THE 222PS

PowerScout
Power Systems
Oscilloscope

Service Manual

Tektronix®
COMMITTED TO EXCELLENCE

Part No. 070-8098-00
Product Group 40

THE 222PS

PowerScout
Power Systems
Oscilloscope

Service Manual

WARNING

The following servicing instructions are for use by qualified service personnel only. To avoid personal injury, do not perform any servicing unless you are qualified to do so. Refer to the Safety Summary prior to performing any service.

Please check for CHANGE INFORMATION at the rear of this manual.

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OPERATORS SAFETY SUMMARY

The safety information in this summary is for operating personnel. Warnings and cautions will also be found throughout the manual where they apply.

Terms in this Manual

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

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

Terms as Marked on Equipment

CAUTION indicates a personal injury hazard not immediately accessible as one reads the markings, 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

Indicates where applicable cautionary or other information is to be found. For maximum input voltage ratings, see the Specifications.

Indicates that the instrument is double insulated. A safety earth ground is not needed.

Symbols as Marked on Equipment

DANGER—High voltage.

ATTENTION—Refer to manual.

DOUBLE INSULATED—No safety ground required.

Safety Grounding

This instrument is double insulated and does not use or require a safety-grounding conductor.

Do Not Operate in an Explosive Atmosphere

To avoid explosion, do not operate this product in an explosive atmosphere unless the product is 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.

SERVICING SAFETY SUMMARY

FOR QUALIFIED SERVICE PERSONNEL ONLY

Refer also to the preceding Operators Safety Summary

Do Not Service Alone

Do not perform internal service or adjustment of this product unless another person capable of rendering first aid and resuscitation is present.

Use Care When Servicing With Power On

Dangerous voltages exist at several points in this product. To avoid personal injury, do not touch exposed connections or components while power is on.

Disconnect power and remove the battery before removing protective panels, soldering, or replacing components.

PERFORMANCE CHARACTERISTICS

INTRODUCTION

Electrical characteristics given in Table 1-1 apply when the instrument has been self calibrated within ±5°C of the ambient temperature and is operating in an ambient temperature between -10°C and +55°C (unless otherwise noted).

Environmental Specifications are shown in Table 1-2 and Mechanical Specifications are shown in Table 1-3.

RECOMMENDED PERFORMANCE CHECK SCHEDULE

To ensure accurate measurements, check the performance of this instrument every 2000 hours of operation (once each year if used infrequently). If used in a severe operating environment, a more frequent performance check schedule is recommended. If repairs are made, affected circuits may need to be readjusted.

Table 1-1
Electrical Characteristics

CHARACTERISTICS	PERFORMANCE REQUIREMENTS
Vertical Deflection System (At The Probe Tip)	
Deflection Factor	
1X probe (P400)	5 mV per division to 50 V per division in a 1-2-5 sequence[1]
10X probe (P850)	50 mV per division to 500 V per division in a 1-2-5 sequence[1]
Vertical Resolution	8 bits, 25 levels per division,10.24 divisions of dynamic range[1]
DC Accuracy	
+15°C to +35°C	±4%[2]
-15°C to +15°C	±5%[2]
+35°C to +55°C	±5%[2]
VOLTS/DIV Variable Control	Increases the deflection factor by 2.5 to 1
Aberrations	+6%, -6%. 6% p-p or less[1] Aberrations are measured with a five division reference signal, from a 50Ω source driving a 50Ω load at the probe tip. Vertically center the top of the reference signal.
Useful Rise Time	$\frac{SEC/DIV \times 1.6}{50}$ [1] Rise time is limited to 17.5 ns by the vertical amplifier response.

[1] **Performance Requirement not checked in manual.**

[2] **When the self calibration has been done within ±5°C of the ambient temperature.**

Table 1-1 (cont)

CHARACTERISTICS	PERFORMANCE REQUIREMENTS
Useful Bandwidth	
SAMPLE (20 s/div to 5 µs/div)	$\frac{5}{SEC/DIV}$ Hz[1] The useful storage bandwidth is limited to the frequency where there are 10 samples per sinewave signal period at the maximum sampling rate. This yields a maximum amplitude error of 5%. Maximum sampling rate is 10 MHz at 5 µs per division. Accuracy at the useful storage bandwidth limit is measured with respect to a six division, 50 kHz sine wave.
REPETITIVE	Repetitive bandwidth is limited to 10 MHz by the analog system.
0.5 µs/div to 50 ns/div	10 MHz
Greater than 0.5 µs/div	$\frac{5}{SEC/DIV}$ Hz[1]
PEAK DETECT (ENV and CONT ENV acquisition modes at 20 µs/div and slower)	
Sinewave Amplitude Capture (5% p-p maximum amplitude uncertainty)	1 MHz
Pulse Width Amplitude Capture (50% p-p maximum amplitude uncertainty)	100 ns
A/D Converter Linearity	Monotonic with no missing codes[1]
Position Control Range	±12 divisions
Input Linear Range	±20 divisions[1]
DC Balance	0.2 division or less trace shift when switching between VOLTS/DIV switch settings when the ambient temperature is within ±5°C of the temperature at which the last self calibration was done[1]
INVERT Balance	0.4 division or less trace shift when switching between INVERT and non-INVERT displays when the ambient temperature is within ±5°C of the temperature at which the last self calibration was done[1]
Input Current	2.5 nA or less (0.5 division or less trace shift when switching between DC and GND input coupling with the VOLTS/DIV switch at 5 mV per division)
Common-to-Chassis Capacitance	Less than 150 pF[1]
Maximum Rated Normal Mode Input Voltage (probe tip to probe common) ⚠	850 V (dc + peak ac) or 600 Vac rms[1] Peak surge voltage – 6000 V for 250 µs or less (P850 only) See Figure 1-1 for voltage versus frequency derating curve.
Maximum Rated Common-Mode Potential (probe common to chassis) ⚠	850 V (dc + peak ac) or 600 Vac rms[1] Peak surge voltage – 6000 V for 250 µs or less (P850 only) See Figure 1-2 for voltage versus frequency derating curve.

[1] **Performance Requirement not checked in manual.**

Table 1-1 (cont)

CHARACTERISTICS	PERFORMANCE REQUIREMENTS
Maximum Rated Potential Between Channels ⚠	1700 V (dc + peak ac) or 1200 Vac rms[1]
Common Mode Rejection Ratio	
DC to 500 kHz	60 dB or more[1]
Isolation: Normal mode	
DC to 20 MHz	80 dB or more[1]
Isolation: Common mode	
DC to 500 kHz	60 dB or more[1]
Maximum Common Mode Slew Rate	10,000 V/μs[1]
Trigger System	
Internal	
Sensitivity	0.5 division to 10 MHz
Level	±20 divisions[1]
External	
Sensitivity	250 mV at 10 MHz
Level	±2.0 V
Input Resistance	1 MΩ ±10%[1]
Input Capacitance	18 pF ±5 pF[1]
Maximum Input Voltage Input to Common, Input to Earth, Common to Earth	42 V (dc + peak ac)
Trigger Jitter	
2 μs/div to 50 ns/div (5 ns/div in X10 MAG)	
X1	1/50th division ±2 ns
X10 MAG	1/5th division ±2 ns
Motor Trigger	
Minimum low time between pulses	2.25 ms ±0.75 ms
Horizontal System	
Range	50 ns per division to 20 s per division[1] The X10 MAG control extends the maximum sweep speed to 5 ns per division.
Displayed Accuracy	
X1	±2%
X10	±5% Accuracy is measured over 10 divisions.

