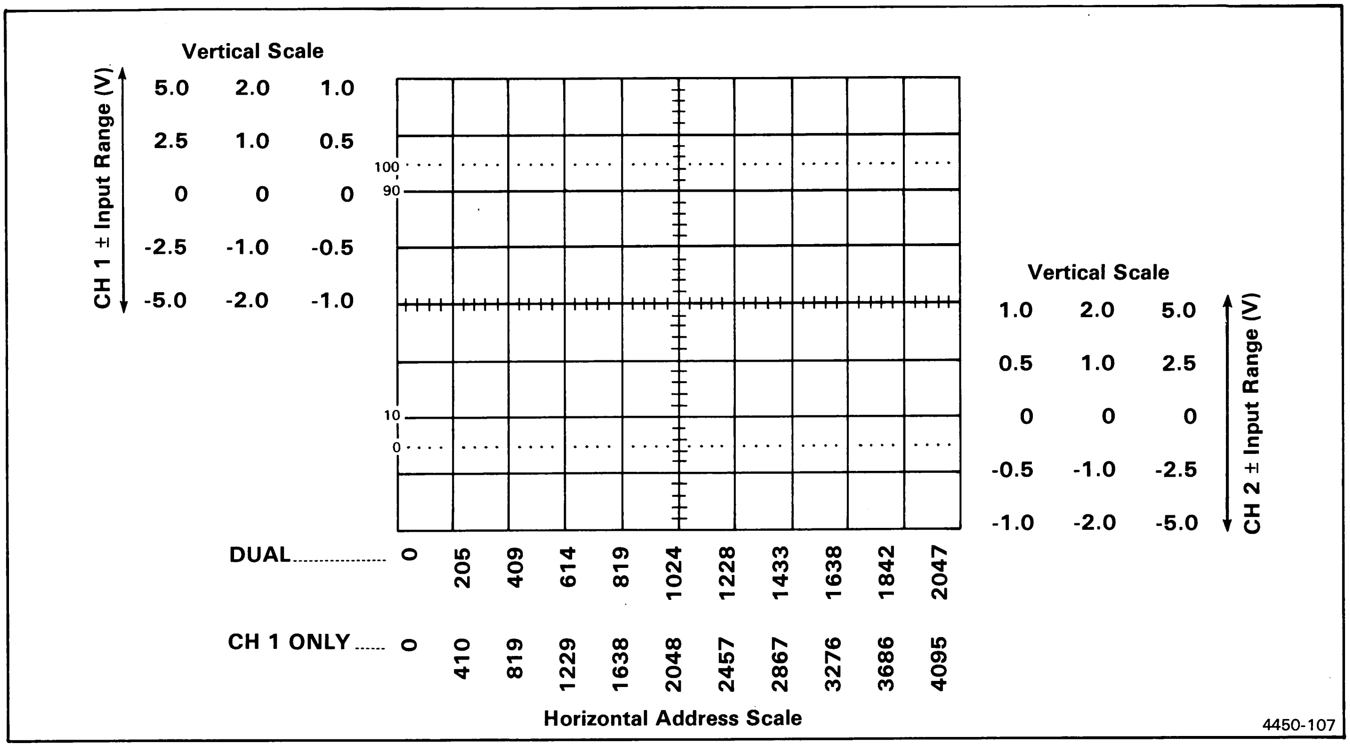

Vertical Scale
CH 1 ± Input Range (V)
5.0 2.0 1.0
2.5 1.0 0.5
0 0 0
-2.5 -1.0 -0.5
-5.0 -2.0 -1.0
100
90
10
0
Vertical Scale
CH 2 ± Input Range (V)
1.0 2.0 5.0
0.5 1.0 2.5
0 0 0
-0.5 -1.0 -2.5
-1.0 -2.0 -5.0
DUAL 0 205 409 614 819 1024 1228 1433 1638 1842 2047
CH 1 ONLY 0 410 819 1229 1638 2048 2457 2867 3276 3686 4095
Horizontal Address Scale
4450-107

Figure 1-5B. Scale readings on monitor with full-scale set for 4 divisions.

## PACKAGING FOR SHIPMENT

If this instrument is to be shipped for long distances by commercial transportation, we recommend that the instrument be packaged in the original manner. The carton and packaging material in which your instrument was shipped should be saved and used for this purpose.

Also, if this instrument is to be shipped to a Tektronix Service Center for service or repair, attach a tag to the instrument showing the following: Owner of the instrument (with address), the name of a person at your firm who can be contacted, complete instrument type and serial number, and a description of the service required.

If the original packaging is unfit for use or not available, package the instrument as follows:

1. Obtain a corrugated cardboard shipping carton having inside dimensions at least six inches greater than the instrument dimensions; refer to Table 1-5 for carton test strength requirements.

2. Enclose the instrument with polyethylene sheeting or equivalent to protect the finish of the instrument.

3. Cushion the instrument on all sides by tightly packing dunnage or urethane foam between the carton and the instrument, allowing three inches of packing on each side.

4. Seal the carton with shipping tape or with an industrial stapler.

5. Mark the address of the Tektronix Service Center and your return address on the carton in one or more prominent locations.

TABLE 1-5
Shipping Carton Test Strength

| Gross Weight (lb) | Carton Test Strength (lb) |
|---|---|
| 0-10 | 200 |
| 10-30 | 275 |
| 30-120 | 375 |
| 120-140 | 500 |

# OPERATING INSTRUCTIONS

## OPERATING TEMPERATURE

The 390AD can be operated where the ambient air temperature is between 0° and +40°C. The instrument can be stored in ambient temperature between −25° and +70°C. After storage at a temperature beyond the operating limits, allow the chassis temperature to stabilize within the operating limits before power is applied.

**WARNING**

*To avoid electric-shock hazard, see Installation in the General Information section of this manual before operating this instrument.*

A thermal switch in the power supply provides thermal protection. It turns off the instrument if the internal temperature exceeds a safe operating level, and automatically restores power when the temperature returns to a safe level.

## CONTROLS AND CONNECTORS

In order to use the 390AD to its full potential, it is important to be familiar with the function and purpose of the controls and connectors. A brief description is given below.

### FRONT PANEL

The controls and connectors on the front panel of the 390AD are grouped into five categories (see Fig. 2-1):

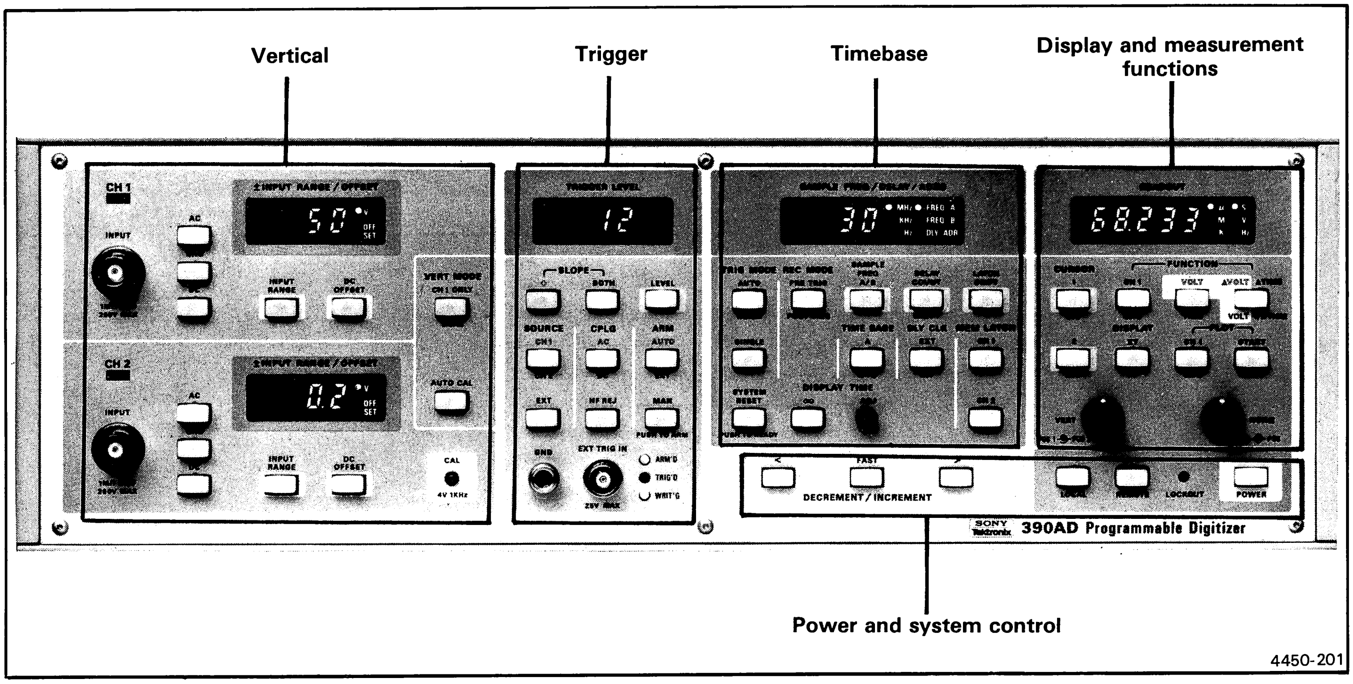

Vertical
Trigger
Timebase
Display and measurement functions
Power and system control
SONY Tektronix 390AD Programmable Digitizer
DECREMENT/INCREMENT
4450-201

Figure 2-1. The 390AD front panel.

1. Power and system control
2. Vertical
3. Trigger
4. Timebase
5. Display and measurement functions

## Power and System Control, Figure 2-2

① **POWER Button**
The POWER button is effective only when the PRINCIPAL POWER SWITCH on the rear panel is switched ON. This button looks just like the other front-panel buttons except that it must be pressed and held for one second to activate the circuit and lights. (This prevents accidental turn-off.)

② **LOCAL Button**
The button returns the 390AD from the Remote mode under the GPIB controller (not locked out) to the Local mode. When the 390AD is in Local mode, the LOCAL button lights.

③ **REMOTE Button**
When the 390AD is enabled to generate the remote service request by the REM command, pressing this button will generate the service request (SRQ) on the GPIB. When the 390AD is in the Remote mode, the REMOTE button lights. For further details, see the paragraph on REM command.

④ **LOCKOUT Lamp**
When the universal command LLO (local lockout) is accepted, the LOCKOUT lamp lights.

⑤ **DECREMENT/INCREMENT Buttons**
Three buttons change the selected value for one of the seven parameters: INPUT RANGE, DC OFFSET, TRIGGER LEVEL, SAMPLE FREQ A/B, DELAY COUNT, LATCH SHIFT, and CURSOR. Pressing the < button decreases the value, and pressing the > button increases it. If the FAST button is pressed with one of the preceding buttons, the value is changed more quickly. For parameters other than INPUT RANGE and SAMPLE FREQ A/B, pressing the < and > buttons at the same time resets the setting to the initial value.

## Vertical Controls, Figure 2-3

⑥ **CH 1 OR X, CH 2 OR Y Connectors**
The input connectors provide paths for feeding external signals to the vertical amplifiers. When the FUNCTION DISPLAY selector 39 is set to XY, Channel 1 is the X input and Channel 2 is the Y input. If a 10× probe having a readout pin is connected, the input range indicator reading is automatically multiplied by 10. The maximum input voltage is 250 V (dc + peak ac).

⑦ **AC-GND-DC Buttons**
These buttons select the mode of coupling the input signal to the vertical amplifier. The activated button lights.

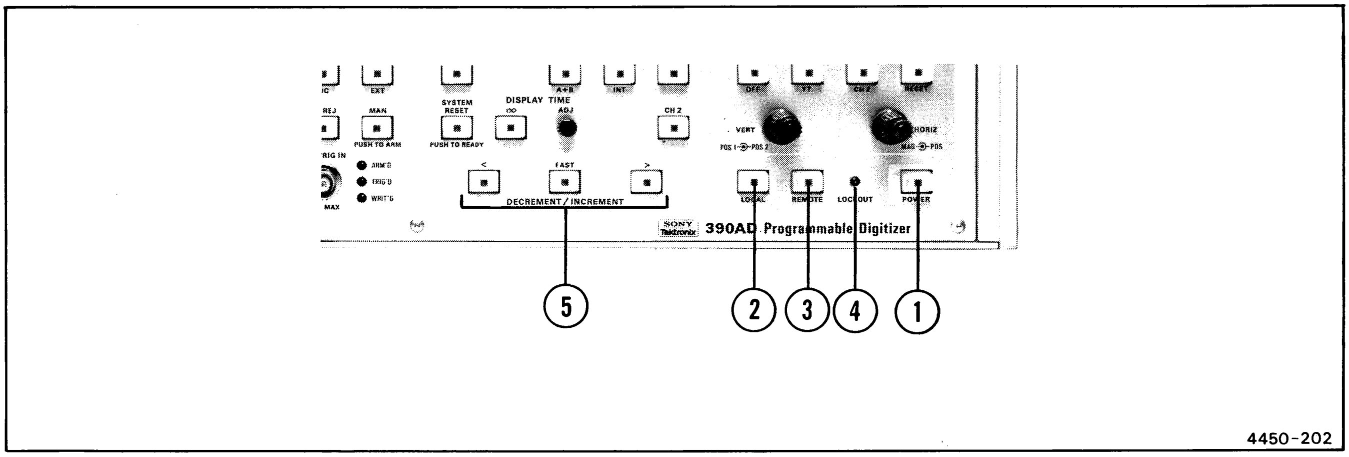

EXT
MAN
PUSH TO ARM
TRIG IN
MAX
ARM'D
TRIG'D
WAIT'G
SYSTEM RESET
PUSH TO READY
DISPLAY TIME
∞
ADJ
A+B
INT
CH 2
<
FAST
>
DECREMENT / INCREMENT
VERT
POS 1 - POS 2
HORIZ
MAG - POS
LOCAL
REMOTE
LOCKOUT
POWER
SONY Tektronix
390AD Programmable Digitizer
5
2
3
4
1
4450-202

Figure 2-2. Power and system controls.

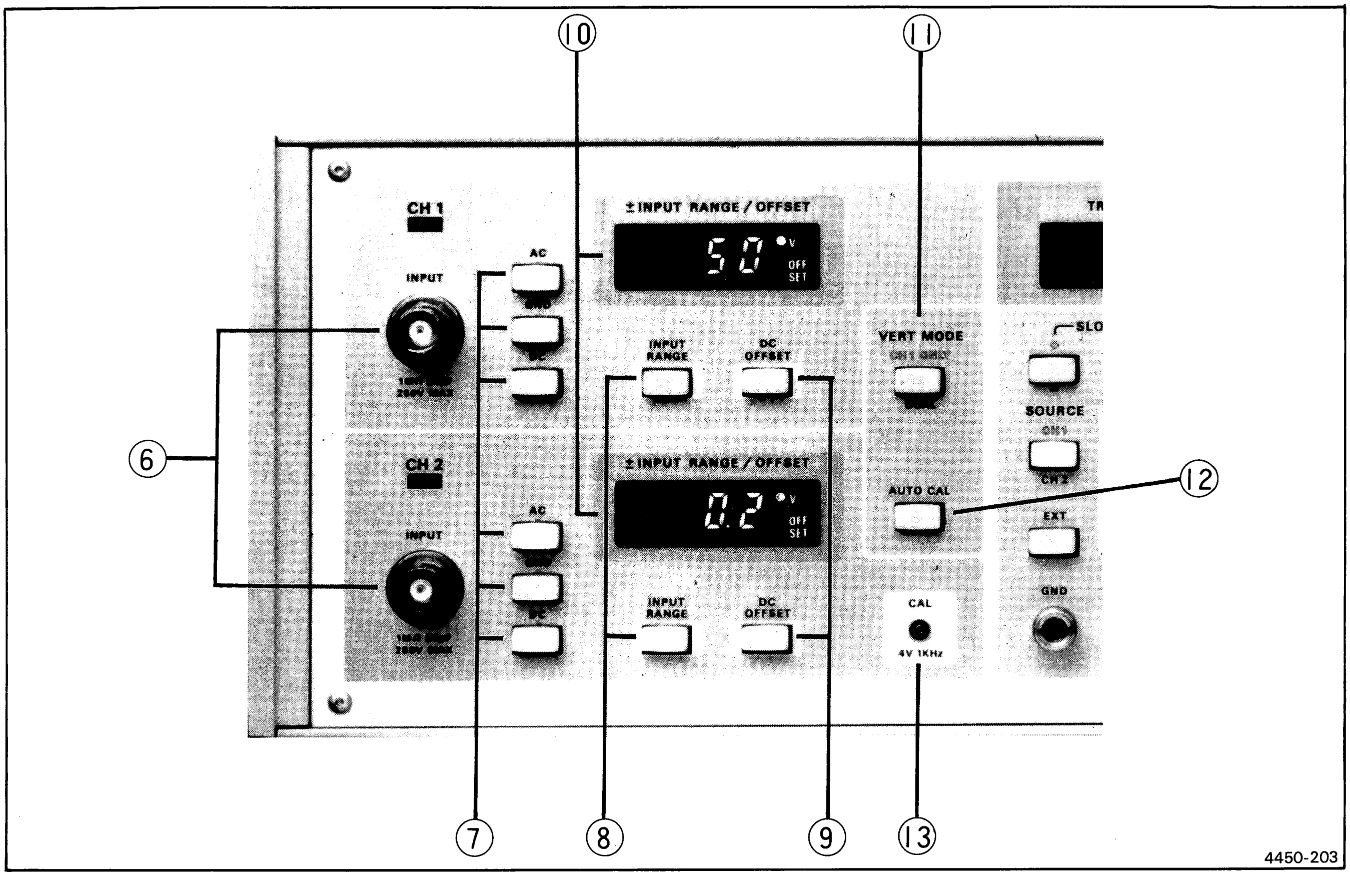


Figure 2-3. Vertical controls.

**AC:** The signal is coupled through a capacitor to block the dc component of the input signal.

**GND:** The input of the vertical amplifier is separated from the input connector, and is grounded.

**DC:** All the frequency components of the input signal are fed into the vertical amplifier.

⑧ **INPUT RANGE Button**

This button is used to display the input sensitivity on the ± INPUT RANGE/OFFSET indicator. The setting can be changed by pressing the DECREMENT/INCREMENT buttons within the range of ±100 mV to ±50 V full scale in nine steps in a 1-2-5 sequence. When activated, the INPUT RANGE button lights.

⑨ **DC OFFSET Button**

Press the DC OFFSET button to display the dc offset value on the ±INPUT RANGE/OFFSET indicator. The setting can be changed in 1% steps from 0 to ±99% by pressing the DECREMENT/ INCREMENT buttons. If the < and > DECREMENT/INCREMENT buttons are pressed at the same time, the setting will be reset to 0% immediately. When activated, the DC OFFSET button lights.

⑩ **±INPUT RANGE/OFFSET Indicator**

When the top LED is lit, the indicator displays the input sensitivity in volts. When the bottom LED is lit, the indicator reads the setting of the dc offset in %. The overrange indicator at the left lights when the input signal exceeds the input range setting, a condition for distortions.

⑪ **VERT MODE Button**

The VERT MODE button selects the operational mode of the vertical system. The button lights when the CH 1 ONLY mode is selected. When set to CH 1 ONLY, the signal connected to the CH 1 OR X connector is digitized. In this case, waveform data requiring as many as 4 k words in record length can be stored, allowing a sample frequency of up to 60 MHz. When DUAL mode is selected, signals connected to both CH 1 OR X and CH 2 OR Y connectors are digitized simultaneously. Waveform data requiring as many as 2 k words in record length can be stored, and sample frequency up to 30 MHz can be selected.

⑫ **AUTO CAL Button**
This button activates circuitry to compensate the drift and gain of the input amplifier. When the sample frequency is 60 MHz, the clock phase is also compensated.

⑬ **CAL OUT**
The CAL OUT connector is an output terminal that supplies a 4 V p-p, 1 kHz square wave for probe compensation.

## Trigger Controls, Figure 2-4

⑭ **SLOPE**
Two buttons select the slope of the trigger signal.

+ and − buttons select the positive- or the negative-going slope of the waveform to trigger data acquisition. When + is selected, the +, − lamp lights.

BOTH button selects both positive- and negative-going slopes of the waveform to trigger data acquisition. It is used for triggering on a signal of unknown slope change, such as a single-shot signal. When Both mode is selected, the BOTH lamp lights.

⑮ **SOURCE**
Two buttons select the source of the trigger signal.

**CH 1–CH 2:** The signal connected either to the CH 1 or the CH 2 connector may be selected as the trigger source. When CH 1 is selected, the CH 1 lamp lights. Even when the Vert Mode is set to CH 1 ONLY, CH 2 can be used as the trigger source, so long as the sample frequency does not exceed 30 MHz.

**EXT:** The signal connected to the EXT TRIG IN connector on the front panel is used as the trigger signal. When Ext is selected, the EXT lamp lights.

⑯ **CPLG**
Two buttons select the method of coupling the signal to the trigger circuit.

**AC/DC:** In ac mode, the signal is fed into the trigger circuit through a capacitor. Signal components of frequency lower than 25 Hz are attenuated, and dc signal is blocked. In dc mode, all the components of the signal are directly fed into the trigger circuit. When ac is selected, the AC lamp lights.

**HF REJ:** Signal components of frequency lower than 25 Hz and higher than 50 kHz are attenuated. The HF REJ lamp lights when the button is pressed.

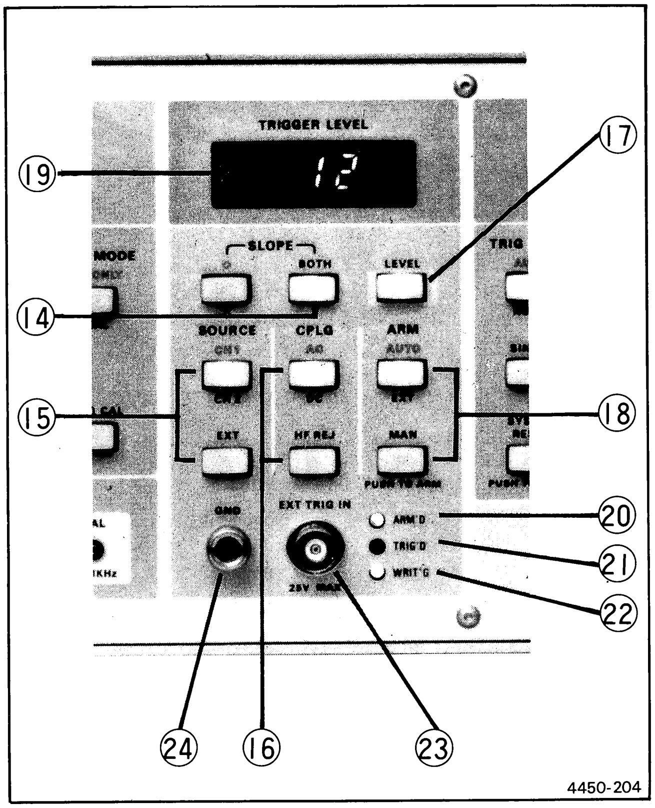


Figure 2-4. Trigger controls.

⑰ **LEVEL Button**
To set the trigger level, press the LEVEL button. Use the Decrement/Increment control to set trigger level between 0% and ±99% of the input range (from 5% to 99% when BOTH is selected). If both < and > are pressed at the same time, the trigger level is immediately reset to 0%. The setting of the trigger level is indicated on the TRIGGER LEVEL indicator.

⑱ **ARM**
Two buttons select the arm mode.

**AUTO/EXT:** In Auto mode, the arm signal is generated automatically. In Ext mode, the input to the EXT ARM connector on the rear panel serves as the arm signal. When Auto is selected, the ARM lamp lights.

**MAN (PUSH TO ARM):** This button is used to manually generate an arm signal. When lit, pressing the button will generate the arm signal.

⑲ **TRIGGER LEVEL Indicator**
This indicator displays the selected value of trigger level.

⑳ **ARM'D Lamp**
The ARM'D lamp is lit when the 390AD is in the armed state and awaiting a trigger. The ARM'D lamp will go out when the circuit is ready to digitize the next waveform.

㉑ **TRIG'D Lamp**
The TRIG'D lamp is lit when triggered, and will go out when the circuit is ready to digitize the next waveform.

㉒ **WRIT'G Lamp**
The WRIT'G lamp is lit when the waveform is being digitized, and will go out when writing ends.

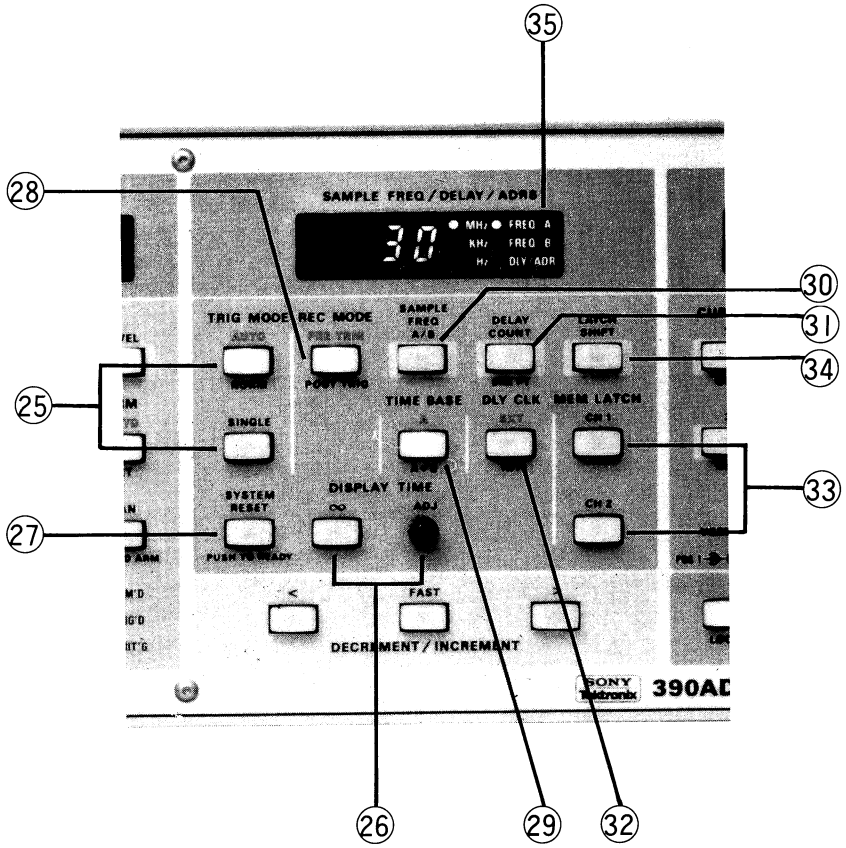
㉓ **EXT TRIG IN Connector**
When the SOURCE selector is set to Ext, the EXT TRIG IN connector will feed an external signal to the trigger circuit. An input signal of ±5 V corresponds to a trigger level of ±100%.

㉔ **GND**
The ground terminal is connected to chassis ground.

## Time Base Controls, Figure 2-5

㉕ **TRIG MODE**
Two buttons select the trigger mode.

**AUTO/NORM:** In Auto mode, the next waveform data are automatically acquired and displayed after a preset display time, regardless of the presence of trigger signal. In Norm mode, the next waveform data are acquired and displayed on receiving a trigger signal after a preset display time. When Auto is selected, the button lights.


35
28
SAMPLE FREQ / DELAY / ADRS
30
MHz FREQ A
KHz FREQ B
Hz DLY ADR
30
31
34
TRIG MODE
AUTO
NORM
REC MODE
PRE TRIG
POST TRIG
SAMPLE FREQ A/B
DELAY COUNT
LATCH SHIFT
25
TIME BASE
DLY CLK
EXT
MEM LATCH
CH 1
SINGLE
33
SYSTEM RESET
DISPLAY TIME
∞
ADJ
CH 2
27
PUSH TO READY
FAST
DECREMENT / INCREMENT
SONY Tektronix 390AD
26
29
32

4450-205

Figure 2-5. Timebase controls.

**SINGLE:** In Single mode, the display time following the waveform acquisition is infinitely long, and the next waveform data will not be acquired and displayed until the SYSTEM RESET (PUSH TO READY) is activated. When Single mode is selected, the SINGLE button lights.

### (26) DISPLAY TIME

The Display Time controls consist of a button (∞) and a potentiometer for setting the waveform display time.

**∞:** When pressed, the ∞ button lights and sets the display time to infinity. If the ∞ button is pressed while a waveform is being digitized, the display time will be set to infinity after the acquisition. The display time can be reset by pressing the SYSTEM RESET button.

**ADJ:** The ADJ control is used to vary the display time from 0.2 to 7 seconds when the IF key is not activated.

### (27) SYSTEM RESET (PUSH TO READY)

This button is pressed to reset the Display Time from ∞. The system can be reset to the ready conditions even during data processing. In SINGLE mode, pressing this button starts a new write cycle.

### (28) REC MODE

The REC MODE button selects pre-triggering or post-triggering display of the waveform.

**PRE TRIG/POST TRIG:** Pre-trigger mode allows observation of the waveform preceding the trigger, while Post-trigger mode allows observation of the waveform following the trigger. The REC MODE lamp lights when PRE TRIG is selected.

### (29) TIME BASE

In A mode, the waveform data are written at a fixed sample frequency. In A+B mode, the sample frequency can be changed in the course of writing. When Time Base A is selected, the lamp lights.

### (30) SAMPLE FREQ A/B

This button is pressed to display sample frequencies of both time bases. The sample frequency can be set from 5 Hz to 60 MHz (or up to 30 MHz when the Vert Mode is set to Dual) with the internal clock in 23 steps, and with the external clock, by using the DECREMENT/INCREMENT button. If the Time Base is set to A+B, sample frequencies A and B are displayed alternately each time the button is pressed, allowing the time bases to be set independently. The SAMPLE FREQ A/B button lights when activated.

### (31) DELAY COUNT/BRK PT

This button is pressed to display delay count when the Time Base is set to A, or break point when the Time Base is set to A+B. Use the DECREMENT/INCREMENT controls to change the delay count or breakpoint settings. When selected, the DELAY COUNT button lights.

### (32) DLY CLK

The DLY CLK button selects the clock for the delay counter.

**EXT/INT:** In Ext mode, the signal connected to the EXT DLY CLK connector on the rear panel is used as the clock for the delay counter. In Int mode, the sample frequency signal is used as the clock. If the Time Base is set to A+B, the B frequency is used for Pre-trigger and the A frequency is used for Post-trigger. When Ext is selected, the EXT-INT button lights.

### (33) MEM LATCH

This control latches the digitized waveform. Latching occurs even while writing at lower sample frequencies. Because CH 1 or CH 2 can be latched or released independently, it is possible to latch one channel and rewrite the other. The Mem Latch feature with Latch Shift is useful for comparing waveforms. When latched, the MEM LATCH lamp lights, and the latch is released when pressed again. The button is also used to select the channel for LATCH SHIFT.

### (34) LATCH SHIFT

The LATCH SHIFT button is used to horizontally shift the waveform latched by MEM LATCH for comparison. When this button is pressed, it selects the channel to be shifted. The selected channel is identified by the lighted button. The waveform can be shifted by one record length to the left or to the right by using the DECREMENT/INCREMENT buttons. This is useful for comparing waveforms that were triggered at different points. If both the < and > buttons are pressed at the same time, the waveform is immediately reset to the unshifted position. The shift magnitude is read on the SAMPLE FREQ/DELAY/ADRS indicator. When selected, the LATCH SHIFT button lights.

㉟ **SAMPLE FREQ/DELAY/ADRS Indicator**
The indicator reads sample frequency A or B, delay count (break point), magnitude of latch shift, or cursor address. One of the three LEDs at the right end lights when sample frequency A (FREQ A), B (FREQ B), or delay count/break point/magnitude of latch shift/cursor address (DLY/ADR) is selected.

## Display and Measurement Functions & Controls, Figure 2-6

㊱ **CURSOR 1, 2**
Press button to activate cursor. The button lights. An intensified dot appers on the waveform, and can be moved along the waveform by the DECREMENT/INCREMENT controls. At the same time, the SAMPLE FREQ/DELAY/ADRS indicator displays the cursor address: 0 at the left edge of the CRT, 4095 at the right. When the < and > buttons are pressed at the same time, cursors 1 and 2 return to the left and the right ends of the screen, respectively. Press the cursor button (when it is lighted) again to de-activate cursor.

㊲ **FUNCTION**
The combination of the three FUNCTION buttons and the two cursors greatly facilitates the defining and measuring of voltage level, voltage difference, time interval and frequency of any portion of the displayed waveform.

**CH 1—CH 2:** When the Vert Mode is set to Dual, this button selects the waveform of CH 1 or CH 2 for the measurement. When a channel is selected, the appropriate button lights.

**VOLT/TIME:** Pressing this button selects voltage or time for measurement. When Volt is selected, the button lights. If Time is selected while only one cursor is displayed, an additional cursor appears automatically.

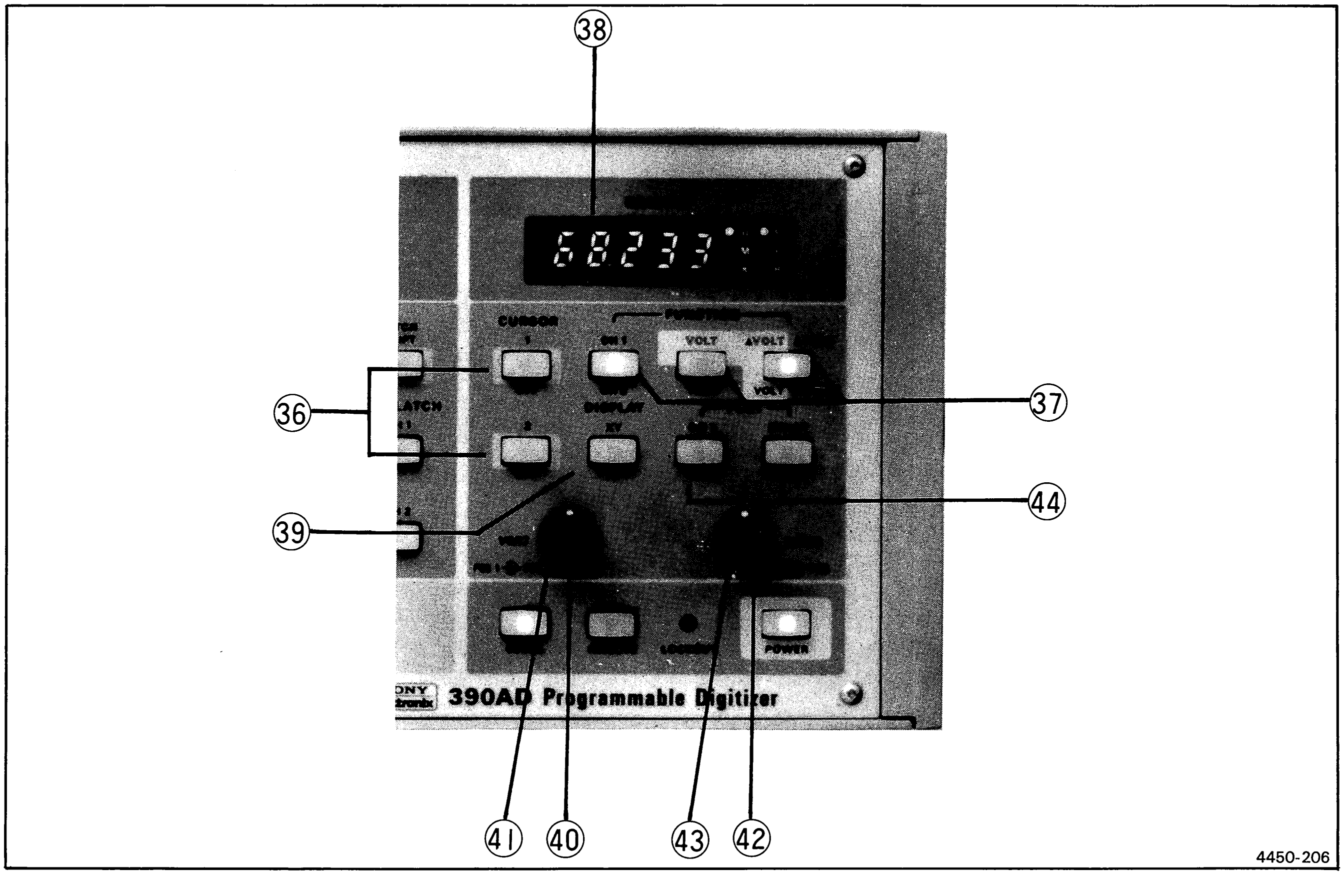


Figure 2-6. Display and measurement function controls.

**ΔVOLT ΔTIME–VOLT 1/ΔTIME:**

| Button Selection | | Measurement |
|---|---|---|
| **VOLT/TIME** | **ΔVOLT ΔTIME/VOLT** $\frac{1}{\Delta \mathrm{TIME}}$ | |
| VOLT<br>(button lit) | VOLT $\frac{1}{\Delta \mathrm{TIME}}$ | Voltage level from ground at the cursor point on waveform. |
| VOLT<br>(button lit) | Δ VOLT Δ TIME (button lit) | Voltage difference between two points defined by the cursors. |
| TIME | Δ VOLT Δ TIME (button lit) | Time interval between two cursors. |
| TIME | VOLT $\frac{1}{\Delta \mathrm{TIME}}$ | Reciprocal of time interval (or frequency). |

㊳ **READOUT Indicator**
The indicator reads the record length of stored waveform (time), results of measurement with cursors, or error number. When Time Base A is selected, the overall record length of stored waveform is displayed in units of time. When the Time Base is set to A+B, the record length of the segment digitized before the break point by Time Base A, or the record length of the segment digitized by Time Base B following the break point is displayed in units of time depending upon the setting of SAMPLE FREQ A/B button.

㊴ **DISPLAY**
When a display monitor or a plotter is connected, either time-domain display or X-Y display can be selected.

**XY/YT:** In XY mode, signals fed into the CH 1 connector are displayed on the X-axis, and those fed into the CH 2 connector are displayed on the Y-axis. In YT mode, the normal time domain display occurs. When XY is selected, the button lights.

㊵ **VERT POS 1**
When a monitor is connected and the Display is set to YT, the VERT POS 1 control adjusts the vertical position of the CH 1 waveform.

㊶ **VERT POS 2**
When a monitor is connected and the Display is set to YT, the VERT POS 2 control adjusts the vertical position of the CH 2 waveform. When the Display is set to XY, it adjusts the vertical position of the composite waveform.

㊷ **HORIZ MAG**
When a monitor is connected and the Display is set to YT, the HORIZ MAG control magnifies the waveform horizontally by 1 to 10×.

㊸ **HORIZ POS**
When a monitor is connected, the HORIZ POS control moves the waveform horizontally.

㊹ **PLOT**
The PLOT controls are used when an X-Y plotter is connected.

**CH 1—CH 2:** Selects CH 1 or CH 2 waveform for plotting. When CH 1 is selected, the button lights.

**START/RESET:** When the Display Time is set to ∞, pressing the START/RESET button starts the plotter and lights up the button. When plotting is finished, the bell will sound and the pen will remain at its final position. When the button is pressed again, the lamp goes out and the pen returns to the origin. If the button is pressed in the course of plotting, the pen will stop plotting, remain halted for a few seconds, and then return to the origin. It is possible to specify the segment to be plotted by using cursors. There is no monitor display while plotting is in process.

### Special Application of Buttons

The 390AD front-panel buttons are illuminated by light-emitting diodes (LEDs). If the illumination is not desired (for example, in a dark room), press the SAMPLE FREQ A/B button and the DECREMENT/INCREMENT FAST buttons simultaneously. All pushbutton LEDs except the power button illumination will go out. Pressing these two buttons again will restore the lights.

## REAR PANEL CONTROLS AND CONNECTORS (Fig. 2-7)

㊺ **PRINCIPAL POWER SWITCH**
The PRINCIPAL POWER switch is the main switch for the power supply. Activating this control will enable the front-panel power switch.

㊻ **Fuse**
The line fuse is a fast-blow type, rated at 250 volts and 4 amperes. Replacement fuse must be of the same type and rating.

㊼ **AC Power Connector**
The ac power connector accepts the power cord with a polarized, three-terminal plug.

㊽ **Voltage Indicator**
This device indicates the operating voltage of the instrument as determined by an internal strapping.

㊾ **GND Terminal**
The GND terminal provides a secure path to earth.

㊿ **EXT ARM Input Connector**
This connector accepts an external arming signal when the Arm mode is set to Ext. The arming is actuated by a positive TTL level signal. (See #57.)

(51) **EXT DLY CLK Input Connector**
This connector accepts the external delay clock signal when the Dly Clk is set to Ext.

(52) **EXT CLK Input Connector**
This connector accepts the external clock signal when the Sample Freq A/B is set to EL or EH (external clock).

(53) **NORM/CH 1 ONLY Switch**
This switch is to be set to CH 1 ONLY when a frequency between 30 and 60 MHz is used as external clock.