[1] **Performance Requirement not checked in manual.**

Table 1-1 (cont)

CHARACTERISTICS	PERFORMANCE REQUIREMENTS
Sample Rate	
NORM	$\frac{50}{SEC/DIV}$ Hz[1]
PEAKDET (ENV and CONT ENV)	10 MHz.[1]
REPETITIVE	
50 ns/div to 1 μs/div	10 MHz[1]
2 μs/div	5 MHz[1]
ACCURACY	±0.01%[1] Sample accuracy is based on the accuracy of the internal 20 MHz oscillator.
Record Length	512 data points; calibrated to 50 points per division[1]
POSITION Control Range	The start of the first division and end of the tenth division can be positioned past the center vertical graticule.
Displayed Trace Length	10.24 divisions[1]
X-Y Operation	
Accuracy	Same as the Vertical system.[1]
Useful Bandwidth	$\frac{5}{SEC/DIV}$ Hz[1]
Skew Between CH 1 and CH 2	5 ns[1]
RS-232 Interface	
Maximum Safe Applied Voltage (any pin) ⚠	25 V (dc + peak ac).[1]
Baud Rates	300, 1200, 2400, 9600.
Signals	RD, TD, and SGND – SGND is connected internally to EXTERNAL TRIG COM. DSR and CTS are always high. A rising edge on DTR will turn the instrument on from the off state; otherwise, DTR is ignored.
Levels	Compatible with RS-232-C.
External Power Requirements	
Voltage Range	
Pin-to-pin	
AC	16 to 20 Vac at 47 to 400 Hz[1]
DC	12 to 28 Vdc[1]
Either Power Pin to EXT TRIG COMM or RS-232 COMM	-0.5 V to +28 V peak[1]
Current	1 ampere maximum when charging batteries[1]
Maximum Power Consumption	15 watts or 16 volt-amperes (when charging batteries)[1]

[1] **Performance Requirement not checked in manual.**

Table 1-1 (cont)

CHARACTERISTICS	PERFORMANCE REQUIREMENTS
Internal Batteries	
Battery	Sealed, lead-acid battery[1]
Charge Time	Three hours for full charge with oscilloscope turned off[1]
Battery Excessive Discharge Protection	Instrument operation is automatically interrupted when battery charge drops to 7.32 V.[1]
Typical Operating Time	Three hours at maximum sample rate with no trigger and auto time out defeated.[1]
Battery Capacity Versus Temperature	-15°C: 80%; 20°C to 30°C: 100%; 55°C: 110%
Probes	
Attenuation	
P400	3X (nomenclated 1X)[1]
P850	30X (nomenclated 10X)[1]
Input Resistance	
P400	1.00 M ± .5%[1]
P850	10 M ± .5%[1]
Input Capacitance	
P400	30.0 pF ± 5.0 pF[1]
P850	4.5 pF ± 0.5 pF[1]
Maximum Nondestructive Input Voltage	
P400	850 V (dc + peak ac) or 600 Vac to 2 MHz[1] See Figure 1-1 for voltage versus frequency derating curve
P850	850 V (dc + peak ac) or 600 Vac[1] Peak Surge Voltage—6000 V for 250 μs or less See Figure 1-2 for voltage versus frequency derating curve

[1] **Performance Requirement not checked in manual.**

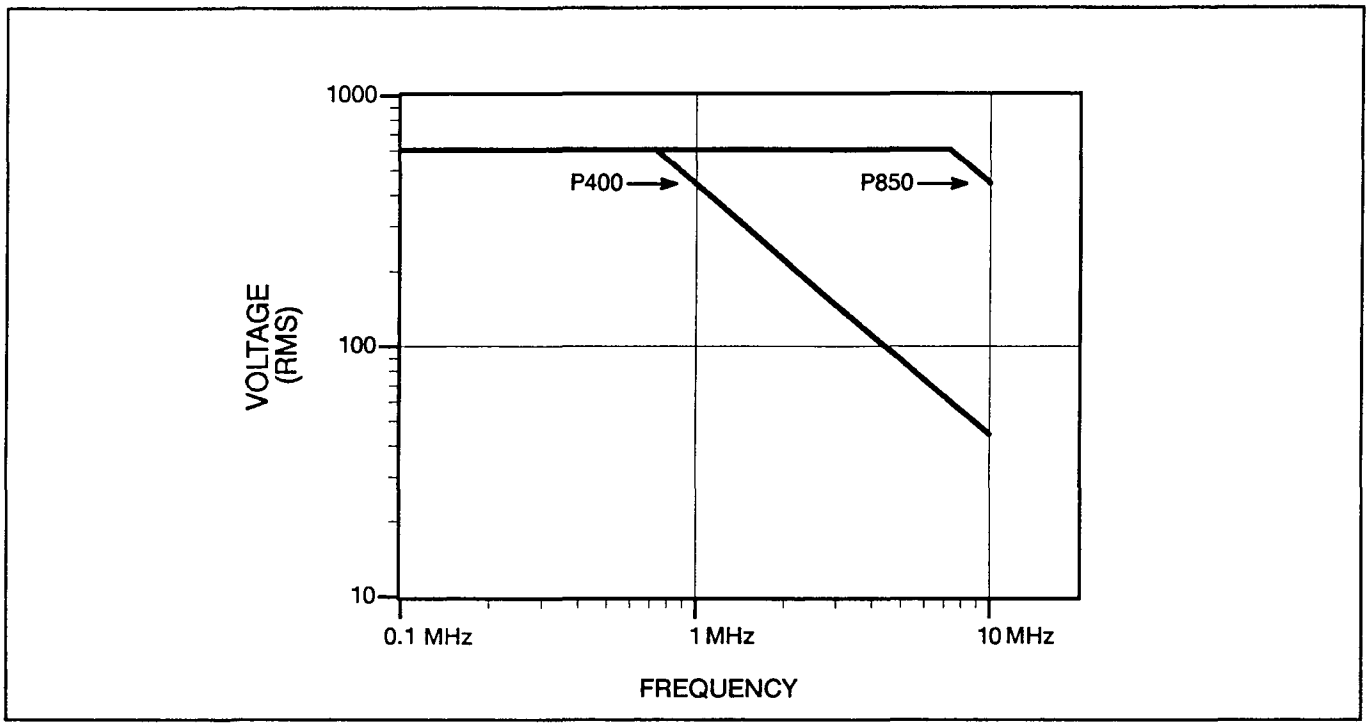


Figure 1-1. Maximum normal-mode voltage versus frequency derating curve.

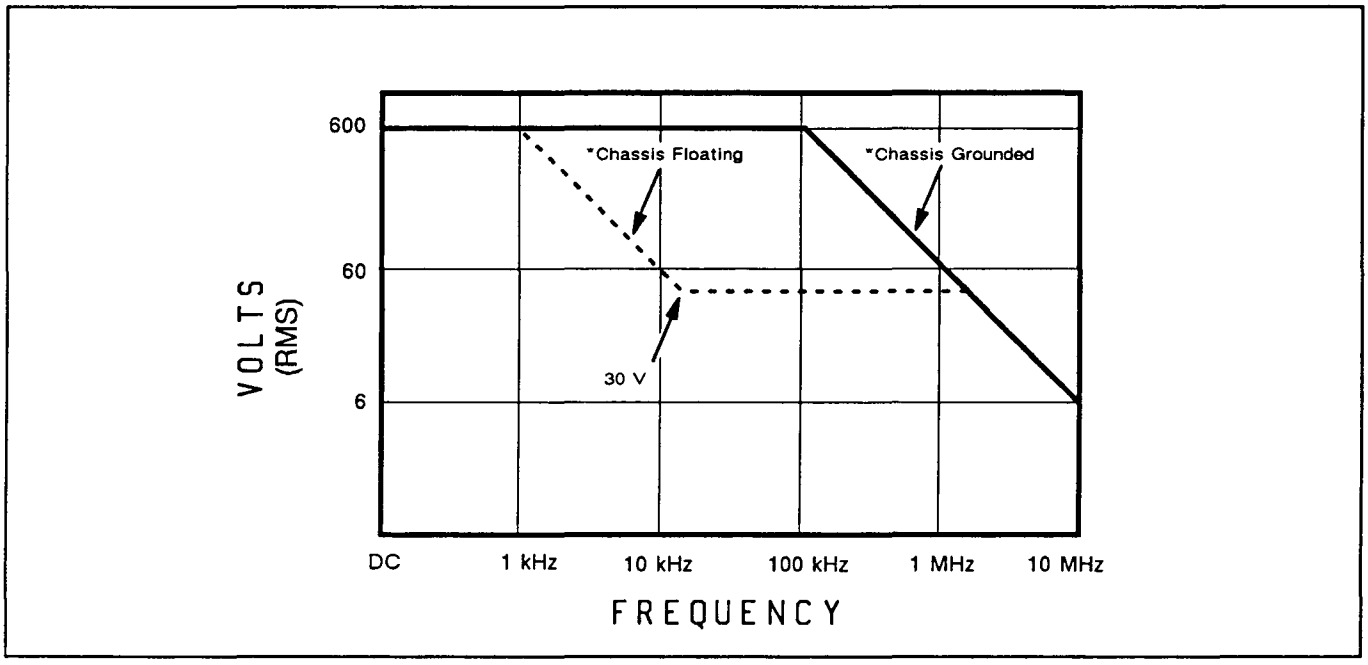


Figure 1-2. Maximum common-mode voltage versus frequency derating curve.

Table 1-2
Environmental Specifications

CHARACTERISTICS	DESCRIPTION
Environmental Requirements	Instrument will meet the requirements of Tektronix Standard 062-2853-00, Class 3. The instrument meets all the following MIL-T-28800D requirements for Type III, Class 3 equipment, except where noted otherwise.
Temperature[1]	
Operating	-15°C to +55°C (+5°F to +131°F)[2]
Nonoperating	-51°C to +71°C (-60°F to +160°F)[2] Tested to MIL-T-28800D, paragraphs 4.5.5.1.3 and 4.5.5.1.4 except that in paragraph 4.5.5.1.3, steps 4 and 5 are performed before step 2 (-51°C nonoperating test). Equipment shall remain off upon return to room-ambient temperature during step 6. Excessive condensation shall be removed before operating during step 7.
Altitude[1]	
Operating	4,572 meters (15,000 feet); maximum operating temperature decreases 1°C per 1,000 feet above 5,000 feet[2]
Nonoperating	To 15,240 meters (50,000 feet)[2]
Humidity[1] (Operating and Nonoperating)	Five cycles (120 hours) referenced to MIL-T-28800D paragraph 4.5.5.1.2 for Type III, Class 3 equipment. Operating and nonoperating at 95% (-5%, -0%) relative humidity. Operating at +30°C to +55°C; nonoperating at +30°C to +60°C.[2]
Vibration [1](operating)	Fifteen minutes along each of three major axes at a total displacement of 0.025 inch p-p (3.8 g at 55 Hz) with frequency varied from 10 Hz to 55 Hz in one minute sweeps. Hold for ten minutes at 55 Hz in each of the three major axes. All major resonances must be above 55 Hz.[2]
Shock (Operating and Nonoperating)	50 g, half-sine, 1 ms duration, three shocks per axis each direction, for a total of 18 shocks.[2]
EMI (Electromagnetic Interference)	Meets radiated and conducted emission requirements per VDE 0871, Class B and Part 15, FCC Rules and Regulations, Subpart J.[2] To meet EMI regulations and specifications, use the specified shielded cable and metal connector housing with the housing grounded to the cable shield on the RS-232 connector.

1 P400 and P850 probes also meet these Performance Requirements.

2 Performance Requirement not checked in manual.

Table 1-3
Mechanical Specifications

CHARACTERISTICS	DESCRIPTION
Weight	
Without accessories	4.4 lbs (2 kg)
With accessories	6 lbs (2.73 kg)
Dimensions	
Length	9.9 in (252 mm)
Height	3.4 in (86.4 mm)
Width	6.25 in (158.8 mm)
Cooling	There are no cooling vents provided.
Finish	The finish is safety yellow with black synthetic rubber hand grips and black vinyl probe pouch.
Construction	The cabinet is plastic with metal-base paint and the circuit boards are glass laminate with surface-mounted components.
CRT	The CRT graticule area is eight divisions high by ten divisions wide. The divisions are 0.5 cm on a side, and the diagonal size is 6.4 cm (approximately 2.5 inches). A special low-reflectance surface on the CRT face aids viewing in high-ambient light areas.

POWER INFORMATION

INTRODUCTION

This section contains information about the power requirements of your oscilloscope. The battery-charger adapter, external supply voltages, general battery information, alternate battery-charging method,and battery replacement is discussed.

SAFETY

The "Operator's Safety Summary" (preceding Section 1 of this manual) contains safety information about the use of this instrument. Before connecting the instrument to a power source, read the "Operator's Safety Summary" and this section.

EXTERNAL POWER AC ADAPTER

Instruments are shipped with a detachable External Power ac Adapter (wall transformer) that plugs into an ac power-source outlet. The adapter converts the power-source ac voltage to the 16 to 20 Vac input voltage needed to operate the instrument (with or without the battery installed) and recharges the oscilloscope's internal battery. Use the External Power ac Adapter to operate the oscilloscope when an ac line voltage source is available to maintain battery charge for use when portable operation of the oscilloscope is needed. The adapter plugs into the instrument's external power receptacle as shown in Figure 2-1.

An optional accessory pouch to carry either the External Power ac Adapter (U.S. model only) or a spare battery may be ordered (see Section 7). The accessory pouch attaches to the side of the instrument carrying case.

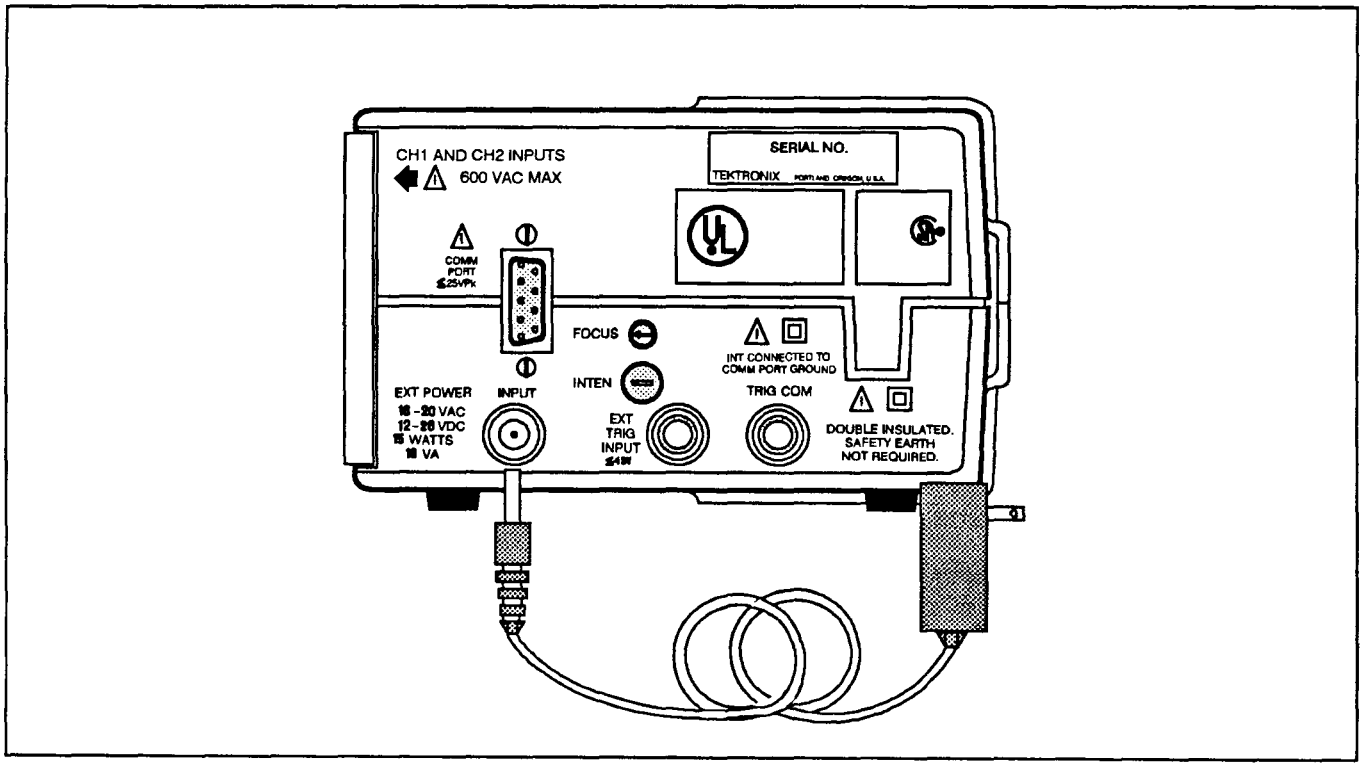


Figure 2-1. External Power Input.

EXTERNAL SUPPLY VOLTAGE

The instrument operates on an external supply voltage of either 12 to 28 Vdc or 16 to 20 Vac (47 to 400 Hz) from a supply that provides at least 15 watts or 16 volt-amperes. If the battery charge state is very low, the current drawn by a charging battery from the supplied External Power ac Adapter (wall transformer) is current-limited, which may result in an unstable CRT display. If this happens, either charge the battery for one hour before operating the oscilloscope or operate without the battery installed until it can be charged.

GENERAL BATTERY INFORMATION

The internal battery is a sealed, lead-acid type with four cells. It is rechargeable using the External Power ac Adapter supplied with the instrument or, outside of the instrument, with the external battery charger unit supplied in the External Battery Charger with Field Accessories. A fully-charged battery operates at least three hours under worst-case conditions. When the charge level reaches a point where only a short amount of operating time remains, a low-battery indicator (⌨) is displayed in the upper right corner of the readout. The oscilloscope turns off automatically when the battery voltage drops below 7.32 V.

If the charge level of the battery drops below 20%, the instrument will not come on without the external power provided by the ac adapter.

An external-power-on indicator (⌨) appears in the upper right corner of the readout when external power is connected. The battery charges anytime external power is supplied, even while the instrument is operating. However, the battery charges faster when the instrument is not operating. Completely recharge the battery as soon as possible after each discharge cycle.