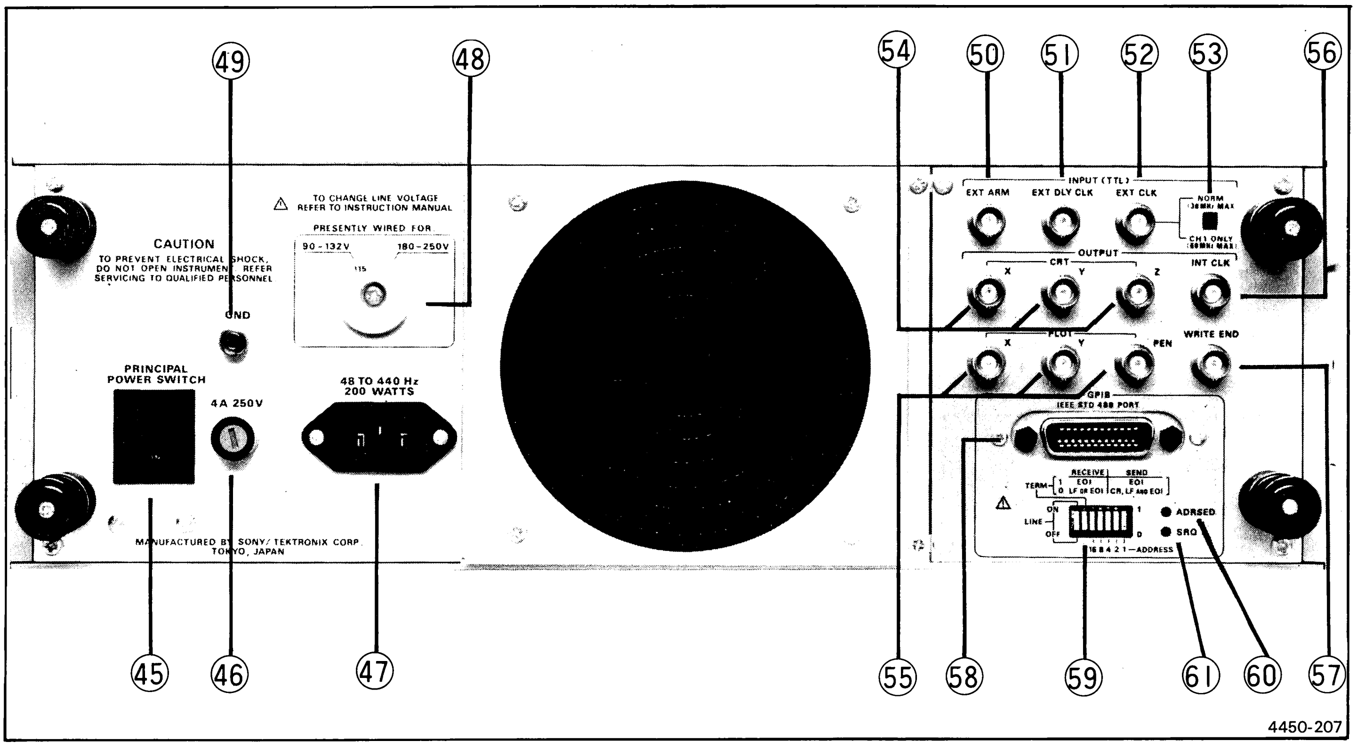

㊾
㊽
(54)
㊿
(51)
(52)
(53)
(56)
TO CHANGE LINE VOLTAGE REFER TO INSTRUCTION MANUAL
PRESENTLY WIRED FOR
90 - 132V
180 - 250V
115
CAUTION
TO PREVENT ELECTRICAL SHOCK, DO NOT OPEN INSTRUMENT. REFER SERVICING TO QUALIFIED PERSONNEL
GND
PRINCIPAL POWER SWITCH
4A 250V
48 TO 440 Hz
200 WATTS
MANUFACTURED BY SONY/ TEKTRONIX CORP. TOKYO, JAPAN
INPUT (TTL)
EXT ARM
EXT DLY CLK
EXT CLK
NORM (30MHz MAX)
CH 1 ONLY (60MHz MAX)
OUTPUT
CRT
X
Y
Z
INT CLK
PLOT
X
Y
PEN
WRITE END
GPIB
IEEE STD 488 PORT
RECEIVE
SEND
TERM
1
EOI
EOI
0
LF OR EOI
CR, LF AND EOI
ON
LINE
OFF
1
0
ADRSED
SRQ
16 8 4 2 1—ADDRESS
㊺
㊻
㊼
(55)
(58)
(59)
(61)
(60)
(57)
4450-207

Figure 2-7. Rear panel controls and connectors.

(54) **CRT/X, Y, Z Output Connector**
This connector provides an analog signal output for the display monitor.

(55) **PLOT/X, Y, $\overline{\text{PEN}}$ Output Connector**
This connector provides an analog signal output for the X-Y plotter and for a TTL output for the plotter pen.

(56) **INT CLK Output Connector**
By connecting this output from one 390AD to the EXT CLK input of another, multiple waveforms can be simultaneously processed by several instruments.

(57) **WRITE END Output Connector**
To form a triggered "daisy chain", connect this output from one 390AD to the EXT ARM input of another.

(58) **GPIB Connector**
This connector is compatible with the IEEE 488-1978 standard.

(59) **GPIB Address Switch**
A DIP switch to connect or disconnect the 390AD to GPIB and to select terminator and address.

(60) **ADRSED Lamp**
The ADRSED lamp lights when the instrument is addressed by the controller on the GPIB.

(61) **SRQ Lamp**
The SRQ lamp lights when a service request occurs on the GPIB.

# DESCRIPTION OF BASIC FUNCTIONS

The basic functions of the 390AD are described in this section.

## SELF-TEST AND INITIALIZE

The 390AD performs a self-test at power up. When the test is completed, the front-panel indicators and buttons come up to their default state. The system is initialized and ready to acquire data.

### Self-Test

The self-test involves the following procedures.

**1. Lamp Lighting Test**

During the self-test, all of button-illuminating lamps and indicator LEDs for numerals and unit designation are lit. DISPLAY TIME, ∞, RESET, and status lamps turn on only momentarily.

**2. ROM Sumcheck**

If there is any error in the ROM sumcheck, an error code is displayed on the READOUT Indicator.

**3. RAM Read/Write Test**

The test checks the read and write functions. If there is error in the read and write functions, an error code is displayed on the READOUT indicator.

**4. Button Switch Test**

This test checks that unpressed buttons are open-circuited. If a closed circuit is detected, a bell will sound and an error code will be displayed on the READOUT indicator. At the same time the buttons are disabled without affecting the GPIB control.

**5. Waveform Data RAM Read/Write Test**

This test checks the read/write ability of the RAM storing the waveform data. If there is any error, a bell will sound and an error code will be displayed on the READOUT indicator.

### 6. Circuit Test

This test checks the hardware in the 390AD. If there is any error, a bell will sound and an error code will be displayed on the READOUT indicator. See Alarms on the Front Panel and Error Messages in this section for error code explanation.

### Initialize

After the self-test, the 390AD controls are set to the following default state:

**VERTICAL**

| | |
|---|---|
| AC-GND-DC | AC |
| INPUT RANGE | ±50 V |
| DC OFFSET | 0% |
| VERT MODE | DUAL |
| AUTO CAL | Off |

**TRIGGER**

| | |
|---|---|
| SLOPE | + |
| SOURCE | CH 1 |
| CPLG | AC |
| LEVEL | 0% |
| ARM | AUTO |

**TIMEBASE**

| | |
|---|---|
| TRIG MODE | AUTO |
| SYSTEM RESET (PUSH TO READY) | Off |
| REC MODE | PRE TRIG |
| DISPLAY TIME ∞ | Off |
| SAMPLE FREQ A/B | 10 MHz |
| TIME BASE | A |
| DELAY COUNT (BRK PT) | 200 |
| DLY CLK | INT |
| LATCH SHIFT | Off |
| MEM LATCH | |
| CH 1 | Off |
| CH 2 | Off |

**DISPLAY AND MEASUREMENT FUNCTIONS**

| | |
|---|---|
| CURSOR | |
| 1-OFF | OFF |
| 2-OFF | OFF |
| DISPLAY | YT |
| FUNCTION | |
| CH 1-CH 2 | CH 1 |
| VOLT-TIME | TIME |
| ΔTIME ΔVOLT-VOLT 1/ΔTIME | VOLT 1/ΔTIME |
| PLOT | |
| CH 1-CH 2 | CH 1 |
| START-RESET | RESET (non-operating) |
| READOUT | 204.70 μs |

**OTHERS**

REMOTE-LOCAL is set to LOCAL.

## INPUT SECTION

### Signal Connection

The 390AD converts signals fed into the input connectors (CH 1 OR X, CH 2 OR Y connectors), within the voltage range selected by ±INPUT RANGE, with 10-bit resolution. In order to make precise measurements, the signal should be connected carefully as instructed below.

### Probe

The probe is the most convenient means of connecting the input signal to the 390AD. The shielded probe is hardly affected by electrical interference from the outside, and the 10× probe ensures high input impedance, reducing the loading effect on the circuit to be measured. The input signal is attenuated to 1/10 its original value. If a 10× probe with a readout changeover pin is used, the true input range multiplied by 10 is displayed automatically on the ±INPUT RANGE indicator.

### Coaxial Cable

When a signal is fed into the input connector through a cable rather than via a probe, the disturbance to the signal should be considered. To ensure the true frequency response characteristics of the input signal, it is essential to use a coaxial cable of high quality and low loss. The coaxial cable is to be terminated in its characteristic impedance.

### Signal Input Range

The vertical sensitivity is represented by the input range. For instance, when the ±INPUT RANGE is set to ±1 V, the part of the signal voltage fed into the signal input connector that is between −1 and +1 V is A/D converted with 10-bit resolution. In this case, the voltage resolution is about 2 mV (2 V ÷ 1024 = 1.95 mV; about 2 mV). If the ±INPUT RANGE is set to ±0.1 V, the part of the signal voltage fed into the signal input connector that is between −0.1 V and +0.1 V is A/D converted with 10-bit resolution. In this case, the voltage resolution is about 200 μV. When the ±INPUT RANGE is set, the following steps should be taken.

1. Press the INPUT RANGE button.
2. Operate DECREMENT/INCREMENT buttons until the desired value is set.

When an input signal exceeds the ±Input Range setting, the waveform displayed on the monitor will be clipped in contrast to the display on an oscilloscope. This is due to the occurrence of overrange. A discussion of overrange follows later in this section.

In order to use 10-bit resolution, the ±Input Range should be set so that the input signal is fully in the input range and overrange does not occur.

### DC Offset

The input circuit of the 390AD is provided with DC Offset. The DC Offset is to be used, like the vertical position control in an oscilloscope, for vertically shifting the waveform on the monitor screen, or for shifting the overranged input signal to place it within the input range. Also, because the DC Offset can be set to within 0 to ±99% of the input range, it can be used for measuring lower frequency components that are superimposed on dc component within this range and may be attenuated in case of ac coupling.

The DC Offset can be set in 1% increments with the following procedure.

1. Press the DC OFFSET button.
2. Operate the DECREMENT/INCREMENT buttons until the desired value is displayed.

For instance, in order to shift a waveform at the top of the screen to the center, press the > button, and when a waveform at the bottom is to be centered, press the < button.

When reading the voltage through the readout function with the DC Offset set at a certain value, the offset value is automatically cancelled, allowing a readout of the absolute value of the input signal. It should be noted that the waveform data are transferred to the GPIB with the offset included, as in the case of the monitor.

## OVERRANGE

The ±Input Range of the 390AD specifies the full-scale range of the A/D converter. For instance, if the ±Input Range is set to ±1 V, the 390AD converts that part of the input signal between −1 V and +1 V with 10-bit resolution. This represents the full-scale range.

When the display monitor is set as shown in Figure 2-8, with the upper half for the CH 1 display and the lower half for the CH 2 display (see How to Set a Display Monitor in Section 1), the ordinate scale corresponds to the voltage readings given at the right of the figure. If a triangular wave of ±2 V is fed into CH 1, and the same wave attenuated by 1/2 into CH 2, waveforms as shown in Figure 2-8 are displayed on the monitor. While a true waveform appears on CH 2, in which the amplitude is equal to the setting of the ±INPUT RANGE, the waveform on CH 1 is clipped because the input signal is greater than the range of CH 1 (±1 V).

The 390AD has an overrange indicator, which consists of two triangular LEDs situated at the left of the seven-segment ±INPUT RANGE indicator. When the overrange occurs in the + side, the upward LED (Δ) lights, and when in the − side, the downward LED (∇) lights. If the overrange occurs in both sides, both LEDs light. The level of overrange

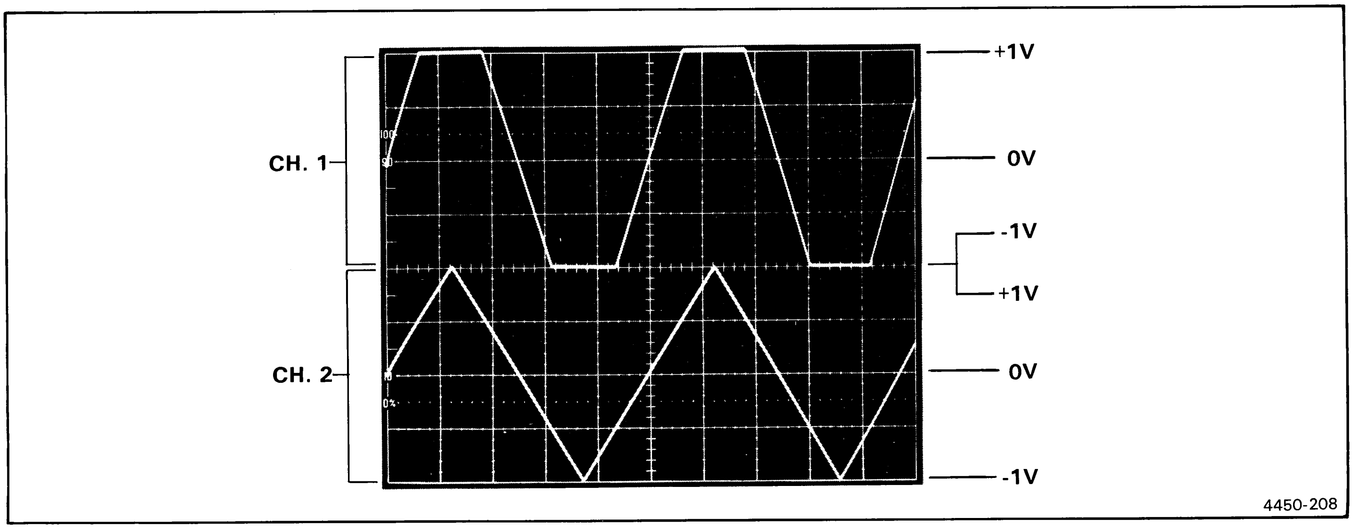


Figure 2-8. Waveforms on the display monitor with overrange on CH 1.

detection is set at about 0.1% beyond the settings of ±INPUT RANGE. The indicator allows the operator to readily prevent the overrange from occurring without using the monitor. The indicator is reset when starting to write in the waveform memory. Even when the Display Time is set to ∞ or the memory is latched, the overrange is indicated because the vertical circuit of the 390AD is active as long as new input signals are available.

When the overrange indicator is lit, adjust the ±INPUT RANGE and the DC OFFSET until the signal is contained in the input range. In case of measurement with a part of a signal expanded, the exact A/D conversion is achieved if the maximum peak-to-peak amplitude of the signal does not exceed five times the setting of the ±INPUT RANGE.

It is possible to check the overrange through GPIB with an external controller. In this case, the overrange conditions that occur prior to the end of waveform writing are sent out.

**CAUTION**

*It should be noted that applying voltage higher than the maximum input voltage may damage the instrument.*

## AUTO CAL

### Outline of AUTO CAL

The 390AD has been designed with emphasis on the accuracy of the entire analog section, from the signal input terminal to the digital data output. In order to ensure high analog accuracy by using the A/D converter with 10-bit resolution, an automatic calibration feature (designated simply as Auto Cal hereinafter) is included. Auto Cal has the following three modes:

1. DC Cal
2. Gain Cal
3. Phase Cal

### DC Cal

The DC Cal mode is a correction mode for exactly digitizing the dc level of a signal.

### Gain Cal

The Gain Cal mode is a correction mode for exactly relating the ±Input Range setting to the full-scale range of the A/D converter.

### Phase Cal

Phase Cal is a mode to be executed only when the sample frequency is 60 MHz, or when using an external clock with the External Clock Selector on the rear panel set to CH 1 ONLY (60 MHz MAX) with the indicator on the front panel reading External High frequency (EH). When the sample frequency is 60 MHz (or EH), the CH 1 and CH 2 input amplifiers, A/D converters, and waveform memories are driven at 30 MHz clock frequency, and an equivalent A/D converter is realized by shifting clock phase 180° between the CH 1 and CH 2 A/D converters. Any shift in the phase relationship will result in the deterioration of accuracy for high-frequency input signals. The Phase Cal corrects the phase shift caused by the signal delay line time difference at the analog sections of input amplifiers and A/D converters to keep the phase at exactly 180°.

### Execution of Auto Cal

The Auto Cal routine is executed in the following cases. (When executed, faint relay noises are audible and the display monitor is blanked.)

1. Switching the INPUT RANGE (from the front panel or GPIB).

2. Changing the SAMPLE FREQ to 60 MHz or EH, or changing from 60 Hz or EH to 30 MHz or lower (from the front panel or GPIB).

3. Pressing the AUTO CAL button or receiving the Cal command from GPIB.

While the execution of Auto Cal normally takes 0.5 sec or less, in some cases it may take a few seconds. During the execution of Auto Cal, none of the buttons on the front panel, except the POWER button, are lighted. Commands from GPIB are not executed immediately, but after ending Auto Cal.

To protect data in the waveform memory, Auto Cal is not executed in the following cases.

1. When the Display Time is set to ∞.

2. For the channel when the Mem Latch is asserted (the MEM LATCH button will be lit).

3. When the vertical mode is set to CH 1 Only and the Sample Frequency is 30 MHz or less, Auto Cal for CH 2 is not executed. However, if the Sample Freq is set to 60 MHz (or EH), Auto Cal is executed for both channels.

**CAUTION**

*Because the data in the waveform memory are eliminated when Auto Cal is executed, it is necessary to protect desired waveform data by Mem Latch.*

## USE OF BOTH SLOPE MODE

The Trigger Slope of the 390AD can be set not only to + or −, as in any instrument, but also to Both. The Both mode is useful when digitizing a single-shot input signal of unknown nature, and operates as described below.

When Both is selected, the available range of Trigger Level setting covers 5 to 99%. This value allows the user to set a trigger window symmetrically with respect to 0 V as shown in Figure 2-9. When a trigger signal crosses either threshold level from the inside, the trigger circuit generates a trigger pulse.

Both slope mode is used through the following procedures.

1. After setting INPUT RANGE and SAMPLE FREQ approximately, set ARM and REC MODE to AUTO and PRE TRIG, respectively.

2. Make sure that the (TRIGGER) SOURCE is set to the desired channel, and set SLOPE and CPLG to BOTH and AC, respectively.

3. Set TRIG MODE to NORM, and adjust TRIGGER LEVEL so that the sweep is not triggered by unwanted signals before the single shot signal occurs. If the WRIT'G lamp stays lit, it indicates that no trigger has occurred.

4. Set TRIG MODE to SINGLE, and when the SYSTEM RESET lamp lights (display of signal ready), input the signal. For another acquisition, press SYSTEM RESET to return to the signal ready.

## ARM FUNCTION

Arm is a control signal for setting the 390AD to the writing mode. The system accepts no trigger until an Arm signal takes place.

If there is an arm input after ending the display time, the system becomes immediately ready for trigger as long as the REC MODE is set to POST TRIG (Fig. 2-10). When the REC MODE is set to PRE TRIG, the system becomes ready for trigger after having written data for a record in the pretrigger region (Fig. 2-11). The ARM'D lamp indicates if the system is ready for a trigger.

The ARM'D lamp lights when the system is ready for a trigger, and goes out when the SYSTEM RESET button is pressed or when the internal reset signal is generated after ending the display time with the Trig Mode set to Auto or Norm.

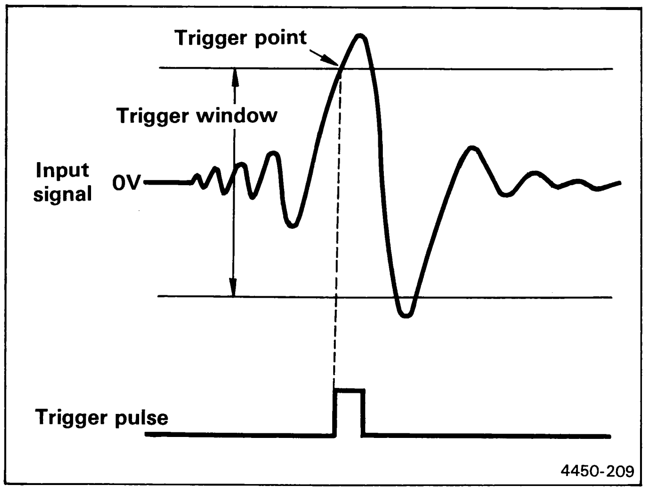


Figure 2-9. Operation of Both slope trigger mode.

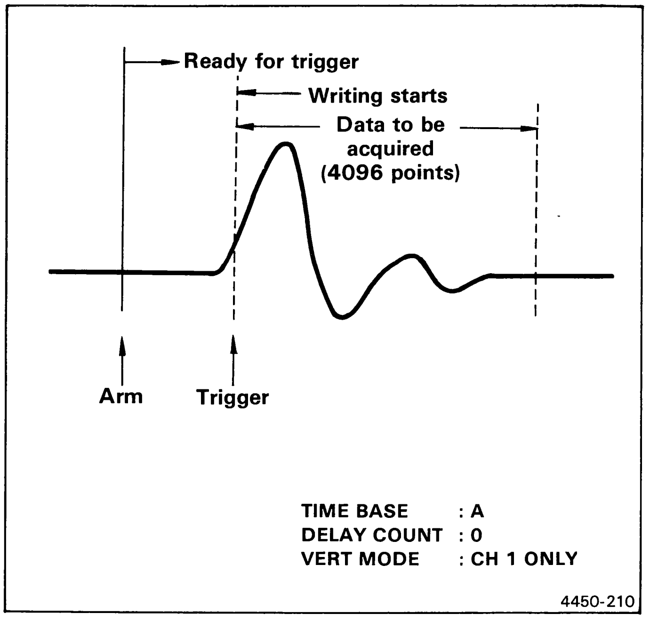


Figure 2-10. Relation of arm and trigger points in post-trigger mode.

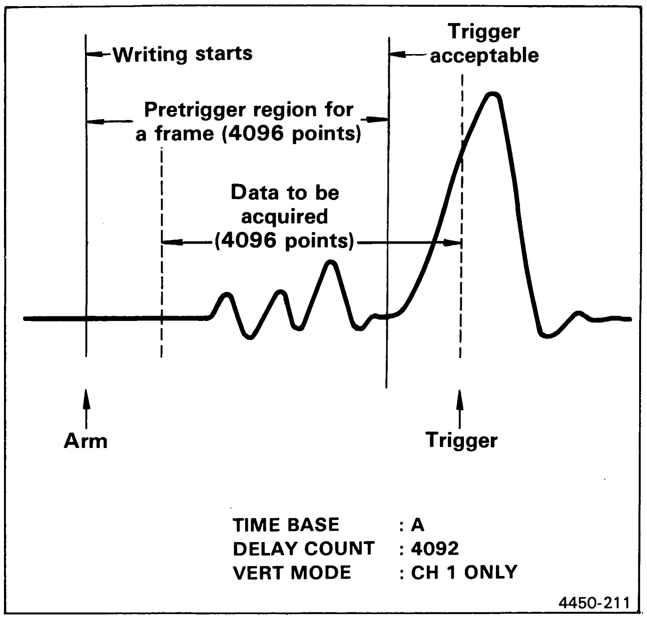


**Figure 2-11. Relation of arm and trigger points in pre-trigger mode.**

The arm function has three modes: Auto, Ext, and Man.

### AUTO

When the display time ends, another arm signal is automatically generated.

### EXT

The input signal to the EXT ARM input connector on the rear panel serves as the arm signal. The Arm function is actuated by a positive transition. While the EXT ARM input connector requires a TTL level input, it is possible to actuate arm with a positive transition obtained by opening a switch connected to the connector. If this arrangement is combined with the Auto or Norm of TRIG MODE, waveform acquisition can be remotely controlled. Because the Ext Arm input cannot be accepted during the display time automatically generated after having acquired a waveform, it is best to turn the DISPLAY TIME ADJ on the front panel fully counterclockwise (minimum, about 0.2 sec.).

### MAN (PUSH TO ARM)

This button is pressed to manually generate an arm signal. When pressed, the lamp lights, and when pressed a second time, the arm signal is generated. If combined with Auto of Trig Mode, the same function as the manual trigger is achieved.

## TRIGGER FUNCTION

The 390AD has Auto, Norm, and Single trigger modes which can be handled in about the same way as in the conventional oscilloscope.

### AUTO

The system is triggered by an input signal after the ARM'D lamp has been lit. If no trigger input signal is available for 20 ms, an internal trigger pulse is generated automatically to acquire and display the waveform. Because some input waveforms, such as recurrent signals of periods longer than 20 ms or single shot waveforms may fail to be triggered properly depending upon the arm input timing, it is preferable to set the Trig Mode to Norm or Single in such cases.

For the operation of the 390AD around the trigger input, see Pre-Trigger Function and Roll Mode and Post-Trigger Function in this section.

If Trig Mode Auto is combined with Arm Man, the Arm Man button will act as a manual trigger button.

### NORM

The system is triggered only by an input signal after the ARM'D lamp has been lit. When the system is not triggered with the Rec Mode set to Post Trig, the waveform acquired by the preceding operation remains on the display monitor as it is. When the Rec Mode is set to Pre Trig, the waveform display continues running without being held if the sample frequency is 10 kHz or lower, and disappears if higher than 20 kHz.

### SINGLE

The system is triggered only by an input signal after the ARM'D lamp has been lit. When triggering fails, the system behaves in the same way as in Norm. The display time after waveform acquisition becomes infinitely long, and the next waveform is not acquired and displayed until the SYSTEM RESET button is pressed again.

**CAUTION**

*When the display is to be repeated with Trig Mode Auto or Norm, it is necessary that Arm be set to Auto or EXT and arm signals occur continuously.*

# PRE-TRIGGER FUNCTION AND ROLL MODE

The pre-trigger mode is to be used for capturing an event that precedes the trigger, or for continuously monitoring a waveform at a lower sample frequency (10 kHz or lower) as a pen recorder would.

## BASIC OPERATION

In the pre-trigger mode, digitizing of a new waveform starts when an arm input is available. As data for a frame in the pre-trigger region have been digitized, the ARM'D lamp lights to be ready for a trigger while updating the waveform memory. When a trigger input occurs, the delay counter starts counting and, when the specified number of sample clock (or external delay clock) pulses have been counted, digitizing stops. Accordingly, the working time of the delay counter corresponds to the data-recording time in the post-trigger region, and the record time in the pre-trigger region is obtained by subtracting the record time in the post-trigger region from the total record time (Fig. 2-12).

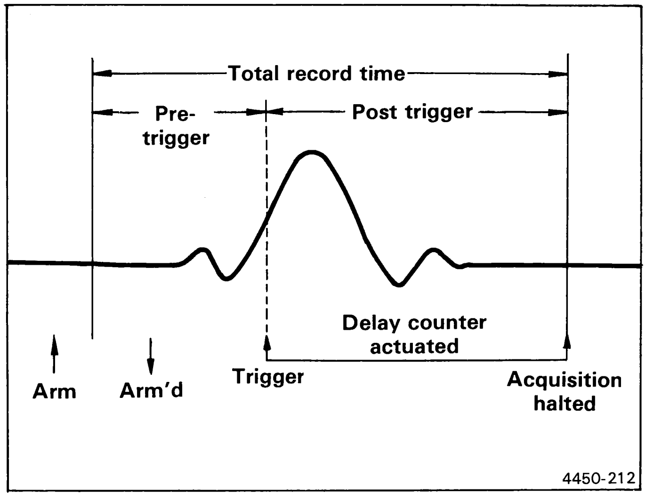


Figure 2-12. Timing of significant events in the pre-trigger mode.

When the internal delay clock is selected, the clock frequency of the delay counter is the same as the sample frequency. Hence, the set value of the delay counter coincides with the number of data words in the post-trigger region. Subtracting this value from the total memory volume yields the number of data in the pre-trigger region. The 390AD, using the internal delay clock, calculates the number of data in the pre-trigger region and displays it on the indicator as the delay count value. When the external delay clock is used, the set value of the delay counter is indicated.

### Operation with Time Base A

All the data are taken in with sample frequency, FREQ A. In the case of the internal delay clock, the delay count value reads the number of data in the pre-trigger region (Fig. 2-13). A bright spot on the display monitor represents the trigger point.

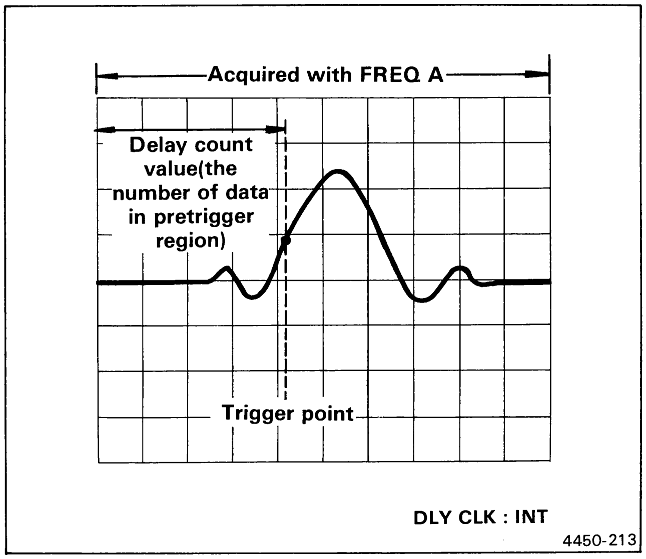


Figure 2-13. Pre-trigger mode using Time Base A.

### Operation with Time Base A+B

The trigger point becomes the break point, where the sample frequency changes from Freq A to Freq B. This may be used for expanding the waveform in the horizontal direction immediately after the event has occurred (Fig. 2-14).

**Sample Period Preceding Break Point.** In the pre-trigger mode with Time Base A+B selected, the sample frequency is switched from A to B when a trigger pulse occurs. This mode is designed for setting Freq A to a lower speed and Freq B to a higher speed, and while recording the overall waveform, obtaining detailed record with high-speed sampling once the event has occurred. Because the sample frequency is switched asynchronously with the trigger pulse, the pulse width is controlled to prevent the internal circuit from malfunctioning. Because of this pulse width control, the time interval from the trigger input to the actual changeover to Freq B may vary between 40 ns and 40 ns + (1/Freq B), and the time interval from the last data point at Freq A to the first data point at Freq B may be between 40 ns and 40 ns + (1/Freq A) + (2/Freq B). Remember this when measuring the time interval including the break point.

**Roll Mode.** When the 390AD uses a sample frequency lower than 10 kHz, it is possible to display a waveform on the monitor while digitizing that waveform. If the Rec Mode is

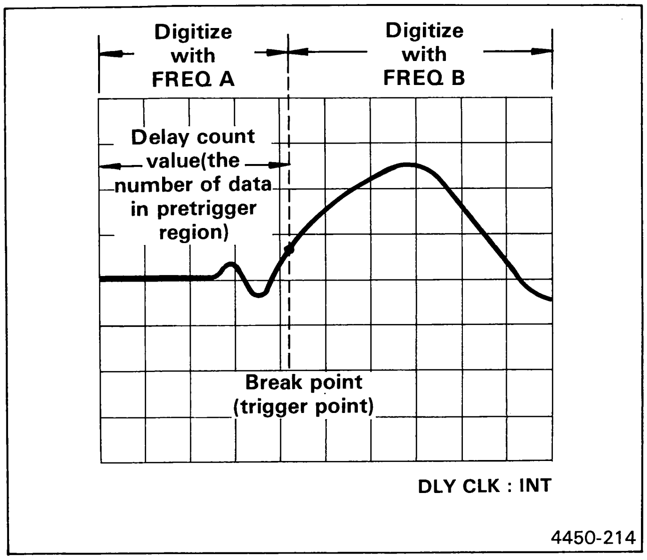

Digitize with FREQ A
Digitize with FREQ B
Delay count value(the number of data in pretrigger region)
Break point (trigger point)
DLY CLK : INT
4450-214

Figure 2-14. Pre-trigger mode using Time Base A + B.

set to Pre Trig, the Trig Mode to Norm, the (Trigger) Source to Ext and no signal is fed into the EXT TRIG IN connector, the waveform memory updates the new data with no trigger pulse generated, and the input signal is displayed on the display monitor continuously as it would with a pen recorder. This operation is designated as roll mode. Roll mode is used for continuously monitoring a low-frequency signal.

## POST-TRIGGER FUNCTION

In the post-trigger mode, the waveform following the trigger generation is displayed as in a conventional oscilloscope.

### Basic Operation

When a trigger input occurs, the delay counter starts, and after having counted a specific number of sample clock (or external delay clock) pulses, it will generate a delayed trigger signal (Fig. 2-15). If Time Base A is selected, A/D conversion of the waveform starts with the delayed trigger signal and ends when the entire waveform memory has been written. If the Time Base A+B mode is selected, A/D conversion of the waveform starts with the trigger; the sample frequency is then switched by the delayed trigger signal from Freq A to Freq B, and the conversion ends when the entire waveform memory has been written.

When the internal delay clock is used, the clock frequency of the delay counter is the same as the sample frequency. In this situation, the number of data in the section with Freq A (if the Time Base is set to A+B) coincides with the set value of the delay counter.

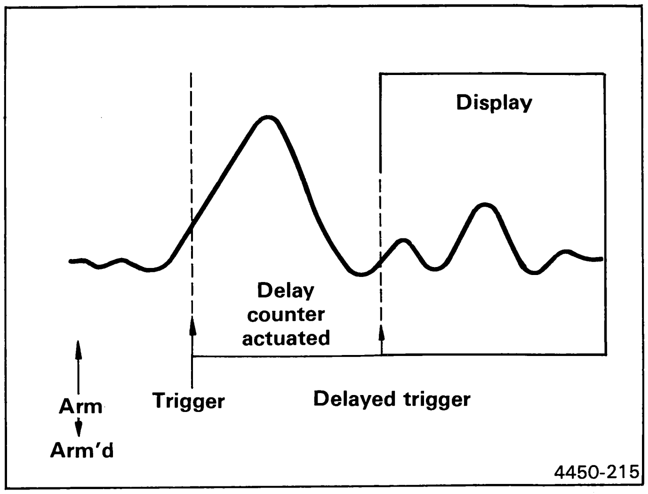


Figure 2-15. Timing of significant events in Delayed-trigger mode.

For both internal and external delay clocks, the value set on the delay counter is displayed on the indicator as the delay count reading.

### Operation with Time Base A

All data are taken in at the sample frequency A. The time interval from the actual trigger point to the start of waveform acquisition, $T_d$, is set by the delay count value. The $T_d$ value is given by the following formula:

When the Dly Clk is set to Int,
$T_d = (1/\text{Freq A}) \times \text{delay-count value (sec)}$

When the Dly Clk is set to Ext,
$T_d = (1/\text{external delay clock frequency}) \times \text{delay-count value (sec)}$

A bright spot on the display monitor represents the delayed trigger point (Fig. 2-16).

### Operation with Time Base A+B

The trigger point will be displayed at the beginning (left end) of the monitor trace, and the delayed trigger point is the break point at which the sample frequency is switched from Freq A to Freq B. This mode is to be used for expanding or compressing the waveform after a certain time from the trigger point, as in the case of a mixed sweep in an oscilloscope (Fig. 2-17).

When the internal delay clock is used, the delay count value represents the number of samples acquired at Freq A. It

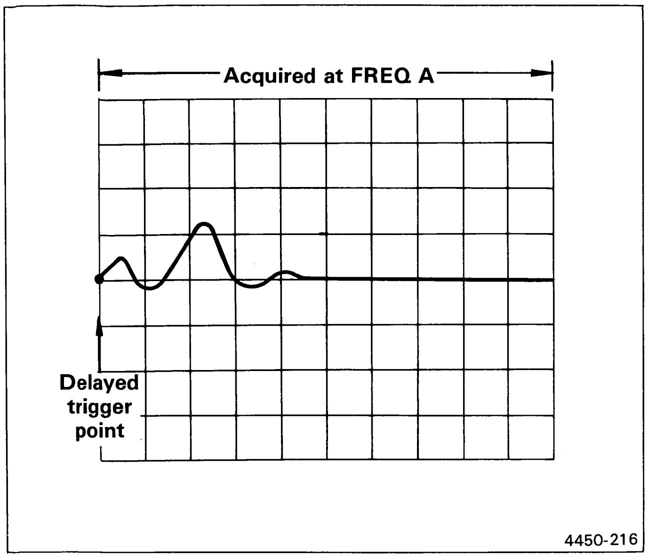


Figure 2-16. Post-trigger mode using Time Base A.

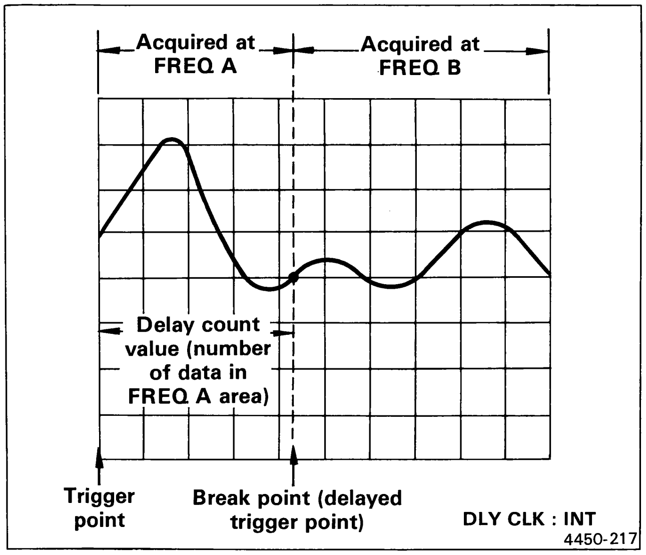

Acquired at FREQ A
Acquired at FREQ B
Delay count value (number of data in FREQ A area)
Trigger point
Break point (delayed trigger point)
DLY CLK : INT
4450-217

Figure 2-17. Post-trigger mode using Time Base A + B.

should be noted that the sample period immediately preceding the break point includes the same error as in the case of the pre-trigger mode. (See Pre Trigger Function and Roll Mode, in this section.)

## DELAY-COUNT VALUE

The 390AD has five kinds of delay-count-value memory. Whenever the modes are changed, the content of corresponding modes is read out as the delay-count value. Each delay-count value can be set independently.

Table 2-1 gives the classification of delay-count-value memory and their respective initial values (at power-on state).

**Table 2-1**
**DELAY-COUNT-VALUE MEMORY**

| Time Base | Record Mode | Vert Mode | Available Setting Range | Initial Values |
|---|---|---|---|---|
| A | POST | CH 1 ONLY<br>DUAL | 0 to 9998 | 0 |
| | PRE | DUAL | 0 to 2046 | 200 |
| | | CH 1 ONLY | 0 to 4092 | 400 |
| A + B | POST<br>PRE | DUAL | 0 to 2046 | 1024 |
| | POST<br>PRE | CH 1 ONLY | 0 to 4092 | 2048 |

Each delay-count value can be changed by one step with the DECREMENT/INCREMENT buttons, though it is changed by two steps when the sample frequency is set to 60 MHz or when the external clock is selected and the rear-panel EXT CLK selector is set to CH 1 ONLY (60 MHz MAX).

When acquiring a waveform with the trigger-point value (break-point position) set by the delay-count value, the position of the bright spot on the monitor may be different from the set value. This is because of trigger error or delayed trigger error. The discrepancy is one point maximum, or within three points if the sample frequency is 60 MHz or if the EXT CLK selector is set to CH 1 ONLY (60 MHz MAX). When Time Base A+B is used, the memory record length (time) value shown on the READOUT indicator before the waveform acquisition may be different from that after the waveform acquisition. This is because of re-indication of true memory length with error corrected after waveform acquisition.

### Use of Time Base A + B

The time base A+B mode is advantageous for observing a part of a waveform expanded in detail while monitoring the entire waveform. When the internal delay clock is used, the memory data length at sample frequency A is set by the delay count value both in the pretrigger and post-trigger modes.

## Pre-Trigger Mode

The data preceding the trigger point are acquired at Freq A, while those after the trigger point are acquired at Freq B. In the case of the waveform shown in Figure 2-18, where a single shot of large-amplitude, high-speed noise occurs in a low-speed signal, it is possible to observe the waveform after the trigger expanded in detail while monitoring the waveform changes preceding it, by setting Freq A to lower and Freq B to higher sample frequencies.

For some purposes, it is also possible to set Freq A to higher and Freq B to lower sample frequencies (see Fig. 2-19).

## Post-Trigger Mode

When triggered, the waveform is taken in at sample frequency A, and as the acquisition in the specified Freq A region is finished, the sample frequency is switched to Freq B. For the single-shot noise waveform shown in Figure 2-18, the waveform can be expanded for detailed observation from any point following the trigger point by setting Freq A to lower and Freq B to higher sample frequencies. In contrast, Freq A may be set to higher and Freq B to lower sample frequencies as shown in Figure 2-20.

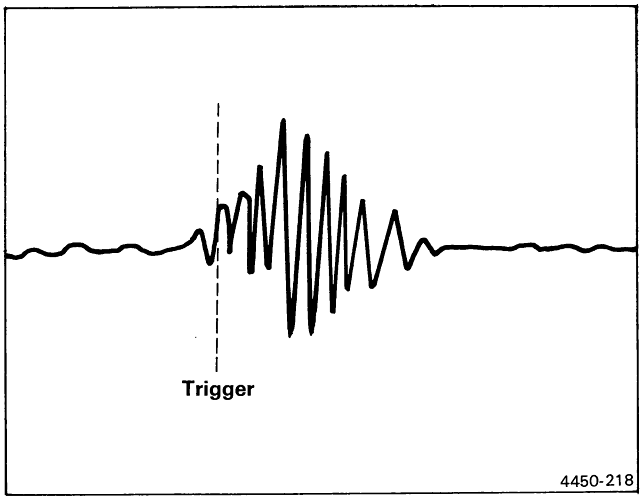


Figure 2-18. Single shot noise signal.

## USE OF EXTERNAL CLOCK

If the available internal sample clock frequencies do not suit the application, an external clock signal can be connected via the EXT CLK IN connector on the rear panel. In such cases, if the input clock frequency is between 0 and 30 MHz, the EXT CLK selector on the rear panel should be set to NORM. If the clock frequency between 30 and 60 MHz is used, set the EXT CLK selector to CH 1 ONLY. When the EXT CLK selector is set to CH 1 ONLY, the VERT MODE must be set to CH 1 ONLY. When the EXT CLK selector is set to NORM, the VERT MODE may be set either to CH 1 ONLY or to DUAL.

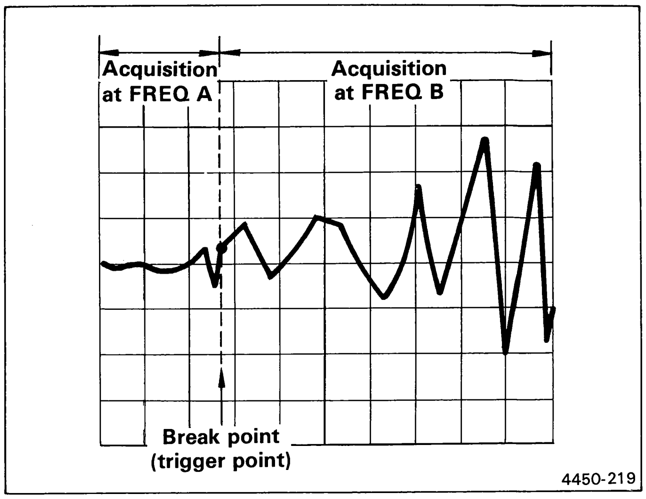


Figure 2-19. Waveform acquisition with Time Base A + B in the pre-trigger mode.

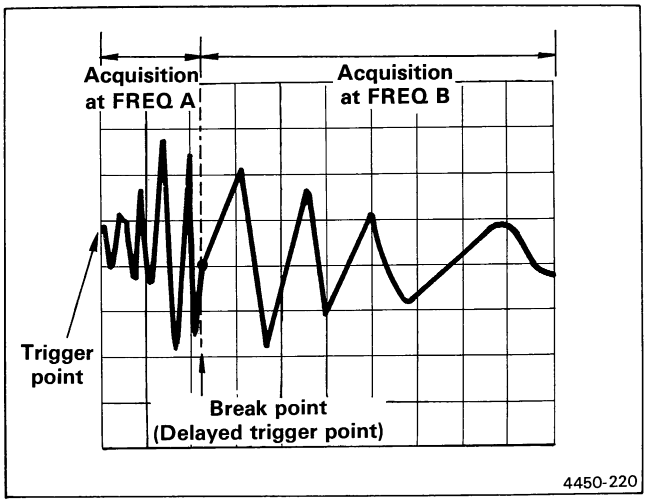


Figure 2-20. Waveform acquisition with Time Base A + B in the post-trigger mode.

When an external clock is to be used, select Sample Freq A/B, press and hold the DECREMENT button pressed until the SAMPLE FREQ indicator reads EL (EXT LOW, at NORM position) or EH (EXT HIGH, at CH 1 ONLY) depending upon the setting of EXT CLK selector. The external clock is now selected. The minimum pulse width of the external clock required in the Specification part of Section 1 should be strictly observed. Otherwise, the instrument could malfunction.

If the EXT CLK selector is set to CH 1 ONLY (60 MHz MAX) and the Vert Mode to Dual, keeping the DECREMENT button pressed may fail to select the external clock. When EH is selected as the sample frequency, the Vert Mode cannot be set to Dual. If the EXT CLK selector is set to CH 1 ONLY (60 MHz MAX) with the Vert Mode set to Dual and EL selected as the sample frequency, the READOUT indicator will display E 605, and the panel input will be invalidated until the EXT CLK selector is reset to NORM.

## HOW TO USE THE EXTERNAL DELAY CLOCK

### Post-Trigger Mode

When the Time Base A is selected, the delay counter starts operating when a trigger signal occurs, and the waveform begins to be acquired immediately after having counted the specified number of external delay clocks. This operation, called "event delay," is one of the most useful applications of the external delay clock. For instance, it is possible to acquire TV video signals on any scanning line by externally triggering with vertical sync and counting with horizontal sync signal used as external delay clock.

When Time Base A+B is selected, waveform acquisition starts at sample frequency A when a trigger signal occurs. At that time, the delay counter starts; when the specified number of external delay clock pulses has been counted, the sample frequency is switched to B. The operation time of the delay counter must be shorter than the time required to write the entire waveform memory at frequency A; i.e., (1/external delay clock frequency) $\times$ delay count value $<$ (1/Freq A) $\times$ memory record length (2048 or 4096).

If this relationship is not held, waveform acquisition will end during the operation of the delay counter, and the normal operation of time base A+B will not be ensured.

### Pre-Trigger Mode

When the internal delay clock is used, the set value of the delay counter is converted into the number of data in the pre-trigger region, which is displayed as the delay-count value. If the external delay clock is used, the set value of the delay counter is directly displayed.

When Time Base A is selected, waveform acquisition starts with the arm input. If a trigger occurs after the ARM'D lamp lights, the delay counter starts counting. When the specified number of external delay clock pulses have been counted, the waveform acquisition will be terminated. Throughout the event, delay operation can be used. In the post-trigger mode, the display of the trigger point becomes meaningless if the operation time of the delay counter is longer than the time required to write all the waveform data into the memory. If the event-delay operation is used, the waveform immediately after the occurrence of the event is acquired in the post-trigger mode, while that immediately preceding the event is acquired in the pre-trigger mode.

When Time Base A+B is selected, the sample frequency is switched from frequency A to frequency B when the trigger input occurs, in contrast to the operation with Time Base A. The operation time of the delay counter should be set shorter than the time required for writing the whole waveform memory at frequency B; i.e., (1/external delay clock frequency) $\times$ delay count value $<$ (1/frequency B) $\times$ memory record length (2048 or 4096)

If this relationship is not maintained, the memory stored at frequency A will be erased, the position of the trigger point will become uncertain, and normal operation with time base A+B is not ensured.

## USE OF WRITE END SIGNAL

When post-trigger data exceeds the waveform memory capacity (4096 words) of the 390AD in the CH 1 ONLY mode, another 390AD can be connected in series in order to expand the memory. The units should be set as described below (Fig. 2-21).

1. Connect the WRITE END output of the first 390AD to the EXT TRIG IN input of the second 390AD. Similarly, connect #2 to #3, #3 to #4, and so on. For these connections, it is necessary to use terminations matching the characteristic impedance of cables used.

2. Connect the input signal in parallel to all 390ADs, and set the ±INPUT RANGE and SAMPLE FREQ as desired.

3. Set the controls of the 390AD units as follows:

| Control | 390AD |  |
|---|---|---|
|  | #1 | All Others |
| ARM | EXT or MAN | AUTO |
| TRIGGER |  |  |
| SLOPE |  | + |
| SOURCE | As Needed | EXT |
| CPLG |  | AC |
| LEVEL |  | 20% |
| TRIG MODE | SINGLE | SINGLE |
| REC MODE | PRE TRIG | PRE TRIG |
| DELAY |  |  |
| Readout | 0 to 5 | 0 to 5 |

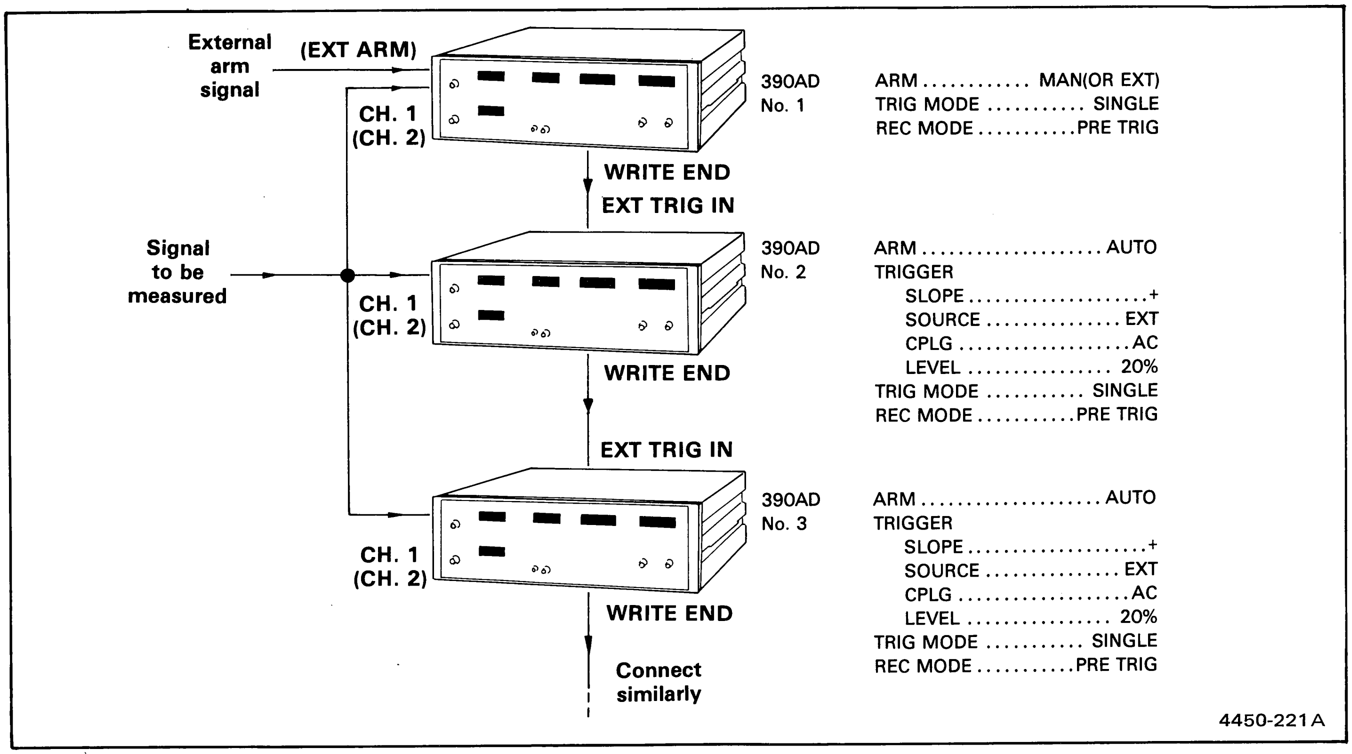

External arm signal
(EXT ARM)
CH. 1
(CH. 2)
390AD No. 1
ARM ........... MAN(OR EXT)
TRIG MODE ........... SINGLE
REC MODE ...........PRE TRIG
WRITE END
EXT TRIG IN
Signal to be measured
CH. 1
(CH. 2)
390AD No. 2
ARM .................... AUTO
TRIGGER
SLOPE ....................+
SOURCE ............... EXT
CPLG ...................AC
LEVEL ................ 20%
TRIG MODE ........... SINGLE
REC MODE ...........PRE TRIG
WRITE END
EXT TRIG IN
CH. 1
(CH. 2)
390AD No. 3
ARM .................... AUTO
TRIGGER
SLOPE ....................+
SOURCE ............... EXT
CPLG ...................AC
LEVEL ................ 20%
TRIG MODE ........... SINGLE
REC MODE ...........PRE TRIG
WRITE END
Connect similarly
4450-221A

**Figure 2-21. Serial connection of several 390ADs to expand the waveform memory record length.**

4. Starting with the first 390AD, press the SYSTEM RESET buttons sequentially. When the READY lamps in all the 390ADs are lit, feed the arm input to the #1 unit.

When the acquisition is completed through these procedures, the ∞ lamps in all the units of the 390AD are lit and the system is ready to present a display on the monitor and transfer a waveform over the GPIB.

If a sample frequency adequately high with respect to the input signal is not available (with few sample points falling in a period of waveform to be acquired), the discontinuity of waveform junction between different units of the 390AD comes to question. In such cases, operate all 390AD units synchronously by using an external clock. When the sample frequency is a few MHz or lower, synchronized operation is achieved by connecting the INT CLK output of the #1 390AD to the EXT CLK inputs of all other units. When connecting the clock, terminate the cables in their characteristic impedance. Variation in the quantity of data in the pre-trigger region due to delay trigger error (by 1 to 3 points) can be compensated by comparing the waveforms at junctions.

When more exact measurement is required, execute AUTO CAL immediately before applying the arm input to all of the 390ADs. Because executing AUTO CAL produces a WRITE END signal, the AUTO CAL sequence should proceed from the last unit toward the #1 unit. When all the steps of Auto Cal are finished, press the SYSTEM RESET buttons in sequence on all 390ADs starting with #1.

## MEMORY LATCH AND LATCH SHIFT

### Memory Latch (MEM LATCH)

The memory latch is used when, with the VERT MODE set to DUAL, one wavefom is kept as a reference waveform and the other is acquired and displayed; or when the waveform is halted immediately in the roll mode. Moreover, when a waveform is transferred via GPIB to the 390AD, the memory is latched automatically. The memory latch cannot be unlatched by the SYSTEM RESET button. When both channels are latched and the DISPLAY TIME becomes infinite, ∞ cannot be cancelled by pressing the SYSTEM RESET button unless either or both channels are unlatched. If the same waveform is input to both channels with the VERT MODE set to DUAL in the roll mode and displayed on the monitor, as soon as an anomaly has occurred, one of the waveforms can be stopped with the memory latch for transferring it to the controller or for detailed visual observation, while constantly monitoring the waveform. (See Pre-Trigger Function and Roll Mode in this section.)

### Latch Shift

The latch shift feature is used to horizontally shift the acquired waveform or the reference waveform transferred from GPIB, while DISPLAY TIME is ∞ and VERT MODE is set to DUAL. This permits the user to compare CH 1 and CH 2 waveforms.

The execution of latch shift while measuring ΔTIME or 1/ΔTIME between two cursors with READOUT may introduce a discontinuity between the cursors. Without the execution of latch shift, ΔTIME or 1/ΔTIME from the left cursor to the right one is indicated. When a point of discontinuity occurs, the readout indicates from the right cursor to the left one along the true flow of time (Fig. 2-22). In this case, the time-unit LED flashes to indicate that true ΔTIME or 1/ΔTIME in reverse direction is read.

Even when the ∞ lamp lights, the LATCH SHIFT button is inoperative unless the waveform acquisition is finished (with the WRIT'G lamp extinguished).

When the LATCH SHIFT button is pressed after the ∞ lamp has lit and the waveform acquisition has been finished, one MEM LATCH button lights exclusively to serve as a selective button for a channel in which the latch shift is to be executed. If both channels have been latched before selecting LATCH SHIFT, the next waveform acquisition cannot be started by SYSTEM RESET. Hence, when the SYSTEM RESET button is pressed, the latch shift function is cancelled to again indicate the current state of MEM LATCH.

## READOUT FUNCTION

Ten different measurements are possible by using various combinations of the two cursors and the three readout functions. The results are read on the indicator. Among these, 1/ΔTIME is used for measuring frequency by placing two cursors across a period of waveform. Table 2-2 shows the 10 combinations of control settings and the readout functions they establish.

The readout function can be selected by one of the following three methods:

1. When the DISPLAY TIME ∞ button is pressed while indicating the waveform acquisiton, the measurement of the same content as the preceding one can be executed.
2. When any FUNCTION button is pressed, the cursors are automatically turned on or off depending upon the content of the selected function.

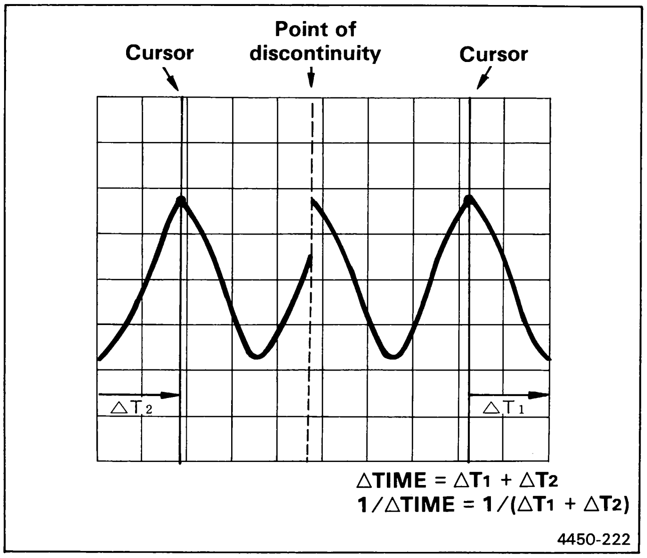


**Figure 2-22. Measurement of ΔTIME or 1/ΔTIME with a point of discontinuity between two cursors.**

3. When the CURSOR button is pressed, Function is selected depending upon the number of cursors indicated.

In any of these cases, when pressing the button during waveform acquisition, the measurement cannot be made until the acquisition is finished (the WRIT'G lamp will go out).

Figure 2-23 shows the measurement of Ch 1 Voltage. The trace intensity is reduced for the channel in which no measurement is made. If the trace disappears entirely, adjus the Intensity control on the monitor. The absolute value voltage at the intersection of the cursor with the waveform is displayed by the indicator.

Figure 2-24 shows the measurement of ΔVoltage between Ch 1 and Ch 2. The indicator reads the voltage difference between the intersections of two waveforms on both channels and the cursor.

Figure 2-25 shows the measurement of Ch 1 ΔVoltage. The intnsity of the Ch 2 trace is reduced, and the voltage difference between the two cursors on the Ch 1 waveform is read in reference to cursor #1 and displayed on the indicator.

Figure 2-26 shows the measurement of Ch 1 ΔTIME. The intensity of the Ch 2 trace is reduced, and the time interval between the two cursors on the Ch 1 waveform is displayed on the indicator in absolute value.

### Table 2-2
### READOUT FUNCTION

| | FUNCTION | | | |
|---|---|---|---|---|
| **Number of Cursors** | **CH 1/ CH 2** | **VOLT/ TIME** | **ΔVOLT ΔTIME/ VOLT 1/ΔTIME** | **Description** |
| 1 | □ | □ | ■ | Absolute value voltage of CH 1 |
| | ■ | □ | ■ | Absolute value voltage of CH 2 |
| | □ | □ | □ | CH 1 VOLT - CH 2 VOLT for one and same time (ΔVoltage between channels 1 and 2) |
| | ■ | □ | □ | CH 2 VOLT - CH 1 VOLT for one and same time (ΔVoltage between channels 2 and 1) |
| 2 | □ | □ | □ | Potential difference between cursors for CH 1 |
| | ■ | □ | □ | Potential difference between cursors for CH 2 |
| | □ | ■ | □ | Time difference between cursors for CH 1 |
| | ■ | ■ | □ | Time difference between cursors for CH 2 |
| | □ | ■ | ■ | Reciprocal of CH 1 ΔTIME |
| | ■ | ■ | ■ | Reciprocal of CH 2 ΔTIME |

| Lamp on: | Lamp off: |
|---|---|
| □ | ■ |

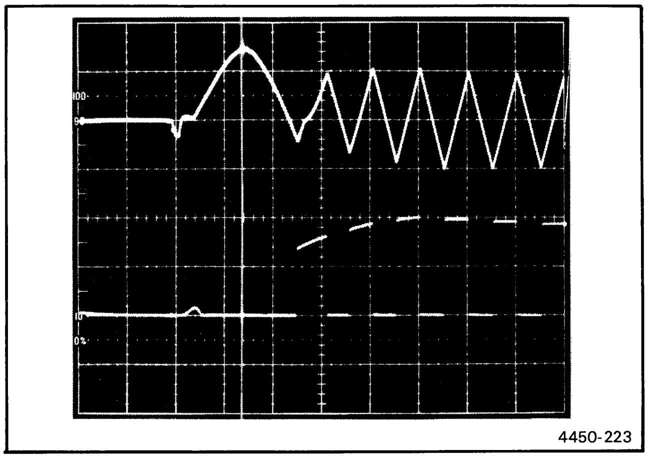


Figure 2-23. Measurement of CH 1 VOLT.

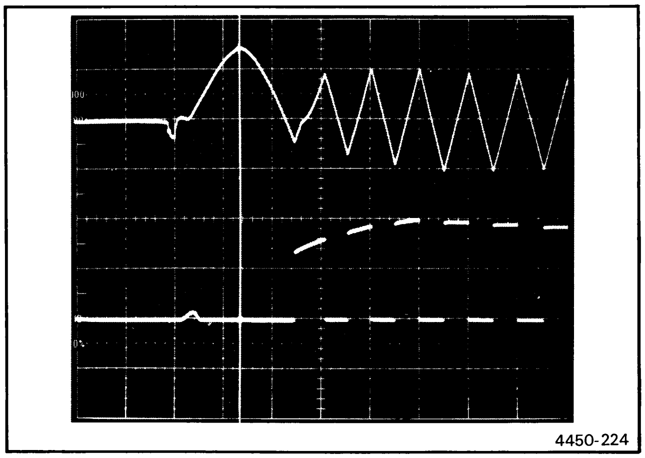


Figure 2-24. Measurement of ΔVOLT between CH 1 and CH 2.

Because ΔTIME in Figure 2-26 corresponds to just one period of the waveforms, the frequency of input waveform is indicated when setting the FUNCTION to 1/ΔTIME.

When cursors 1 and 2 are off, the READOUT indicator reads the memory record length as time. If one of the waveforms acquired is latched with the Vert Mode set to Dual and the sample frequency is changed, two channels have different memory record length (time). However, it is possible to display respective memory record lengths (time) correctly by pressing the CH 1-CH 2 FUNCTION button. The readout function operates properly in this way even when two channels have different sample frequencies.

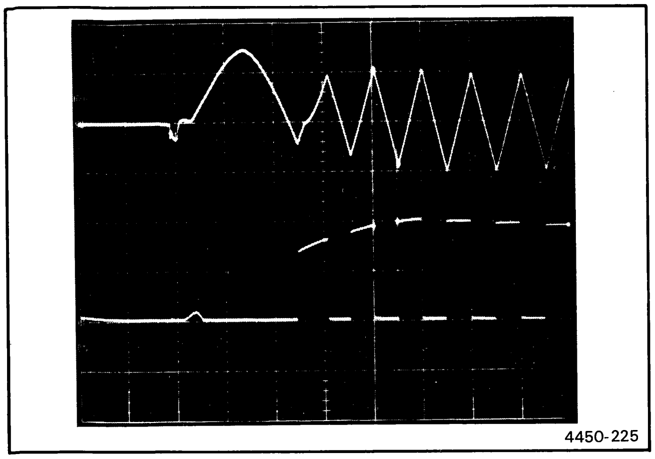


Figure 2-25. Measurementof CH 1 ΔVOLT.

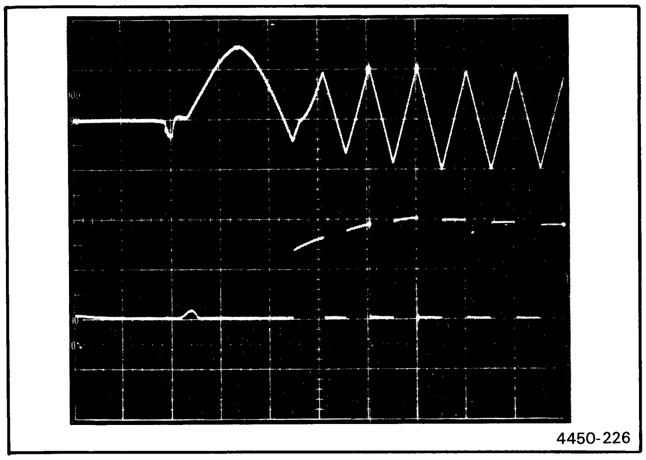


Figure 2-26. Measurement of CH 1 ΔTIME and 1/ΔTIME.

## OUTPUT TO PLOTTER

### Selection of Plot Clock

The plotter output clock in the 390AD has AUTO FAST and AUTO SLOW modes in addition to the ordinary fixed clock mode (selectable for 20, 50, and 100 ms). The AUTO FAST mode is suited for plotters with pens that stabilize within 1 second when an input signal of maximum ampitude is applied. The AUTO SLOW mode is suitable for plotters whose pens need 1 second or more to stabilize. When the AUTO mode is selected, the clock is automatically set slow or fast depending upon whether the signal variation in the waveform acquired is small or large, so that the waveform can be recorded in the minimum time. When the waveform is expanded and recorded with a plotter, the AUTO SLOW mode should be used. To set the plot clock, refer the 390AD to qualified service personnel.

### Specifying Plot Channel and Plot Segment

When the waveform is recorded on a plotter, the DISPLAY TIME should be set to ∞. When the WRIT'G lamp goes out, select the desired channel by using the PLOT CH 1-CH 2 button. When the Display is set to XY, it is not necessary to select the channel. Turn Cursor 1 and Cursor 2 on, and specify the plot segment on the monitor (Fig. 2-27). When Cursor 1 and Cursor 2 positions are interchanged, the same operation is obtained. When both Cursor 1 and Cursor 2 are Off, all the data in the selected channel will be recorded. As in the case of data transfer to GPIB, when a segment is specified with cursors, data from the left cursor to the right one are recorded or transferred, even if the segment includes a point of discontinuity due to the latch shift.

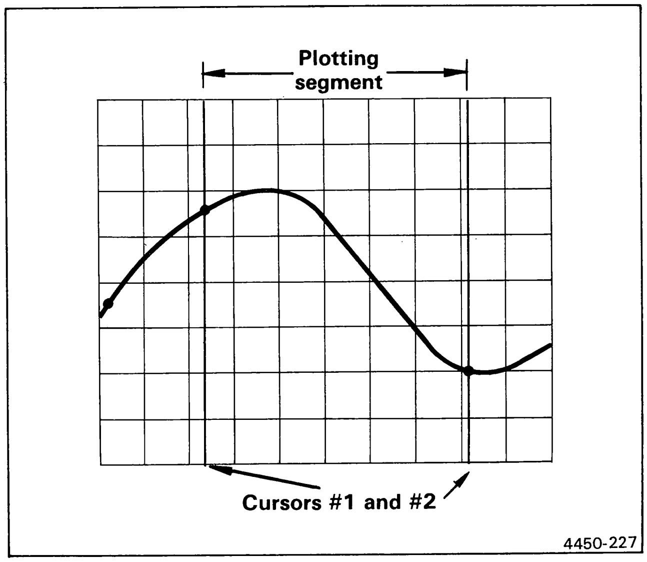


Figure 2-27. Specifying the plot segment with cursors.

### Plot Start

Before recording the waveform, run the plotter without putting the pen down, while adjusting the position and gain controls of the plotter. The POSITION and MAG controls of the 390AD cannot be used for this purpose.

The 390AD converts the full-scale input for ±INPUT RANGE into a signal of 0 to +5 V and sends it to the PLOT X, Y OUTPUT. Accordingly, the ground level is always at +2.5 V.

When the terminal point of the plotting segment is reached, the pen stops. If the plotter adjustment has been completed, press the PLOT START-RESTART button to return the pen to the origin and press the same button again to start. The pen reset to the origin stays there for a few seconds. The delay is provided to put the pen down manually when using a plotter that has no pen up/down feature based on the signal input. Put the pen down and recording will start in a few seconds.

### Plot Reset

When the end point of the plotting segment is reached, the bell sounds and the pen stops. If the plotter is not provided with the signal-input-based pen up/down feature, raise the pen manually. To reset the system to the monitor display, press the PLOT START-RESET button.

If the PLOT START-RESET button is pressed in the course of recording, the pen will stop at that point for a few seconds and then return to the origin.

## SELECTING A SAMPLE FREQUENCY

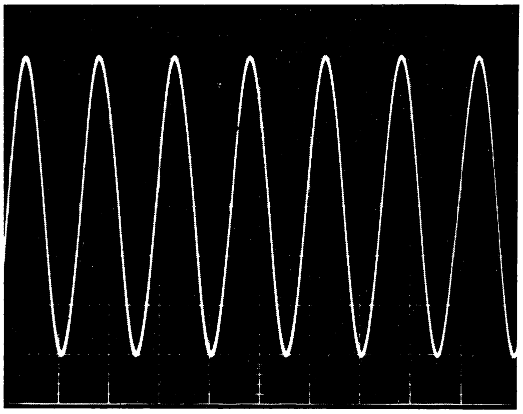
The 390AD samples the analog input signal at discrete time intervals, and A/D converts (quantizes) the voltage levels at sampled time points and stores the data in the digital memory. To measure the analog input signal exactly, the sample frequency must be selected carefully.

Figure 2-28 shows an analog input signal and its waveforms digitized by the 390AD with different sample frequencies, as displayed on the monitor. The waveform in Figure 2-28B is digitized at a sample frequency about 30 times as high as the analog input signal frequency, while that in Figure 2-28C is about 150 times. Because the digitized waveform is displayed as a dot-pattern on the screen of the monitor connected to the 390AD, waveform data of higher fidelity are obtained by digitizing at a higher sample frequency, as shown in Figure 2-28.

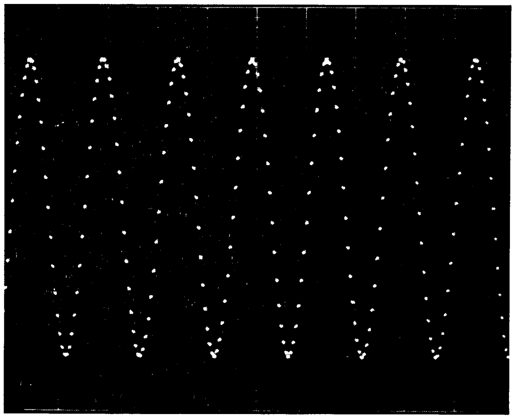
Figure 2-29 shows a slow-changing signal superimposed with fast noise spikes. When sampled at a sampling interval greater than the width of a noise spike (i.e., with a lower sample frequency), a noise spike occurring at the middle of a sampling interval fails to be detected, as shown in Figure 2-29B. However, when a shorter sampling interval (i.e., a higher sample frequency) is used, the noise spike is digitized as shown in Figure 2-29C. It should be noted that much higher sample frequency is required for measuring the waveform of spike noise.

### Aliasing

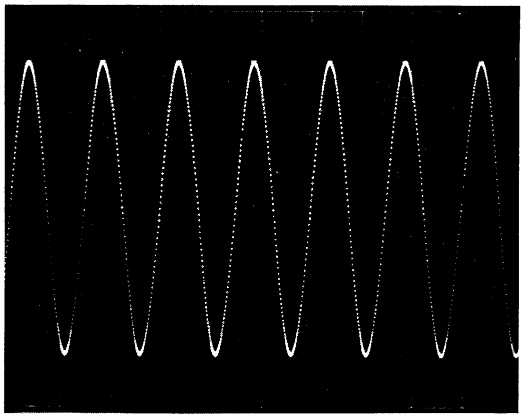
The waveform digitizer involves some unique problems related to sampling in contrast to the conventional oscilloscope. One problem is called aliasing, which occurs when the sample frequency is too low in comparison to the analog input signal.



A. Analog input signal



B. Digitized output waveform



C. Output waveform digitized at a sample frequency 5 times as high as that in B.

4450-228

Figure 2-28. Analog input signal and monitor display of the 390AD output.

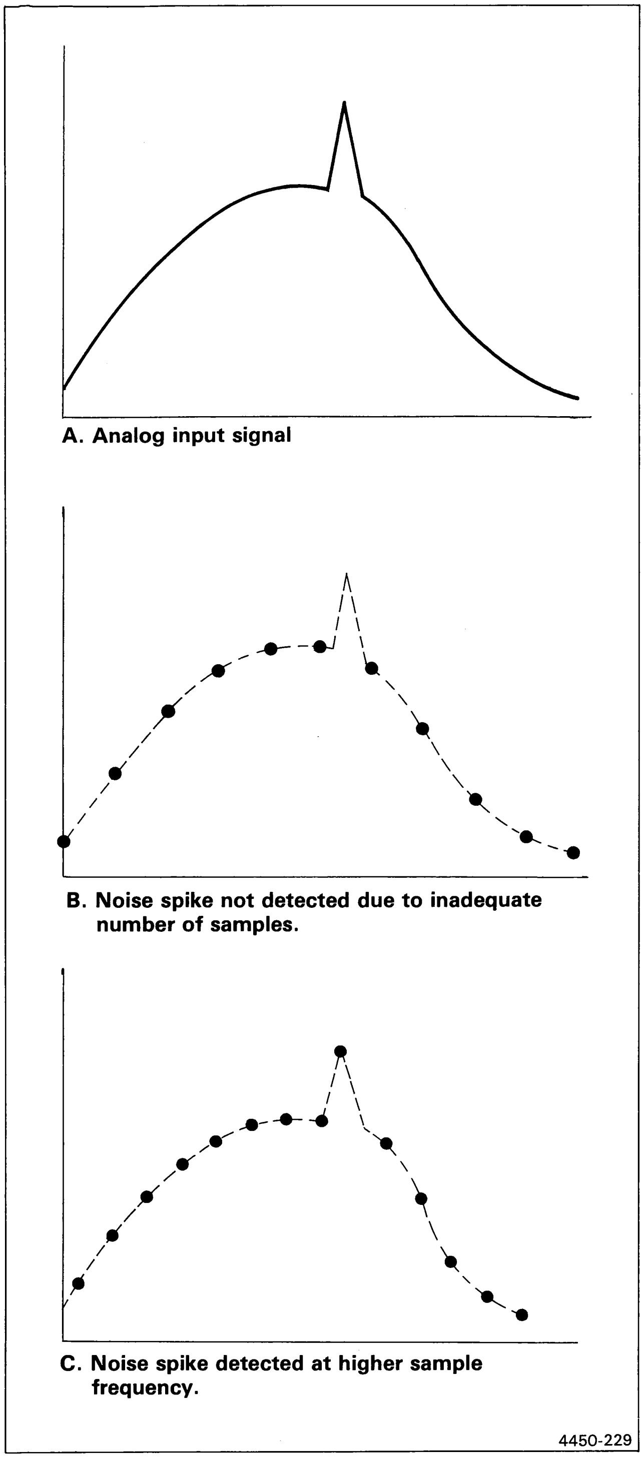

A. Analog input signal
B. Noise spike not detected due to inadequate number of samples.
C. Noise spike detected at higher sample frequency.
4450-229

Figure 2-29. Examples of using too low a sample frequency.

Figure 2-30 shows the occurrence of aliasing. When a sinusoidal wave is fed into the input terminal and digitized at an adequately high sample frequency, the waveform is reproduced on the monitor as shown in Figure 2-30B.

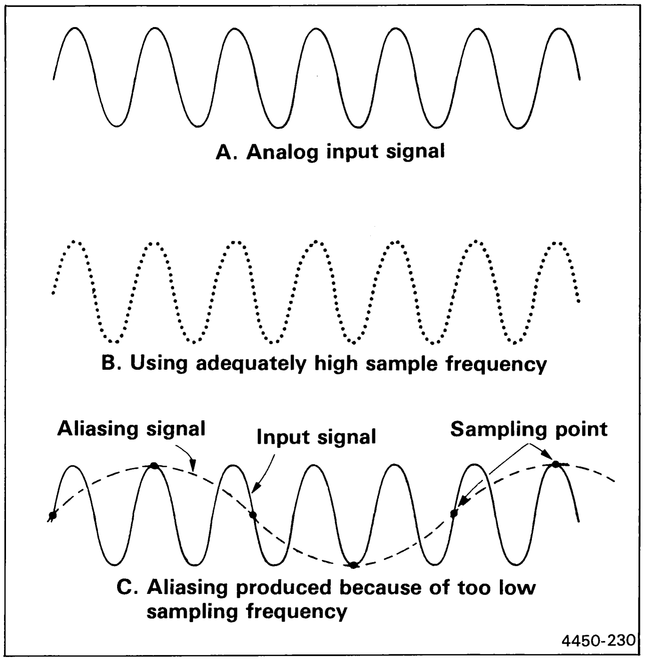

A. Analog input signal
B. Using adequately high sample frequency
Aliasing signal
Input signal
Sampling point
C. Aliasing produced because of too low sampling frequency
4450-230

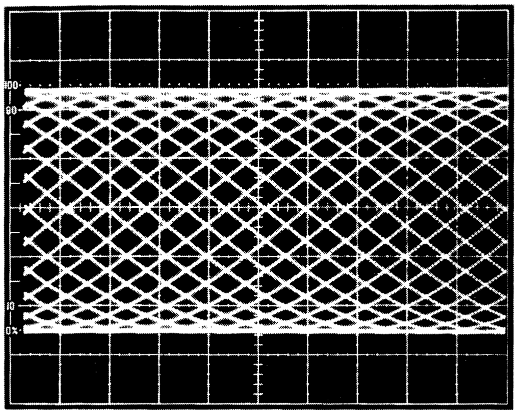
Figure 2-30. Occurrence of aliasing.

However, if the sample frequency is lowered (or the analog input signal frequency is raised) until the sample frequency is slightly lower than the input signal frequency, as shown in Figure 2-30C, the waveform is recorded as shown by the dotted line in Figure 2-30C. The signal is called an aliasing (folded-up) signal, and differs from the input signal.

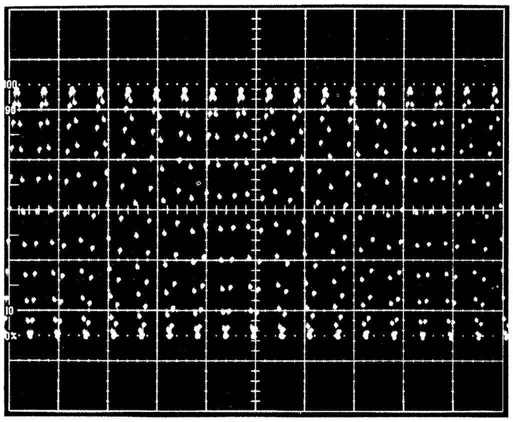
In order to avoid aliasing, it is necessary to select the sample frequency at least twice as high as the highest frequency component of the input signal. If the input signal is unknown, the sample frequency must be set adequately high. If the input signal contains frequency components high enough to cause aliasing even at a 60 MHz sample frequency, use of a filter to eliminate components of frequency higher than the Nyquist frequency (1/2 of sample frequency) is recommended.

Because the monitor used with the 390AD displays the output waveform in dots, interference stripes appear as shown in Figure 2-31A if the sample frequency is an integral multiple of input signal frequency, even when the former is much higher than twice the input signal frequency. This is called perceptual aliasing, a sort of visual illusion caused by dot representation.

In Figure 2-31B, the abscissa of Figure 2-31A is expanded by 10. This display shows that the input signal is a high-frequency signal, not low-frequency as Figure 2-31A seems to indicate. In the normal display, interference stripes ap-



A. Display with perceptual aliasing



B. Display with expanded abscissa by 10.

4450-231

Figure 2-31. Perceptual aliasing.

pear because adjacent dots are visually connected. In contrast to aliasing that occurs with signals of higher frequency than the Nyquist frequency, perceptual aliasing does not prevent faithful display and analysis of waveforms. In order to avoid perceptual aliasing, it is necessary to select a sample frequency as high as possible.

To eliminate aliasing and reduce perceptual aliasing, it is desirable to use as high as possible a sample frequency. However, using a high sample frequency reduces the record time. When a slowly changing signal includes a fast signal, more effective recording can be achieved by using the break point feature. For further detail, see Use of Time Base A+B earlier in this section.

### Setting of Sample Frequency

The 390AD internal clock allows selection of a sample frequency from 5 Hz to 60 MHz when the Vert Mode is set to CH 1 Only, and from 5 Hz to 30 MHz when set to Dual. When the external clock is used, the sample frequency can be set from dc to 60 MHz with the external clock selector switch on the rear panel set to CH 1 Only, or from dc to 30 MHz with the selector set to Norm.

### Precautions for Setting Sample Frequency

1. If the sample frequency is set higher than the upper limit of the external clock frequency, the system may malfunction. It is imperative to observe the specification.

2. When operating in the roll mode, set the sample frequency to 10 kHz or lower, whether the internal or external clock is used. If too high a sample frequency is used, lower the frequency and press the RESET button. For settings in the roll mode, see Pre Trigger Function and Roll Mode earlier in this section.

3. In the GPIB Roll mode, waveform data are continuously sent to the GPIB while acquiring the waveform just as in roll mode. When using the GPIB Roll mode, the sample frequency should be set to 1 kHz or 500 Hz with the Vert Mode set to CH 1 Only or Dual, respectively. Subsequently, as the controller gives Read Roll command, waveform data are continuously sent to the GPIB. When the external clock is used, too, the upper limit of the sample frequency should be 1 kHz or 500 Hz, as mentioned above. When the GPIB controller operates at a lower speed or is doing complicated processing, the maximum sample frequency in the GPIB Roll mode is limited by the processing rate of the GPIB controller.

   If the sample frequency is too high, the 390AD will give a SRQ signal to the GPIB and leave GPIB Roll mode automatically.

## ALARM AND ERROR MESSAGES ON FRONT PANEL

If an error is detected through the self test or automatic calibration, the bell sounds and an error code is displayed on the READOUT indicator. The errors involve internal errors detected in the self test, internal warnings given in the automatic calibration, execution errors related to actual button operation, and power-fail errors concerning the power supply.

Table 2-3
INTERNAL ERRORS

| No. | Meaning |
|---|---|
| 001 to 010 | ROM checksum errors |
| 101 to 104 | RAM read-write test errors |
| 201 to 240 | Waveform data RAM read-write test errors |
| 301 to 346 | Front-panel key switch constantly closed errors |
| 401 to 410 | Circuit test errors |

When an internal error occurs, a hardware failure may be suspected.

Table 2-4
INTERNAL WARNING

| No. | Meaning |
|---|---|
| 501 to 521 | Automatic calibration error |

If an internal warning is given, it is necessary to readjust the 390AD.

Table 2-5
EXECUTION ERROR

| No. | Meaning |
|---|---|
| 605 | When an external clock is selected as the sample clock and Vert Mode is set to Dual, the EXT CLK selector switch on the rear panel should not be moved. When this error occurs, all the keys are inoperative. Return the EXT CLK selector switch to the NORM position immediately. |

If the bell sounds when pressing a button, it means that the command cannot be executed with the 390AD's current settings.

Table 2-6
POWER-FAIL ERROR

| No. | Meaning |
|---|---|
| 901 | Power supply trouble |

When this error occurs, either the ac power connected to the 390AD or the power supply in the 390AD has failed. In this case, turn off the ac power to the 390AD immediately. Check the power line. If the power line is normal, the power supply in the 390AD is at fault. Contact your local Tektronix field office or representative.

# SIMPLE OPERATIONAL PROCEDURES

## METHOD OF WAVEFORM STORAGE

Before connecting the 390AD power cord to the power outlet, read Connecting AC Power in Section 1.

Check the line voltage and set the PRINCIPAL POWER SWITCH on the rear panel to ON. Press the POWER switch on the front panel and the 390AD will be powered up. Keep the POWER switch pressed for a few seconds because the response time is set long to avoid erasing the stored waveform data unintentionally.

If the display monitor is connected, the ground level is displayed as shown in Figure 2-32A, where the full scale of input range is set to eight divisions on the monitor screen.

For acquiring a sinusoidal wave of about ±0.5 V, proceed as follows. Set the ±Input Range to ±1 V.

Press the DECREMENT button (abbreviated as DEC) and release it immediately. The setting of ±Input Range is reduced by one step (input sensitivity raised). Faint relay noise is audible for each stepping, as in the case of executing Auto Cal.

The ±Input Range can be set from ±50 V down to ±1 V by pressing the DEC button five times. Otherwise, keep the DEC button pressed to reduce the setting continuously and release it when the desired range is attained.

Feed a sinusoidal wave of ±0.5 V, 50 kHz from a signal generator into the 390AD, and the waveform is displayed on the monitor as shown in Figure 2-32B. Other settings on the front panel are the same as those at the power-on state.

The 390AD will acquire the waveform and display it on the monitor, repeatedly. The WRIT'G lamp at the bottom of the trigger section on the front panel will flash, indicating that waveform acquisition and display on the monitor are being repeated. The repetition rate can be changed by turning the DISPLAY TIME ADJ control. When the acquired waveform is to be observed in detail, the display time on the monitor can be extended by turning the ADJ control clockwise. If the ADJ control is turned counterclockwise, changes in the waveform can be traced as with a conventional oscilloscope.

A bright spot at the first graduation on the abscissa of the monitor represents the trigger point.

When the acquired waveform is to be stored, the waveform data in the waveform memory on the CH 1 side can be protected by pressing the MEM LATCH CH 1 button. The CH 2 waveform can still be acquired.

The WRIT'G lamp flashes to indicate that the waveform acquisition and monitor display are repeated on the CH 2 side. To release the latched waveform memory on the CH 1 side, press the MEM LATCH CH 1 button again.