CAUTION

When storing the instrument for periods longer than two months, fully charge the battery; then remove the battery and store it in a cool place. If the battery is left in the instrument, the small trickle current drawn in the off state can deplete the battery after two months of storage, leading to a deep-discharge condition. When deep discharge occurs, the battery accepts a charge very slowly and in some cases, it may not recharge. Refer to "Tips on Battery Care" in this section for information on restoring a deep-discharged battery.

FIRST TIME BATTERY OPERATION

The battery supplied with the instrument is charged at the factory and shipped disconnected to prolong its shelf life. However, it is recommended that you charge the battery for three hours before operating the oscilloscope the first time, since the state of battery charge at the time you receive it will be unknown.

To connect the battery, perform the following steps.

1. Place the oscilloscope on its left side (as viewed from the front panel) and slide the battery compartment cover (and probe pouch) toward the rear to disengage the locking tabs.
2. Lift the battery compartment cover up and remove it.
3. Connect the 3-wire battery connector to the pins at the rear of the instrument. The orientation of the connector does not matter.
4. Position the cover locking tabs into the matching slots in the battery compartment. Make sure the locking tabs are all the way into the slots on both the top and bottom of the cover. If the tabs don't seat easily, seat the top tabs first then press on the bottom of the cover to seat the bottom tabs.
5. Push forward on the rear of the battery compartment cover to engage the locking tabs.

TIPS ON BATTERY CARE

These useful tips will help extend the life of your battery.

1. Completely recharge the battery after each discharge cycle. Continued partial recharges shorten the battery life. The battery charges any time external power is used to operate the instrument. However, the battery recharges faster when the instrument is not operating.
2. Avoid situations that can lead to deep discharge of the battery.

   If the instrument starts and remains on only briefly before shutting off, the battery charge state is low. If the battery charge is too low (below 7.32 V) the instrument will not start on battery power. The battery must be recharged as soon as possible when either of these conditions occur. Do not store the battery (or instrument with the battery installed) in a discharged state. The small trickle current in the off state or storage in high temperatures will deplete the remaining charge, leading to a deep-discharge condition. When deep discharge occurs, the battery accepts a charge very slowly; in some cases, it may not recharge.

3. If a deep-discharge condition occurs, it may be possible to recover the battery with the following procedure.

   Charge the battery for 24 hours. If the battery does not retain a charge, remove it from the instrument and attempt to charge it using a 20 V power supply that is current limited to 100 milliamperes. When attempting to recover the battery using an external power supply, check the power supply frequently for the current-limit state. If the battery recovers from the deep-discharge state, it will cause the power supply to current limit. When this happens, reinstall the battery in the instrument and charge it normally. Do not leave the battery on the external power supply for long periods of time without checking it. If the battery does not recover, dispose of it safely.

4. When storing the instrument for an extended period of time, fully charge the battery and remove it from the instrument. Store the fully-charged battery in a cool place. For short periods of storage, the battery may remain installed. During "sleep" mode the current drawn from the battery is less than 1 mA. With the battery installed, the data in nonvolatile memory will remain stored and be available when the oscilloscope is turned on again.

5. The instrument will operate from the battery-charger adapter or other suitable ac or dc power source with the battery removed from the instrument.

ALTERNATE METHOD FOR BATTERY CHARGING

Batteries may be charged outside the instrument using the External Battery Charger accessory coupled with the ac adapter. An alternate method is to use an external dc power supply set at 9.8 Vdc at 20°C with the current limited to one ampere. For best results over a wide temperature range, the charging voltage should be thermally compensated for -10 mV per degree C. For example, at 50°C, the charging voltage should be

$$9.80\ V + [(50 - 20)\ X\ -10\ mV] = 9.50\ V$$

BATTERY REPLACEMENT

If you frequently operate the oscilloscope using the battery only, you may wish to obtain extra batteries and carry them in a fully-charged condition to the servicing site. Spare batteries may be carried in an optional accessory pouch that attaches to the instrument carrying case (see section 10 for the part number). The accessory pouch may also be used to carry the standard U.S. battery-charger adapter (wall transformer) when operating the instrument on battery only.

When the charge level of the battery in the oscilloscope reduces to the shutoff level, one of the spare, charged batteries may be used to provide more operating time.

The battery is in a compartment behind the probe pouch. To remove and replace it, follow this procedure:

1. If the probes are attached, open the probe pouch and take the probes out of it. This allows the battery compartment cover freedom to move away from the oscilloscope.

2. Place the oscilloscope on its right side and slide the battery compartment cover toward the rear to disengage the locking tabs. The hole for the probe leads makes a convenient place to apply the needed force with your finger.

3. Lift the battery compartment cover up and, if the probes are attached, slide it far enough down the probe leads to lay the cover down.

4. Disconnect the 3-wire battery connector.

NOTE

If you reconnect power to the battery connector from the charged battery in less than 30 seconds, the saved waveforms and front-panel setups will not be lost.

5. Lift the battery pack out of the battery compartment.

6. Place the charged, replacement battery into the battery compartment with the battery leads on the bottom side facing toward the rear.

7. Connect the battery plug.

8. Position the cover locking tabs into the matching slots in the battery compartment. Make sure the locking tabs are all the way into the slots on both the top and bottom of the cover. If the tabs don't seat easily seat the top tabs first then press on the bottom of the cover to seat the bottom tabs.

9. Push forward on the rear of the battery compartment cover to engage the locking tabs.

10. Remember to recharge the low battery at the first opportunity. This prevents it from going into a deep-discharge state, which may prevent it from taking a charge.

BLOCK DIAGRAM OVERVIEW

INTRODUCTION

Your instrument comprises five major functional blocks (see Figure 3–1). These are the floating acquisition system, the time base, the processor system, the display system, and the power supplies. The operation of each of these functional blocks is described. A brief overview follows.

The signal is applied to the floating acquisition system (so named because of the electrical isolation of the inputs from the remainder of the functional blocks). There it is amplified, offset (for position and calibration), and limited (to the dynamic range of the A/D converter). The signal is then digitized and stored in acquisition memory.

An internal trigger signal is also derived from the input signal. That signal starts events in the time base that cause the acquisition of the input signal to be completed. (Acquisition is the digitization of the input signal and storing of the digital values.)

The processor system transfers the digital waveform information from the acquisition memory to the display memory. That data can then be displayed or stored in the save memory for later recall and viewing. The processor system scans the front-panel and top-panel switches to determine when the user presses a button. It also controls the time base, the acquisition system, and the power supplies. An RS-232-C compatible serial port provides the processor system with an interface to external communication devices. Waveform data may be sent or received over the interface, and the control settings of the instrument may be changed or queried.

In the Display System the digital waveform data are converted back to analog signals. These analog signals are amplified and applied to the CRT deflection plate to provide a visual display of the signal's waveshape.

Either the internal battery or the external wall transformer provides the supply voltage for the power supplies. A battery charger circuit supplies charging current to the battery whenever external power is applied to the instrument. The external power may be used to run the instrument with or without the battery installed. Separate supplies provide power for the CRT, the floating acquisition system, and the remaining digital circuitry of the instrument.

ACQUISITION SYSTEM

The acquisition system contains two complete, isolated vertical channels, each with its own attenuator, amplifier, trigger circuit, A/D converter, peak detector, acquisition memory, and isolated power supply (see Figure 3–2). The channel grounds are isolated from each other and instrument ground. Data and clock signals are passed through pulse transformers and opto-couplers to maintain the isolation.

The attenuator, amplifier, and trigger circuit for each channel are formed by a hybrid circuit on a single ceramic carrier. Passive attenuators provide X1, X10, X100, and X1000 attenuation of the input signal. The gain amplifier has a high input impedance and a low output impedance. A high-speed trigger pulse is derived from the input signal by the trigger circuit portion of the hybrid component. Output signals from the amplifier are in the range of 0 to 2.5 V to be applied to the A/D converter.

Output voltage samples from the amplifier are converted into 8-bit digital words. Conversions occur at a sample rate of 10 MHz that does not change with the seconds per division setting. To provide lower sampling rates of the input signal, the data words are stored in the acquisition memory at a save clock rate that varies with the seconds per division setting.

The acquisition memory is a first in, first out (FIFO) memory system. The length of the data pipeline is 512 data bytes (of 8 bits each). In the normal sample mode, each data byte produced by the A/D Converter is stored into the pipeline at the sample clock rate (10 MHz). At time base settings above 5 μs/div, the save clock rate (which changes with the seconds per division setting) is used to store converted samples into the pipeline. With peak detect enabled, two data bytes are stored into the pipeline for each save clock. The data bytes are loaded into a shift register at the output of the FIFO and the bits of the data byte are shifted out serially through an isolation pulse transfer to be placed into the display memory for eventual display.