To observe in detail or analyze the acquired waveform, press the DISPLAY TIME ∞ button. Both CH 1 and CH 2 stop acquiring waveforms, and the data acquired immediately before are stored.

In contrast to an analog storage oscilloscope, the 390AD allows the user to vertically shift or horizontally expand the stored waveform, if an oscilloscope is used as a monitor. It is also possible to displace the waveform horizontally or to expand the abscissa continuously up to 10 times. The horizontal displacement and expansion can be accomplished by turning the HORIZ POS and MAG controls, respectively, at the right side of the front panel (Fig. 2-32C).

To acquire new waveform data after having finished the analysis of waveform data, press the SYSTEM RESET button. Now, the system is ready to acquire and display a new waveform on a monitor.

The 390AD is provided with the manual trigger feature allowing the operator to acquire a waveform at any time. When using this feature, make sure that the Trig Mode is set to Auto and press the MAN-PUSH TO ARM button. When this button is pressed for the first time, the system is set to the manual arm mode, and as the key is subsequently pressed, a waveform will be acquired and displayed on the monitor.

## CAPTURE OF A TRANSIENT WAVEFORM

A single-shot event is captured with the 390AD as described below. The signal occurring at the moment of energizing a sinusoidal wave oscillator is used as an example of transient waveform. The oscillator output amplitude in the steady state is set to ±0.5 V, and the frequency to 500 Hz. Settings on the front panel of the 390AD are the same as those in the initialize state immediately after powering up the system.

With no power applied to the oscillator, connect its output connector to the input connector of the 390AD (CH 1 OR X input in this case) through a coaxial cable.

Set the ±INPUT RANGE on the CH 1 side of the 390AD to ±1 V, as described in Method of Waveform Storage earlier in this section. Because the transient event lasts tens of milliseconds, the sample frequency should be set to 50 kHz.

Press the SAMPLE FREQ A/B button (surrounded by the yellow area), then keep the DEC button pressed until the SAMPLE FREQ A/B indicator reads 50 kHz. Setting can be accelerated by pressing the FAST button and the DEC (<) button together. At this moment, the READOUT indicator reads 40,940 ms for the time required for storing the waveform data in the waveform memory; that is, the overall recording time. The time corresponds to the waveform time from the left to the right ends on the monitor. Accordingly, a division of abscissa on the monitor represents 4.094 ms (40.94 ÷ 10).

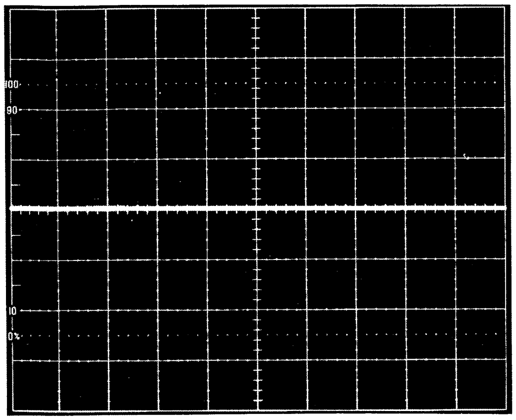
The transient waveform is acquired in the pre-trigger mode. When the system is initialized, the pre-trigger region is set at 200 points (approximately at the position of the first division).

With the sample frequency set at 50 kHz, one division corresponds to about 4.1 ms and to pre-trigger segment 200 address. If the pre-trigger segment is to be set to about 8 ms, the segment should be set to 400 address.

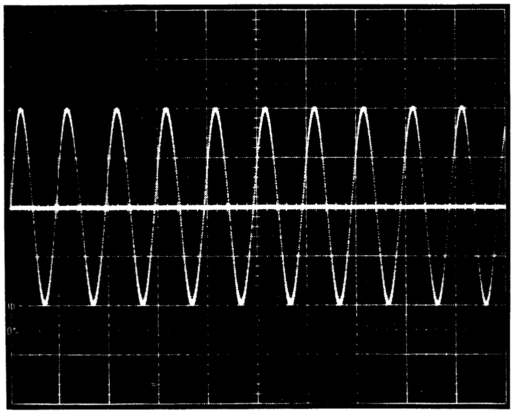
Press the DELAY COUNT button and set the pre-trigger region with the INCREMENT button (abbreviated as INC). When the DELAY COUNT button is pressed, the READOUT indicator reads not sample frequency but the number of pre-trigger region data.

The source of trigger signal is set to CH 1. Because it is unknown whether the transient signal initially deviates in a positive or negative direction, the Slope is set to Both.

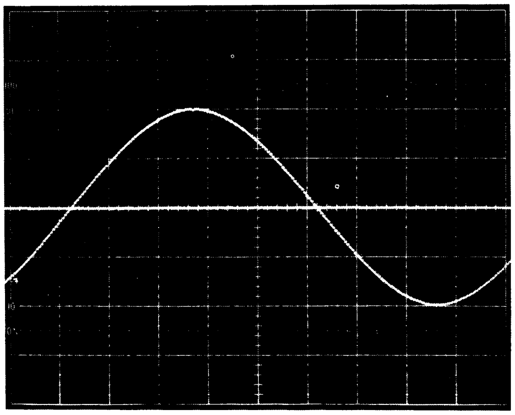
At this moment, the trigger level is automatically set to 5.



A. No input signal



B. Entering a sinusoidal wave of ±0.5 V with the ±INPUT RANGE set to ±1 V



C. Waveform in B with the abscissa expanded by 10

Figure 2-32. Simple waveform displays.

To keep the display of previously acquired transient waveform on the monitor without being affected by new waveforms acquired by subsequent trigger signals, the Trig Mode should be set to Single.

A few seconds after pressing the SINGLE button, the SYSTEM RESET button lights. This means that the trigger circuit is ready to accept a trigger. When the SYSTEM RESET button lights, the system is prepared to acquire the transient waveform.

As the power switch of the oscillator is turned On, a transient wave as shown in Figure 2-33 is acquired. Channel 2, which is receiving no signal, displays the ground level.

The waveform rises from around the second division on the monitor screen, and a bright spot is seen at this point, which represents the trigger point. The area to the left of the bright spot is the pre-trigger region, and the area to the right is the post-trigger region.

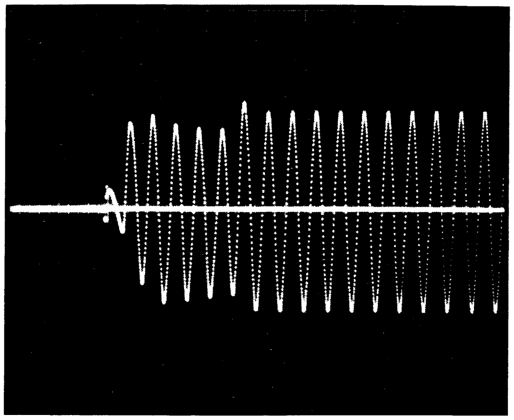


Figure 2-33. Power-on transient of an oscillator.

## USE OF READOUT INDICATOR

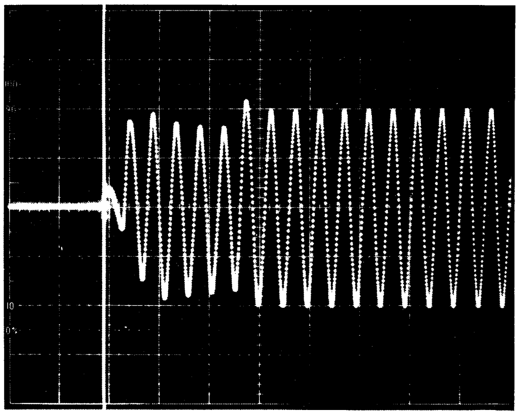
The transient waveform acquired in the previous discussion will be studied with the READOUT indicator.

When the CURSOR button is pressed, a cursor will appear on the monitor.

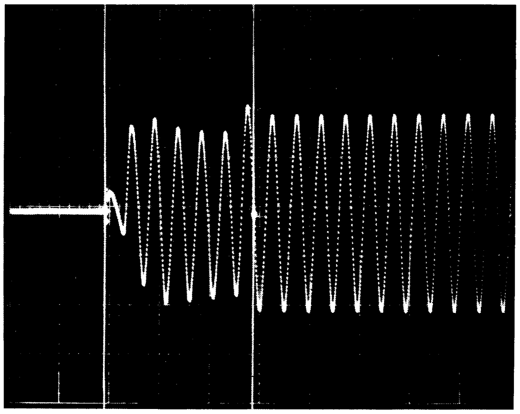
Press the CURSOR 1 button, and a cursor will appear at the left end of the monitor display. At the same time, the SAMPLE FREQ/DELAY/ADRS indicator reads not the sample frequency but the address position (memory address position) of the cursor (initially 0). The READOUT indicator reads the CH 1 voltage with respect to ground. The cursor can be moved to the right or left by pressing the INC or DEC buttons, respectively (Fig. 2-34A).

The READOUT indicator reads the voltage at the intersection of the cursor with the waveform. In this way, the voltage at any point can be read by moving the cursor to the desired point on the waveform.

Press the CURSOR 2 button. Cursor 2 will appear at the right end of the monitor display. At the same time, the SAMPLE FREQ/ADRS indicator reads the address value of cursor 2. (Initially, this will be 2047.) At this time, the READOUT indicator will read the difference voltage (ΔVOLT) between the voltages at the intersections of cursors 1 and 2 with the waveform. For instance, the amplitude of a wave-



A. Cursor #1



B. Cursors #1 and #2

4450-234

Figure 2-34. Use of cursors.

form can be measured by putting cursor 1 to a peak and cursor 2 to a trough of the waveform.

Press the VOLT/TIME button. The lamp will go out, and the READOUT indicator will read the time interval between cursors 1 and 2.

In Figure 2-34B, the time interval from the moment of energizing the oscillator to the time when its output is approximately stabilized is measured by using cursors 1 and 2.

In the case of repetitive waves as shown in Figure 2-34, the period can be measured by placing two cursors across a wave for one period. If the ΔVOLT ΔTIME-VOLT 1/Δ TIME button is pressed during the measurement, the lamp will go out and the READOUT indicator will read 1/ΔTIME, that is, the frequency.

When the measurement is finished, press the CURSOR button again to erase the cursor.

To eliminate the cursor and acquire a new waveform, press the SYSTEM RESET button.

# PROGRAMMING

## INTRODUCTION

This section provides detailed information on programming the 390AD. The section is divided into three main parts. The first part is an introduction to the IEEE 488 bus, while the second discusses the IEEE 488 interface functions implemented in the 390AD. Addressing considerations and response to interface control messages are also discussed. The third part describes the 390AD command set. Message syntax and execution are discussed and detailed descriptions of each command are provided.

## INTRODUCTION TO IEEE 488

IEEE Standard 488-1978 describes a general purpose bus called the IEEE-IB, the IEEE 488 bus, the standard interface bus, the IEC bus, or the general purpose interface bus (GPIB) for instrument systems. Its purpose is to provide an effective communications link over which messages can be carried between instruments in a clear and orderly manner. Instruments designed to operate according to the standard can be connected directly to the bus and operated by a controller with appropriate programming.

### IEEE 488 SYSTEM

The bus has 16 lines, eight for data and eight for control. Information is transferred bit-parallel, byte-serial by an asynchronous handshake. This allows instruments with different transfer rates to operate together if they conform to the handshake state diagrams and other protocols defined in the IEEE standard.

A typical system (Fig. 3-1) could include a controller, such as the TEKTRONIX CP4165 Controller with the CP4100/IEEE 488 Interface, TEKTRONIX CP1164 Controller with the CP1100/IEEE 488 Interface or TEKTRONIX 4050-Series desktop graphic computer; a talker, such as a counter or digital multimeter; and a listener, such as a line printer or signal generator. More than one function can be combined in a single instrument. For example, the SONY/TEKTRONIX 390AD Programmable Digitizer has both a listener and talker function. Many instruments, including the 390AD, also implement some or all of the other functions defined in the IEEE 488 standard, which allow them to, for example, interrupt the normal sequence of events on the bus, report their status, or initiate a device function simultaneously with other devices on the bus. A complete list of the interface functions implemented in the 390AD is given in Table 3-1.

Up to 15 devices, distributed over no more than 20 meters total cable length, can be connected to a single IEEE 488 bus. It is possible, however, to interface more than 15 instruments to a single bus. This is accomplished by connecting several instruments to a primary device, and then connecting just the primary device to the bus. Such a scheme can be used for programmable plug-in units housed in a mainframe. In this configuration the mainframe can be addressed with a primary address code, and the plug-in units can be addressed with secondary address codes.

IEEE 488 is a flexible system—it works either in a star or linear configuration (Fig. 3-2). To maintain the bus electrical characteristics, a device load must be connected for each two meters of cable, and more than half the devices connected at any time must be powered-up. Although devices are usually spaced no more than two meters apart, they can be separated further if the required number of device loads are lumped at any point. Also, if the system includes only the 390AD and a controller, they can be separated by four meters total cable length because each provides a device load.

Messages on the bus are either interface messages or device-dependent messages. Interface messages are used to manage the interface functions of the instruments. They designate talkers and listeners, for example. Device-dependent messages, by contrast, are not used by the interfaces to change their state or configuration, but are passed

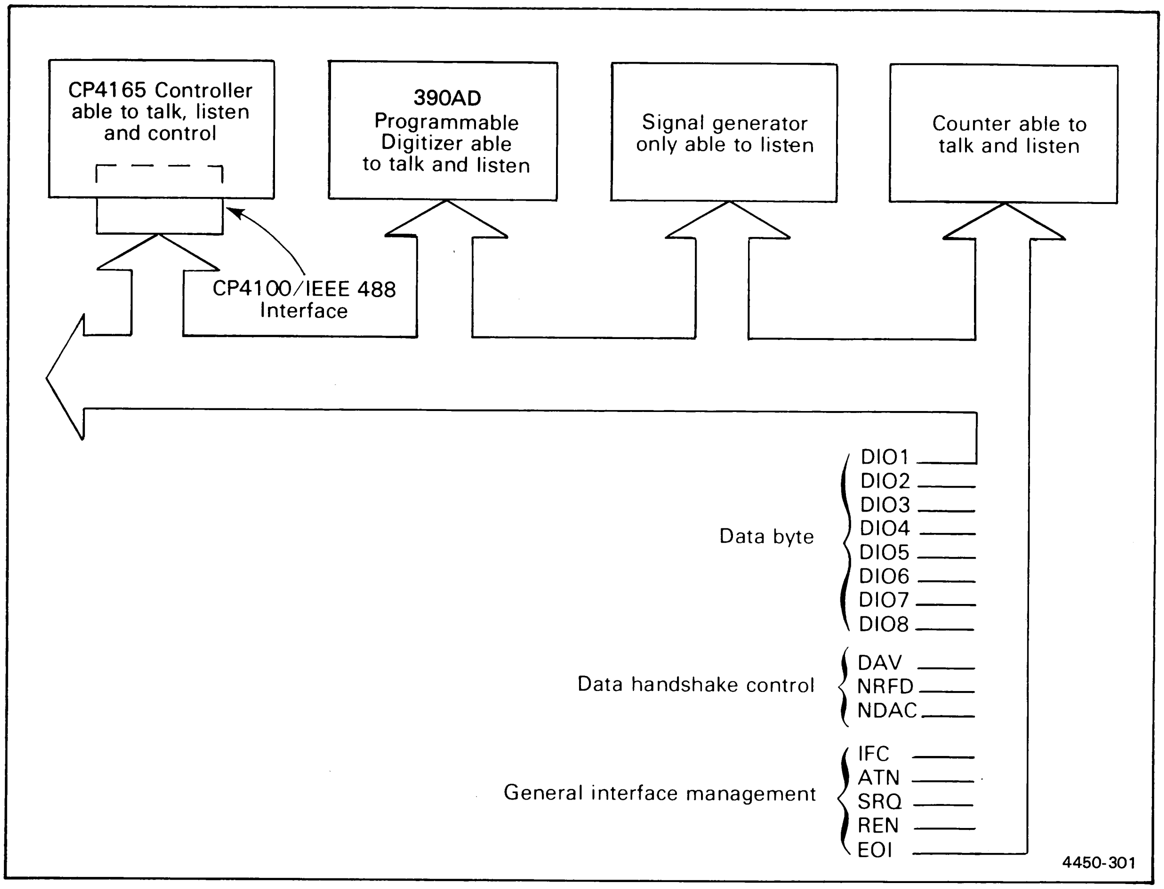

CP4165 Controller able to talk, listen and control
390AD Programmable Digitizer able to talk and listen
Signal generator only able to listen
Counter able to talk and listen
CP4100/IEEE 488 Interface
Data byte
DIO1
DIO2
DIO3
DIO4
DIO5
DIO6
DIO7
DIO8
Data handshake control
DAV
NRFD
NDAC
General interface management
IFC
ATN
SRQ
REN
EOI
4450-301

Figure 3-1. An IEEE 488 system showing some typical instruments and the bus signal lines.

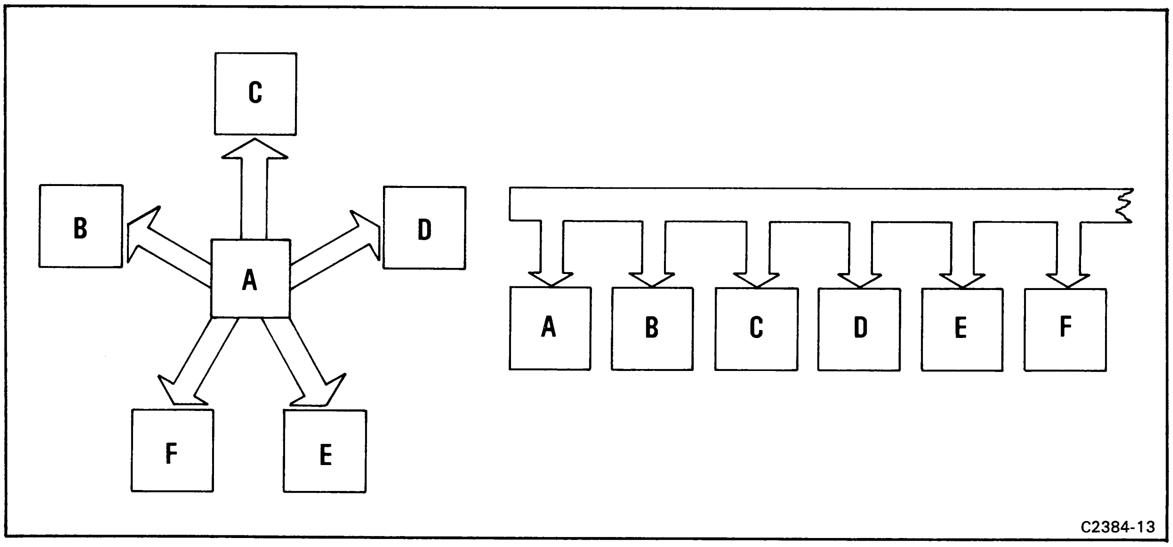

C
B
D
A
F
E
A
B
C
D
E
F
C2384-13

Figure 3-2. An IEEE 488 system can be configured in either a star or linear manner without imparing the bus electrical characteristics.

on to the device functions of the instruments. Such messages can be data, such as a waveform acquired by the 390AD, or remote-control messages, such as the setting of the 390AD's record-length parameter.

## IEEE 488 BUS SIGNAL LINES

The IEEE 488 bus has three groups of signal lines: data, handshake, and control.

1. Eight lines, DI01 through DI08, are used to carry data (message) bytes on the bus.
2. The asynchronous, three-wire handshake is controlled by these lines:
   - DAV (data valid)—asserted by the transmitting device.
   - NRFD (not ready for data) and NDAC (not data accepted)—asserted by the receiving device.
3. Five interface lines are used for other control functions:
   - ATN (attention)—specifies how data on the DIO lines is to be interpreted: as interface messages when asserted; as device dependent messages when unasserted.
   - IFC (interface clear)—used to initialize the interface functions of all instruments and return control to the system controller.
   - SRQ (service request)—asserted to request service from the controller-in-charge.
   - REN (remote enable)—allows remote control of devices on the bus.
   - EOI (end or identify)—indicates the last byte of a message or, when asserted with ATN, polls devices connected to the bus. But the 390AD has no parallel poll function.

See IEEE Standard 488-1978 (ANSI MC 1.1-1975), IEEE Standard Digital Interface for Programmable Instrumentation, for full definition of these lines and protocol for their use. A brief discussion is presented here.

## A BYTE AT A TIME

The data and handshake lines are used for the source and acceptor handshake. Actually, they are two parts of the same handshake. Figure 3-3 shows the states of these lines as they are set by a talker using the source handshake and a listener using the acceptor handshake. Note that the timing diagram relates the electrical signals on the bus to the states of the source and acceptor handshakes. By looking at both, it may be easier to grasp the sequence of the interlocked handshakes than it is to absorb the state diagrams in the standard.

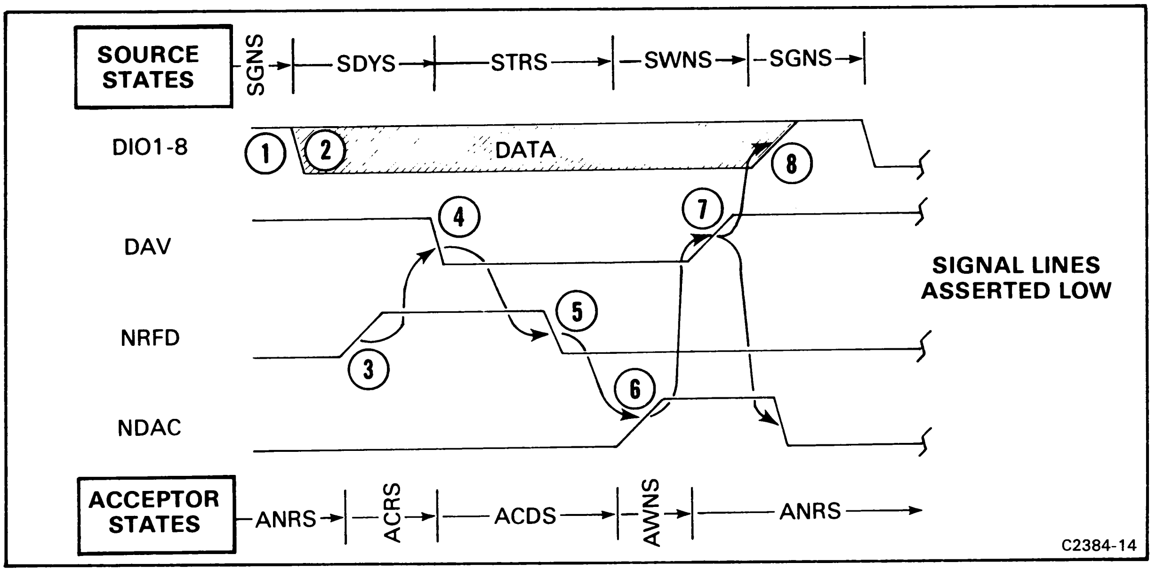


Figure 3-3. Handshake cycle to move a byte over the IEEE 488 bus. The numbers refer to steps described in the text.

1. To begin, the source goes to the Source GeNerate State (SGNS). In this state, the source is not asserting a data byte on the data lines or DAV. When no bus driver is asserting a line, it rises to the high level set by the bus terminating network. The acceptors are in the Acceptor Not Ready State (ANRS), asserting both NRFD and NDAC. In this condition, NRFD and NDAC are low.

2. The source sets the data byte on the data lines and enters the Source DelaY State (SDYS). If this is the last data byte in the message, the source may assert the EOI line at the same time. The source waits for the data to settle on the lines and for all acceptors to reach the ACceptor Ready State (ACRS).

3. Each acceptor says, "I'm ready" by releasing NRFD to move to ACRS. This is one of the points in the handshake designed to accommodate slower listeners. The NRFD line can be thought of as a wired-OR input to the source handshake logic. Any acceptor can delay the source handshake by asserting this line.

4. When the source sees NRFD high, it enters the Source TRansfer State (STRS) by validating the data with DAV. The source then waits for the data to be accepted.

5. When the receiving devices see DAV true, they go to the ACcept Data State (ACDS). Each device asserts NRFD because it is busy with the current data byte and is not ready for another.

6. As each device accepts the data, it releases NDAC to move from the ACDS to the Acceptor Wait for New cycle State (AWNS). Again, all receivers must release the NDAC line for the source to see a high level. When the source sees NDAC high (all have accepted the data), it enters the Source Wait for New cycle State (SWNS).

7. In the SWNS, the source can unassert DAV. This causes the acceptors to proceed to the ANRS, their initial state in the handshake. In ANRS, they assert NDAC.

8. The source continues to the SGNS, its initial state in the handshake. In this state, it can change the data lines to prepare a new byte for transmission.

This is a typical sequence. The exact sequence is defined by the state diagrams in the standard. The only requirement is that if what happens on the signal lines differs from the above sequence, it must still conform to the state diagrams.

Although the above sequence involved a talker and listener(s), they are not the only ones allowed to use the handshakes. The source handshake is also used by the controller-in-charge to send system control messages; these are called interface messages to distinguish them from the device dependent messages sent from talkers to listeners (see Fig. 3-4). The controller asserts ATN to get the attention of all devices on the bus and then uses the source handshake to send interface messages on the data lines.

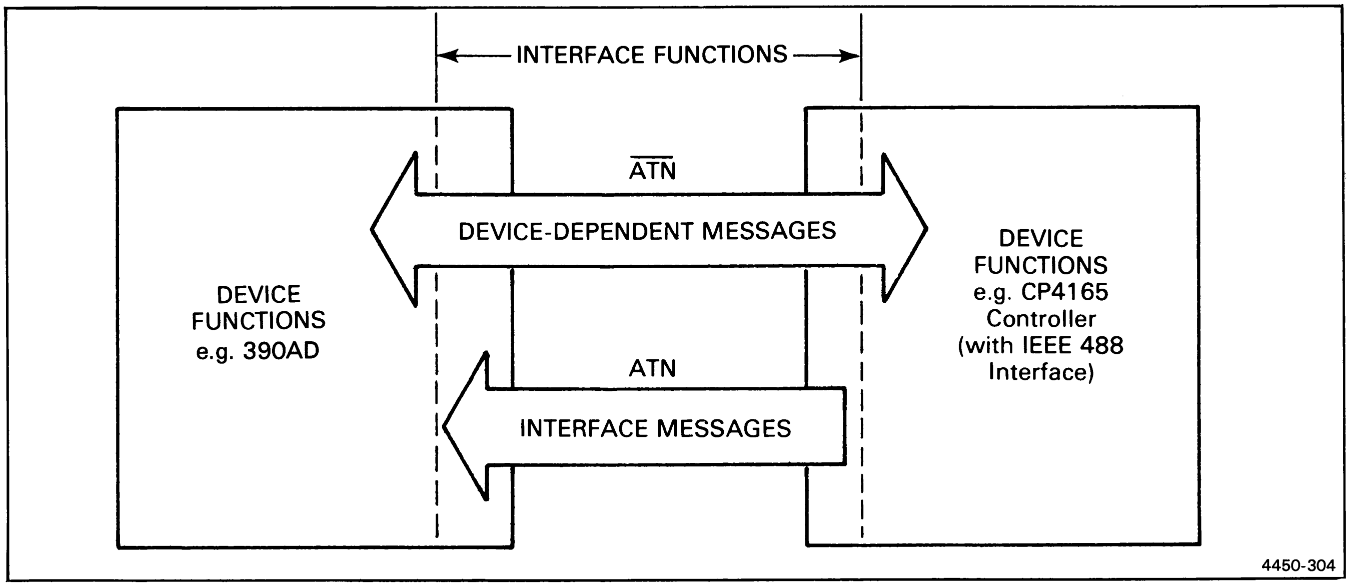

INTERFACE FUNCTIONS
$\overline{\text{ATN}}$
DEVICE-DEPENDENT MESSAGES
DEVICE FUNCTIONS e.g. 390AD
ATN
INTERFACE MESSAGES
DEVICE FUNCTIONS e.g. CP4165 Controller (with IEEE 488 Interface)
4450-304

Figure 3-4. The controller-in-charge asserts the ATN line when sending interface messages.

The interface messages that constitute the controller's vocabulary are defined by the standard. They can be thought of as ASCII codes given new meanings when sent by the controller with ATN asserted.

Three groups of interface messages are reserved for the listen, talk, and secondary addresses. For instance, when a device sees its talk address (called My Talk Address or MTA) and ATN simultaneously, it must become a talker. When the controller removes ATN, the device begins the source hanshake to transmit its data. Similarly, My Listen Address (MLA) and ATN tell a device to listen to the data sent by a talker. Secondary addresses provide unique addresses for devices that share a single listen or talk address.

The controller uses other kinds of interface messages for other tasks. The Serial Poll Enable command (SPE) and the Serial Poll Disable command (SPD) used by the service request interface function are included in these messages. Suppose an instrument is designed to assert SRQ when it has acquired some data. The controller must poll the devices to find the interrupting device, because any one (or more than one) can assert SRQ. To conduct the poll, called a serial poll, the controller sends SPE, a universal command, and then addresses each device in turn and reads a status byte from each. If the device asserted SRQ, it can code the status byte to tell the controller why. When a serial poll is completed, the controller asserts SPD to show the Serial Poll Disable state.

Parallel Poll Configure (PPC) is an example of an addressed command. It prepares addressed devices to indicate who is requesting service. When ready, the devices respond together so a parallel poll is quicker than a serial poll, though more complicated. Parallel poll is not implemented in the 390AD.

Device Trigger (DT) is another function that uses an addressed command: Group Execute Trigger (GET). The DT command arms the 390AD, which will then be triggered by a GET command on the GPIB.

The controller issues the Device Clear message (DCL) to initialize internal functions of devices on the bus. A universal command, DCL applies to all devices. Its effect on each instrument, however, is decided by the designer who can choose to initialize any device function to any state that suits the purpose of the instrument. When the 390AD receives a DCL message, it resets its input and output buffers and resets the status byte (except power-up).

# 390AD/IEEE-488 INTERFACE

The 390AD can be operated by remote control over the bus specified in IEEE Standard 488-1978. This section describes the functional characteristics of the interface and its response to interface control messages. Because the interface is the link between the IEEE 488 bus and the 390AD, an understanding of the interface functions is necessary to effectively program the instrument.

The 390AD is fully programmable; all the panel functions except ON/OFF, display monitor adjustments, DISPLAY TIME control, and rear-panel switches can be controlled over the IEEE 488 bus.

*NOTE*

*Hereafter, the programming examples in ( ) are performed with a Tektronix 4050-series desktop computer.*

## IEEE INTERFACE FUNCTION SUBSETS

IEEE Standard 488-1978 identifies the interface function repertoire of a device on the bus in terms of interface function subsets. These subsets are defined in the standard. The subsets that apply to the 390AD are shown in Table 3-1.

**Table 3-1**
**390AD INTERFACE FUNCTIONS**

| Function | Subset | Capability |
|---|---|---|
| Source handshake | SH 1 | Complete |
| Acceptor handshake | AH 1 | Complete |
| Talker | T 6 | Does not use secondary address.<br>Cannot be set to talk-only mode. |
| Listener | L 4 | Does not use secondary address.<br>Cannot be set to listen-only mode. |
| Service request | SR 1 | Complete |
| Remote/local | RL 1 | Complete |
| Parallel poll | PP 0 | None |
| Device clear | DC 1 | Complete |
| Device trigger | DT 1 | Complete |
| Controller | C 0 | None |

## ADDRESSING

The 390AD IEEE 488 bus addresses are selected by rear-panel switches. Primary bus addresses can be set over the full range allowed by the IEEE 488 standard: 32 to 62 (decimal) for My Listen Address (MLA) and 64 to 94 for My Talk Address (MTA). However, the values of the 390AD MLA and MTA are not independent of each other—they share the same lower five bits. If the internal switches are set for a MLA of 33, for instance, MTA is set to 65.

Because a secondary address cannot be set in the 390AD, it is not necessary to send it to the 390AD. If a secondary address is sent, it will have no effect.

*NOTE*

*In the following programming examples, Device (Primary) address is set to 1. In other words, listen address (MLA) is set to 33 and talk address (MTA) to 65.*

## REMOTE/LOCAL FUNCTION

The remote/local function of the 390AD is controlled by the IEEE 488 system controller and the front-panel LOCAL button. The instrument may be in one of four states: local, remote, local-with-lockout, or remote-with-lockout (Fig. 3-5).

### Local

The 390AD will power-up in the local state. To return to the local state from the remote state, one of the following conditions must occur:

1. The LOCAL button must be pressed (when not in remote-with-lockout state).
2. The remote enable line (REN) must change from asserted to unasserted.
3. The instrument must receive the GTL (Go To Local) message while addressed as a listener.

The LOCAL button will light to indicate that the instrument has returned to local control.

An execution error occurs if a device-dependent message that may change the 390AD setting (i.e., input range change) is received in the local state. This kind of message can be received in the remote state only.

### Remote

The 390AD makes the local-to-remote state transition when it receives MLA with ATN and REN asserted. Front-panel functions that affect the state of the 390AD or its data memory are disabled, except for LOCAL, REMOTE and POWER. All front-panel functions, such as indicators and lamps, that do not affect the state of the instrument or data memory remain operational. The front-panel indicators are always active and they show the current state of the instrument. (Example: ATN line comes to be asserted by @ mark and not to be asserted by ":". REN line comes to be asserted automatically while a program is executing. WBYTE @63, 95, 33:.......)

### Lockout

When the local lockout (LLO) interface message is received with ATN asserted, the 390AD lights the LOCKOUT button and enters the remote-with-lockout state, or the local-with-lockout state.

In local-with-lockout state, both the LOCAL and LOCKOUT buttons are lighted. It appears the same as the local state to the operator; however, there is a difference to the programmer. When the 390AD receives MLA with ATN asserted in this state, it goes to the remote-with-lockout state (assuming REN has not been unasserted), instead of simply going to the remote state as usual. In this state, the front-panel LOCAL button becomes disabled, it cannot be turned to the local state with the front-panel button. Lockout state is reset with REN line unasserted. Figure 3-5 shows examples of transitions between lockout states and the 4050-series commands to cause them.

## RESPONSE TO INTERFACE CONTROL MESSAGES

The 390AD does not respond to the following interface control messages:

1. PPC - Parallel Poll Configure
2. PPU - Parallel Poll Unconfigure
3. TCT - Take Control

The 390AD does respond to the following interface control messages as described:

**GTL** — Go To Local. This causes the instrument to go to the local state. In the local state, device-dependent messages continue to be accepted by the instrument, but only commands that do not affect the state of the instrument or data memory will be executed (e.g., WBYTE @ 33, 1, 63:).

**GET** — Group Execute Trigger. Enabled by DT ON (off at power-on). Executes arming when GET is received with ARM mode set to MAN and MAR command already received before receiving GET. This function is useful in arming simultaneously when more than one 390D is controlled by one controller (e.g., WBYTE @ 8:).

**LLO** — Local Lockout. If the 390AD is in the remote state, the instrument will "lock out" all front-panel controls that affect the state of the instrument or its data memory, including the LOCAL button, except POWER and REMOTE. If the 390AD is in the local state, this message causes the instrument to lock out front-panel controls, except POWER and REMOTE, as soon as the instrument is set to the remote state (e.g., WBYTE @ 17:).

**SDC, DCL** — Selected Device Clear and Device Clear. Either of these messages will reset the input and output buffers, stop the waveform data transfer and reset the status byte (except power-up).
(e.g., WBYTE @33, 4, 65:/WBYTE @20:
WBYTE @33, 4, 65:/WBYTE @20:)

**SPE, SPD** — Serial Poll Enable and Disable. The 390AD has full serial poll capability (e.g., POLL I, J; 1; 2.....).

**IFC** — Interface Clear. This message resets the interface functions only and does not affect the operating modes of the instrument. It has the same effect as sending the UNT (UNTalk) and UNL (UNListen) messages to disable the talker or listener state (e.g., INIT).

## SRQ

One of the interface management bus lines that interrupts the controller is service request (SRQ). An SRQ will result each time the 390AD is turned on, and when any of the following four conditions occur:

| Condition | 390AD Command |
|---|---|
| 1. Input signal exceeds input range of 390AD | OVE(R) |
| 2. Plotter finishes a plotting sequence | PTS |
| 3. User presses 390AD REMOTE button | REM |
| 4. A "waveform-readable interrupt" occurs | WRI |

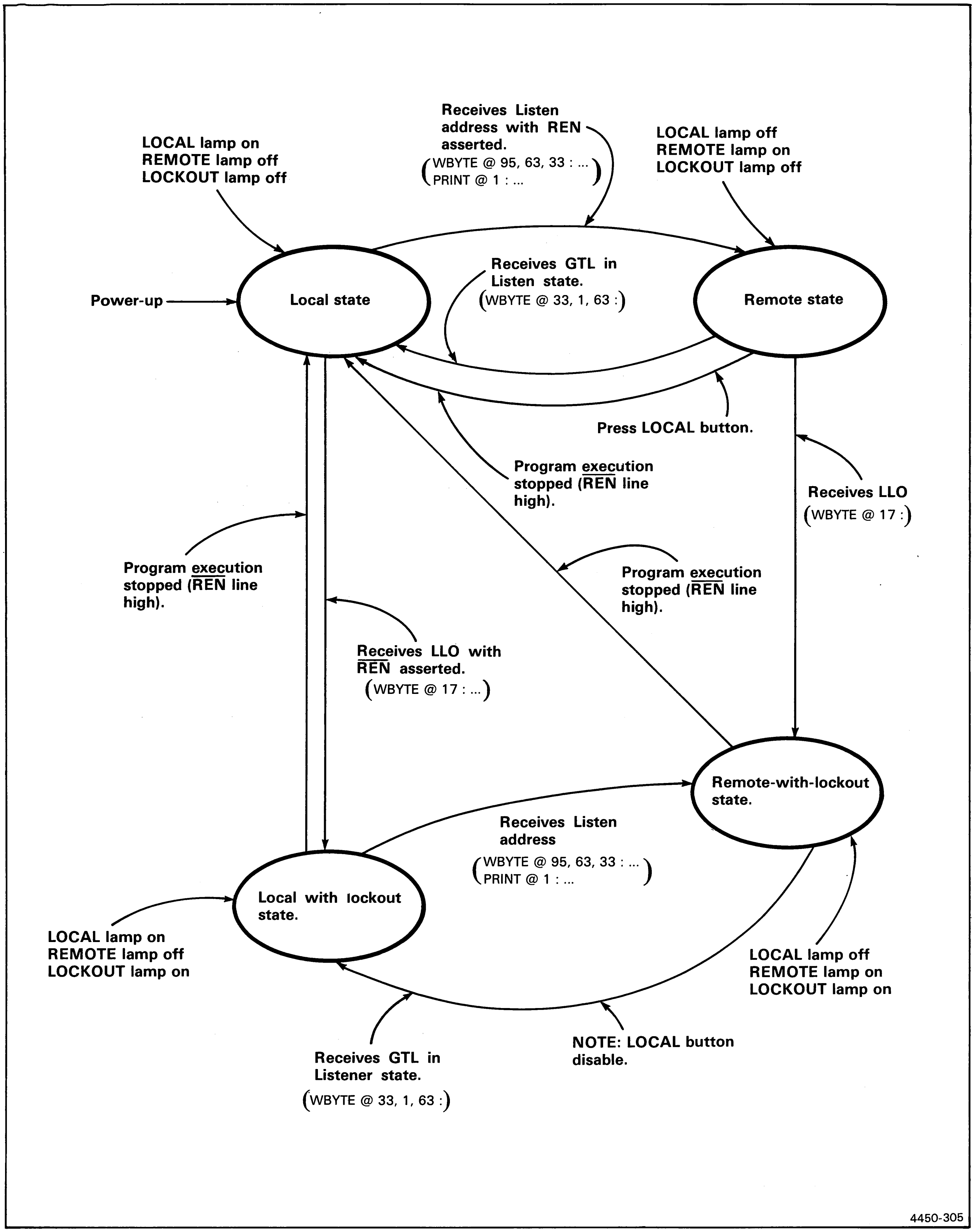

Receives Listen address with REN asserted.
(WBYTE @ 95, 63, 33 : ...
PRINT @ 1 : ...)
LOCAL lamp on
REMOTE lamp off
LOCKOUT lamp off
LOCAL lamp off
REMOTE lamp on
LOCKOUT lamp off
Receives GTL in Listen state.
(WBYTE @ 33, 1, 63 :)
Power-up
Local state
Remote state
Press LOCAL button.
Program execution stopped (REN line high).
Receives LLO
(WBYTE @ 17 :)
Program execution stopped (REN line high).
Program execution stopped (REN line high).
Receives LLO with REN asserted.
(WBYTE @ 17 : ...)
Remote-with-lockout state.
Receives Listen address
(WBYTE @ 95, 63, 33 : ...
PRINT @ 1 : ...)
Local with lockout state.
LOCAL lamp on
REMOTE lamp off
LOCKOUT lamp on
LOCAL lamp off
REMOTE lamp on
LOCKOUT lamp on
NOTE: LOCAL button disable.
Receives GTL in Listener state.
(WBYTE @ 33, 1, 63 :)
4450-305

Figure 3-5. Remote/Local lockout state transition.

When it is polled to determine the origin of the SRQ, the 390AD will return a code to indicate what caused the SRQ, and clear the SRQ.

More detail about the polling process is included in the Processing for SRQ part of Programming Examples, in this section.

# REMOTE CONTROL MESSAGES

The 390AD remote-control messages are device-dependent messages on the IEEE 488 bus. As such, they are not specified in the IEEE standard. Tektronix has developed a Codes and Formats Standard to enhance compatibility with other IEEE 488 bus-interfaced instruments. To accomplish this, the standard specifies codes and syntax designed to be unambiguous, correspond to those used by similar devices, and be as simple and obvious as possible. The 390AD conforms to this standard, making it easier for the programmer to write and understand the device-dependent code.

The 390AD responds to device-dependent messages that contain one or both of two types of commands: set commands and query commands. A set command causes the instrument to set an operating parameter or mode, begin an acquisition, or send waveform data over the IEEE 488 bus. A query command causes the instrument to return the status of a specified operating parameter or function.

Remote control messages are sent in ASCII and all responses from the instrument, except for waveform data, are in ASCII. The parity bit is ignored on input and set to zero on ASCII input (e.g., PRINT @1: "set or query command").

## INPUT BUFFERING AND EXECUTION

All input to the 390AD is processed by the internal microprocessor. A remote control message begins when the 390AD is addressed as a listener, and the transmitting device begins talking. The message ends when the message terminator is detected by the 390AD. The microprocessor buffers all messages it receives. It does not begin executing the commands until:

1. the input buffer becomes full, or

2. the message terminator is received.

## COMMAND SYNTAX

Formats given for the set and query commands are intended as guides and are not intended to fully define the format.

The following format symbols are used:

| | |
|---|---|
| \|\| | selectable only one |
| <> | indicates a defined element |
| [] | indicates that the element or group of elements is optional and may be omitted |
| ... | follows an element or group of elements that may be repeated |
| {} | grouping |

The following delimiters are used to punctuate 390AD commands:

| Delimiter | Follows |
|---|---|
| <space> | Header |
| <comma> | Argument |
| <semicolon> | Message unit (command) |

When listening, the 390AD responds to either of two message terminators.

1. The EOI line asserted concurrently with the last byte in the message whether data, a format character, or a lower-order delimiter such as a semicolon. This is the standard terminator for Tektronix instruments.

2. The ASCII code for line feed (LF) sent as a byte following the message.

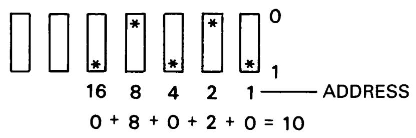
The 390AD can be set in the following two ways to end the message, using the rear-panel switch (Fig. 3-6).

1. When receiving a data transfer, the 390AD recognizes an asserted EOI level as the "End of Message."

   When transmitting, the 390AD asserts EOI with the last character of data being transferred.

2. When receiving a data transfer, the 390AD recognizes an asserted EOI level, or the ASCII code for Line Feed (LF), as the "End of Message." When transmitting, the 390AD sends CR and LF at the end of the message, and asserts EOI at the same time that LF is sent.

**Example: To set primary address to 10.**



*** indicates that this side of the switch is pressed in.**

1. **Set DIP switch in a binary pattern that matches the required address.**
2. **Primary address plus 32 is set as MLA, and primary address plus 64 is set as MTA.**
3. **When the 390AD is operated on the bus in a system of EOI message terminator, sets the switch as follows (Set TERM to 1 when operating with Tektronix controller).**
4. **The 390AD is removed from GPIB with LINE OFF setting, however, the bus load is still connected.**

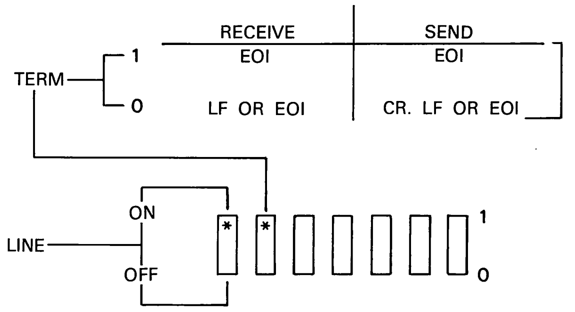


Figure 3-6. Rear-panel address switch.

In the first setting, it is possible to insert a format character (i.e., CR, LF, and/or space) before and after the message, or after the delimiter.

In the second setting, CR and space of a format character can be set between the message as in the first setting. When it receives LF, the 390AD executes the command, for LF is defined as a terminator.

"?;" is transferred when the 390AD is addressed to talk and has no message to transfer. In such a case using the first message terminator setting, the EOI line is asserted when transferring a semicolon. When the second terminator setting is used, CR or LF follows after semicolon, and EOI is asserted when transferring LF.

## NUMBERS

Numbers are assumed to be ASCII-coded decimal digits. Two kinds of numbers are used:

| Representation | Description |
|---|---|
| <NR1> | Signed or unsigned integers including 0 |
| <NR3> | Signed scientific notation |

Examples are:

<NR 1> 0, 123, −4500
<NR 3> 0.23E+4, 1.234E−2

## WAVEFORM DATA I/O

The 390AD can send data in binary rather than ASCII.

Waveform data is sent by the READ command, and entered by the WRT command. This waveform data has the following format:

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

Where:

- % is the ASCII percent character; it acts as a header of the waveform data.
- BYTE COUNT is a 16-bit binary number sent in two bytes, more significant byte first. The value indicates the number of data bytes that remain to be transmitted in the block, including the checksum.
- Data byte is the waveform data. Because the 390AD has 10-bit resolution, 10-bit waveform data is divided into two bytes. The upper two bits are first entered or sent. The lower two bits of the upper byte are the waveform data, and the rest of the upper bits are always 0.

- CHECKSUM is an eight-bit, twos-complement binary number that is the modulo-256 sum of all preceding bytes in the block excluding the % character.
- ; is the ASCII semicolon character.

EOI is asserted when transmitting the last semicolon (;) in the waveform data.

## SET COMMANDS

All commands except those listed as Query-Only commands in Table 3-2 can be used as set commands. The last letter of four-letter headers and arguments can be omitted from set commands.

The format for a single set command is:

<header><space><argument>[{<comma><argument>}...]

Examples of set commands are:

```
ARM NOR
DTI
READ CH1, 0, 1023
```

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

<set command><semicolon><set command>[<semicolon><set command>]...[<semicolon>]

Command example:

```
IR 1 2; IR2 2; OF1 10; OF2 10
(e.g., PRINT @1:" IR1 2; IR2 2; OF1 10; . . .)
```

## QUERY COMMANDS

Unless noted as a set command only, all commands in Table 3-2 can be used as query commands. A query is executed in either the remote or local state. A message that contains only a query command requires the following syntax:

<header><question mark>[<semicolon>]

Examples are:

```
ID?
IR1?;
```

More than one query command can be sent as a single message by inserting a semicolon between commands. Set commands linked with query commands can be sent as single messages; however, SET? cannot be sent in conjunction with other queries.

Command examples are:

```
OF1?; OF2?
TMO NOR; TSL?; TLV 10
```

Example:

```
100 PRINT @ 1: "OF1?"
110 INPUT @ 1: A$
120 PRINT     A$
```

The response (CH 1 offset value) returns to display on the crt.

## COMMAND SUMMARY

Table 3-2 provides a summary of 390AD commands and arguments. Complete command descriptions are given later in Command Descriptions (e.g., PRINT @1: "command").

*NOTE*

1. *The set form of this command is not executed in the Local state. The query form (where applicable) is executed in Local or Remote. (NOTE: The 4050-series controller is automatically set to the remote state by PRINT @1: or WBYTE @ 95, 63, 33:.)*
2. *Can be used only as a set command.*
3. *Power-up condition.*
   *(NOTE: At power-on, power-on SRQ is asserted in the local state.)*

## Table 3-2
## 390AD COMMAND SUMMARY

| Header | Argument | Description | Notes |
|---|---|---|---|
| | | **Instrument Commands** | |
| CLR | CH1 | Clears Channel 1 waveform data. | 2 |
| | CH2 | Clears Channel 2 waveform data. | 2 |
| DT | ON | Enables the device trigger function. | 1 |
| | OFF | Disables the device trigger function. | 1, 3 |
| LAM(P) | ON | Turns the front panel lamp on. | 1, 3 |
| | OFF | Turns the front panel lamp off. | 1 |
| OVE(R) | ON | Asserts SRQ for the input overrange condition. | 1 |
| | OFF | Does not assert SRQ for the input overrange condition. | 1, 3 |
| PTS | ON | Asserts SRQ when the plotter output is completed. | 1 |
| | OFF | Does not assert SRQ when the plotter output is completed. | 1, 3 |
| RDS | AMD | Investigates the arming condition. | 2 |
| | TRD | Investigates the triggering condition. | 2 |
| | WTG | Investigates the writing condition. | 2 |
| | RDY | Investigates the ready condition when the trigger mode is set to single. | 2 |
| | PLT | Investigates whether the XY plotter is recording. | 2 |
| | DT1 | Investigates the display time condition. | 2 |
| REM | ON | Asserts SRQ when the REMOTE button is pressed. | 1 |
| | OFF | Does not assert SRQ when the REMOTE button is pressed. | 1, 3 |
| WRI | ON | Asserts SRQ when the writing is completed. | 1 |
| | OFF | Does not assert SRQ when the writing is completed. | 1, 3 |
| | | **Input Command** | |
| CAL | | The instrument is automatically calibrated. | 1, 2 |
| CP1 | AC | Sets Channel 1 input coupling to AC. | 1, 3 |
| | GND | Sets Channel 1 input coupling to GND. | 1 |
| | DC | Sets Channel 1 input coupling to DC. | 1 |
| CP2 | AC | Sets Channel 2 input coupling to AC. | 1, 3 |
| | GND | Sets Channel 2 input coupling to GND. | 1 |
| | DC | Sets Channel 2 input coupling to DC. | 1 |
| IR1 | <NR 1> \| <NR3> | Determines Channel 1 INPUT RANGE. | 1 |
| IR2 | <NR 1> \| <NR3> | Determines Channel 2 INPUT RANGE. | 1 |
| OF1 | <NR 1> | Determines Channel 1 DC OFFSET. | 1 |
| OF2 | <NR 1> | Determines Channel 2 DC OFFSET. | 1 |
| VMO | DUA(L) | Sets the vertical mode to DUAL. | 1, 3 |
| | CH 1 | Sets the vertical mode to CH 1 ONLY. | 1 |

Table 3-2 (cont)

| Header | Argument | Description | Notes |
|---|---|---|---|
| | | **Trigger Command** | |
| ARM | AUT(O)<br>MAN<br>EXT | Sets the arm mode to auto.<br>Sets the arm mode to manual.<br>Allows arming with the external input. | 1, 3<br>1<br>1 |
| MAR | | Allows arming when the arm mode is set to manual. | 1, 2 |
| TCP | AC<br>HFR<br>DC | Sets the trigger coupling to AC.<br>Sets the trigger coupling to HF REJ.<br>Sets the trigger coupling to DC. | 1, 3<br>1<br>1 |
| TLV | <NR 1> | Determines the trigger level. | 1 |
| TP1 | <NR 1> | Sets a bright spot that represents the Channel 1 trigger point on the monitor. | |
| TP2 | <NR 1> | Sets a bright spot that represents the Channel 2 trigger point on the monitor. | |
| TSL | POS<br>NEG<br>BOT(H) | Sets the trigger slope to positive.<br>Sets the trigger slope to negative.<br>Sets the trigger slope to both positive and negative. | 1, 3<br>1<br>1 |
| TSR | CH 1<br>CH 2<br>EXT | Sets the trigger source to Channel 1 input.<br>Sets the trigger source to Channel 2 input.<br>Sets the trigger source to the external input. | 1, 3<br>1<br>1 |
| | | **Timebase Commands** | |
| DCK | INT<br>EXT | Uses the internal clock for a delay counter.<br>Uses the external clock for a delay counter. | 1, 3<br>1 |
| DLY | <NR 1> | Determines the setting of a delay counter. | 1 |
| DTI | | Sets the display time to infinite. | 1, 2 |
| ML1 | ON<br>OFF | Latches Channel 1 waveform data.<br>Unlatches Channel 1 waveform data. | 1<br>1, 3 |
| ML2 | ON<br>OFF | Latches Channel 2 waveform data.<br>Unlatches Channel 2 waveform data. | 1<br>1, 3 |
| RES | | Resets a system operation. | 1, 2 |
| RMO | PRE<br>POS(T) | Sets the record mode to pretrigger.<br>Sets the record mode to posttrigger. | 1, 3<br>1 |
| SFA | <NR 1>\|<NR 3>\|<br>EXT | Sets sample frequency A. | 1 |
| SFB | <NR 1>\|<NR 3>\|<br>EXT | Sets sample frequency B. | 1 |
| TB | A<br>A+B | Sets timebase A only.<br>Sets timebase A+B. | 1, 3<br>1 |
| TMO | AUT(O)<br>NOR<br>SGL | Sets the trigger mode to auto.<br>Sets the trigger mode to normal.<br>Sets the trigger mode to single. | 1, 3<br>1<br>1 |

Table 3-2 (cont)

| Header | Argument | Description | Notes |
|---|---|---|---|
| **Waveform Data Transfer Commands** | | | |
| R EA(D) | CH 1 | Reads Channel 1 waveform data. | 2 |
| | CH 1, <NR 1>,<NR 1> | Reads the waveform data between the specified addresses in Channel 1. | 2 |
| | CH 1, CUR | Reads the waveform data between the cursors in Channel 1. | 2 |
| | CH 2 | Reads Channel 2 waveform data. | 2 |
| | CH 2, <NR 1>,<NR 1> | Reads the waveform data data between the specified addresses in Channel 2. | 2 |
| | CH 2, CUR | Reads the waveform data between the cursors in Channel 2. | 2 |
| | ROL(L) | Reads the waveform data through GPIB continuously while writing. | 2 |
| QUI(T) | | Completes the mode that reads waveform data through GPIB continuously by READ ROLL command. | 2 |
| WRT | CH 1 | Writes the waveform data to Channel 1 through GPIB. | 2 |
| | CH 1, <NR 1> | Writes the waveform data to Channel 1 from the specified address through GPIB. | 2 |
| | CH 1, <NR 1>, <NR 1> | Writes the waveform data to Channel 1 between the specified addresses through GPIB. | 2 |
| | CH 1, CUR | Writes the waveform data to Channel 1 from the cursor location through GPIB. | 2 |
| | CH 2 | Writes the waveform data to Channel 2 through GPIB. | 2 |
| | CH 2, <NR 1> | Writes the waveform data to Channel 2 from the specified address through GPIB. | 2 |
| | CH 2, <NR 1>, <NR 1> | Writes the waveform data to Channel 2 between the specified addresses through GPIB. | 2 |
| | CH 2, CUR | Writes the waveform data to Channel 2 from the cursor location through GPIB. | 2 |
| **Readout Function Command** | | | |
| CU1 | <NR 1> | Positions Cursor 1 to the specified absolute address. | 1 |
| | REL,<NR 1> | Positions Cursor 1 to the specified relative address. | 1 |
| | OFF | Turns off Cursor 1. | 1, 3 |
| CU2 | <NR 1> | Positions Cursor 2 to the specified absolute address. | 1 |
| | REL,<NR 1> | Positions Cursor 2 to the specified relative address. | 1 |
| | OFF | Turns off Cursor 2. | 1, 3 |
| DSP | YT | Sets the monitor display to the YT mode. | 1, 3 |
| | XY | Sets the monitor display to the XY mode. | 1 |

Table 3-2 (cont)

| Header | Argument | Description | Notes |
|---|---|---|---|
| **Readout Function Command (cont)** | | | |
| LSH | CH 1, <NR 1> | Shifts a latched portion of Channel 1 waveform data into the specified address. | 1 |
| | CH 2, <NR 1> | Shifts a latched portion of Channel 2 waveform data into the specified address. | 1 |
| PLT | CH 1 | Sends Channel 1 waveform data to the XY plotter. | 1 |
| | CH 2 | Sends Channel 2 waveform data to the XY plotter. | 1 |
| | STA | Starts output to the XY recorder. | 1 |
| | RES | Stops output to the XY recorder. | 1 |
| RDV | AV 1 | Reads the absolute voltage at Channel 1 cursor position. | 1, 2 |
| | AV 2 | Reads the absolute voltage at Channel 2 cursor position. | 1, 2 |
| | DV 1 | Reads the relative voltage at Channel 1 cursor position. | 1, 2 |
| | DV 2 | Reads the relative voltage at Channel 2 cursor position. | 1, 2 |
| | TM 1 | Reads the time difference between Channel 1 cursors. | 1, 2 |
| | TM 2 | Reads the time difference between Channel 2 cursors. | 1, 2 |
| | FR 1 | Reads the reciprocal of the time difference between Channel 1 cursors. | 1, 2 |
| | FR 2 | Reads the reciprocal of the time difference between Channel 2 cursors. | 1, 2 |
| **Query Commands** | | | |
| ERR? | <NR 1> | Returns a code for a current error condition. | |
| ID? | ID SONY-TEKTRONIX/ 390AD, V79.1, FX.Y | Identifies the instrument and firmware version. | |
| OV1? | PLS<br>MNS<br>BOTH<br>NO | Returns the input condition for Channel 1 input range. | |
| OV2? | PLS<br>MNS<br>BOTH<br>NO | Returns the input condition for Channel 2 input range. | |
| PR1? | 1X<br>10X | Returns the attenuation factor of Channel 1 input probe. | |
| PR2? | 1X<br>10X | Returns the attenuation factor of Channel 2 input probe. | |
| SET? | Character | Returns all the settings of the 390AD. | |

## COMMAND DESCRIPTIONS

The 390AD commands listed in Table 3-2 are listed alphabetically and described in detail here. Many of the commands have both the set and query forms as previously discussed. Some commands may be used in one form only. The heading at the beginning of each command description indicates which of the form is valid for that command.

## ARM (SET OR QUERY)

### Syntax

$$\text{ARM} \begin{Bmatrix} \text{AUT(O)} \\ \text{MAN} \\ \text{EXT} \end{Bmatrix} \quad \text{(SET FORM)}$$

ARM? (QUERY FORM)

### Examples

ARM AUT
ARM?

### Query Response

ARM AUT
ARM MAN
ARM EXT

### Power-on State

ARM AUTO

### Discussion

**AUT(O)** — Sets the arm mode to auto. After the display time is completed, the arming signal is automatically given.

**MAN** — Sets the arm mode to manual. MAR command, or pressing the MAN button on the front panel, allows arming.

**EXT** — The external input from the EXT ARM connector on the rear panel allows arming.

## CAL (SET ONLY)

### Syntax

CAL

### Examples

CAL
CAL;

### Discussion

Compensates dc drift and gain in the vertical amplifier. Additionally, compensates the sample clock phase simultaneously when the sample frequency is set to 60 MHz, or when the EXT CLK selector switch is set to CH 1 ONLY (60 MHz max) when using the external sample clock.

*NOTE*

*As this feature interrupts the waveform acquisition momentarily, it is available only in the acquisition or free running mode.*

## **CLR** (SET ONLY)

### Syntax

$$\text{CLR}\begin{Bmatrix}\text{CH 1}\\ \text{CH 2}\end{Bmatrix}$$

### Examples

CLR CH 1
CLR CH 2

### Discussion

Clears waveform data acquired in single sweep mode to ground level. Memory Latch for channel in use must be set to OFF.

### Argument

CH 1 — Clears Channel 1 waveform data.

CH 2 — Clears Channel 2 waveform data.

## **CP1** (SET OR QUERY)

### Syntax

$$\text{CP1}\ \begin{Bmatrix}\text{AC}\\ \text{GND}\\ \text{DC}\end{Bmatrix}\ \text{(SET FORM)}$$

CP1? (QUERY FORM)

### Examples

CP1 AC
CP1 DC;
CP1?

### Query Response

CP1 AC
CP1 GND
CP1 DC

### Power-on State

CP1 AC

### Discussion

Selects Channel 1 input coupling.

### Argument

**AC** — Sets the input coupling to ac.

**GND** — The input of the vertical amplifier is disconnected from the input connector and grounded.

**DC** — Sets the input coupling to dc.

## CP2 (SET OR QUERY)

### Syntax

$$\text{CP2}\ \begin{Bmatrix}\text{AC}\\ \text{GND}\\ \text{DC}\end{Bmatrix}\ \text{(SET FORM)}$$

CP2? (QUERY FORM)

### Examples

CP2 GND
CP2?

### Query Response

CP2 AC
CP2 GND
CP2 DC

### Power-on State

CP2 AC

### Discussion

Selects Channel 2 input coupling. This command, in either set or query form, is not available when the sample frequency is set to 60 MHz or when the EXT CLK selector switch is set to CH 1 ONLY (60 MHz max).

### Argument

**AC** — Sets the input coupling to ac.

**GND** — The input of the vertical amplifier is disconnected from the input connector and grounded.

**DC** — Sets the input coupling to dc.

## CU1 (SET OR QUERY)

### Syntax

CU1 {(RED,)<NR1>} | OFF (SET FORM)
CU1? (QUERY FORM)

### Examples

CU1 100
CU1 REL, −50
CU1?

### Query Response

CU1 200
CU1 OFF

### Discussion

Turns Cursor 1 on, and sets its position to the absolute or relative address. It is also possible to turn Cursor 1 off.

### Argument

**<NR1>** — Positions Cursor 1 to the specified absolute address.

**REL, <NR1>** — Positions Cursor 1 to the specified relative address.

**OFF** — Turns Cursor 1 off.

## **CU2** (SET OR QUERY)

### Syntax

CU2 {(RED,)<NR1>} | OFF (SET FORM)
CU2? (QUERY FORM)

### Examples

CU2 50
CU2 REL, 50
CU2?

### Query Response

CU2 50
CU2 OFF

### Discussion

Turns Cursor 2 on, and sets its position to the absolute or relative address. It is also possible to turn Cursor 2 off.

### Argument

**<NR1>** — Positions Cursor 2 to the specified absolute address.

**REL, <NR1>** — Positions Cursor 2 to the specified relative address.

**OFF** — Turns Cursor 2 off.

## **DCK** (SET OR QUERY)

### Syntax

DCK $\begin{Bmatrix}\text{INT}\\ \text{EXT}\end{Bmatrix}$ (SET FORM)
DCK? (QUERY FORM)

### Examples

DCK INT
DCK EXT
DCK?

### Query Rsponse

DCK INT
DCK EXT

### Power-on State

DCK INT

### Discussion

Selects the clock for a delay counter.

### Argument

**INT** — Selects the same clock as the internal sample frequency. Sample frequency A is used when the timebase is set to A, or when the timebase is set to A+B with a record mode set to post-trigger. With a record mode set to pre-trigger and the timebase set to A+B, sample frequency B is used for the delay clock.

**EXT** — Selects the external clock from the EXT DLY CLK connector on the rear panel.

## **DLY** (SET OR QUERY)

### Syntax

```
DLY  <NR 1> (SET FORM)
DLY?        (QUERY FORM)
```

### Examples

```
DLY 100
DLY?
```

### Query Response

```
DLY 1024
```

### Discussion

Determines the delay counter setting value. The meaning of a setting value depends on a selection of a record mode or a timebase. See Delay Count Value, in Section 2, for further information.

## **DSP** (SET OR QUERY)

### Syntax

$$\text{DSP} \begin{Bmatrix} \text{XY} \\ \text{YT} \end{Bmatrix} \quad \text{(SET FORM)}$$

```
DSP?        (QUERY FORM)
```

### Examples

```
DSP YT;
DSP?
```

### Query Response

```
DSP XY
DSP YT
```

### Power-on State

```
DSP YT
```

### Discussion

Selects the display mode on the waveform monitor.

### Argument

**XY** — Displays Channel 1 output as X-axis, Channel 2 output as Y-axis. This feature is allowed only when the vertical mode is set to Dual.

**YT** — Displays each channel output as Y-axis, and abcissa as the timebase.

## DT (SET OR QUERY)

### Syntax

$\text{DT} \begin{Bmatrix}\text{ON}\\ \text{OFF}\end{Bmatrix}$ (SET FORM)

DT? (QUERY FORM)

### Examples

DT ON;

### Query Response

DT ON
DT OFF

### Power-on State

DT OFF

### Discussion

Enables or disables the function of GET, an interface control message.

### Argument

**ON** — Enables GET function. In this state, receiving the MAR command in manual arm mode cannot start arming immediately. The next GET can start arming.

**OFF** — Disables GET function

## DTI (SET ONLY)

### Syntax

DTI

### Examples

DTI
DTI;

### Discussion

Sets the display time to infinite. Receiving this command while writing, the display time becomes infinite after writing.

## ERR (QUERY ONLY)

### Syntax

ERR?

### Examples

ERR?;

### Query Response

ERR 601
ERR 0

### Discussion

Returns an error code. The error code is kept until ERR? is executed or another error occurs. An error code is reset to 0 after an execution of ERR?.

## ID (QUERY ONLY)

### Syntax

ID?

### Examples

ID?
ID?;

### Query Response

ID SONY-TEK/390AD, V79.1, F1.0

### Discussion

Returns an identification message for the instrument type and firmware version. F79.1 states the version of Tektronix standard GPIB Codes and Formats in use-Version 79.1. F1.0 states that firmware version 1.0 is installed in the instrument.

## **IR1** (SET OR QUERY)

### Syntax

IR1 <NR 1>|<NR 3> (SET FORM)
IR1? (QUERY FORM)

### Examples

IR1 5
IR1 5E1
IR1?

### Query Response

IR1 5E+1
IR1 1E−1

### Power-on State

With 1× probe IR1 5E+1
With 10× probe IR1 5E+2

### Discussion

Sets Channel 1 input range and auto calibration simultaneously. The setting range is 0.1 V to 50 V with a 1× probe, and 1 V to 500 V with a 10× probe, in a 1-2-5 sequence with nine steps.

## **IR2** (SET OR QUERY)

### Syntax

IR2 <NR 1>|<NR 3> (SET FORM)
IR2? (QUERY FORM)

### Examples

IR2 5;
IR2 1E1
IR2?

### Query Response

IR2 1E+1

### Power-on State

With 1× probe IR2 5E+1
With 10× probe IR2 5E+2

### Discussion

Sets Channel 2 input range and auto calibration simultaneously. This command, in either set or query form, is not available when the sample frequency is set to 60 MHz, or the EXT CLK selector switch is set to CH 1 ONLY (60 MHz max). The setting range is 0.1 V to 50 V with a 1× probe, and 1 V to 500 V with a 10× probe, in a 1-2-5 sequence with nine steps.

## LAM(P) (SET OR QUERY)

### Syntax

$$\text{LAM(P)} \begin{Bmatrix} \text{ON} \\ \text{OFF} \end{Bmatrix} \quad \text{(SET FORM)}$$

LAM(P)? (QUERY FORM)

### Examples

LAMP OFF
LAM?

### Query Response

LAMP ON
LAMP OFF

### Power-on State

LAMP ON

### Discussion

Turns all the button lamps, except POWER, off.

### Argument

**ON** — Turns the lamps on.

**OFF** — Turns the lamps off.

## LSH (SET ONLY)

### Syntax

$$\text{LSH} \begin{Bmatrix} \text{CH1, <NR 1>} \\ \text{CH2, <NR 1>} \end{Bmatrix}$$

### Examples

LSH CH1, 100
LSH CH2, −500

### Discussion

Shifts the waveform data in a waveform memory. (Command operates only when the display time is set to infinite.)

**LSH CH1,** <**NR 1**> — Shifts Channel 1 waveform data.

**LSH CH2,** <**NR 1**> — Shifts Channel 2 waveform data.

Sets a positive integer for the shift to the right, and a negative integer for a shift to the left. The amount of the shift is an absolute value from the initial setting of 0. Its range comes to −2047 to 2047 with the vertical mode set to DUAL, and −4095 to 4095 with the CH 1 ONLY setting.

## MAR (SET ONLY)

### Syntax

MAR

### Examples

MAR
MAR;

### Discussion

Performs arming in a trigger circuit with manual arm mode selected. This command is related to the DT command. When DT is off, receiving the MAR command can start arming immediately. Conversely, when DT is on, receiving the MAR command cannot start arming; the next GET, an interface control message, starts arming. This command is available only when the arm mode is set to manual.

## ML1 (SET OR QUERY)

### Syntax

ML1 $\begin{Bmatrix}\text{ON}\\\text{OFF}\end{Bmatrix}$ (SET FORM)
ML1? (QUERY FORM)

### Examples

ML1 ON
ML1?

### Query Response

ML1 ON
ML1 OFF

### Power-on State

ML1 OFF

### Discussion

Latches waveform data acquired from Channel 1. Even when writing has already started, the execution of this command latches the waveform data immediately.

### Argument

**ON** — Latches Channel 1 waveform data immediately.

**OFF** — The latched Channel 1 waveform data can be written.

## **ML2** (SET OR QUERY)

### Syntax

$\text{ML2} \begin{Bmatrix}\text{ON}\\ \text{OFF}\end{Bmatrix}$ (SET FORM)
ML2? (QUERY FORM)

### Examples

ML2 ON
ML2?

### Query Response

ML2 ON
ML2 OFF

### Power-on State

ML2 OFF

### Discussion

Latches waveform data acquired from Channel 2. Even when writing has already started, the execution of this command latches the waveform data immediately. This command is available only when the vertical mode is set to DUAL.

### Argument

**ON** — Latches Channel 2 waveform data immediately.

**OFF** — The latched Channel 2 waveform data can be written.

## **OF1** (SET OR QUERY)

### Syntax

OF1 <NR 1> (SET FORM)
OF1? (QUERY FORM)

### Examples

OF1 10
OF1 −80;
OF1?

### Query Response

OF1 +32
OF1 −04

### Power-on State

OF1 +00

### Discussion

Offsets for Channel 1 input. The offset value can be set from −99% to +99% of Channel 1 input range in 1% steps.

## OF2 (SET OR QUERY)

### Syntax

| | |
|---|---|
| OF2 <NR 1> | (SET FORM) |
| OF2? | (QUERY FORM) |

### Examples

OF2 −35
OF2 5;

### Query Response

OF2 +08
OF2 −45

### Power-on State

OF2 +00

### Discussion

Offsets for Channel 2 input. The offset value can be set from −99% to +99% of Channel 2 input range in 1% steps. Like the CP2 and IR2 commands, this command or its query form is not available when the sample frequency is set to 60 MHz, or when the EXT CLK control is set to CH 1 ONLY (60 MHz MAX).

## OV1 (QUERY ONLY)

### Syntax

OV1?

### Examples

OV1?
OV1?;

### Query Response

OV1 PLS
OV1 MNS
OV1 BOTH
OV1 NO

### Discussion

This query will cause a reply about how the magnitude of the input signal compares with the input range of Channel 1.

**PLS** — The input signal is beyond the positive limit of the input range.

**MNS** — The input signal is beyond the negative limit of the input range.

**BOTH** — The input signal is beyond both the positive and negative limits of the input range.

**NO** — The input signal is within the input range.

## OV2 (QUERY ONLY)

### Syntax

OV2?

### Examples

OV2?
OV2?;

### Query Response

OV2 PLS
OV2 MNS
OV2 BOTH
OV2 NO

### Discussion

This query will cause a reply about how the magnitude of the input signal compares with the input range of Channel 2. This command is not available when the sample frequency is set to 60 MHz, or when the EXT CLK switch is set to CH 1 ONLY (60 MHz max) when using the external sample clock.

## OVE(R) (SET OR QUERY)

### Syntax

| | |
|---|---|
| OVE(R) $\begin{Bmatrix} \text{ON} \\ \text{OFF} \end{Bmatrix}$ | (SET FORM) |
| OVE(R)? | (QUERY FORM) |

### Examples

OVER ON
OVER OFF;
OVER?

### Query Response

OVER ON
OVER OFF

### Power-on State

OVER OFF

### Discussion

Controls SRQ for the input signal overrange condition.

### Argument

**ON** — Asserts SRQ for the input signal overrange condition.

**OFF** — Does not assert SRQ for the input signal overrange condition.

## **PLT** (SET OR QUERY)

### Syntax

$$\text{PLT} \begin{Bmatrix} \text{CH1} \\ \text{CH2} \\ \text{STA} \\ \text{RES} \end{Bmatrix} \quad \text{(SET FORM)}$$

PLT? (QUERY FORM)

### Examples

PLT CH1;PLT STA
PLT RST
PLT?

### Query Response

PLT CH1
PLT CH2

### Discussion

Used to control the XY recorder connected to OUTPUT PLOT on the rear panel. This command is available only when the display time is set to infinite.

### Argument

**CH 1** — Selects Channel 1 as output to the XY recorder.

**CH 2** — Selects Channel 2 as output to the XY recorder.

**STA** — Starts sending voltage output to the XY recorder. The data is plotted in one of the following ways: all the waveform in each channel with both the Cursor 1 and 2 set to off, a portion of the waveform from the first address to the cursor location with only one cursor set to on, and the waveform between the cursors with both the Cursor 1 and 2 set to on.

**RST** — Resets output to the XY recorder while recording.

## **PR1** (QUERY ONLY)

### Syntax

PR1?

### Examples

PR1?
PR1?;

### Query Response

PR1 1×
PR1 10×

### Discussion

Returns attenuation factor of Channel 1 probe.

**1×** — Shows a 1× probe connected to CH 1 OR X input connector.

**10×** — Shows a 10× probe connected to CH 1 OR X input connector.

## PR2 (QUERY ONLY)

### Syntax

PR2?

### Examples

PR2?
PR2?;

### Query Response

PR2 1×
PR2 10×

### Discussion

Returns attenuation factor of Channel 2 probe. This command is not available when the sample frequency is set to 60 MHz, or when the EXT CLK switch is set to CH 1 ONLY (60 MHz max) when using the external sample clock.

**1×** — Shows a 1× probe connected to CH 2 OR Y input connector.

**10×** — Shows a 10× probe connected to CH 2 OR Y input connector.

## PTS (SET OR QUERY)

### Syntax

PTS $\begin{Bmatrix} \text{ON} \\ \text{OFF} \end{Bmatrix}$ (SET FORM)
PTS? (QUERY FORM)

### Examples

PTS ON
PTS OFF
PTS?

### Query Response

PTS ON
PTS OFF

### Power-on State

PTS OFF

### Discussion

SRQ when the plotter output is completed.

### Argument

**ON** — Asserts SRQ when the plotter output is completed.

**OFF** — Does not assert SRQ when the plotter output is completed.

## QUI(T) (SET ONLY)

### Syntax

QUI(T)

### Examples

QUIT
QUI;

### Discussion

Completes the mode (GPIB roll mode) that reads the waveform data continuously while writing, through the GPIB. Also, see the discussion in READ command.

## RDS (SET ONLY)

### Syntax

RDS (AMD(, TRD(, WTG(, RDY(, PLT(, DTI))))))

### Examples

RDS
RDS AMD, TRD, DTI

### Discussion

Reads the 390AD status.

### Argument

**AMD** — Reads the arming condition. The result of a reading is as follows:

**AMD YES** — Shows armed condition.

**AMD NO** — Shows not armed condition.

**TRD** — Reads the triggering condition. The result of a reading is as follows:

**TRD YES** — Shows triggered condition.

**TRD NO** — Shows not triggered condition.

**WTG** — Reads waveform writing condition. The result of a reading is as follows:

**WTG YES** — Shows writing condition.

**WTG NO** — Shows not writing condition.

**RDY** — Reads the ready condition with a single trigger mode selected. The result of a reading is as follows:

**RDY YES** — Shows ready condition.

**RDY NO** — Shows not ready condition.

**PLT** — Reads the plotting condition to the XY recorder. The result of a reading is as follows:

**PLT YES** — Shows plotting condition.

**PLT NO** — Shows not plotting condition.

**DTI** — Reads the display time condition. The result of a reading is as follows:

**DTI YES** — Shows the display time set to infinite.

**DTI NO** — Shows the display time not set to infinite.

## RDV (SET ONLY)

### Syntax

```
RDV <RDV ARGUMENT>({,<RDV ARGUMENT>}...)
   <RDV ARGUMENT> is one of the following:
      DV1, DV2, AV1, AV2, TM1, TM2, FR1, FR2
```

### Examples

```
RDV AV1, AV2
RDV DV1, DV2, TM1, TM2
```

### Discussion

Reads the resultant display of a measurement using the readout function.

### Argument

**AV1** — Reads the absolute value of a voltage determined by Channel 1 cursor location.

**AV2** — Reads the absolute value of a voltage determined by Channel 2 cursor location.

**DV1** — Reads the voltage difference between the two cursors, with Cursor 1 in Channel 1 as a reference, when both Cursor 1 and 2 are on. If both cursors are off, they are automatically switched on at the same time. When only one cursor is on, DV1 reads the voltage difference, referenced to the absolute voltage at Channel 2 cursor location.

**DV2** — Reads the voltage difference between the two cursors, with Cursor 1 in Channel 2 as a reference, when both Cursor 1 and 2 are on. If both cursors are off, they are automatically switched on at the same time. When only one cursor is on, DV2 reads the voltage difference, referenced to the absolute voltage at Channel 1 cursor location.

**TM1** — Reads the time difference between Channel 1 cursors.

**TM2** — Reads the time difference between Channel 2 cursors.

**FR1** — Reads the reciprocal of the time difference between Channel 1 cursors.

**FR2** — Reads the reciprocal of the time difference between Channel 2 cursors.

## READ (SET ONLY)

### Syntax

```
REA(D) CH1 (,{{<NR 1>, <NR 1>}|CUR})
REA(D) CH2 (,{{<NR 1>, <NR 1>}|CUR})
REA(D) ROL(L)
```

### Examples

```
READ CH1
READ CH2, 0, 511
READ CH1, CUR
READ ROL
```

### Discussion

Reads the waveform data through GPIB.

### Argument

**CH 1** — Reads Channel 1 waveform data.

**CH 2** — Reads Channel 2 waveform data.

**CH 1, <NR1>, <NR1>** — Reads Channel 1 waveform data between the specified addresses.

**CH 2, <NR1>, <NR1>** — Reads Channel 2 waveform data between the specified addresses.

**CH1, CUR** — Reads Channel 1 waveform data between the cursors.

**CH2, CUR** — Reads Channel 2 waveform data between the cursors.

**ROL(L)** — Reads both channels' waveform data continuously while writing (see QUI command). This command is not available when the display time is set to infinite, or when either Channel 1 or Channel 2 is latched. When Dual vertical mode is selected, Channel 1 and Channel 2 waveform data are sent alternately; or when CH 1 Only mode is selected, only Channel 1 waveform data is sent over the GPIB in sequence of "low byte follows high byte". See Programming Examples for further information.

## REM (SET OR QUERY)

### Syntax

REM $\begin{Bmatrix}\text{ON}\\ \text{OFF}\end{Bmatrix}$ (SET FORM)
REM? (QUERY FORM)

### Examples

REM ON;
REM OFF
REM?

### Query Response

REM ON
REM OFF

### Power-on State

REM OFF

### Discussion

Controls SRQ when the REMOTE button is pressed.

### Argument

**ON** — Asserts SRQ when the REMOTE button is pressed.

**OFF** — Does not assert SRQ when the REMOTE button is pressed.

## RES (SET ONLY)

### Syntax

RES

### Examples

RES
RES;

### Discussion

Resets the display time from infinite setting. When the command is executed while writing or displaying the waveform, it returns to the writing start state. This command is not available when Channel 1 waveform data is latched with CH 1 ONLY vertical mode selected, or both channels' waveform data are latched with Dual mode selected.

## RMO (SET OR QUERY)

### Syntax

RMO $\begin{Bmatrix}\text{POS(T)}\\ \text{PRE}\end{Bmatrix}$ (SET FORM)
RMO? (QUERY FORM)

### Examples

RMO POS
RMO PRE;
RMO?

### Query Response

RMO POS
RMO PRE

### Power-on State

RMO PRE

### Discussion

Selects the record mode.

### Argument

**POST** — Sets the record mode to post-trigger to record the waveform after the trigger point.

**PRE** — Sets the record mode to pre-trigger to record the waveform before the trigger point. See Pre-trigger Mode and Roll Mode and Post-trigger Function in Section 2, Operating Instructions, for further information.

## SET (QUERY ONLY)

### Syntax

SET?

### Examples

SET?
SET?;

### Query Response (example)

VMO DUA;CP1 AC;CP2 AC;IR1 5E+1;
IR2 5E+1;OF1 +00;OF2 +00;TSL POS;
TLV+00;TSR CH1;TCP AC;ARM AUT;
TMO AUT;RMO PRE;TB A;SFA +10E+6;
DCK INT;DLY 0200;CU1 OFF;CU2 OFF;
DSP YT;PLT CH1;DT OFF;OVER OFF;
PTS OFF;REM OFF;WRI OFF

### Discussion

Returns the current settings of the 390AD controls. The settings of the 390AD at any time can be recalled returning the exact response for SET?. The response has about 300 characters; however, the variable for receiving response must store more than 300 characters.

## **SFA** (SET OR QUERY)

### Syntax

SFA $\left\{\begin{matrix}\text{<NR 1>|<NR 3>} \\ \text{EXT}\end{matrix}\right\}$ (SET FORM)
SFA? (QUERY FORM)

### Examples

SFA 500
SFA 10E6
SFA EXT

### Query Response

SFA +10E+6
SSFA EXT

### Power-on State

SFA +10E+6

### Discussion

Sets sample frequency A.

### Argument

**<NR 1>|<NR 3>** — Uses the internal sample clock. The possible settings are as follows:

5, 10, 20, 50, 100, 200, 500, 1E3, 2E3, 5E3, 10E3, 20E3, 50E3, 100E3, 200E3, 500E3, 1E6, 2E6, 5E6, 10E6, 20E6, 30E6

When CH 1 ONLY vertical mode is selected, 60E6 can also be selected.

**EXT** — Uses the external sample clock from the EXT CLK connector on the rear panel.

## **SFB** (SET OR QUERY)

### Syntax

SFB $\left\{\begin{matrix}\text{<NR 1|<NR 3>} \\ \text{EXT}\end{matrix}\right\}$ (SET FORM)
SFB? (QUERY FORM)

### Examples

SFB 500
SFB 30E6
SFB EXT

### Query Response

SFB +10E+6
SFB EXT

### Discussion

Sets sample frequency B.

**<NR 1>|<NR 3>** — Uses the internal sample clock. The possible settings are the same as those for SFA.

**EXT** — Uses the external sample clock from the EXT CLK connector on the rear panel.

## **TB** (SET OR QUERY)

### Syntax

$\text{TB} \begin{Bmatrix} \text{A} \\ \text{A+B} \end{Bmatrix}$ (SET FORM)

TB? (QUERY FORM)

### Examples

TB A
TB A+B;

### Query Response

TB A
TB A+B

### Power-on State

TB A

### Discussion

Selects timebase.

### Argument

**A** — Performs all the writing at sample frequency A.

**A+B** — Performs the writing while the sample frequency is switching from A to B according to the delay setting.

## **TCP** (SET OR QUERY)

### Syntax

$\text{TCP} \begin{Bmatrix} \text{AC} \\ \text{HFR} \\ \text{DC} \end{Bmatrix}$ (SET FORM)

TCP? (QUERY FORM)

### Examples

TC AC
TC DC;
TCP?

### Query Response

TCP AC
TCP HFR
TCP DC

### Power-on State

TCP AC

### Discussion

Selects the trigger coupling.

### Argument

**AC** — Sets the trigger coupling to AC.

**HFR** — Sets the trigger coupling to HF REJ.

**DC** — Sets the trigger coupling to DC.

## **TLV** (SET OR QUERY)

### Syntax

TLV <NR1> (SET FORM)
TLV? (QUERY FORM)

### Examples

TLV +32
TLV −20
TLV?

### Query Response

TLV +00
TLV −45

### Power-on State

TLV +00

### Discussion

Determines the trigger level. The level can be set from −99% to +99% of the input range when the trigger slope is set to positive or negative, or from 5% to 99% when the slope is set to BOTH. With the trigger source set to EXT, ±5 V is equivalent to ±100%.

## **TMO** (SET OR QUERY)

### Syntax

$\text{TMO} \begin{Bmatrix} \text{AUT(O)} \\ \text{NOR} \\ \text{SGL} \end{Bmatrix}$ (SET FORM)
TMO? (QUERY FORM)

### Examples

TMO AUTO
TMO SGL;
TMO?

### Query Response

TMO AUT
TMO NOR
TMO SGL

### Power-on State

TMO AUT

### Discussion

Selects the trigger mode.

### Argument

**AUT(O)** — Starts a new write operation automatically even when an adequate trigger is absent after a display time is completed.