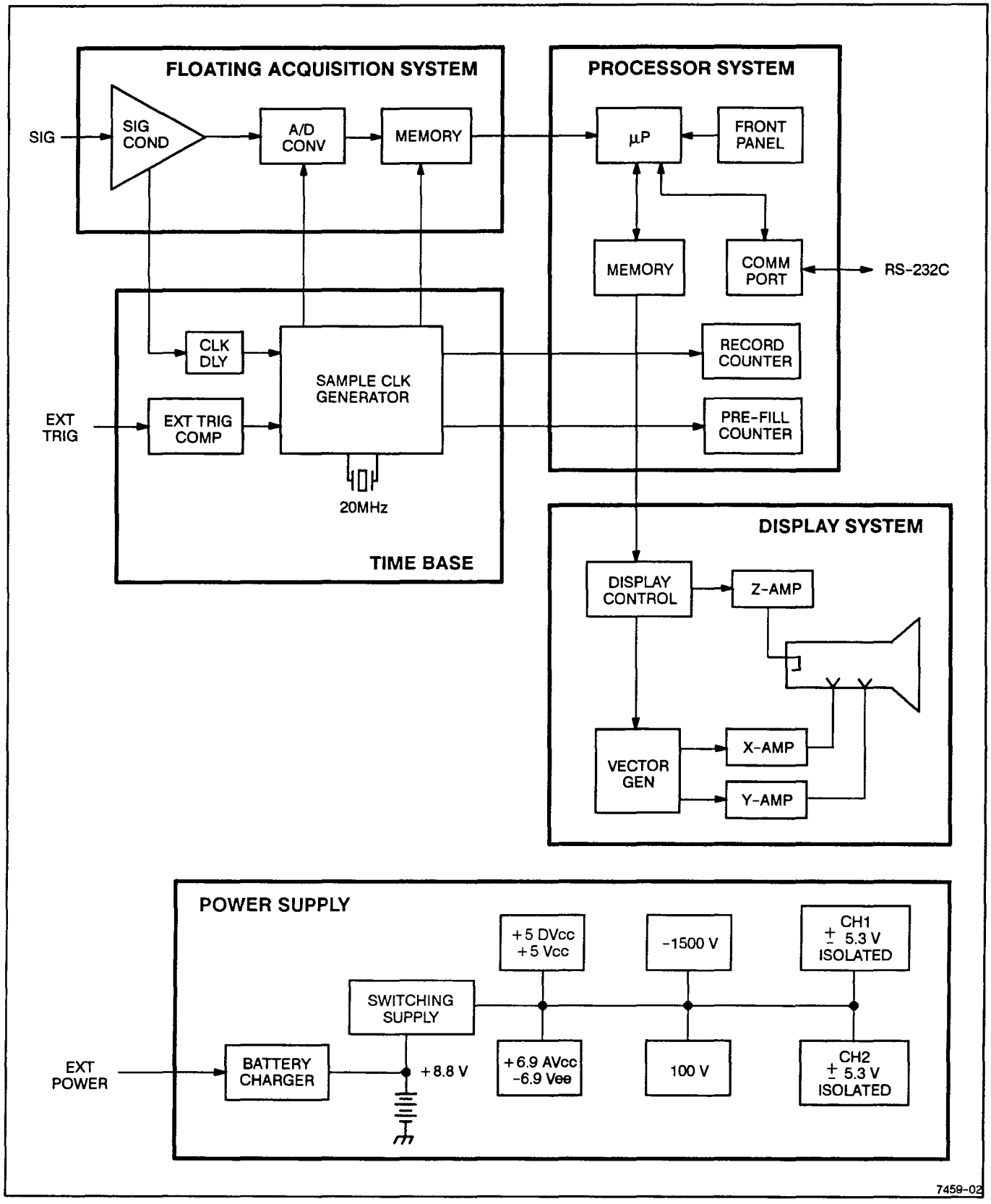


Figure 3-1. Simplified block diagram of the instrument.

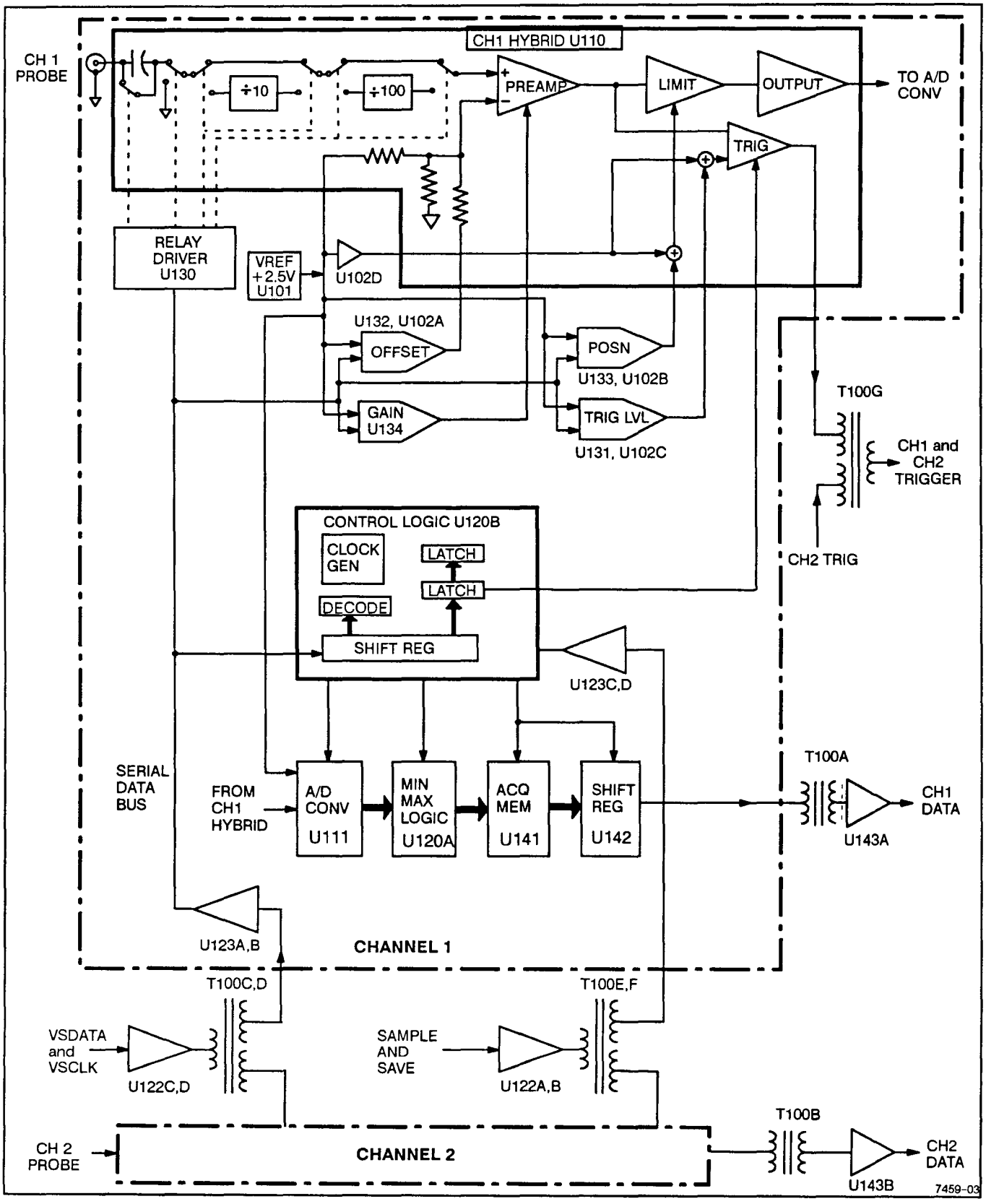


Figure 3-2. Floating Acquisition System.

TIME BASE

All acquisition clock signals are derived from a free-running 20 MHz master oscillator. The sample clock generator contains counters and multiplexers to produce the various clocking signals to the A/D converter, the acquisition memory, and the data counters that keep track of the number of samples taken for a waveform record (see Figure 3-3).

The pre-fill counter counts to determine when pretrigger waveform data has been acquired. Then the trigger circuit is enabled to accept a trigger event. When the trigger occurs, the remaining data points needed to fill the waveform record are acquired. The record counter determines when those data points have been acquired and then halts the acquisition system. A complete waveform record is then held in the acquisition memory. An interrupt is also generated to the processor to inform that device that the acquisition is completed.