**NOR** — Starts a new write operation only when an adequate trigger is present after a display time is completed.

**SGL** — Similar to NOR, starts a new write operation only when an adequate trigger is present. After a write operation, the waveform data is completed, and the display time is automatically set to infinite.

## **TP1** (SET OR QUERY)

### Syntax

TP1 <NR 1> (SET FORM)
TP1? (QUERY FORM)

### Examples

TP1 1000
TP1?

### Query Response

TP1 0200
TP1 1023

### Discussion

Sets a bright spot that represents Channel 1 trigger point or a break point on the waveform monitor at any location. Additionally, it returns a trigger point address. This command is available to recall the waveform, including a trigger point, acquired before using the READ and TP1 commands, on the waveform monitor connected to the 390AD using WRT and TP1 <NR 1> command. A bright spot that represents a trigger point or a break point can be set to even-numbered addresses only when the sample frequency is set to 60 MHz, or when the EXT CLK selector is set to CH 1 ONLY (60 MHz max) in the case of using the external sample clock. Therefore, if an odd-numbered value is to be set, it is automatically truncated to a multiple of two.

## **TP2** (SET OR QUERY)

### Syntax

TP2 <NR 1> (SET FORM)
TP2? (QUERY FORM)

### Examples

TP2 500
TP2?

### Query Response

TP2 0312
TP2 2000

### Discussion

Sets a bright spot that represents Channel 2 trigger point or a break point on the waveform monitor at any location. Additionally, returns a trigger point address.

## **TSL** (SET OR QUERY)

### Syntax

```
      ⎧POS   ⎫
TSL   ⎨NEG   ⎬  (SET FORM)
      ⎩BOT(H)⎭
TSL?            (QUERY FORM)
```

### Examples

TSL BOTH
TSL POS;
TSL?

### Query Response

TSL POS
TSL NEG
TSL BOT

### Power-on State

TSL POS

### Discussion

Selects the slope on which the timebase triggers.

### Argument

**POS** — Sets the trigger slope to positive.

**NEG** — Sets the trigger slope to negative.

**BOT(H)** — Sets the trigger when the input signal exceeds ± trigger level set by the level control.

## **TSR** (SET OR QUERY)

### Syntax

```
      ⎧CH1⎫
TSR   ⎨CH2⎬     (SET FORM)
      ⎩EXT⎭
TSR?            (QUERY FORM)
```

### Examples

TSR CH 1
TSR EXT;
TSR?

### Query Response

TSR CH1
TSR CH2
TSR EXT

### Power-on State

TSR CH1

### Discussion

Selects the source of the trigger signal.

### Argument

**CH 1** — The signal applied to the CH 1 input connector is the source of the trigger signal.

**CH 2** — The signal applied to the CH 2 input connector is the source of the trigger signal. This argument is not available when the sample frequency is set to 60 MHz, or when the EXT CLK selector is set to CH 1 ONLY (60 MHz Max).

**EXT** — The external signal connected to the EXT TRIG IN connector, on the front panel, is used for triggering.

## **VMO** (SET OR QUERY)

### Syntax

VMO $\begin{Bmatrix}\text{DUA(L)}\\ \text{CH1}\end{Bmatrix}$ (SET FORM)
VMO? (QUERY FORM)

### Examples

VMO DUAL
VMO CH1;
VMO?

### Query Response

VMO DUA
VMO CH1

### Power-on State

VMO DUA

### Discussion

Selects the vertical mode.

### Argument

**DUAL** — Acquires Channel 1 and Channel 2 waveform data. The capacity of the waveform is 2048 points for each channel, and the sample frequency is selectable up to 30 MHz. This argument is not available when the sample frequency is set to 60 MHz, or the EXT CLK selector is set to CH 1 ONLY (60 MHz max) when using the external sample clock.

**CH 1** — Acquires Channel 1 waveform data only. The capacity of the waveform is 4096 points, and the sample frequency is selectable up to 60 MHz. This argument is not available when the display mode on the waveform monitor is set to XY.

## **WRI** (SET OR QUERY)

### Syntax

WRI $\begin{Bmatrix}\text{ON}\\ \text{OFF}\end{Bmatrix}$ (SET FORM)
WRI? (QUERY FORM)

### Examples

WRI ON
WRI OFF;
WRI?

### Query Response

WRI ON
WRI OFF

### Power-on State

WRI OFF

### Discussion

Controls SRQ when the writing is completed.

### Argument

**ON** — Asserts SRQ when the writing is completed.

**OFF** — Does not assert SRQ when the writing is completed.

## WRT (SET ONLY)

### Syntax

```
WRT CH1
WRT CH1, <NR 1>
WRT CH1, <NR 1>, <NR 1>
WRT CH1, CUR
WRT CH2
WRT CH2, <NR 1>
WRT CH2, <NR 1>, <NR 1>
WRT CH2, CUR
```

### Examples

```
WRT CH1, 0, 511
WRT CH2, 512
WRT CH1, CUR
```

### Discussion

Writes the waveform data, which was previously sent from the 390AD, from the controller to the 390AD. This data must have the same format as the data sent from the 390AD using the READ command. The WRT command is available only when the display time is set to infinite with the waveform data unlatched.

### Argument

**CH 1** — Writes all the waveform data from the leading address in Channel 1.

**CH 2** — Writes all the waveform data from the leading address in Channel 2.

**CH 1, <NR 1>** — Writes the waveform data from the specified address in Channel 1.

**CH 2, <NR 2>** — Writes the waveform data from the specified address in Channel 2.

**CH 1, <NR 1>, <NR 1>** — Writes the waveform data between the specified addresses in Channel 1.

**CH 2, <NR 1>, <NR 1>** — Writes the waveform data between the specified addresses in Channel 2.

**CH 1, CUR** — Writes the waveform data from the cursor location in Channel 1 when only one cursor is on. When both cursors are on, writes the waveform data btween the cursors.

**CH 2, CUR** — Writes the waveform data from the cursor location in Channel 2 when only one cursor is on. When both cursors are on, writes the waveform data between the cursors.

# INSTRUMENT STATUS

The 390AD reports a status byte when serial polled by the system controller. The status byte contains the internal status of the instrument. Two main types of status may be reported: System status and device status. System status indicates conditions that are common among all instruments that conform to the Tektronix Codes and Formats Standard (e.g., Command Error). Device status indicates conditions that are unique to a single instrument type.

An example of handling an SRQ and reading the status byte is shown in the Programming Examples part of this section. The status byte reports errors in general terms. The ERR? query returns a code that more specifically defines the error.

## STATUS

The status byte read from the 390AD during a serial poll contains the following information:

BIT 8 — Device status=1; System status=0

7 — Service requested

6 — Abormal condition=1; Normal condition=0

5 — Busy. In the 390AD, waveform data writing condition=1; not writing condition=0

4 — Device/system status

3 — Device/system status

2 — Device/system status

1 — Device/system status

Normal condition system status:

| BIT 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | |
|---|---|---|---|---|---|---|---|---|
| 0 | 1 | 0 | X | 0 | 0 | 0 | 1 | — Power-on |
| 0 | 1 | 0 | X | 0 | 0 | 1 | 0 | — Remote request (press REMOTE) |

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

Abnormal condition system status:

| BIT 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | |
|---|---|---|---|---|---|---|---|---|
| 0 | 1 | 1 | X | 0 | 0 | 0 | 1 | — Command Error |
| 0 | 1 | 1 | X | 0 | 0 | 1 | 0 | — Execution Error |
| 0 | 1 | 1 | X | 0 | 0 | 1 | 1 | — Internal Error |
| 0 | 1 | 1 | X | 0 | 1 | 0 | 0 | — Power Fail Error |
| 0 | 1 | 1 | X | 0 | 1 | 0 | 1 | — Execution Warning |
| 0 | 1 | 1 | X | 0 | 1 | 1 | 0 | — Internal Error Warning |

Command Error indicates that the 390AD has received a command that it cannot understand or implement under any circumstances. The command does not affect the state of the instrument.

Execution Error indicates that the 390AD has received a command that it understands but cannot implement due to the current state of the instrument. The command does not affect the state of the instrument.

Internal Error indicates an internal hardware failure. If the 390AD fails during self-test at power-on, this error condition will occur.

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

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

Internal Warning indicates that the instrument has detected an internal error. The instrument remains operational, but the source of the problem should be found and corrected as soon as possible. In the 390AD, this warning occurs when the auto calibration function cannot be executed.

### Device Status

The 390AD has the following status as the device status.

Normal condition system status:

| BIT 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | |
|---|---|---|---|---|---|---|---|---|
| 1 | 1 | 0 | X | 0 | 0 | 1 | 1 | —Waveform data writing completed. (When WRI ON) |
| 1 | 1 | 1 | X | 0 | 0 | 0 | 1 | —Input signal overrange condition (When OVER ON) |
| 1 | 1 | 0 | X | 0 | 0 | 1 | 0 | —Plotter output completed (When PTS ON) |

# WARNING AND ERROR CONDITIONS

## WARNING MESSAGES

The warnings consist of the internal warning, which indicates the internal hardware failure, and the execution error. Tables 3-3 and 3-4 show the message numbers and descriptions for each message.

Table 3-3
INTERNAL WARNING MESSAGE

| Number | Description |
|---|---|
| 501 to 521 | Instrument failed during auto calibration |

These warnings indicate that the 390AD needs to be adjusted. For adjustment, refer the instrument to qualified service personnel.

Table 3-4
EXECUTION WARNING MESSAGES

| Numbers | Description |
|---|---|
| 701 | The sample frequency is too high in Read Roll mode, which writes and sends the waveform data simultaneously. |
| 702 | Accepted an invalid header when the waveform data was to be entered (WRT) through the GPIB. |
| 703 | Checksum error occurred in the waveform data whenthe waveform data was to be entered through the GPIB. |
| 704 | Accepted an invalid terminator when the waveform data is to be put in through the GPIB. |

### Error Messages

The error messages include the internal error messages that indicate the internal hardware failure after the self-test executed at power-on, the execution error messages that indicate the failure in the functional execution, and the command error messages concerning command errors received from the GPIB. Tables 3-5, 3-6, and 3-7 show these messages in detail.

Table 3-5
INTERNAL ERROR MESSAGES

| Numbers | Description |
|---|---|
| 001 to 010 | Checksum error found in ROM. |
| 101 to 104 | Read-write test error found in RAM. |
| 201 to 240 | Read-write test error found in the waveform data RAM. |
| 301 to 346 | Found a front-panel switch closed during switch test, when not pressed. |
| 401 to 410 | Found error in circuit test. |

These errors indicate internal hardware failure. To correct this condition, refer the instrument to qualified service personnel.

### Table 3-6
### EXECUTION ERROR MESSAGES

| Numbers | Description |
|---|---|
| 601 | The function cannot be executed with the current settings. |
| 602 | Argument out of range. |
| 603 | Specified an invalid step when setting the sample frequency and input range. |
| 604 | Output buffer overflow condition. |
| 605 | Switched the EXT CLK selector on the rear panel to CH 1 ONLY with the external sample clock selected and the vertical mode set to Dual. For this condition, set the EXT CLK selector to Norm. |
| 606 | Instrument failed to execute the set command accepted in the local state. |

### Table 3-7
### COMMAND ERROR MESSAGES

| Numbers | Description |
|---|---|
| 801 | Invalid command header. |
| 802 | Invalid argument string. |
| 803 | The command cannot be allowed as a set command. |
| 804 | The command cannot be allowed as a query command. |

### Table 3-8
### POWER-FAIL ERROR MESSAGE

| Number | Description |
|---|---|
| 901 | Power failure is imminent. |

# PROGRAMMING EXAMPLES

The following programming examples show how to control the 390AD through a GPIB controller using the programming languages of Tektronix 4050 BASIC and TEK SPS BASIC.

In the programs, the controls are divided into three classes: 1) processing for SRQ, 2) set command and query command, and 3) input/output of the waveform data.

## PROCESSING FOR SRQ

As soon as a device connected on the bus asserts SRQ, the controller polls the devices to find who is requesting service. The 390AD responds only to a serial poll; a good example is shown below.

- **4050 BASIC**

```
100  INIT
110  ON SRQ THEN 1000
120

1000 POLL K, L; 1; 2;....
1010 IF L−INT(L/32)*32<16 THEN 1030
1020 L = L−16
1030 IF L=65 THEN 2000
1040 PRINT @K:"ERR?"
1050 INPUT @K:A$
1060 PRINT A$
1100 RETURN
2000 PRINT "POWER UP"
2010 GOTO 1100
```

| Program | Description |
|---|---|
| 100 | Initialization |
| 110 | Moves control to line number 1000 when an SRQ occurs. |
| 120 | Afterwards, programming proceeds normally. |
| 1000 | Executes a serial poll in order of GPIB addresses 1, 2, .... As a result, K is set equal to the number of the polled device that has asserted SRQ and L is set equal to its status byte. |
| 1010 to 1020 | Takes SRQ status busy bit. |
| 1030 | Moves to 2000 if power-on SRQ. |
| 1040 | Queries error if other SRQ. |
| 1050 | Enters error code. |
| 1060 | Displays error code. |
| 1100 | Completes the processing for SRQ, then returns to the original program. |
| 2000 | Displays "POWER UP." |
| 2010 | To 1100. |

- **TEK SPS BASIC Instrument Driver**

```
10      SRQDISABLE @0
110     ATTACH #1 AS INS1: @0
120     WHEN #1 HAS "POW" GOSUB 1000
130     WHEN #1 HAS "ABN" GOSUB 2000
140     WHEN #1 HAS "303" GOSUB 3000
150     WHEN #1 HAS "SRQ" GOSUB 4000
160     LOCKSRQ
170     SRQENABLE @0

1000    Processing for power-on SRQ

1900    SRQENABLE @0
1910    RETURN
2000    Processing for SRQ which indicates abnormal
        condition
2900    SRQENABLE @0
2910    RETURN
3000    Processing for SRQ which indicates writing
        completion
3900    SRQENABLE @0
3910    RETURN
4000    Processing for other SRQ

4900    SRQENABLE @0
4910    RETURN
```

| Program | Description |
|---|---|
| 100 | Disables processing for SRQ reception by GPIB interface No. 0. |
| 110 | Specifies the device, addressed to No. 1 on the GPIB, as instrument No. 1. |
| 120 | For power-on SRQ, moves control to line number 1000. |
| 130 | For SRQ that indicates abnormal state, moves control to line number 2000. |

| Program | Description |
|---|---|
| 140 | For SRQ that indicates writing completion, status byte 303 (octal) moves control to line number 3000. |
| 150 | For other SRQ, moves control to line number 4000. |
| 160 | Disables SRQ after each occurrence of SRQ and returns to each processing routine. |
| 170 | Enables processing for SRQ. |

For each SRQ processing routine, after processing but before returning, SRQENABLE @0 must be executed to enable the next SRQ.

## SET COMMAND AND QUERY COMMAND

### • 4050 BASIC

```
100     INIT
110     ON SRQ THEN 1000
120     PRINT "COMMAND:";
130     INPUT C$
140     PRINT @1:C$
150     A$=SEG(C$, LEN C$, 1)
160     IF A$<>"?" THEN 120
170     REM WHEN QUERY COMMAND
180     INPUT @1 : Q$
190     PRINT "ANSWER:";Q$
200     GOTO 120
1000    POLL A, B; 1
1010    PRINT @1:"ERR?"
1020    INPUT @1:E$
1030    PRINT "SRQ OCCURRED STATUS:G";B,E$
1040    RETURN
```

| Program | Description |
|---|---|
| 100 | Initialization |
| 110 | Moves control to line number 1000 when an SRQ occurs. |
| 120,130 | Requests that the command be entered into the 390AD. |
| 140 | Sends the command to the 390AD, GPIB address No. 1. |
| 150 | Takes the last character of the command out to A$. |
| 160 | Requests next command again unless the last character is not "?" (which means a set command). |
| 180 | Sends a response to a query command. |
| 190 | Displays the response. |
| 200 | Requests a command again. |

| Program | Description |
|---|---|
| 1000 | Performs a serial poll at the 390AD, GPIB address No. 1. |
| 1010 | Issues ERR? query command. |
| 1020 | Sends error code. |
| 1030 | Displays the status byte and error code. |
| 1040 | Returns to the original program. |

### • TEK SPS BASIC INSTRUMENT DRIVER

### • Set Command

```
 90 LOAD "INS"
100 ATTACH #1 AS INS1: @0
110 PUT1 "IR1 2;IR2 2" INTO #1
120 PUT "OF1 10;OF2 10" INTO #1
```

| Program | Description |
|---|---|
| 90 | Loads the instrument driver. |
| 100 | Specifies the 390AD, GPIB address No. 1, as instrument No. 1. |
| 110 | Sets Channel 1 and Channel 2 input range to 2 V. |
| 120 | Sets Channel 1 and Channel 2 dc offset to 10%. |

### • Query Command

```
 90     LOAD "INS"
100     ATTACH #1 AS INS1: @0
110     GET A$ FROM #1, "ID?"
120     PRINT A$
130     GET H$;F FROM #1, "SFA?"
140     PRINT "SAMPLE FREQUENCY A:";F;"HZ"
```

| Program | Description |
|---|---|
| 90 | Loads the instrument driver. |
| 100 | Specifies the 390AD, GPIB address No. 1, as instrument No. 1. |
| 110 | Issues ID? query command, and puts the response in to A$. |
| 120 | Displays the response. |
| 130 | Issues SFA? query command, and puts the response header into H$, and the frequency into F as a number. |
| 140 | Displays the sample frequency |

## INPUT/OUTPUT OF WAVEFORM DATA

### • 4050 BASIC

An example to send a waveform, once received, to Channel 2.

```
100     INIT
110     DIM D(1024), C(2), Y (512)
120     PRINT @1: "ML1 OFF;ML2 OFF;RES"
130     PRINT @1: "DTI;READ CH1, 0, 511"
140     WBYTE @95, 63, 65:
150     RBYTE H, C
160     RBYTE D
170     RBYTE S, T
180     WBYTE @95, 63:
190     FOR I=2 TO 1024 STEP 2
200     Y (I/2)=D(I-1) *256+D (I)
210     NEXT I
220     PRINT @1: "CLR CH2"
230     PRINT @1: "WRT CH2, 0, 511"
240     WBYTE @95, 63, 33:
250     WBYTE H, C
260     WBYTE D
270     WBYTE S, T
280     WBYTE @95, 63:
290     END
```

| Program | Description |
|---|---|
| 100 | Initialization |
| 110 | Assigns D for the input waveform data, C for the byte counter, and Y for the transformed 10-bit waveform data. |
| 120 | Resets memory latch in both channels of the 390AD. |
| 130 | Issues the command that enters the data between addresses 0 and 511 into Channel 1 memory. |
| 140 | Specifies GPIB address No. 1. |
| 150 | Enters the header and byte counter. |
| 160 | Enters the waveform data. |
| 170 | Enters the checksum and terminator. |
| 180 | Performs untalk and unlisten. |
| 190 to 210 | Formats the waveform data sent in one point, two bytes. |
| 220 | Clears Channel 2 waveform RAM in the 390AD to ground level. |
| 230 | Issues the command that writes between the addresses 0 and 511 from the GPIB. |
| 240 | Specifies GPIB address No. 1. |
| 250 | Sends the header and byte counter. |
| 260 | Sends the waveform data. |
| 270 | Sends the checksum and terminator. |
| 280 | Performs untalk and unlisten. |
| 290 | End |

### • TEK SPS BASIC INSTRUMENT DRIVER

```
 90     LOAD "INS"
100     ATTACH #1 AS INSI: @0
110     MODE #1, "PAK", "HBF"
120     DIM D1 (511), D2(511)
130     GET D1 FROM #1, "READ CH1, 0.511"
140     GET D2 FROM #1, "READ CH2, 0.511"
150     END
```

| Program | Description |
|---|---|
| 90 | Loads the instrument driver. |
| 100 | Specifies the 390AD, GPIB address No. 1 as instrument No. 1. |
| 110 | Sets the processor to high byte first (HBF) mode in a pack style. |
| 120 | Assigns D1 for Channel 1 and D2 for Channel 2. |
| 130 | Puts the waveform data between Channel 1 addresses 0 and 511 into memory array D1. |
| 140 | Puts the waveform data between Channel 2 address 0 and 511 into memory array D2. |
| 150 | End |

## WAVEFORM DATA INPUT IN GPIB ROLL MODE

### • 4050 BASIC

```
100     INIT
110     DIM D(1024), Y (512)
120     WINDOW 1, 512, 0, 1023
130     PRINT @1: "VMO CH1"
140     PRINT @1: "SFA 50"
150     PRINT @1: "READ ROLL"
160     FOR I=1 TO 10
170     WBYTE @95, 63, 65:
180     RBYTE D
190     WBYTE @95, 63:
200     FOR K=2 TO 1024 STEP 2
210     Y (K/2)=D(K-1) * 256+D(K)
220     NEXT K
230     PAGE
240     MOVE 1, Y(1)
250     FOR K=2 TO 512
260     DRAW K, Y(K)
270     NEXT K
280     NEXT I
290     PRINT @1: "QUIT"
300     END
```

| Program | Description |
|---|---|
| 100 | Initialization |
| 110 | Assigns D for the waveform data and Y for the transformed 10-bit waveform data. |
| 120 | Specifies window to be made into graph. |
| 130 | Sets the vertical mode to CH 1 ONLY. |
| 140 | Sets sample frequency A to 50 Hz. |
| 150 | Issues a command in the GPIB roll mode. |
| 160 | Repeats ten times |
| 170 | Specifies GPIB address No. 1. |
| 180 | Enters the waveform data. |
| 190 | Performs untalk and unlisten. |
| 200 to 220 | Frames the waveform data sent in one point, two bytes. |
| 230 | Erases the screen preparing for the graphic display. |
| 240 to 270 | Makes waveform into graph. |
| 280 | Repeats. |
| 290 | Resets GPIB roll mode. |
| 300 | End |

- **TEK SPS BASIC INSTRUMENT DRIVER**

```
 80     LOAD "GPI"
 90     LOAD "INS"
100     ATTACH #1 AS INS1: @0
110     DIM D(511)
120     PUT "VMO CH1; SFA 50" INTO #1
130     IFDTM @0, "PAK", "HBF"
140     PUT "READ ROLL" INTO #1
150     FOR I=1 TO 10
160     GET D FROM @0, 65
170     PAGE
180     GRAPH D
190     NEXT I
200     PUT "QUIT" INTO #1
210     END
```

| Program | Description |
|---|---|
| 80 | Loads GPIB driver. |
| 90 | Loads the instrument driver. |
| 100 | Specifies the 390AD, GPIB address No. 1 as instrument No. 1. |
| 110 | Assigns D for the waveform data. |
| 120 | Sets the vertical mode to CH 1 ONLY and the sample frequency to 50 Hz. |
| 130 | Sets GPIB interface No. 0 mode to the high-byte first (HBF) mode in a pack style. |
| 140 | Issues a command in the GPIB roll mode. |
| 150 | Repeats ten times. |
| 160 | Enters the waveform data from the 390AD to GPIB address No. 1. |

# INSTRUMENT OPTIONS

Your instrument may have one or more options. A brief description of each option is given here. Detailed information about each option is provided in appropriate places in this manual. For further information about options, see your Tektronix Catalog or contact your Tektronix Field Office.
for page 4-1

## LIST OF OPTIONS

### OPTION 10

The 390AD Option 10 has a pair of sliding chassis tracks and a pair of handles to install the 390AD in a 19-inch rack, plus a pair of track slides for the rack.

### OPTION A1

The standard power cord is replaced with the Universal European 240 V type power cord (Tektronix Part 161-0066-09).

### OPTION A2

The standard power cord is replaced with the United Kingdom 240 V type power cord (Tektronix Part 161-0066-10).

### OPTION A3

The standard power cord is replaced with the Australian 240 V type power cord (Tektronix Part 161-0066-11).

### OPTION A4

The standard power cord is replaced with the North American 240 V type power cord (Tektronix Part 161-0066-12).

### OPTION A5

The standard power cord is replaced with the Switzerland 240 V type power cord (Tektronix Part 161-0154-00).

# HOW TO IDENTIFY THE OPTIONS

## OPTIONS A1 THROUGH A5

Refer to Figure 1-2, in Section 1, to determine which type of cord is used with your instrument.

Table 4-1
OPTION INFORMATION LOCATOR

| Option | Location in Manual | | Information |
|---|---|---|---|
| | Section | Heading | |
| 10 | 4 Instrument Options | Option 10 | Gives a brief description of Option 10 |
| A1 | 1 General Information | Connecting AC Power Figure 1-2 | Lists details of Option A1 |
| | 4 Instrument Options | Option A1 | Gives a brief description of Option A1 |
| A2 | 1 General Information | Connecting AC Power Figure 1-2 | Lists details of Option A2 |
| | 4 Instrument Options | Option A2 | Gives a brief description of Option A2 |
| A3 | 1 General Information | Connecting AC Power Figure 1-2 | Lists details of Option A3 |
| | 4 Instrument Options | Option A3 | Gives a brief description of Option A3 |
| A4 | 1 General Information | Connecting AC Power Figure 1-2 | Lists details of Option A4 |
| | 4 Instrument Options | Option A4 | Gives a brief description of Option A4 |
| A5 | 1 General Information | Connecting AC Power Figure 1-2 | Lists details of Option A5 |
| | 4 Instrument Options | Option A5 | Gives a brief description of Option A5 |

# WARNING

THE FOLLOWING SERVICING INSTRUCTIONS ARE FOR USE BY QUALIFIED PERSONNEL ONLY. TO AVOID PERSONAL INJURY, DO NOT PERFORM ANY SERVICING OTHER THAN THAT CONTAINED IN OPERATING INSTRUCTIONS UNLESS YOU ARE QUALIFIED TO DO SO. REFER TO OPERATORS SAFETY SUMMARY AND SERVICE SAFETY SUMMARY PRIOR TO PERFORMING ANY SERVICE.

# APPENDIX A

## LINE VOLTAGE SELECTOR

The 390AD will operate on 115 V or 230 Vac. To change from one range to the other, proceed as follows:

1. Disconnect the 390AD from ac power.

2. Remove the top cover (seven screws fasten it to the chassis; see Fig. 2-35).

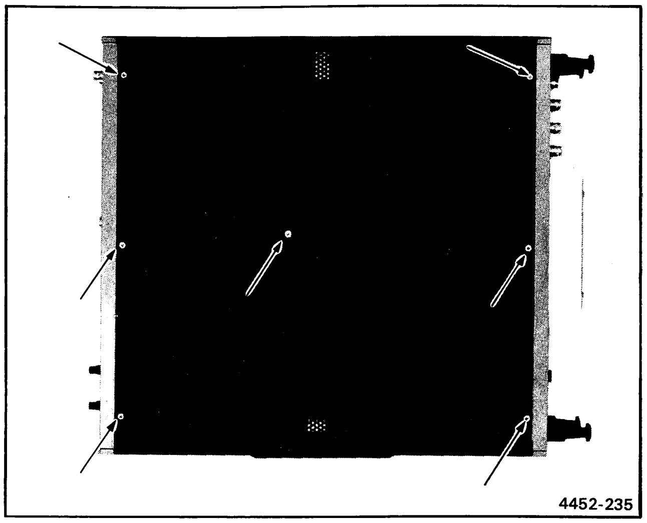


Figure A-1. Screws that retain top cover.

3. Disconnect the power connector from the power supply (see Fig. 2-36).

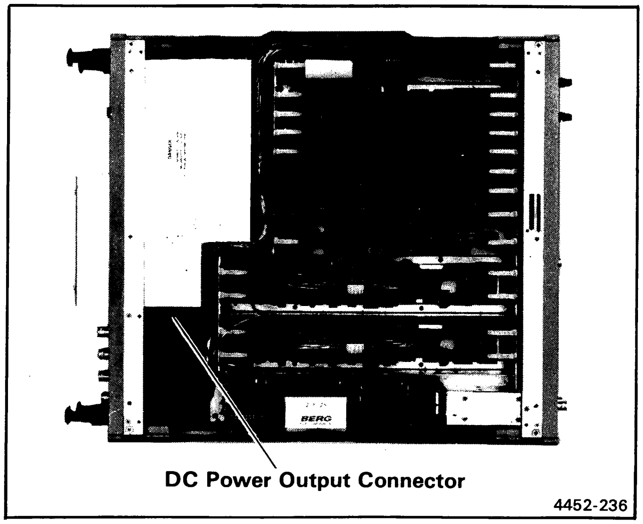


Figure A-2. DC power output connector.

4. Remove the four screws at the four corners of the power supply (see Fig. 2-37).

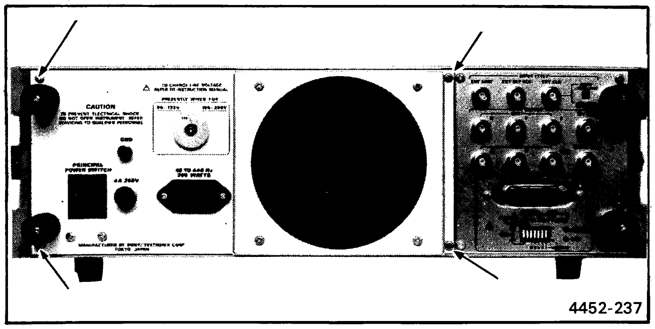


Figure A-3. Screws that retain power supply.

5. Carefully withdraw the power supply through the rear panel.

6. Remove the nine screws that fasten the cover to the power supply (see Fig. 2-38), then remove the cover.

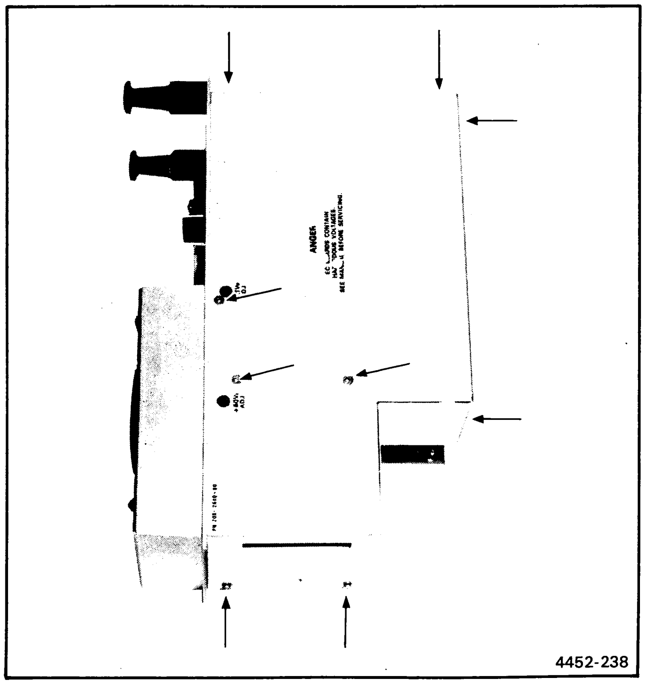


Figure A-4. Screws that fasten cover to power supply.

7. Place plug P100, on the Line Board, in the desired position. Figure 2-39 shows P100.

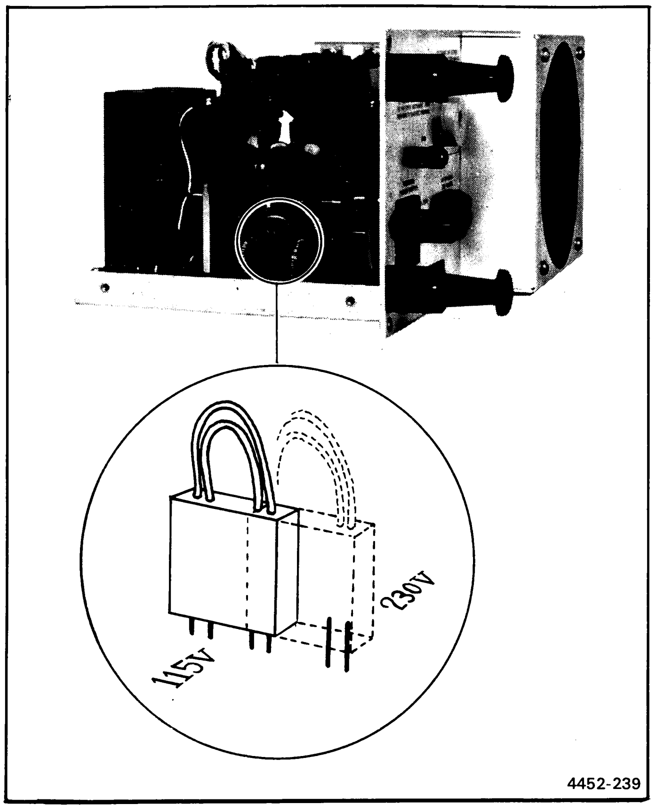


Figure A-5. Location of P100, and its 115 V and 230 V positions.

8. Set the Line Voltage Indicator, on the power supply rear panel, to match the range you selected in part 7.

9. Install the power supply cover, the power supply, connect the power connector, and install the 390AD top cover.

## MONITOR OUTPUT SELECTORS AND CONTROL

The A28 Trigger/Analog Output board has five selectors, as follows.

### X Level, Y Level, Z Level (P280, P240, P310)

Each of these selectors selects the corresponding monitor output to 5 V or 1 V, full scale. Set the selector(s) as required by the monitor in use. When using a TEKTRONIX 624 Monitor, set the Z level selector to 1 V. Figure 2-40 shows the X, Y, and Z Level Selectors.

### Intensity Modulation Selector (Z Pol, P311)

The Z Pol selector selects either positive or negative pulses to intensity modulate the monitor in use. Set the Z Pol Selector as required for your monitor. Figure 2-40 shows the Z Pol Selector.

### Cursor Selector (Hair, P230)

The Hair Cursor selector, P230, selects the cursor that will be displayed on the monitor. The cursor will be a vertical line when P230 is set to Hair On, or a dot when P230 is set to Off. Figure 2-40 shows the Hair Cursor Selector.

If the hair cursor is not clearly visible because of limited monitor bandwidth, set P230 to Off (this selects dot cursor).

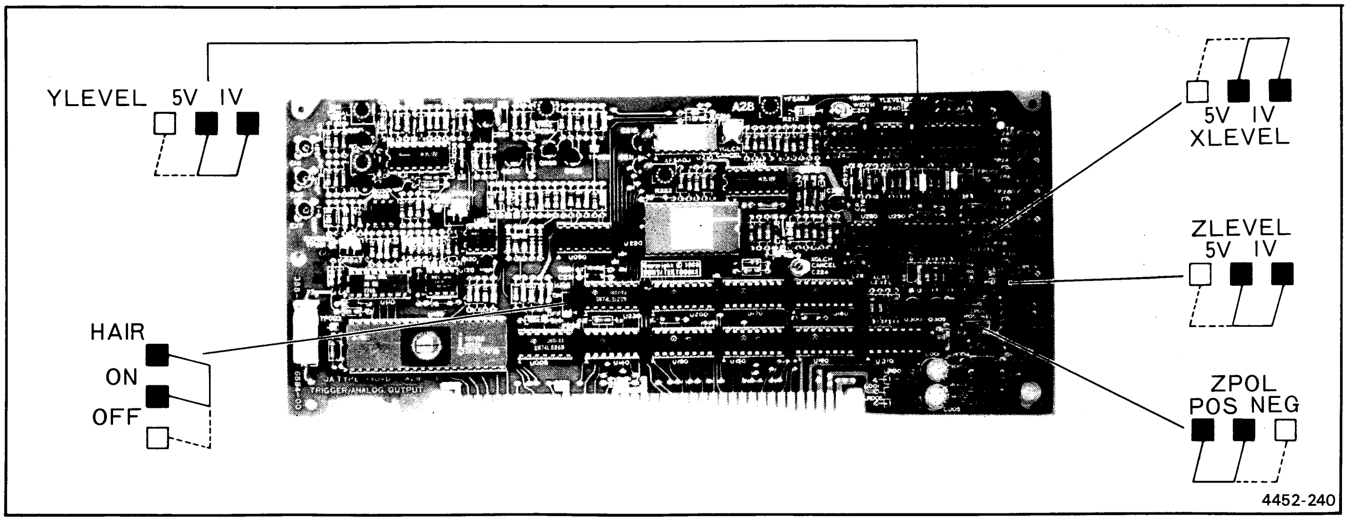


Figure A-6. Location of X, Y, and Z Level; Z Pol, and Hair Cursor Selectors.

Then adjust A25/R108, Cursor Int Adj, for optimum cursor intensity. Figure 2-41 shows the location of R108.

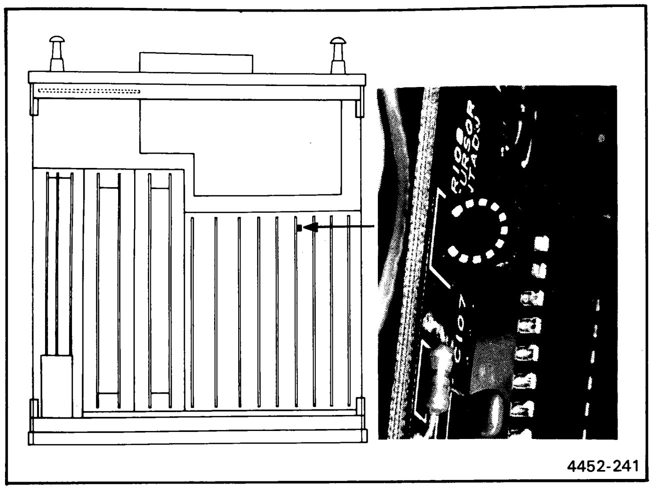


Figure A-7. Location of A25 board and R108 Cursor Intensity Adjustment.

## MISCELLANEOUS SELECTORS

### Alarm Loudness Selector (A27/P060)

This selector sets the sound output of the 390AD alarm to high (H) or low (L). If it is desirable to have no audible alarm, install P060 on only the center pin of J060. Figure 2-42 shows the Alarm Loudness Selector.

### Plot Mode Selector (A27/P070)

This selector selects one of three modes of reading data from the 390AD to an XY plotter. Select Auto Fast or Auto Slow to suit the plotter being used. Figure 2-42 shows the Plot Mode Selector (A27/P070).

When the Plot Mode Selector is set to Fix, the data readout rate must be selected by the Plot Clock Selector (A22/P170) on the Clock Generator Board. The Plot Clock Selector (A22/P170) has Fast (5 MHz), Medium (2 MHz), and Slow (1 MHz) positions. Figure 2-43 shows the Plot Clock Selector (A22/P170).

### Pen-Down Signal Polarity Selector (A60/P030)

The Pen-Down Signal Polarity Selector selects a TTL-high or TTL-low signal (when set to Pos or Neg, respectively) to activate the pen in an XY plotter. Select the polarity to suit the plotter in use. Figure 2-44 shows the Pen-Down Signal Polarity Selector (A60/P030).

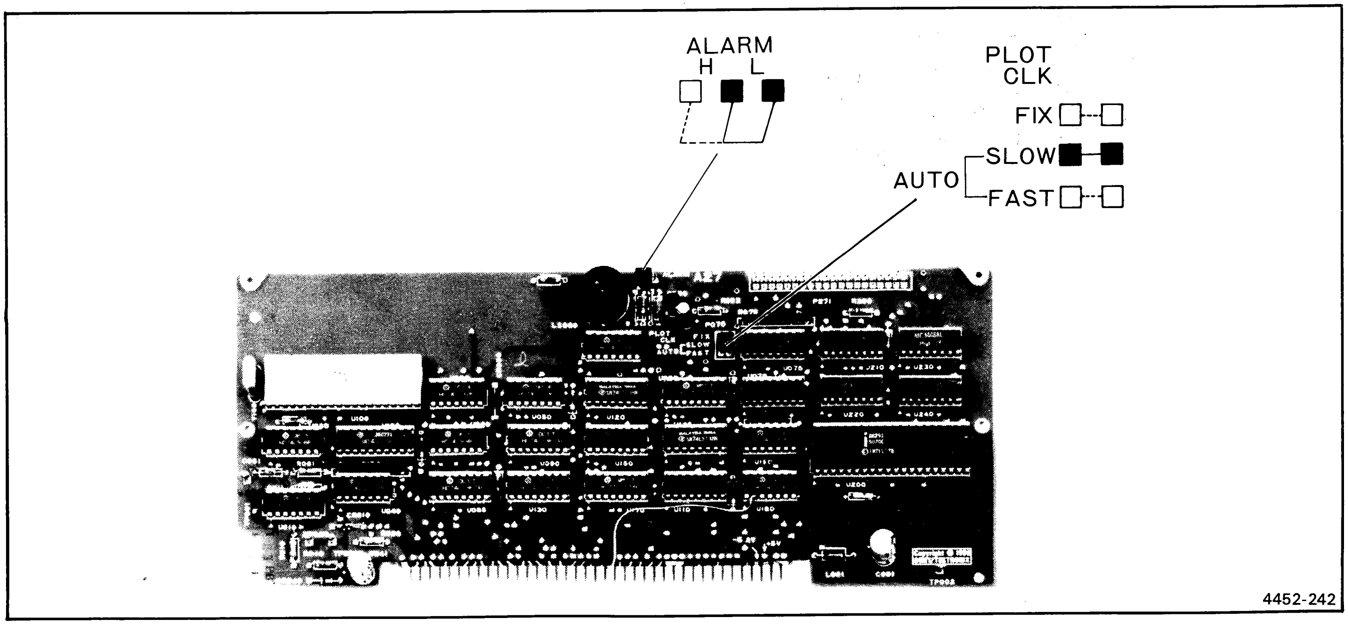


Figure A-8. Location of Alarm Loudness and Plot Mode Selectors.

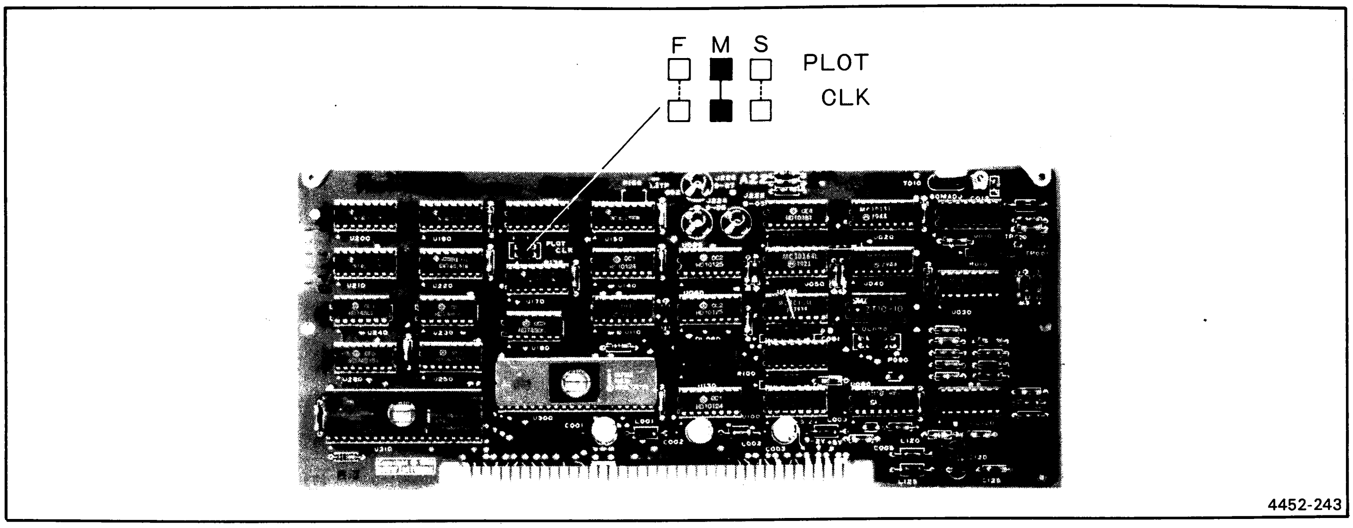

F M S
PLOT
CLK
4452-243

Figure A-9. Location of Plot Clock Selector.