The output of the clock delay circuit is used during repetitive store mode. The time difference between the trigger event and the rising edge of the sample clock is measured so that repetitive samples taken on different triggers may be correctly placed in the waveform record. The resolution of the clock delay timer is 0.5 ns.

When external trigger signals are connected to the instrument, the external trigger comparator is used to produce the actual trigger event from the applied signals. For operation on internal trigger signals, the Schmitt trigger circuit is used to allow the signal to return to zero without producing a false trigger signal.

PROCESSOR SYSTEM

The processor system contains a microcontroller, a memory, chip-select logic, and the RS-232 interface (see Figure 3-4). It receives inputs from the front panel or RS-232 interface and controls the acquisition system, time base, and display system through its synchronous serial interface. The processor system is clocked by an 8 MHz oscillator that is not frequency related to the time base clocks (not derived from the 20 MHz time base oscillator).

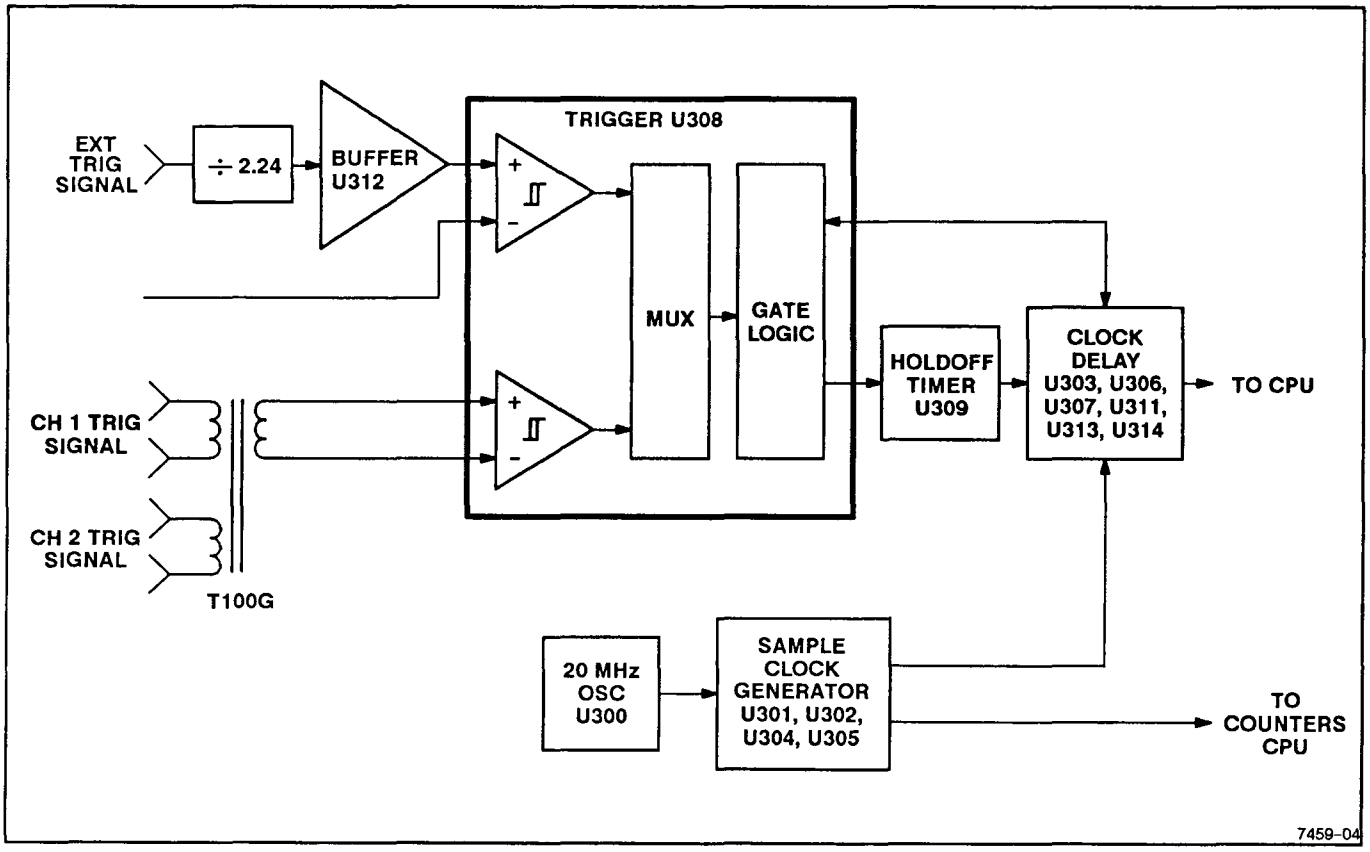


Figure 3-3. Time Base block diagram.

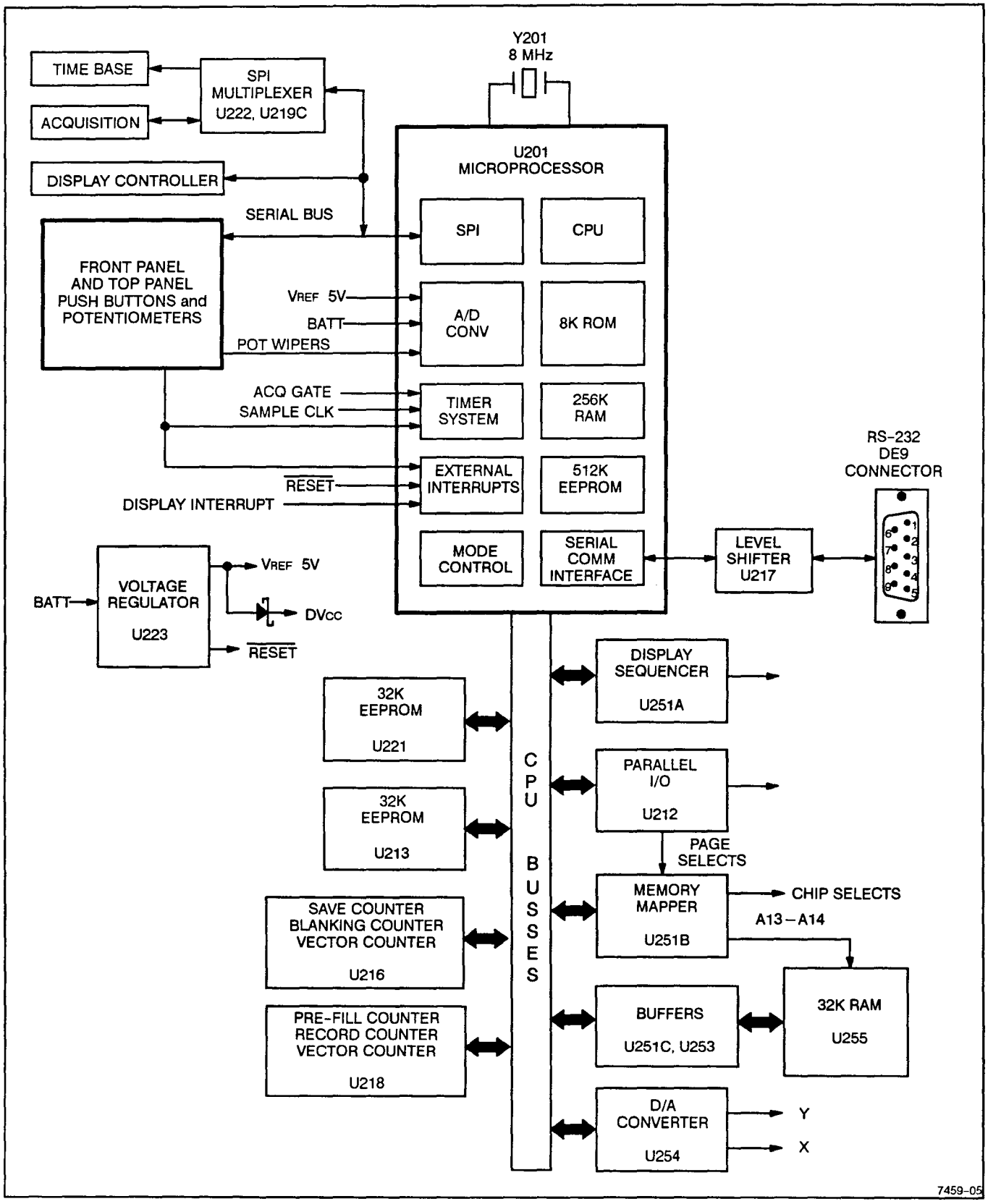


Figure 3-4. Processor System simplified block diagram.