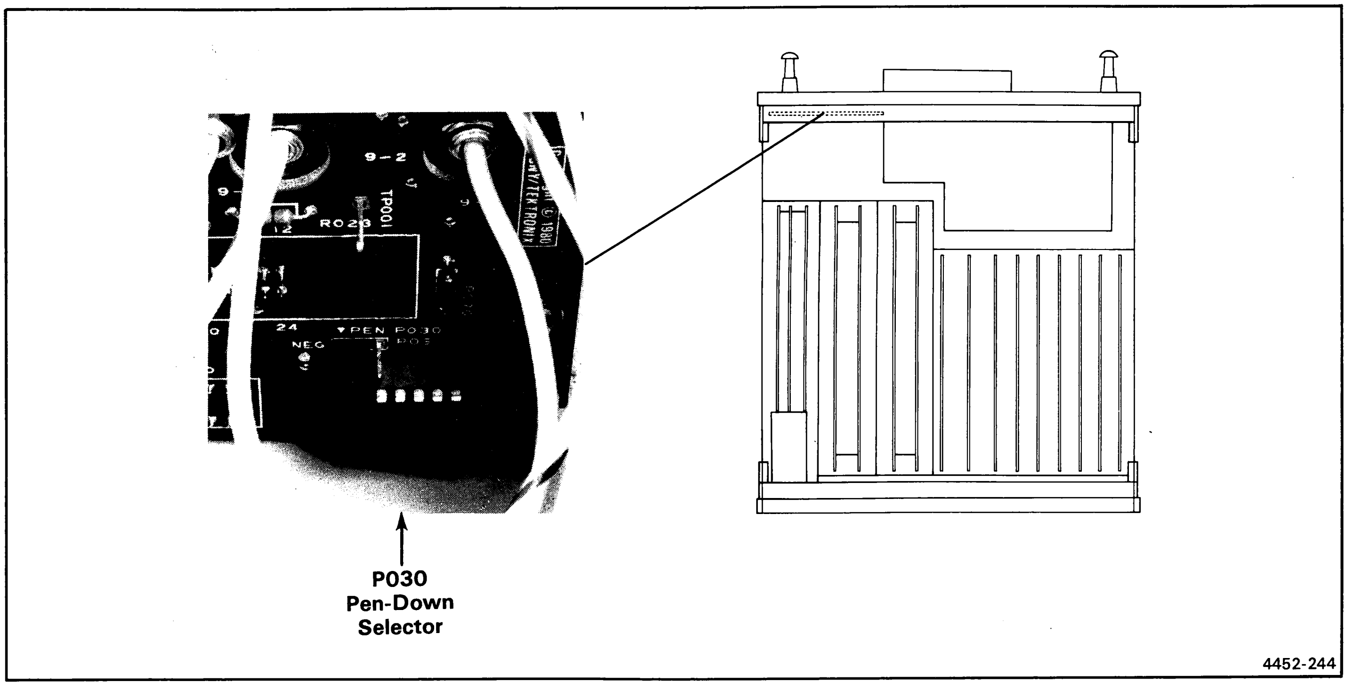

P030
Pen-Down
Selector
4452-244

Figure A-10. Location of A60 I/O Board and P030 Pen-Down Signal Polarity Selector.

# MANUAL CHANGE INFORMATION

At Tektronix, we continually strive to keep up with latest electronic developments by adding circuit and component improvements to our instruments as soon as they are developed and tested.

Sometimes, due to printing and shipping requirements, we can't get these changes immediately into printed manuals. Hence, your manual may contain new change information on following pages.

A single change may affect several sections. Since the change information sheets are carried in the manual until all changes are permanently entered, some duplication may occur. If no such change pages appear following this page, your manual is correct as printed.

# 390AD Instrument Interfacing Guide

390AD Programmable Digitizer
SONY Tektronix

1729-01

This interfacing guide is designed to help you get started using the SONY/TEK 390AD Programmable Digitizer on the GPIB as quickly and easily as possible. It provides information on setting up the 390AD for GPIB operation as well as some sample programs that illustrate a few simple operations with the 390AD on the GPIB. This guide is not intended to take the place of the 390AD Operators Manual or the manuals for your controller. These manuals will help you become familiar with the controller and the 390AD.

## CABLING THE GPIB SYSTEM

Attach the 390AD to the GPIB using a standard GPIB cable. The GPIB system may be cabled in two general configurations: star or linear (Fig. 1). While the star is the recommended configuration, these configurations may be mixed as long as the total cable length does not exceed 20 meters and the instruments are distributed on the bus according to a few rules.

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First, no more than 15 total devices (including controller) can be included on a single bus. In addition, to maintain the bus electrical characteristics, one device load must be connected for every two meters of cable (generally each instrument represents one device load to the bus). The 390AD represents one device load.

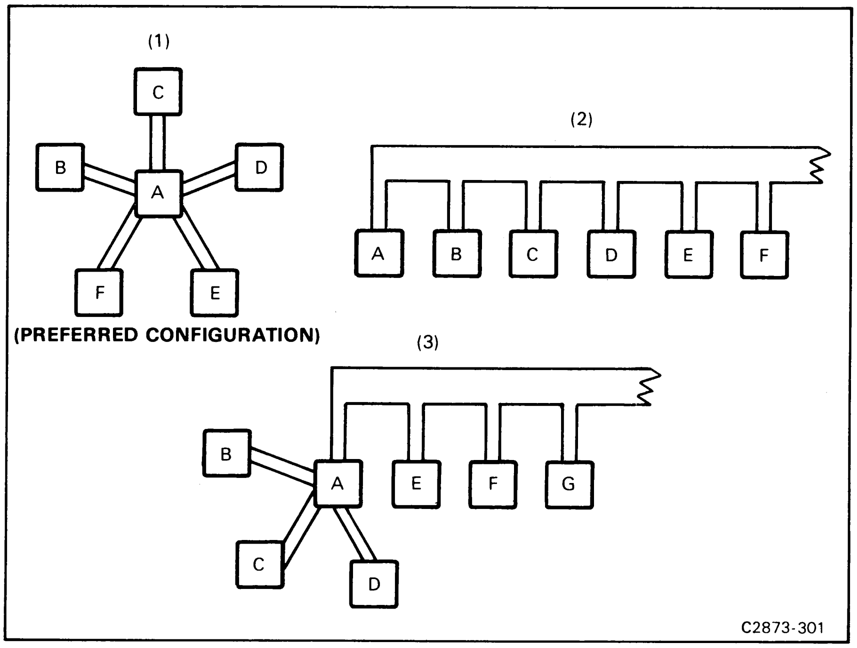

**Fig. 1** *The two basic GPIB cable configurations are star and linear, but the two can also be mixed as long as a few restrictions are observed.*

## Instrument Configuration (Selection and Verification)

The 390AD provides for the selection of the bus address, terminator, and whether the instrument is functionally connected to the bus (on line). These selections are made using the Address selection switch on the rear panel of the 390AD as shown in Fig. 3.

## Address Selection

Each instrument connected to the bus must have a unique address that is used by the controller to direct the flow of data.

The 390AD is shipped from the factory with the bus address set to 1 (one). This address setting can be determined and/or changed by examining the address switch settings, located on the rear of the 390AD. (Fig. 3)

When you are choosing a bus address for the instrument, keep a few things in mind. First, the address must be unique—no other devices on the same bus may have the same address. Second, remember that some controllers reserve an address for themselves. For instance, the Tektronix 4050-Series Graphic Computing Systems reserve address zero for themselves, and the Tektronix 4041 uses address 30 by default which may be changed. If your controller reserves an address, the instrument cannot be set to that address.

Finally, setting any device to address 31 effectively removes it from the bus—the device cannot be addressed.

## Absolute Talk and Listen Addresses

Every instrument on the bus that can talk and listen actually has at least two addresses—a "talk" address and a "listen" address. The talk address is used when the instrument is sending data and the listen address is used when the instrument is receiving data. The primary address determines the talk and listen

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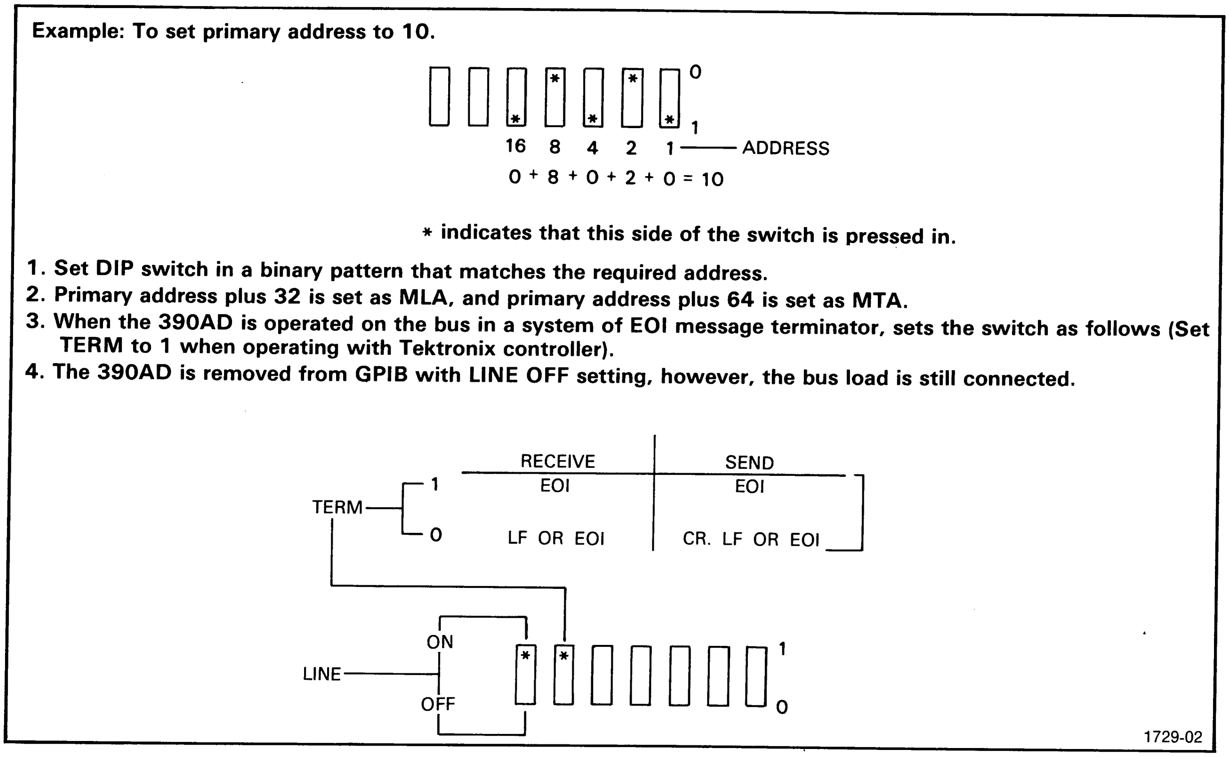
addresses. The talk address is simply the primary address plus 64 and the listen address is the primary address plus 32.

In most cases, these talk and listen addresses are transparent to the user because the controller automatically generates them from the primary address. The controller issues the talk address when expecting to receive data from the instrument and it issues the listen address when getting ready to send data to the instrument. In some cases, such as with TEK SPS BASIC using the low-level GPIP driver, you are required to use the absolute talk and listen addresses in the I/O statements.

| Address Type | Address Range Decimal | Primary Address |
|---|---|---|
| MLA (Listen Add.) | 32 - 62 | 0 - 30 |
| "Un-Listen All" | 63 | 31 |
| MTA (Talk Address) | 64 - 94 | 0 - 30 |
| "Un-Talk All" | 95 | 31 |

**Fig. 2.** *Summary of GPIB address relationships.*



**Example: To set primary address to 10.**

*** indicates that this side of the switch is pressed in.**

1. **Set DIP switch in a binary pattern that matches the required address.**
2. **Primary address plus 32 is set as MLA, and primary address plus 64 is set as MTA.**
3. **When the 390AD is operated on the bus in a system of EOI message terminator, sets the switch as follows (Set TERM to 1 when operating with Tektronix controller).**
4. **The 390AD is removed from GPIB with LINE OFF setting, however, the bus load is still connected.**

**Fig. 3.** *390AD rear-panel address select switch.*

## Terminator Selection

The terminator indicates when a sending device is finished with the current message. The two most common terminator types are EOI (End or Identify), and LF (Line Feed).

The 390AD may be set to either configuration with the second switch in the address selection switch bank (Fig. 3). With switch 2 "on" (EOI selected), the 390AD asserts the EOI line concurrently with the last data byte in the message, and recognizes "end of message" whenever it receives an asserted EOI line. With switch 2 "off" (LF selected), the 390AD sends CR and LF after the last byte in the message, and asserts EOI at the same time that LF is sent. When receiving a data transfer, the 390AD recognizes an asserted EOI level, or the ASCII code for line feed (LF), as the "end of message".

The best way to determine which terminator to use is to look at the specifications for your controller, and match the terminator recognized by it. For Tektronix controllers that is the EOI terminator.

### Instrument Interface Mode Selections

The 390AD has one interface mode selection available via the rear-panel address select switch bank, "on" or "off-line". This is accomplished with switch 1 of the address select switch (Fig. 3). While in the "off line" position, proper bus loading is maintained, but the instrument cannot receive or send messages. It is functionally disconnected from the bus.

## PROGRAMMING THE 390AD

### Power Up Test

With the 390AD cabled and the address and message terminator set, you're ready to power-up the system. Keep in mind that when powering up a system containing several GPIB instruments on the bus, that at least one-half must be powered up before the controller is brought "on line".

To turn on the power on the 390AD, first turn on the primary power switch located on the rear of the instrument. After that, the front-panel momentary switch must be held in for at least 1 second. The 390AD performs a Self-Test on power-up, and initializes itself to a predefined state, ready to digitize incoming data. For information about the power-up test and other instrument functions, please see the 390AD Operators Manual.

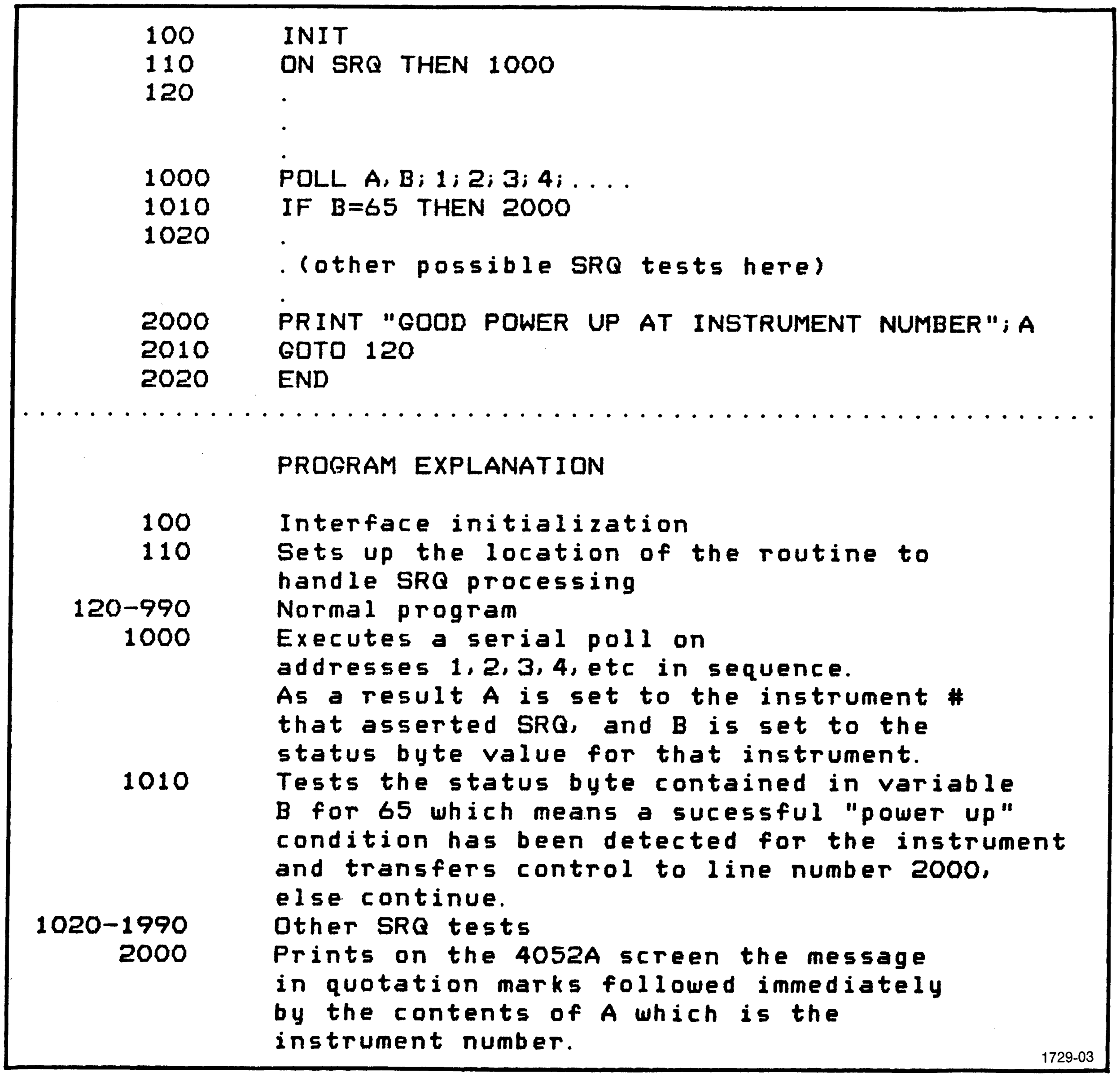
### Power Up SRQ

When the power-up tests are complete, the 390AD asserts the GPIB line called SRQ. In the interface, the status byte is set to reflect either a normal power-up (65) or the code for the type of failure in the power-up test (see error codes in the 390AD Operators Manual). If the controller's SRQ interupt is disabled, the power-up SRQ can be ignored. However, the interupt can only be cleared by performing a serial poll as illustrated in Fig. 4. In normal system operation, you will probably want to poll the instruments and check the power-up status to see that the instruments powered up normally.

If you are using a Tektronix 4051 or 4052 Controller without the 405XR14 ROM pack, the message:

"NO SRQ ON UNIT"

will be printed if an SRQ handler routine is not linked when the power-up SRQ occurs.



```
     100     INIT
     110     ON SRQ THEN 1000
     120     .
             .
             .
    1000     POLL A,B;1;2;3;4;....
    1010     IF B=65 THEN 2000
    1020     .
             .(other possible SRQ tests here)
             .
    2000     PRINT "GOOD POWER UP AT INSTRUMENT NUMBER";A
    2010     GOTO 120
    2020     END
.............................................................

             PROGRAM EXPLANATION

     100     Interface initialization
     110     Sets up the location of the routine to
             handle SRQ processing
 120-990     Normal program
    1000     Executes a serial poll on
             addresses 1,2,3,4,etc in sequence.
             As a result A is set to the instrument #
             that asserted SRQ, and B is set to the
             status byte value for that instrument.
    1010     Tests the status byte contained in variable
             B for 65 which means a sucessful "power up"
             condition has been detected for the instrument
             and transfers control to line number 2000,
             else continue.
1020-1990    Other SRQ tests
    2000     Prints on the 4052A screen the message
             in quotation marks followed immediately
             by the contents of A which is the
             instrument number.
```

**Fig. 4.** *Performing a serial poll with the Tektronix 4052A controller.*

### Power Up Default Settings

When the 390AD powers up, all instrument settings are set to default values. Table 1 shows the default power-up settings.

**Table 1**
**POWER-UP DEFAULT SETTINGS**

| | |
|---|---|
| VERTICAL | |
| AC-DC-GND | AC |
| INPUT RANGE | 50V |
| DC OFFSET | 0% |
| VERT MODE | DUAL |
| AUTO CAL | OFF |
| TRIGGER | |
| SLOPE | + |
| SOURCE | CH 1 |
| CPLG | AC |
| LEVEL | 0% |
| ARM | AUTO |
| TIMEBASE | |
| TRIG MODE | AUTO |
| SYSTEM RESET | OFF |
| REC MODE | PRE TRIG |
| DISPLAY TIME ∞ | OFF |
| SAMPLE FREQ A/B | 10MHz |
| TIME BASE | A |
| DELAY COUNT (BRK PT) | 200 |
| DLY CLK | INT |
| LATCH SHIFT | OFF |
| MEM LATCH-CH 1 | OFF |
| MEM LATCH-CH 2 | OFF |
| DISPLAY AND MEASUREMENT FUNCTIONS | |
| CURSOR-CH 1 | OFF |
| CURSOR-CH 2 | OFF |
| DISPLAY | YT |
| FUNCTION | |
| (CH 1-CH 2) | CH 1 |
| (VOLT-TIME) | TIME |
| (ΔTIME-ΔVOLT)- | |
| (VOLT-1/ΔTIME) | VOLT-1/ΔTIME |
| PLOT | |
| CH 1-CH 2 | CH 1 |
| START-RESET | RESET |
| READOUT | 204.60μs |
| REMOTE-LOCAL | LOCAL |

## GPIB MESSAGES

All messages transferred over the GPIB can be divided into two general classes: (Fig. 5)

*INTERFACE MESSAGES

*DEVICE-DEPENDENT MESSAGES

INTERFACE MESSAGES are commands that control interface functions. The IEEE 488 standard specifies these messages so that they are standard for all devices. The controller asserts the ATN line on the GPIB to distinguish these messages from the device-dependent messages. The commands used to send these messages depends entirely upon the particular controller used.

Using the TEKTRONIX 4041 controller, the following statements would send interface messages to the instrument with a primary address of 1:

WBYTE #1: GET(1)

This sends a Group Execute Trigger

WBYTE #1: ATN(MLA)

This addresses instrument #1 as a listener

### 390AD Response to Interace Control Messages

The 390AD does not respond to the following interface control messages:

*PPC—Parallel Poll Configure

*PPU—Parallel Poll Unconfigure

*TCT—Take Control

The 390AD does respond to the other interface control messages as follows:

GTL —Go To Local. This causes the instrument to go to the local state. In this state, device-dependent messages continue to be accepted by the instrument, but only commands that do not affect the state of the instrument or data memory will be executed.

GET —Group Execute Trigger. This will simultaneously arm multiple instruments (390AD's). Instrument has to be in the ARM MAN, and MAR mode for this to occur.

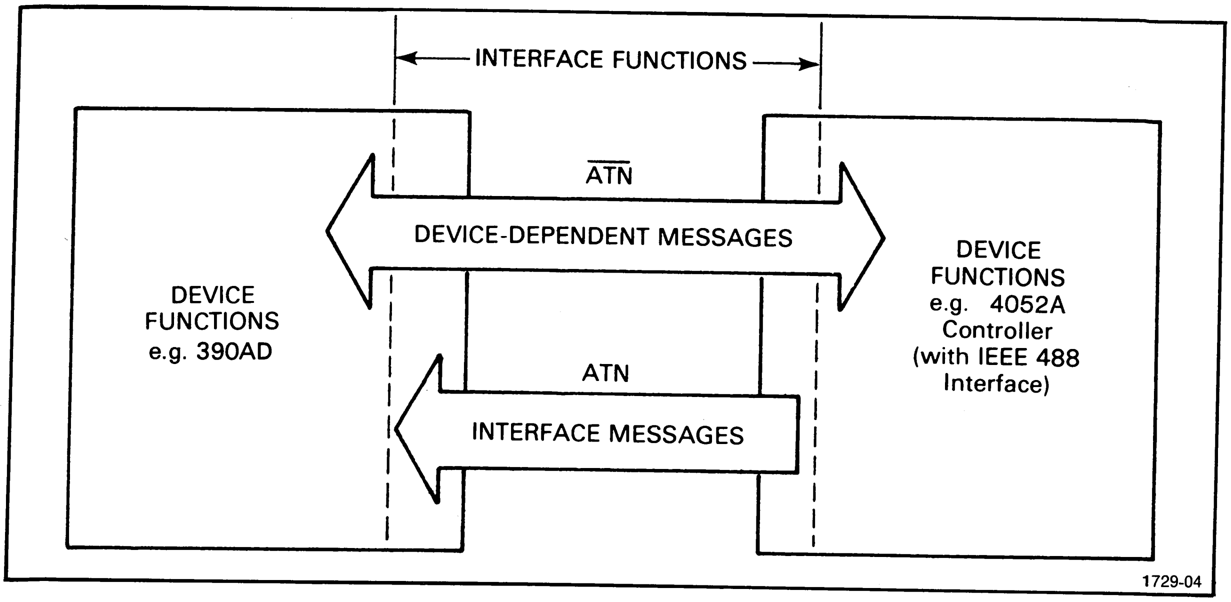

INTERFACE FUNCTIONS
$\overline{\text{ATN}}$
DEVICE-DEPENDENT MESSAGES
DEVICE FUNCTIONS e.g. 390AD
DEVICE FUNCTIONS e.g. 4052A Controller (with IEEE 488 Interface)
ATN
INTERFACE MESSAGES
1729-04

**Fig. 5.** *All messages on the GPIB are either interface messages that control interface functions or device-dependent messages that control instrument settings or parameters.*

LLO —Local Lock Out. This will lock out all front-panel controls of the 390AD if the instrument is in the remote state. The only controls still functional are POWER and REMOTE.

SDC,DCL —Selected Device Clear and Device CLear. Either of these messages will reset the instrument input and output buffers used for transfer of device-dependent messages, and if in the waveform transfer mode, will halt all transfer.

SPE,SPD —Serial Poll Enable and Serial Poll Disable. The 390AD has full serial poll capability.

IFC —Interface Clear. This will reset the interface only and does not affect any instrument function. It has the same effect as sending UNT(alk) and UNL(isten) messages to disable the talker or listerner state.

DEVICE-DEPENDENT MESSAGES consist of the commands or data that control instrument functions. For example, a command to set the 390AD digitizing rate is a device-dependent message. These types of messages are sent with the GPIB ATN line in the unasserted state. The message content and format is not specified in the IEEE 488 standard, and therefore is left to the instrument designer.

These device-dependent messages are the basic vocabulary of the instrument specifically provided to control the various functions of that instrument. This vocabulary is called the Command Set, and is unique to each instrument.

Device-dependent messages are further divided into two classes:

*SET COMMANDS—commands telling the instrument to perform a function

*QUERY COMMANDS—commands asking the instrument a question.

## Sending Commands to the 390AD

390AD commands are sent in ASCII after the controller has addressed it as a listener. The 390AD then accepts these "strings" and begins execution of the commands immediately after either:

1. the 390AD input message buffer becomes full, or
2. the message terminator is received.

The "strings" that are the commands to the 390AD have the following format :

```
SET COMMANDS:
        <header><space><argument>{<comma><argument>...}

        READ CH1,0,1023

QUERY COMMANDS:
        <header><question mark>

        ARM?

COMBINING MULTIPLE COMMANDS:
        <command><semicolon><command><semicolon>....

        READ CH1,0,1023;ARM AUTO;CP1 AC                1729-05
```

**Fig. 6.** *Format of GPIB Commands.*

Most GPIB controllers provide a set of simple statements that allow the operator to transfer device-dependent messages to and from the GPIB instruments. In the Tektronix 4050 and 4041 series system controllers, the PRINT statement is used to send these device-dependent messages, while the INPUT command accepts responses from the instruments. Fig. 7 shows some examples of these types of commands using various controller types:

| CONTROLLER TYPE | OUTPUT COMMANDS | INPUT COMMANDS |
|---|---|---|
| Tektronix 405X BASIC | PRINT @1:"string" | INPUT @1:A$ |
| Tektronix 4041 BASIC | PRINT #1:"string" | INPUT #1:A$ |
| TEK SPS BASIC | PUT "string" INTO #1 | GET A$ FROM #1 |
| FLUKE 1720A BASIC | PRINT @1%:"string" | INPUT @1%:A$ |
| HP-85 BASIC | OUTPUT 701 ;"string" | INPUT 701 ;A$ |
| HP 9826A BASIC | OUTPUT 701 ;"string" | INPUT 701 ;A$ |
| HP 9825 HPL | wrt 701,"string" | red 701,A$ |

1729-06

**Fig. 7.** *Controller I/O command examples using an instrument primary GPIB address of "1".*

Examples of commands that are recognized by the 390AD are shown in Fig. 8.:

| | |
|---|---|
| CP1 AC | this sets channel 1 coupling to the AC mode |
| TB A | this selects Time Base A |

1729-07

**Fig. 8.** *390AD command strings.*

Using the Tekronix 4052A BASIC and TEK SPS BASIC, the above commands would look like this:

```
      4052A BASIC                          TEK SPS BASIC

100   PRINT @1:"CP1 AC"               100   PUT "CP1 AC" INTO #1
110   PRINT @1:"TB A"                 110   PUT "TB A" INTO #1
          -OR-                                  -OR-
200   PRINT @1:"CP1 AC;TB A"          200   PUT "CP1 AC;TB A" INTO #1
```

1729-08

**Fig. 9.** *Complete 390AD commands using two controller types.*

Notice from the above examples that the syntax of the 390AD message in the quotes is the same. All that changes is the syntax of the controller's output statement. Generally there are three components in any GPIB output statement:

*The keyword (such as PRINT, WRITE, INPUT, wrt, etc)

*The GPIB address of the instrument (the address number 1 was used in the above example), and

*The message itself (usually presented in quotation marks).

Line number 200 shows both commands combined in one statement for brevity, but it accomplishes the same task as line numbers 100 and 110. Commands may be combined in that manner in any order, as long as they are separated by semicolons.

### Set Commands and Query Commands

The above examples showed the use of "SET" commands, which will set a function in the instrument being addressed. "QUERY" commands, by contrast, ask the instrument a question, such as "what are all the current instrument settings?" This takes the form of "string?". The question mark differentiates the QUERY commands from the SET commands.

Examples of QUERY commands using the 4052A controller are:

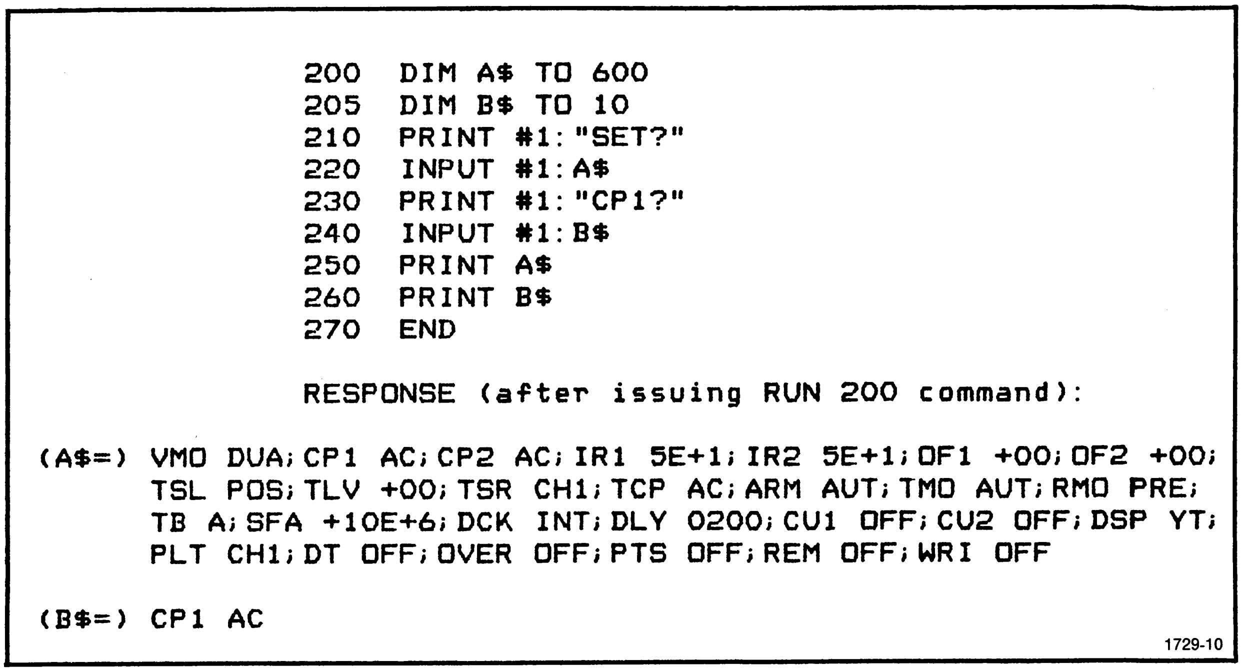
```
100   PRINT @1:"SET?"
120   PRINT @1:"CP1?"
```

1729-09

**Fig. 10.** *Examples of 390AD QUERY commands.*

In the above example, line number 100 asked the instrument to return all the instrument settings, and line number 120 asked specifically what the coupling switch for channel 1 is currently set to. Please note in the command table the section labeled "QUERY COMMANDS". These are "QUERY ONLY" commands, and all others not otherwise specified may be either SET or QUERY commands. Line number 120 in the above example shows this.

When sending a QUERY command, a question is being asked of the instrument. It, however, does not answer until told by the controller to do so. Then if the operator also wants to know the answer, the controller must be told to output that answer to the screen. Following is a complete example and the expected response using the Tektronix 4041 controller:



```
200  DIM A$ TO 600
205  DIM B$ TO 10
210  PRINT #1:"SET?"
220  INPUT #1:A$
230  PRINT #1:"CP1?"
240  INPUT #1:B$
250  PRINT A$
260  PRINT B$
270  END

RESPONSE (after issuing RUN 200 command):

(A$=) VMO DUA;CP1 AC;CP2 AC;IR1 5E+1;IR2 5E+1;OF1 +00;OF2 +00;
      TSL POS;TLV +00;TSR CH1;TCP AC;ARM AUT;TMO AUT;RMO PRE;
      TB A;SFA +10E+6;DCK INT;DLY 0200;CU1 OFF;CU2 OFF;DSP YT;
      PLT CH1;DT OFF;OVER OFF;PTS OFF;REM OFF;WRI OFF

(B$=) CP1 AC
```

**Fig. 11.** *390AD Query command examples with expected responses using the Tektronix 4041 controller.*

In the above example, the 4041 was told to reserve a space of 600 characters for the expected response I called A$, and 10 characters for the response called B$ in line numbers 200 and 205. Line numbers 210 and 230 pose the question, while line numbers 220 and 240 ask the instrument to output these to the controller. Line numbers 250 and 260 then tell the controller to print these on the system screen. Line number 270 defines the end of the program.

The answer A$ could have been saved for later recall, to more quickly set up the instrument "as it was".

### 390AD Waveform Transfer

The 390AD sends its waveform data in binary rather than ASCII as in QUERY responses. Binary data transfer requires fewer bytes than the equivalent ASCII transfer for the same amount of data, so the transfer is faster. But receiving binary data usually requires using some different commands than receiving ASCII data.

The 390AD sends its binary data in a binary block format specified by the Tektronix Codes and Formats Standard. The format of the binary block is shown in Fig. 12.:

%<byte count><data bytes><checksum>;

Where:

% is the ASCII percent (%) character

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

DATA BYTES are the waveform data. Because the 390AD has 10-bit resolution, 10-bit waveform data is divided into two bytes. The upper two bits of each waveform point is in the upper byte (two least significant bits) while the rest of the upper byte bits are always 0. The waveform data is sent upper byte first.

CHECKSUM is an eight-bit, twos-complement binary number that is the modulo-256 sum of all preceding bytes in the block excluding the % charcter.

; is the ASCII semicolon (; ) character

EOI is asserted when transmitting the last semicolon (; ) in the waveform data.

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Fig. 12. *390AD Binary waveform block format.*

## Reading Binary Waveform Data

If you are using simple RBYTE commands to read binary data from the bus, the percent sign and both bytes of the byte count must be read into individual variables with an RBYTE statement. Then the waveform data can be read into an array set aside to accept the waveform data. Finally, the checksum and semicolon must be read. Fig. 13 shows a 4052A program (not using the 4052AR14 ROM Pack) to read a 390AD binary waveform.

```
110   PRINT @1:"READ CH1,0,1023"
120   WBYTE @95,63,65:
130   RBYTE PCNT,CNT1,CNT2,WFM1,CHKS,SEMI
140   WBYTE @95,63:
150   END
```

Where WFM1 is the array set aside to accept the waveform points from the 390AD from point 0 through 1023, for a total of 1024 data points. Since each point consists of two bytes, twice the space, or 2048 bytes, must be set aside to accept this waveform. Line number 110 tells intrument number 1 to get ready to send waveform data points out of channel 1 between points 0 and 1023. This sets up the transfer. Line number 120 addresses three devices, only one of which is present (65) which corresponds to the talk address (MTA) for device 1. This effectively makes sure that no other device will pay attention besides device #1 for talking. Line number 130 reads five value types:

| | | |
|---|---|---|
| 1. | PCNT | is a local variable that will accept the % symbol from the waveform |
| 2. | CNT1,CNT2 | two-byte variable that will contain the total byte count for the waveform. |
| 3. | WFM1 | This is the waveform, and will be 2048 total bytes sequentially, or 1024 data points. |
| 4. | CHKS | is the checksum modulo-256 |
| 5. | SEMI | is the terminator (semicolon), and EOI will be asserted simultaneously with this to signal the end of transfer. |

Line number 140 tells all devices to "un-listen" and "un-talk".

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**Fig. 13.** *4052A program to transfer waveform from 390AD to 4052A memory.*

Using the Tektronix 4041 controller, the waveform transfer just described may be accomplished with the program in Fig. 14.:

```
100 INTEGER WFM1(1024)
200 INPUT #1 PROMPT "READ CH1,0,1023" USING "+16%":WFM1
300 END
```

1729-13

**Fig. 14.** *Reading a 390AD binary waveform into 4041 memory.*

The 4041 defaults to 16 bit integer values, therefore WFM1 reserves space for 1024 values each having 16 bits in statement 100. Statement 200 sends the read prompt, and subsequently accepts the waveform data after checking the header and byte count, and closes the waveform after calculating the checksum and receiving the terminator. Statement 300 ends the program.

### Sending Binary Waveform Data to the 390AD

To send waveform data to the 390AD, the above order is reversed, as shown in the following examples:

```
210   PRINT @1:"WRT CH2,0,1023"
220   WBYTE @95,63,33:
230   WBYTE PCNT,CNT1,CNT2,WFM1,CHKS,SEMI
240   WBYTE @95,63:
250   END
```

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**Fig. 15.** *Sending a binary waveform from 4052A memory to the 390AD.*

The assumption in Fig. 15 is made that the waveform was first moved into the controller using the program previously shown in Fig. 13. All the data was maintained until the transfer to the 390AD program was executed, hence all variable names were still there and contained the correct values. If this program were executed without first having set up the variables using the program in Fig. 13 or equivalent, the user will be prompted with errors.

```
400 PRINT #1:"WRT CH2,0,1023"
500 PRINT #1 USING "+16%":WFM1
600 END
```

1729-15

**Fig. 16.** *Sending a binary waveform from 4041 memory to the 390AD.*

In the 4041 program shown in Fig. 16, the proper header, byte count, checksums, and terminator will be automatically inserted at the proper time. The only variable the user is responsible for is the waveform array WFM1.

## The 390AD Command Set

Table 2 provides a summary of the 390AD commands and arguments. Complete command descriptions are given in the 390AD Operators Manual. The notes identified have the following meaning:

1. The set form of this command is not executed in the Local state. The query form (where applicable) is executed in Local ior Remote. (Note: The 4050 series controller is automatically set to the remote state by PRINT @1: or WBYTE @1: 95,63,33:.)
2. Can be used only as a set command
3. Power-up condition (NOTE: At power-on, power-on SRQ is asserted in the Local state.)