Microprocessor

The heart of the Processor is an 8-bit microprocessor with built-in RAM, ROM, EEPROM, timers, A/D converter, and serial and parallel ports. An external crystal-controlled, 8 MHz oscillator produces the timing for all the processor and display operations.

The microprocessor has its own internal reset circuitry for handling power down and does not require an external reset circuit. However, the EEPROM circuitry requires some handling on loss of power to maintain its stored data intact. A reset signal is generated when the voltage falls below 6 V. Placing a shorting jumper between pins one and two of P6 will cause the microprocessor to reset.

A dedicated address bus is used for addressing the ROM, the address decoders and timers of the processor circuitry.

The internal ROM of the microprocessor contains the diagnostic routines used to check out the external devices on the bus when the EEPROMs cannot be accessed.

The display memory is formed by an external 32K by 8 bit static CMOS RAM that is accessed by the microprocessor for loading in waveform data or reading out waveform data when it is being sent over the RS-232 interface.

An internal A/D converter in the microprocessor is used to encode the front panel potentiometer settings and monitor the battery voltage level.

Control data used to set the external devices for such things as gain, attenuation, and time base multiplexing is sent simultaneously to the display system, the acquisition system, the front panel, and the acquisition control latch. The display system only accepts serial data when its select line is high. The front panel, acquisition control latch, and the acquisition system contain latches that are strobed so that only the desired latch is loaded and only the serial data needed for a chosen latch is sent.

RS-232 Interface

The microprocessor has an asynchronous communications port for interfacing with external RS-232 devices. Baud rates of 300, 1200, 2400, and 9600 are available; 9600 is the default. The diagnostic software also uses this port to export error messages to a terminal or host computer so that the results can be seen even if the instrument display system fails. The CMOS levels output from the microprocessor are level shifted to ±6 V to conform with the RS-232 ±5 V minimum operating levels. The external RS-232 port is non-standard but the pin assignments conform to that of the IBM® AT PC. It is, however, a female connector and configured as a DTE (modem) device. This setup allows a direct connection to an IBM AT (or compatible) when using the special adapter cable listed on page 10-5. (See the Performance Check for information on the pin assignments.) Pin 9 of the RS-232 connector is used to provide the 12 V needed to program the EEPROMs; it is enabled only when a jumper is installed internally in the instrument.

Front Panel

The front panel consists of a switch matrix, three potentiometers, two shaft encoders, and an LED. All controls on the front panel are routed through the processor. With the exception of the three potentiometers, the front panel is interrupt driven and is only serviced when a control is moved or a button is pressed. Data is sent and received serially to keep the number of interconnections between the processor and the front panel to a minimum.

The front panel and top panel keypad are encoded using the same switch matrix. When one of the buttons is pressed, an interrupt is sent to the processor. The processor then latches the row data from the switch matrix and processes it to determine if a switch in that row was pressed. Each row is processed in turn to determine which switch was pressed.

Shaft Encoders

The volts per division and seconds per division shaft encoders are 16-position devices that produce a quadrature (gray code), 2-bit output. Each position change causes only one of the two bits to change states. This change is sensed and an interrupt is sent to the processor. On an interrupt, the processor latches the encoder's outputs, and then processes that information against the previous settings to determine the direction and amount of shaft rotation.

Potentiometers

The three potentiometers are scanned by the processor's internal 8-bit A/D converter. Their voltage outputs are compared with previously digitized values to determine if a new level setting has been made.

DISPLAY SYSTEM

The display system consists of the display memory, the display controller, X and Y vector generators, and the CRT drivers (see Figure 3-5). A portion of the static 32K by 8-bit random-access memory (RAM) makes up the display memory, which is organized as 512, 16-bit words. When displaying a waveform, the 16-bit word contains waveform data only and just the upper (even) byte is displayed. In XY mode and when displaying characters, the 16-bit word contains Y data in the upper byte and X data in the lower one. The least significant bit of the X data is used as a blanking bit in character mode.

Access to the display memory is shared by the processor and the display system. Each has access on alternate halves of an enabling clock. During a display cycle, data is read from the memory and transferred to a dual 8-bit digital-to-analog converter (DAC). The analog output from the DAC drives the X- and Y-axis circuits. When displaying waveform data, the X-axis is driven by a simple single-speed sweep generator.

During a memory write cycle, the processor stores newly acquired waveform data in preparation for the next display cycle.

Display Controller

The display controller consists of a state machine, display address counter, vector counter, and a blanking counter. The state machine produces read and write signals to the display memory and clocks the address counter, vector counter, and blanking counter. It also controls the sweep, vector generators, and CRT blanking. The processor loads control data to the display controller serially via the microprocessor's serial interface.

The display address counter is part of a gate array used to address the display memory. Counting data is loaded serially from the processor. The vector counter keeps track of the number of vectors displayed, and when the preloaded count for a display is reached it resets the display state machine. The blanking counter is used to extend the initial blanking period by a number of vector periods. The effects of the blanking counter combined with moving the starting address of the display address counter produces the scanning effect of moving the display to the right on the face of the CRT.

Vector Generator

The X- and Y-vector generators are identical. They both produce a range of output voltages from 0 to 3.2 V. These voltages correspond to 10.24 divisions of deflection (X and Y) when the X and Y amplifiers are calibrated. A description of the Y vector generator follows.

Y data is read from the display memory and latched. The latched data is then converted to an analog value in the DAC. Output current from the DAC is converted to a voltage signal and applied to a differential amplifier. The differential amplifier produces an output signal that is the difference between the present analog value (next display position) and the previous analog value (present display position). This difference signal is integrated to produce a vector that will cause a straight line to be drawn between the current display position and the next display position (vector display mode). The vector generator is bypassed in dot display mode and the CRT is blanked between dot displays.

Sweep Generator

Only a single sweep speed is needed when the display is being updated. The sweep generator produces a 500 volts per second ramp during sweep periods.

X- and Y-Amplifiers

The X- and Y-amplifiers are identical; operation of the Y-amplifier is described. The Y-amplifier consists of a differential amplifier pair and a grounded base amplifier pair. The differential pair provides the signal gain, which is adjustable to match the CRT characteristics. A 0 to 3.2 V change from the Y vector generator will produce a 70 V swing at the collectors of the common base amplifier stage.

One side of the differential pair is driven by the Y-vector Generator; the other is driven by a dc voltage level that is varied to produce the vertical positioning of the waveform display.

Since the gain of the X and Y amplifiers is identical (with only slight gain differences), electronic horizontal and vertical alignment is done. A small portion of the X signal is applied to the Y amplifier and vice versa. The amount of opposite signal added can be varied from 0 to 10% for ±5.4 degrees of trace rotation.