## Table 2
## 390AD COMMAND SUMMARY

| Header | Argument | Description | Notes |
|---|---|---|---|
| | | **Instrument Commands** | |
| CLR | CH1 | Clears Channel 1 waveform data. | 2 |
| | CH2 | Clears Channel 2 waveform data. | 2 |
| DT | ON | Enables the device trigger function. | 1 |
| | OFF | Disables the device trigger function. | 1, 3 |
| LAM(P) | ON | Turns the front panel lamp on. | 1, 3 |
| | OFF | Turns the front panel lamp off. | 1 |
| OVE(R) | ON | Asserts SRQ for the input overrange condition. | 1 |
| | OFF | Does not assert SRQ for the input overrange condition. | 1, 3 |
| PTS | ON | Asserts SRQ when the plotter output is completed. | 1 |
| | OFF | Does not assert SRQ when the plotter output is completed. | 1, 3 |
| RDS | AMD | Investigates the arming condition. | 2 |
| | TRD | Investigates the triggering condition. | 2 |
| | WTG | Investigates the writing condition. | 2 |
| | RDY | Investigates the ready condition when the trigger mode is set to single. | 2 |
| | PLT | Investigates whether the XY plotter is recording. | 2 |
| | DT1 | Investigates the display time condition. | 2 |
| REM | ON | Asserts SRQ when the REMOTE button is pressed. | 1 |
| | OFF | Does not assert SRQ when the REMOTE button is pressed. | 1, 3 |
| WRI | ON | Asserts SRQ when the writing is completed. | 1 |
| | OFF | Does not assert SRQ when the writing is completed. | 1, 3 |
| | | **Input Command** | |
| CAL | | The instrument is automatically calibrated. | 1, 2 |
| CP1 | AC | Sets Channel 1 input coupling to AC. | 1, 3 |
| | GND | Sets Channel 1 input coupling to GND. | 1 |
| | DC | Sets Channel 1 input coupling to DC. | 1 |
| CP2 | AC | Sets Channel 2 input coupling to AC. | 1, 3 |
| | GND | Sets Channel 2 input coupling to GND. | 1 |
| | DC | Sets Channel 2 input coupling to DC. | 1 |
| IR1 | <NR 1> \| <NR3> | Determines Channel 1 INPUT RANGE. | 1 |
| IR2 | <NR 1> \| <NR3> | Determines Channel 2 INPUT RANGE. | 1 |
| OF1 | <NR 1> | Determines Channel 1 DC OFFSET. | 1 |
| OF2 | <NR 1> | Determines Channel 2 DC OFFSET. | 1 |
| VMO | DUA(L) | Sets the vertical mode to DUAL. | 1, 3 |
| | CH 1 | Sets the vertical mode to CH 1 ONLY. | 1 |

**Table 2 (cont)**

| Header | Argument | Description | Notes |
|---|---|---|---|
| | | **Trigger Command** | |
| ARM | AUT(O) | Sets the arm mode to auto. | 1, 3 |
| | MAN | Sets the arm mode to manual. | 1 |
| | EXT | Allows arming with the external input. | 1 |
| MAR | | Allows arming when the arm mode is set to manual. | 1, 2 |
| TCP | AC | Sets the trigger coupling to AC. | 1, 3 |
| | HFR | Sets the trigger coupling to HF REJ. | 1 |
| | DC | Sets the trigger coupling to DC. | 1 |
| TLV | <NR 1> | Determines the trigger level. | 1 |
| TP1 | <NR 1> | Sets a bright spot that represents the Channel 1 trigger point on the monitor. | |
| TP2 | <NR 1> | Sets a bright spot that represents the Channel 2 trigger point on the monitor. | |
| TSL | POS | Sets the trigger slope to positive. | 1, 3 |
| | NEG | Sets the trigger slope to negative. | 1 |
| | BOT(H) | Sets the trigger slope to both positive and negative. | 1 |
| TSR | CH 1 | Sets the trigger source to Channel 1 input. | 1, 3 |
| | CH 2 | Sets the trigger source to Channel 2 input. | 1 |
| | EXT | Sets the trigger source to the external input. | 1 |
| | | **Timebase Commands** | |
| DCK | INT | Uses the internal clock for a delay counter. | 1, 3 |
| | EXT | Uses the external clock for a delay counter. | 1 |
| DLY | <NR 1> | Determines the setting of a delay counter. | 1 |
| DTI | | Sets the display time to infinite. | 1, 2 |
| ML1 | ON | Latches Channel 1 waveform data. | 1 |
| | OFF | Unlatches Channel 1 waveform data. | 1, 3 |
| ML2 | ON | Latches Channel 2 waveform data. | 1 |
| | OFF | Unlatches Channel 2 waveform data. | 1, 3 |
| RES | | Resets a system operation. | 1, 2 |
| RMO | PRE | Sets the record mode to pretrigger. | 1, 3 |
| | POS(T) | Sets the record mode to posttrigger. | 1 |
| SFA | <NR 1>\|<NR 3>\|<br>EXT | Sets sample frequency A. | 1 |
| SFB | <NR 1>\|<NR 3>\|<br>EXT | Sets sample frequency B. | 1 |
| TB | A | Sets timebase A only. | 1, 3 |
| | A+B | Sets timebase A+B. | 1 |
| TMO | AUT(O) | Sets the trigger mode to auto. | 1, 3 |
| | NOR | Sets the trigger mode to normal. | 1 |
| | SGL | Sets the trigger mode to single. | 1 |

**Table 2 (cont)**

| Header | Argument | Description | Notes |
|---|---|---|---|
| | | **Waveform Data Transfer Commands** | |
| REA(D) | CH 1 | Reads Channel 1 waveform data. | 2 |
| | CH 1, <NR 1>,<NR 1> | Reads the waveform data between the specified addresses in Channel 1. | 2 |
| | CH 1, CUR | Reads the waveform data between the cursors in Channel 1. | 2 |
| | CH 2 | Reads Channel 2 waveform data. | 2 |
| | CH 2, <NR 1>,<NR 1> | Reads the waveform data data between the specified addresses in Channel 2. | 2 |
| | CH 2, CUR | Reads the waveform data between the cursors in Channel 2. | 2 |
| | ROL(L) | Reads the waveform data through GPIB continuously while writing. | 2 |
| QUI(T) | | Completes the mode that reads waveform data through GPIB continuously by READ ROLL command. | 2 |
| WRT | CH 1 | Writes the waveform data to Channel 1 through GPIB. | 2 |
| | CH 1, <NR 1> | Writes the waveform data to Channel 1 from the specified address through GPIB. | 2 |
| | CH 1, <NR 1>, <NR 1> | Writes the waveform data to Channel 1 between the specified addresses through GPIB. | 2 |
| | CH 1, CUR | Writes the waveform data to Channel 1 from the cursor location through GPIB. | 2 |
| | CH 2 | Writes the waveform data to Channel 2 through GPIB. | 2 |
| | CH 2, <NR 1> | Writes the waveform data to Channel 2 from the specified address through GPIB. | 2 |
| | CH 2, <NR 1>, <NR 1> | Writes the waveform data to Channel 2 between the specified addresses through GPIB. | 2 |
| | CH 2, CUR | Writes the waveform data to Channel 2 from the cursor location through GPIB. | 2 |

Table 2 (cont)

| Header | Argument | Description | Notes |
|---|---|---|---|
| | | **Readout Function Command** | |
| CU1 | <NR 1> | Positions Cursor 1 to the specified absolute address. | 1 |
| | REL,<NR 1> | Positions Cursor 1 to the specified relative address. | 1 |
| | OFF | Turns off Cursor 1. | 1, 3 |
| CU2 | <NR 1> | Positions Cursor 2 to the specified absolute address. | 1 |
| | REL,<NR 1> | Positions Cursor 2 to the specified relative address. | 1 |
| | OFF | Turns off Cursor 2. | 1, 3 |
| DSP | YT | Sets the monitor display to the YT mode. | 1, 3 |
| | XY | Sets the monitor display to the XY mode. | 1 |
| LSH | CH 1, <NR 1> | Shifts a latched portion of Channel 1 waveform data into the specified address. | 1 |
| | CH 2, <NR 1> | Shifts a latched portion of Channel 2 waveform data into the specified address. | 1 |
| PLT | CH 1 | Sends Channel 1 waveform data to the XY plotter. | 1 |
| | CH 2 | Sends Channel 2 waveform data to the XY plotter. | 1 |
| | STA | Starts output to the XY recorder. | 1 |
| | RES | Stops output to the XY recorder. | 1 |
| RDV | AV 1 | Reads the absolute voltage at Channel 1 cursor position. | 1, 2 |
| | AV 2 | Reads the absolute voltage at Channel 2 cursor position. | 1, 2 |
| | DV 1 | Reads the relative voltage at Channel 1 cursor position. | 1, 2 |
| | DV 2 | Reads the relative voltage at Channel 2 cursor position. | 1, 2 |
| | TM 1 | Reads the time difference between Channel 1 cursors. | 1, 2 |
| | TM 2 | Reads the time difference between Channel 2 cursors. | 1, 2 |
| | FR 1 | Reads the reciprocal of the time difference between Channel 1 cursors. | 1, 2 |
| | FR 2 | Reads the reciprocal of the time difference between Channel 2 cursors. | 1, 2 |

**Table 2 (cont)**

| Header | Argument | Description | Notes |
|---|---|---|---|
| | | **Query Commands** | |
| ERR? | <NR 1> | Returns a code for a current error condition. | |
| ID? | ID SONY-TEKTRONIX/ 390AD, V79.1, FX.Y | Identifies the instrument and firmware version. | |
| OV1? | PLS<br>MNS<br>BOTH<br>NO | Returns the input condition for Channel 1 input range. | |
| OV2? | PLS<br>MNS<br>BOTH<br>NO | Returns the input condition for Channel 2 input range. | |
| PR1? | 1X<br>10X | Returns the attenuation factor of Channel 1 input probe. | |
| PR2? | 1X<br>10X | Returns the attenuation factor of Channel 2 input probe. | |
| SET? | Character | Returns all the settings of the 390AD. | |

## Instrument Status

The 390AD reports a status byte when it is polled by the controller. The status byte contains the internal status of the instrument. Two main types of status bytes may be reported:

System status —which indicates conditions that are common among all instruments that conform to the Tektronix Standard Codes and Formats (e.g., Command Error).

Device Status —which indicates conditions that are unique to that instrument type only.

An example of handling an SRQ and reading the status byte is shown in the Programmaing Examples part of this Instrument Interfacing Guide. The status byte reports errors in general terms. The ERR? query returns a code that more specifically defines the error.

## The Status Byte

The status byte read from the 390AD during a serial poll contains the following information:

Bit 8 —Device Status=1; System Status=0
7 —Service Requested (SRQ)
6 —Abnormal Condition=1; Normal=0
5 —Busy
4 —Device/System status
3 —Device/System status
2 —Device/System status
1 —Device/System status

**390AD Status Bytes**

| | | | | | | | | | | DECIMAL CODE | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **STATUS** | **Bit** | **8** | **7** | **6** | **5** | **4** | **3** | **2** | **1** | **NOT BUSY** | **BUSY** |
| NORMAL CONDITIONS (SYSTEM STATUS) | | | | | | | | | | | |
| Power On | | 0 | 1 | 0 | X | 0 | 0 | 0 | 1 | 65 | 81 |
| Remote Request | | 0 | 1 | 0 | X | 0 | 0 | 1 | 0 | 66 | 82 |
| ABNORMAL CONDITIONS (SYSTEM STATUS) | | | | | | | | | | | |
| Command Error | | 0 | 1 | 1 | X | 0 | 0 | 0 | 1 | 97 | 113 |
| Execution Error | | 0 | 1 | 1 | X | 0 | 0 | 1 | 0 | 98 | 114 |
| Internal Error | | 0 | 1 | 1 | X | 0 | 0 | 1 | 1 | 99 | 115 |
| Power Fail Error | | 0 | 1 | 1 | X | 0 | 1 | 0 | 0 | 100 | 116 |
| Execution Warning | | 0 | 1 | 1 | X | 0 | 1 | 0 | 1 | 101 | 117 |
| Internal Error Warn. | | 0 | 1 | 1 | X | 0 | 1 | 1 | 0 | 102 | 118 |
| NORMAL CONDITION (DEVICE STATUS) | | | | | | | | | | | |
| Waveform write done (When WRI ON) | | 1 | 1 | 0 | X | 0 | 0 | 1 | 1 | 195 | 211 |
| Input Sig. Overrange (When OVER ON) | | 1 | 1 | 1 | X | 0 | 0 | 0 | 1 | 225 | 241 |
| Plotter Output done (When PTS ON) | | 1 | 1 | 0 | X | 0 | 0 | 1 | 0 | 194 | 210 |

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**Fig. 17.** *390AD Status bytes. X indicates 1 if busy and 0 if not.*

## Utility Software

Utility Software is available for the 390AD from the Tektronix Instrumentation Software Library. The software consists of a series of subroutines and subprograms that perform common 390AD GPIB functions such as data acquisistion, data transfer, front-panel set-up, etc. Software is available on appropriate media for a variety of controllers, including the Tektronix 4052A and 4041.

## PROGRAMMING EXAMPLES (APPENDIX A)

## PROCESSING FOR SRQ

As soon as a device connected on the bus asserts SRQ, the controller polls the devices to find who is requesting service. The 390AD responds only to a serial poll; a good example is shown below.

- **4050 BASIC**

```
100     INIT
110     ON SRQ THEN 1000
120

1000    POLL K, L; 1; 2;....
1010    IF L-INT(L/32)*32<16 THEN 1030
1020    L = L-16
1030    IF L=65 THEN 2000
1040    PRINT @K:"ERR?"
1050    INPUT @K:A$
1060    PRINT A$
1100    RETURN
2000    PRINT "POWER UP"
2010    GOTO 1100
```

| **Program** | **Description** |
|---|---|
| 100 | Initialization |
| 110 | Moves control to line number 1000 when an SRQ occurs. |
| 120 | Afterwards, programming proceeds normally. |
| 1000 | Executes a serial poll in order of GPIB addresses 1, 2, .... As a result, K is set equal to the number of the polled device that has asserted SRQ and L is set equal to its status byte. |
| 1010 to 1020 | Takes SRQ status busy bit. |
| 1030 | Moves to 2000 if power-on SRQ. |
| 1040 | Queries error if other SRQ. |
| 1050 | Enters error code. |
| 1060 | Displays error code. |
| 1100 | Completes the processing for SRQ, then returns to the original program. |
| 2000 | Displays "POWER UP." |
| 2010 | To 1100. |

- **4041 BASIC**

```
100     INIT
110     ON SRQ THEN GOSUB 1000
120     ENABLE SRQ

1000    POLL L,K
1010    IF L-INT(L/32)*32<16 THEN GOTO
        1030
1020    L=L-16
1030    IF L=65 THEN GOTO 2000
1040    PRINT #K:ASK$("ERROR")
1050    INPUT #K:A$
1060    PRINT A$
1100    RETURN
2000    PRINT "POWER UP"
2010    GOTO 1100
```

- **TEK SPS BASIC Instrument Driver**

```
10      SRQDISABLE @0
110     ATTACH #1 AS INS1: @0
120     WHEN #1 HAS "POW" GOSUB 1000
130     WHEN #1 HAS "ABN" GOSUB 2000
140     WHEN #1 HAS "303" GOSUB 3000
150     WHEN #1 HAS "SRQ" GOSUB 4000
160     LOCKSRQ
170     SRQENABLE @0

1000    Processing for power-on SRQ

1900    SRQENABLE @0
1910    RETURN
2000    Processing for SRQ which indicates
        abnormal condition
2900    SRQENABLE @0
2910    RETURN
3000    Processing for SRQ which indicates
        writing completion
3900    SRQENABLE @0
3910    RETURN
4000    Processing for other SRQ

4900    SRQENABLE @0
4910    RETURN
```

| Program | Description |
|---|---|
| 100 | Disables processing for SRQ reception by GPIB interface No. 0. |
| 110 | Specifies the device, addressed to No. 1 on the GPIB, as instrument No. 1. |
| 120 | For power-on SRQ, moves control to line number 1000. |
| 130 | For SRQ that indicates abnormal state, moves control to line number 2000. |
| 140 | For SRQ that indicates writing completion, status byte 303 (octal) moves control to line number 3000. |
| 150 | For other SRQ, moves control to line number 4000. |
| 160 | Disables SRQ after each occurrence of SRQ and returns to each processing routine. |
| 170 | Enables processing for SRQ. |

For each SRQ processing routine, after processing but before returning, SRQENABLE @0 must be executed to enable the next SRQ.

## SET COMMAND AND QUERY COMMAND

### • 4050 BASIC

```
100      INIT
110      ON SRQ THEN 1000
120      PRINT "COMMAND:";
130      INPUT C$
140      PRINT @1:C$
150      A$=SEG(C$, LEN C$, 1)
160      IF A$<>"?" THEN 120
170      REM WHEN QUERY COMMAND
180      INPUT @1 : Q$
190      PRINT "ANSWER:";Q$
200      GOTO 120
1000     POLL A, B; 1
1010     PRINT @1:"ERR?"
1020     INPUT @1:E$
1030     PRINT "SRQ OCCURRED
         STATUS:G";B,E$
1040     RETURN
```

| Program | Description |
|---|---|
| 100 | Initialization |
| 110 | Moves control to line number 1000 when an SRQ occurs. |
| 120,130 | Requests that the command be entered into the 390AD. |
| 140 | Sends the command to the 390AD, GPIB address No. 1. |
| 150 | Takes the last character of the command out to A$. |
| 160 | Requests next command again unless the last character is not "?" (which means a set command). |
| 180 | Sends a response to a query command. |
| 190 | Displays the response. |
| 200 | Requests a command again. |
| 1000 | Performs a serial poll at the 390AD, GPIB address No. 1. |
| 1010 | Issues ERR? query command. |
| 1020 | Sends error code. |
| 1030 | Displays the status byte and error code. |
| 1040 | Returns to the original program. |

### • 4041 BASIC

```
100      INIT
110      ON SRQ THEN 1000
115      ENABLE SRQ
120      PRINT "COMMAND:";
130      INPUT C$
140      PRINT #1:C$
150      A$=SEG$(C$,LEN(C$),1)
160      IF A$<>"?" THEN GOTO 120
170      REM WHEN QUERY COMMAND
180      INPUT #1:Q$
190      PRINT "ANSWER:";Q$
200      GOTO 102
1000     POLL A,B
1010     PRINT #1:ASK$("ERROR")
1020     INPUT #1:E$
1030     PRINT "SRQ OCCURRED
         STATUS:∧G";B,E$
1040     RETURN
```

### • TEK SPS BASIC INSTRUMENT DRIVER

### • Set Command

```
 90    LOAD "INS"
100    ATTACH #1 AS INS1: @0
110    PUT1 "IR1 2;IR2 2" INTO #1
120    PUT "OF1 10;OF2 10" INTO #1
```

| Program | Description |
|---|---|
| 90 | Loads the instrument driver. |
| 100 | Specifies the 390AD, GPIB address No. 1, as instrument No. 1. |
| 110 | Sets Channel 1 and Channel 2 input range to 2 V. |
| 120 | Sets Channel 1 and Channel 2 dc offset to 10%. |

### • Query Command

```
 90    LOAD "INS"
100    ATTACH #1 AS INS1: @0
110    GET A$ FROM #1, "ID?"
120    PRINT A$
130    GET H$;F FROM #1, "SFA?"
140    PRINT "SAMPLE FREQUENCY
       A:";F;"HZ"
```

| Program | Description |
|---|---|
| 90 | Loads the instrument driver. |
| 100 | Specifies the 390AD, GPIB address No. 1, as instrument No. 1. |
| 110 | Issues ID? query command, and puts the response in to A$. |
| 120 | Displays the response. |
| 130 | Issues SFA? query command, and puts the response header into H$, and the frequency into F as a number. |
| 140 | Displays the sample frequency |

## INPUT/OUTPUT OF WAVEFORM DATA

### • 4050 BASIC

An example to send a waveform, once received, to Channel 2.

```
100    INIT
110    DIM D(1024), C(2), Y (512)
120    PRINT @1: "ML1 OFF;ML2 OFF;RES"
130    PRINT @1: "DTI;READ CH1, 0, 511"
140    WBYTE @95, 63, 65:
150    RBYTE H, C
160    RBYTE D
170    RBYTE S, T
180    WBYTE @95, 63:
190    FOR I=2 TO 1024 STEP 2
200    Y (I/2)=D(I-1) *256+D (I)
210    NEXT I
220    PRINT @1: "CLR CH2"
230    PRINT @1: "WRT CH2, 0, 511"
240    WBYTE @95, 63, 33:
250    WBYTE H, C
260    WBYTE D
270    WBYTE S, T
280    WBYTE @95, 63:
290    END
```

| Program | Description |
|---|---|
| 100 | Initialization |
| 110 | Assigns D for the input waveform data, C for the byte counter, and Y for the transformed<br>10-bit waveform data. |
| 120 | Resets memory latch in both channels of the 390AD. |
| 130 | Issues the command that enters the data between addresses 0 and 511 into Channel 1 memory. |
| 140 | Specifies GPIB address No. 1. |
| 150 | Enters the header and byte counter. |
| 160 | Enters the waveform data. |
| 170 | Enters the checksum and terminator. |
| 180 | Performs untalk and unlisten. |
| 190 to 210 | Formats the waveform data sent in one point, two bytes. |
| 220 | Clears Channel 2 waveform RAM in the 390AD to ground level. |
| 230 | Issues the command that writes between the addresses 0 and 511 from the GPIB. |
| 240 | Specifies GPIB address No. 1. |
| 250 | Sends the header and byte counter. |
| 260 | Sends the waveform data. |
| 270 | Sends the checksum and terminator. |
| 280 | Performs untalk and unlisten. |
| 290 | End |

- **4041 BASIC**

```
100     INIT
110     INTEGER D(512)
120     PRINT #1: "ML1 OFF:ML2 OFF:RES"
130     PRINT #1: "DTI:READ CH1,0,511"
140     INPUT #1 USING "+16%":D
150     REM Lines 140 through 210 in the
160     REM 4050 BASIC example are the same
170     REM as line 140 of this program
220     PRINT #1: "CLR CH2"
230     PRINT #1: "WRT CH2,0,511"
240     PRINT #1 USING "+16%":D
250     REM Lines 240 through 280 in the
260     REM 4050 BASIC example are the same
270     REM as line 240 of this program
280     END
```

- **TEK SPS BASIC INSTRUMENT DRIVER**

```
 90     LOAD "INS"
100     ATTACH #1 AS INSI: @0
110     MODE #1, "PAK", "HBF"
120     DIM D1 (511), D2(511)
130     GET D1 FROM #1, "READ CH1, 0.511"
140     GET D2 FROM #1, "READ CH2, 0.511"
150     END
```

| Program | Description |
|---|---|
| 90 | Loads the instrument driver. |
| 100 | Specifies the 390AD, GPIB address No. 1 as instrument No. 1. |
| 110 | Sets the processor to high byte first (HBF) mode in a pack style. |
| 120 | Assigns D1 for Channel 1 and D2 for Channel 2. |
| 130 | Puts the waveform data between Channel 1 addresses 0 and 511 into memory array D1. |
| 140 | Puts the waveform data between Channel 2 address 0 and 511 into memory array D2. |
| 150 | End |

## WAVEFORM DATA INPUT IN GPIB ROLL MODE

- **4050 BASIC**

```
100     INIT
110     DIM D(1024), Y (512)
120     WINDOW 1, 512, 0, 1023
130     PRINT @1: "VMO CH1"
140     PRINT @1: "SFA 50"
150     PRINT @1: "READ ROLL"
160     FOR I=1 TO 10
170     WBYTE @95, 63, 65:
180     RBYTE D
190     WBYTE @95, 63:
200     FOR K=2 TO 1024 STEP 2
210     Y (K/2)=D(K-1) * 256+D(K)
220     NEXT K
230     PAGE
240     MOVE 1, Y(1)
250     FOR K=2 TO 512
260     DRAW K, Y(K)
270     NEXT K
280     NEXT I
290     PRINT @1: "QUIT"
300     END
```

| Program | Description |
|---|---|
| 100 | Initialization |
| 110 | Assigns D for the waveform data and Y for the transformed 10-bit waveform data. |
| 120 | Specifies window to be made into graph. |
| 130 | Sets the vertical mode to CH 1 ONLY. |
| 140 | Sets sample frequency A to 50 Hz. |
| 150 | Issues a command in the GPIB roll mode. |
| 160 | Repeats ten times |
| 170 | Specifies GPIB address No. 1. |
| 180 | Enters the waveform data. |
| 190 | Performs untalk and unlisten. |
| 200 to 220 | Frames the waveform data sent in one point, two bytes. |
| 230 | Erases the screen preparing for the graphic display. |
| 240 to 270 | Makes waveform into graph. |
| 280 | Repeats. |
| 290 | Resets GPIB roll mode. |
| 300 | End |

## • TEK SPS BASIC INSTRUMENT DRIVER

```
 80    LOAD "GPI"
 90    LOAD "INS"
100    ATTACH #1 AS INS1: @0
110    DIM D(511)
120    PUT "VMO CH1; SFA 50" INTO #1
130    IFDTM @0, "PAK", "HBF"
140    PUT "READ ROLL" INTO #1
150    FOR I=1 TO 10
160    GET D FROM @0, 65
170    PAGE
180    GRAPH D
190    NEXT I
200    PUT "QUIT" INTO #1
210    END
```

| Program | Description |
|---|---|
| 80 | Loads GPIB driver. |
| 90 | Loads the instrument driver. |
| 100 | Specifies the 390AD, GPIB address No. 1 as instrument No. 1. |
| 110 | Assigns D for the waveform data. |
| 120 | Sets the vertical mode to CH 1 ONLY and the sample frequency to 50 Hz. |
| 130 | Sets GPIB interface No. 0 mode to the high-byte first (HBF) mode in a pack style. |
| 140 | Issues a command in the GPIB roll mode. |
| 150 | Repeats ten times. |
| 160 | Enters the waveform data from the 390AD to GPIB address No. 1. |

# TEKTRONIX INSTRUMENTATION SOFTWARE LIBRARY

## Utility Software for 390AD

Utility Software is available from Tektronix, Inc. for the 390AD Programmable Digitizer. This software consists of a set of subroutines and subprograms that perform common instrument functions over the GPIB such as data acquisition, front-panel set-up, etc. These routines are designed to be easily integrated into your application programs. And since they are small and well documented, the routines are easy to modify to suit your particular applications. Refer to the current Tektronix Instrumentation Software Library Catalog for instrument options, ROM packs, and other required equipment.

The following Utility Software was available when this Instrument Interfacing Guide was printed. Other software may be available; contact your local Tektronix Field Office for further information.

| Description | Tektronix Part No. |
|---|---|
| 390AD/4041 Utility Software (DC-100 tape) | 062-6959-01 |
| 390AD/4052A Utility Software (DC-300 tape) | 062-6961-01 |

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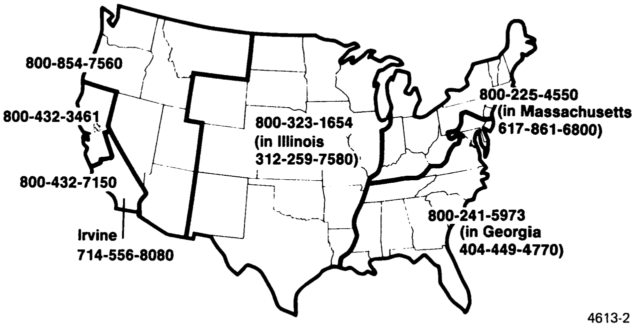

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To contribute a program, submit a copy of the program on media along with a listing and a Tektronix Instrument Software Library release form (see current library catalog). If the program was created as part of your employment, the release must be signed by an authorized representative of your employer. Acceptance of the program is subject to review of the Tektronix Instrumentation Software Library staff.

For further information on submitting a program or for information about coding and documentation standards, contact:

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TEK HSDO

SPECIFICATIONS
ORDERING INFORMATION

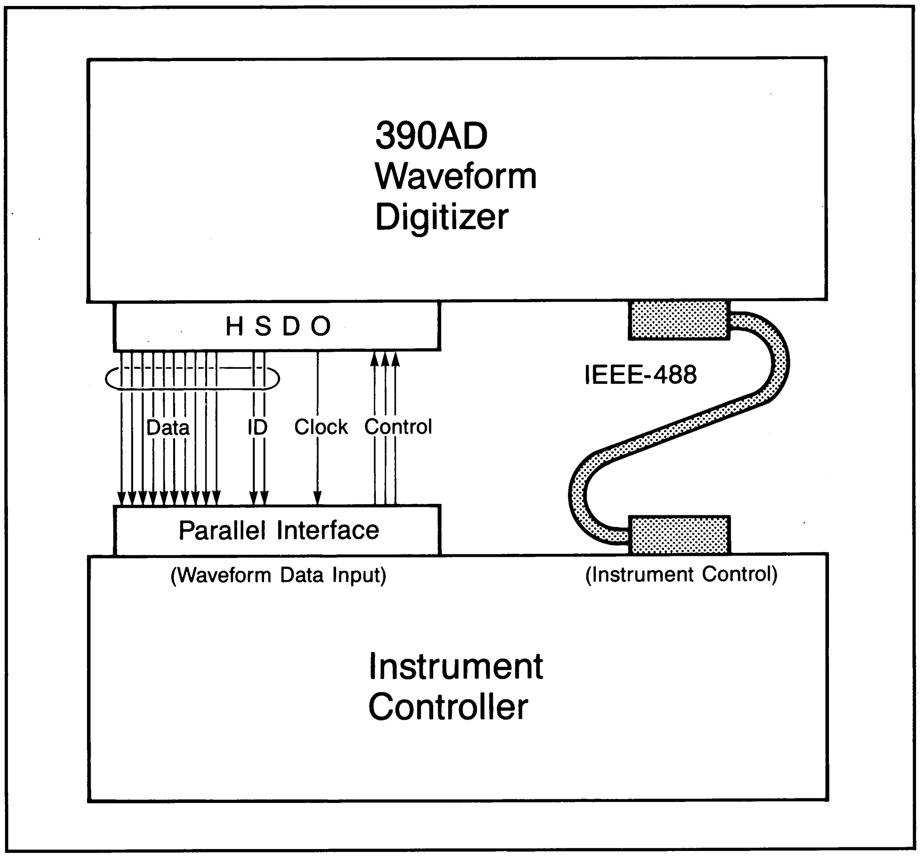
# High Speed Data Out Interface for SONY/TEK 390AD Programmable Waveform Digitizer

- **Parallel Data Transfer**
- **Automatic Rearming**
- **Higher Throughput**

The High Speed Data Out (HSDO) interface for the SONY/TEK 390AD Programmable Waveform Digitizer provides a faster way to transfer digitized waveform data from the 390AD to a controller. It does not change the operation of the 390AD or the GPIB interface, but adds a higher speed path for waveform data.

**Compatibility**
The HSDO is compatible with most general-purpose parallel CPU interfaces equipped with Cache or DMA features (e.g., DEC DRV11-B and DR11-W, or Hewlett-Packard 98622A with 98620A/B DMA). The interface provides ten bits of digitized data and two bits of waveform status information (optional) in parallel, along with clock and control lines to synchronize the transfer.

**Operation**
The 390AD must be in the single-shot digitizing mode when using the HSDO. If consecutive-trigger data logging is required, the HSDO can be strapped to automatically arm the digitizer after each waveform transfer. In either case, waveform data is transferred from 390AD memory to the parallel interface in the controller as soon as a digitize operation is complete. The data transfer to the controller is synchronized by the HSDO's output clock signal of approximately 250 kHz, derived from the 390AD's Z-Axis.



In its normal mode of operation, the HSDO transmits 2048 words from Channel 1 and 2048 words from Channel 2 waveform memories. The controller can be set to accept a smaller number of words, but 4096 will still be sent at the 250 kHz rate. For example, if the controller is set to accept 1024 words, the first 1024 words of Channel 1 will be transferred into controller memory; the remaining 1024 words of Channel 1 and all 2048 words of Channel 2 will be lost.

The transfer of these extra data can be aborted by asserting the CLOCK HALT line in the HSDO after accepting the first 1024 words. Reasserting the REQUEST line to initiate a new "arm and transfer" sequence will also abort a transfer in progress.

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**Program Example 1**

```
10 REM --- HSDO.DUA --- ACQUIRE 8 WAVEFORMS OF 4096 SAMPLES IN DUAL MODE
20 REM --- 390AD-HSDO WITH DRV11-B, DR11-B OR DR11-W
30 REM --- TEK SPS BASIC V02XM OR V03XM
40 NW=8
50 NP=4096
60 DELETE IA,IB,AA,CX
70 INTEGER IA(3,4095),IB(3,4095)\DIM AA(NW-1),CX(NW-1)
80 OSET WC="772410"\REM    WORD COUNT REGISTER
90 OSET AR="772412"\REM    BUS ADDRESS REGISTER
100 OSET CR="772414"\REM   CONTROL STATUS REGISTER
110 OSET CD="101"\REM      DATA FOR CSR (I.E. GO)
120 LOAD "IV","GPI"
130 SIFTO @0,1000
140 REM --- SET UP THE 390AD USING THE GPIB
150 PUT "VMO DUA;TMO SGL;SFA 30E6" INTO @0,35
160 PUT "RES" INTO @0,35
170 REM --- BUILD DMA ADDRESS ARRAY, WORD COUNT AND CONTROL WORD CONSTANTS
180 FOR I=0 TO 3\VARADR IA(I,0:NP-1),VA\HA=ITP(VA/65536)
190 AA(I)=VA-HA*65536\CX(I)=16*HA+CD\NEXT I
200 FOR I=4 TO 7\VARADR IB(I-4,0:NP-1),VA\HA=ITP(VA/65536)
210 AA(I)=VA-HA*65536\CX(I)=16*HA+CD\NEXT I
220 NC=65536-NP
230 REM --- LINK THE INTERRUPT VECTOR DRIVER
240 ATTACH #1 AS IV84:
250 WHEN #1 GOSUB 610
260 REM --- DMA THE DATA
270 PRINT "BEGIN DATA LOGGING . . . ";
280 LL=0\PUTLOC WC,NC\PUTLOC AR,AA(0)\PUTLOC CR,CX(0)
290 IF LL=0 THEN 290
300 LL=0\PUTLOC WC,NC\PUTLOC AR,AA(1)\PUTLOC CR,CX(1)
310 IF LL=0 THEN 310
320 LL=0\PUTLOC WC,NC\PUTLOC AR,AA(2)\PUTLOC CR,CX(2)
330 IF LL=0 THEN 330
340 LL=0\PUTLOC WC,NC\PUTLOC AR,AA(3)\PUTLOC CR,CX(3)
350 IF LL=0 THEN 350
360 LL=0\PUTLOC WC,NC\PUTLOC AR,AA(4)\PUTLOC CR,CX(4)
370 IF LL=0 THEN 370
380 LL=0\PUTLOC WC,NC\PUTLOC AR,AA(5)\PUTLOC CR,CX(5)
390 IF LL=0 THEN 390
400 LL=0\PUTLOC WC,NC\PUTLOC AR,AA(6)\PUTLOC CR,CX(6)
410 IF LL=0 THEN 410
420 LL=0\PUTLOC WC,NC\PUTLOC AR,AA(7)\PUTLOC CR,CX(7)
430 IF LL=0 THEN 430
440 PUTLOC CR,"000000"
450 PRINT "COMPLETE"
460 REM --- GRAPH THE WAVEFORMS
470 SETGR NOGRAT
480 PAGE
490 GRAPH IA(0,0:4095)
500 FOR I=1 TO 3
510 PAGE
520 DISPLAY IA(I,0:4095)
530 NEXT I
540 FOR I=0 TO 3
550 PAGE
560 DISPLAY IB(I,0:4095)
570 NEXT I
580 PRINT CHR(31);
590 END
600 REM --- INTERRUPT SERVICE ROUTINE
610 LL=1\RETURN
```

Program Example 1 shows a TEK SPS BASIC V02XM/V03XM routine to acquire, via the HSDO, eight waveforms of 4096 samples each in dual mode. This program will work with both the MicroPDP-11 (the DRV11-B interface was used) and the PDP-11/34 (DR11-B used). The general flow of the program is as follows:

a) Define data storage arrays in extended memory.

b) Set up the 390AD using the GPIB.

c) Determine a table of address pointers.

d) Link the interrupt vector handler.

e) Perform the DMA transfer by loading the Word Count Register, the Bus Address Register, and the Control Register on the DEC interface.

f) Graph the acquired waveforms.

**Program Example 2**

```
100   ! 390AD TIMING TESTS
110   Gpio=12 !SET GPIO ADDRESS TO 12
120   GCLEAR !CLEAR GRAPHICS AREA
130   WRITEIO Gpio,0;0 !TEST STATUS
140   PRINT "TRANSFER"
150   Status=READIO(Gpio,0) !READ STATUS
160   IF BINAND(Status,8)=0 THEN
170   BEEP
180   PRINT "390AD IS NOT FOUND"
190   END IF
200   WRITEIO Gpio,1;255 !RESET GPIO
210   WRITEIO Gpio,3;9 !SET BURST MODE
220   WRITEIO Gpio,5;0 !RESET TRIGGER BIT
230    INTEGER Data0(0:4095) BUFFER !BUF 1
240    INTEGER Data1(0:4095) BUFFER !BUF 2
250    INTEGER Data2(0:4095) BUFFER !BUF 3
260    INTEGER Data3(0:4095) BUFFER !BUF 4
270    INTEGER Data4(0:4095) BUFFER !BUF 5
280    INTEGER Data5(0:4095) BUFFER !BUF 6
290    INTEGER Data6(0:4095) BUFFER !BUF 7
300    INTEGER Data7(0:4095) BUFFER !BUF 8
310   ASSIGN @Buf TO BUFFER Data0(*);WORD !BUF 1
320   ASSIGN @Device TO Gpio;WORD !ASSIGN DEVICE
330   WRITEIO Gpio,5;1 !SET TRIGGER
340   TRANSFER @Device TO @Buf;WAIT !GET DATA
350   WRITEIO Gpio,5;0 !RESET TRIGGER
360   ASSIGN @Buf TO BUFFER Data1(*);WORD !BUF 2
370   WRITEIO Gpio,5;1 !SET TRIGGER
380   TRANSFER @Device TO @Buf;WAIT !GET DATA
390   WRITEIO Gpio,5;0 !RESET TRIGGER
400   ASSIGN @Buf TO BUFFER Data2(*);WORD !BUF 3
410   WRITEIO Gpio,5;1 !SET TRIGGER
420   TRANSFER @Device TO @Buf;WAIT !GET DATA
430   WRITEIO Gpio,5;0 !RESET TRIGGER
440   ASSIGN @Buf TO BUFFER Data3(*);WORD !BUF 4
450   WRITEIO Gpio,5;1 !SET TRIGGER
460   TRANSFER @Device TO @Buf;WAIT !GET DATA
470   WRITEIO Gpio,5;0 !RESET TRIGGER
480   ASSIGN @Buf TO BUFFER Data4(*);WORD !BUF 5
490   WRITEIO Gpio,5;1 !SET TRIGGER
500   TRANSFER @Device TO @Buf;WAIT !GET DATA
510   WRITEIO Gpio,5;0 !RESET TRIGGER
520   ASSIGN @Buf TO BUFFER Data5(*);WORD !BUF 6
530   WRITEIO Gpio,5;1 !SET TRIGGER
540   TRANSFER @Device TO @Buf;WAIT !GET DATA
550   WRITEIO Gpio,5;0 !RESET TRIGGER
560   ASSIGN @Buf TO BUFFER Data6(*);WORD !BUF 7
570   WRITEIO Gpio,5;1 !SET TRIGGER
580   TRANSFER @Device TO @Buf;WAIT !GET DATA
590   WRITEIO Gpio,5;0 !RESET TRIGGER
600   ASSIGN @Buf TO BUFFER Data7(*);WORD !BUF 8
610   WRITEIO Gpio,5;1 !SET TRIGGER
620   TRANSFER @Device TO @Buf;WAIT !GET DATA
630   WRITEIO Gpio,5;0 !RESET TRIGGER
640   ABORTIO @Device !RESET I/O
650   GCLEAR !CLEAR GRAPHIC AREA
660   GRAPHICS ON !SET GRAPHIC ON
670   WINDOW -100,4150,-100,2100 !SET WINDOW SIZE
680   LINE TYPE 1 !SET LINE STYLE
690   AXES 1024,256 !SET AXES
700   MOVE 0,Data0(0) !MOVE TO START
710   FOR I=0 TO 4095 !DO IT THIS MANY TIMES
720   DRAW I,Data0(I) !DRAW IT
730   NEXT I !GO BACK
740   END
```

Program Example 2 again shows eight waveforms of 4096 data points each being acquired, this time using the HSDO with an HP 9826 controller. The configuration used is as follows:

Hewlett-Packard 9826 controller with:

- HP Basic 3.0
- 672 kbytes memory
- 98622A GPIO card (parallel interface)
- 98620(A or B) DMA card

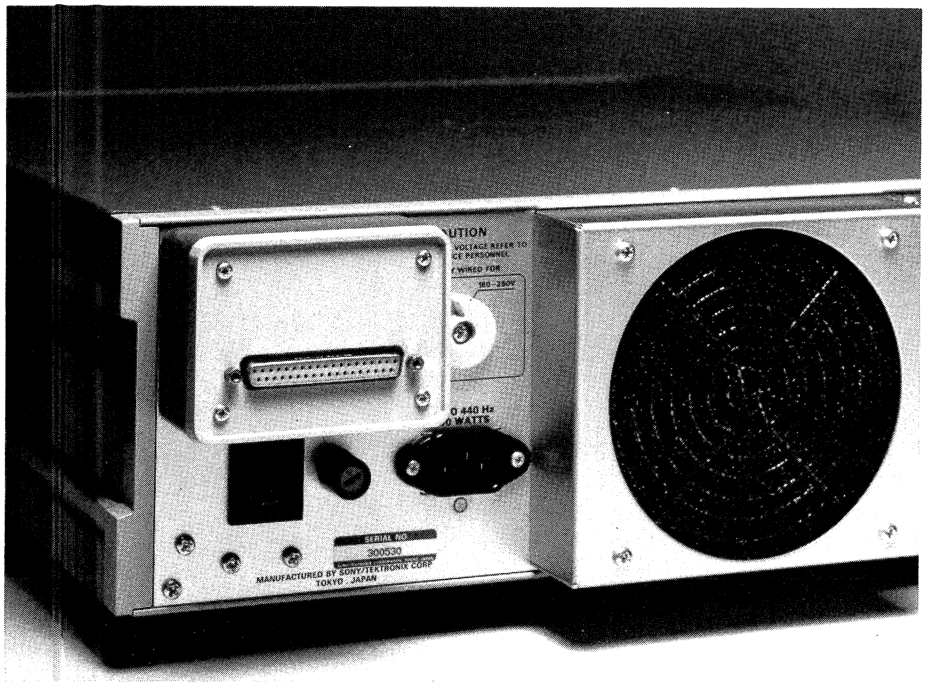

*Figure 1: 390AD Rear Panel Showing HSDO port.*

## Configuration

The physical implementation of the interface is shown in Figure 1. It consists of a single card inside a rectangular package that is mounted on the rear panel of the 390AD. A standard 37-pin female D-series connector (for connecting to the controller) is provided. The interconnecting cable is not included. The supporting documentation includes sample driver software, along with instructions for connecting the HSDO to the DEC DRV11-B and DR11-W, and HP 9826.

## Performance

Table 1 lists HSDO performance using MicroPDP-11, PDP-11/34, and HP 9826 controllers. Program examples with brief descriptions appear on previous pages.

The **Words Transferred** column of Table 1 shows the amount of data actually accepted by the controller. The HSDO always transmits 4096 words, 2048 from Channel 1 followed by 2048 from Channel 2. Since there is no handshake between interfaces, complete transmission of all samples commences as soon as the digitizing process is complete. For this reason, the 390AD is essentially viewed as a single-channel device by the controller when accepting 2048 or less words.

When the controller accepts a full 4096 words, they represent 4096 samples of Channel 1 if the 390AD is in the **single** mode, or 2048 samples of Channel 1 and 2048 samples of Channel 2 if the 390AD is in the **dual** mode. If the controller is set to accept only the first 1024 words, they will always be the first 1024 samples of Channel 1, regardless of the 390AD mode.

**Table 1**

| | | Waveforms/second | | |
|---|---|---|---|---|
| **Words Transferred** | | **Micro PDP-11** | **PDP-11/34** | **HP 9826** |
| Single Channel Mode | 256 | 60 | 60 | 60 |
| | 512 | 60 | 60 | 60 |
| | 1024 | 30 | 48 | 59 |
| | 2048 | 30 | 30 | 58 |
| | 4096 | 30 | 30 | 30 |
| Dual Channel Mode | 4096* | 30** | 30** | 30** |

* *2048 words/channel.*
** *30 2 k waveforms/second/channel.*

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