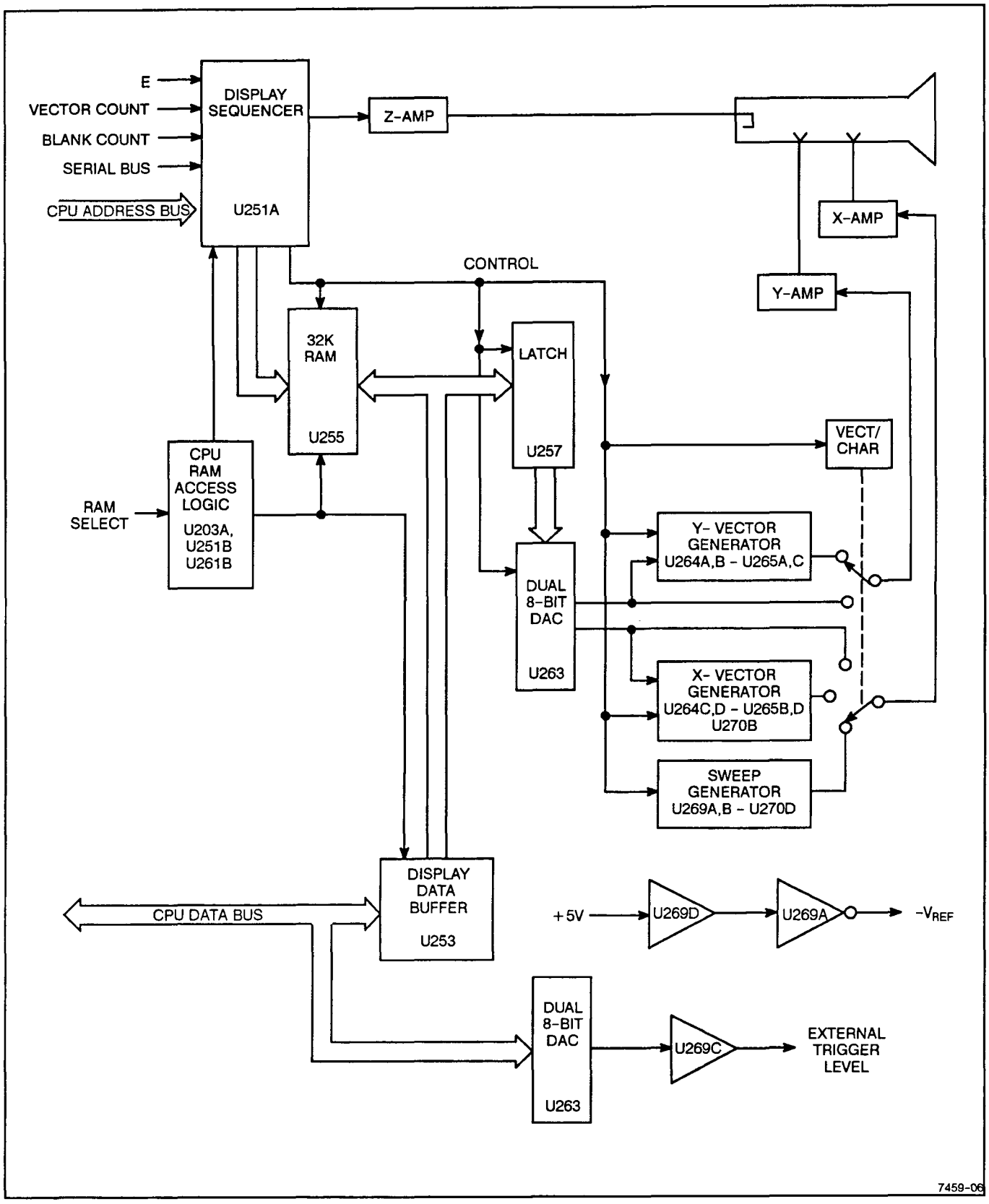


Figure 3-5. Display System.

Z-Amplifier

The Z-amplifier is a class B stage that is nonlinear, since it only needs two output states: blanked and unblanked. When on the output of the amplifier is about 0.2 V; when off, its output goes to 119.3 V. This pulse is coupled via a dc restorer to the grid of the CRT to turn the electron beam on and off for blanking. The grid voltage of the CRT is about -1550 V and the dc restorer circuit allows the Z-amplifier to take the grid 119 V below that level to blank. Blanking times are under control of the processor and are held to less than 10 ms.

BATTERY CHARGER REGULATOR

The battery charger circuit (see Figure 3-6) is active whenever appropriate external power (AC or DC) is applied. When external power is not applied, operating power is drawn from the battery.

AC power from the mains supply is transformed to approximately 18 Vac for application to the external power supply connector. The external power is applied to an input bridge rectifier via line filters and two line fuses. The rectified input is filtered by a large capacitor and applied to the battery charger switching transformer and a pulse-width-modulator regulator device.

The regulator develops the drive signal to a switching FET. Feedback from the output of the battery charger rectifier controls the width of the switching pulses to the FET to maintain a constant output voltage to the battery and instrument power supply. Switching current is monitored by an overcurrent sensing circuit. The sensing circuit acts to shut down the switching supply if current exceeds the design limit.

Secondary voltage from the switching transformer is rectified and filtered to produce the charging and operating power for the instrument.

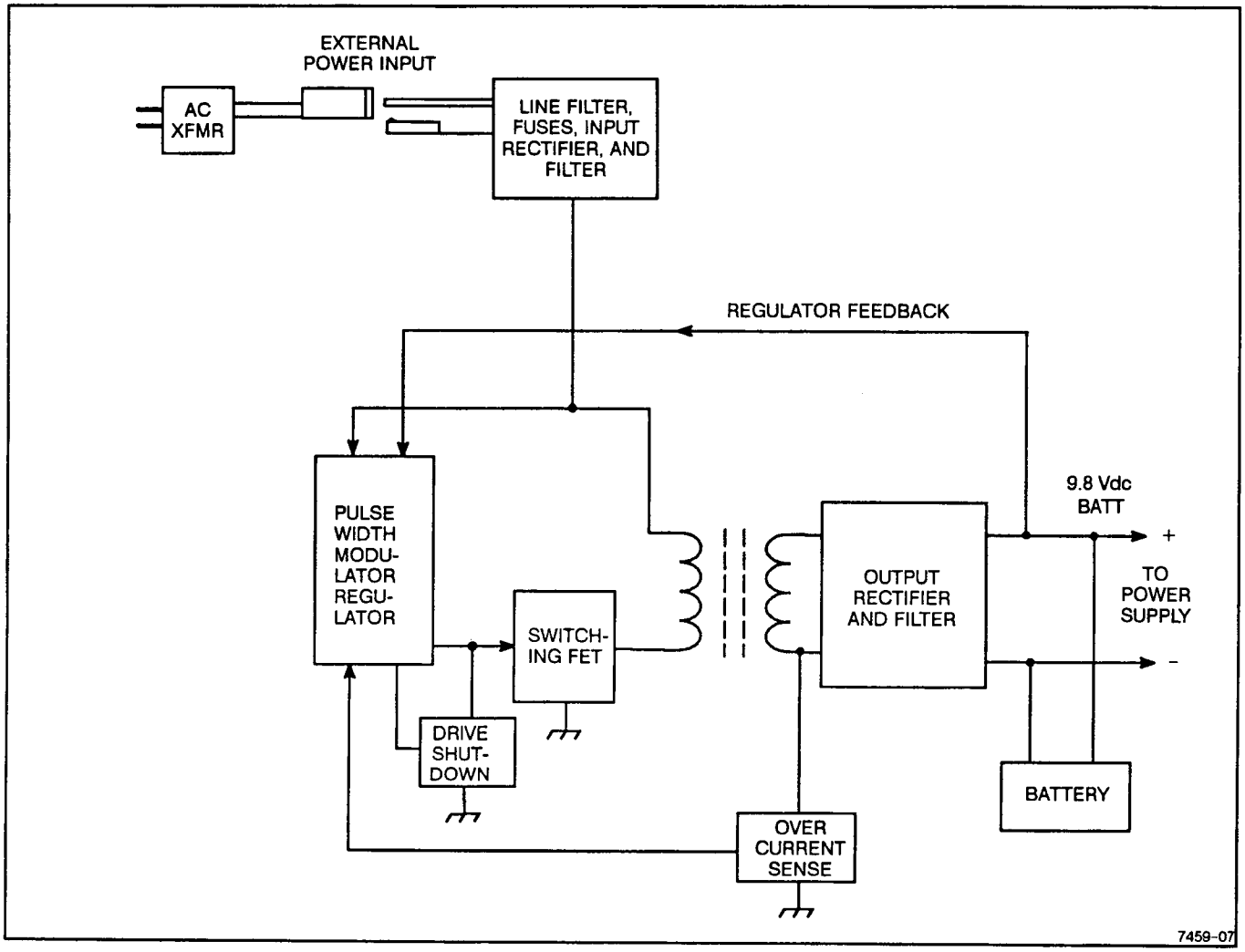


Figure 3-6. Battery Charger block diagram.

POWER SUPPLY

DC power from either the battery or the battery charger circuit is applied to a center-tapped switching transformer in the power supply circuit (see Figure 3-7). Power is applied to a pulse-width modulator device (identical to the one used in the battery-charger circuit) via an ON/OFF circuit controlled by the oscilloscope's operating system. When the applied voltage is high enough, the supply turns on. While operating on battery power, the automatic time out will shut down the power supply after two minutes of no front panel activity. Also, the power supply will be shut down if the battery voltage drops to below 7.32 volts.

As with the battery charger circuit, the regulator develops the drive signals; in this case, to a pair of switching FETs. The switching transformer has two secondary windings: one isolated winding supplies the CRT heater voltage; one multi-tapped winding supplies the various secondary levels to power the instrument and the CRT. The secondary voltages are rectified and filtered to produce the operating dc potentials.

Output voltage is regulated by monitoring the output of the high voltage secondary tap. A feedback voltage is applied to the pulse-width modulator regulator to control the width of the drive signals to the switching FETs. The width is adjusted as needed to maintain the correct operating voltage at the output. Switching current is also monitored. Excess switching current will cause the regulator to shut down the drive to the switching FETs.

High voltage to the CRT is developed by a voltage multiplier circuit off the high voltage tap of the transformer secondary winding. The negative high voltage is applied to the cathode of the CRT to provide acceleration potential for the electron beam. That level is also referenced to the CRT grid and Z-axis circuit for proper biasing of the intensity grid. Focus voltage is derived from a resistive divider across a portion of the high voltage multiplier circuit.

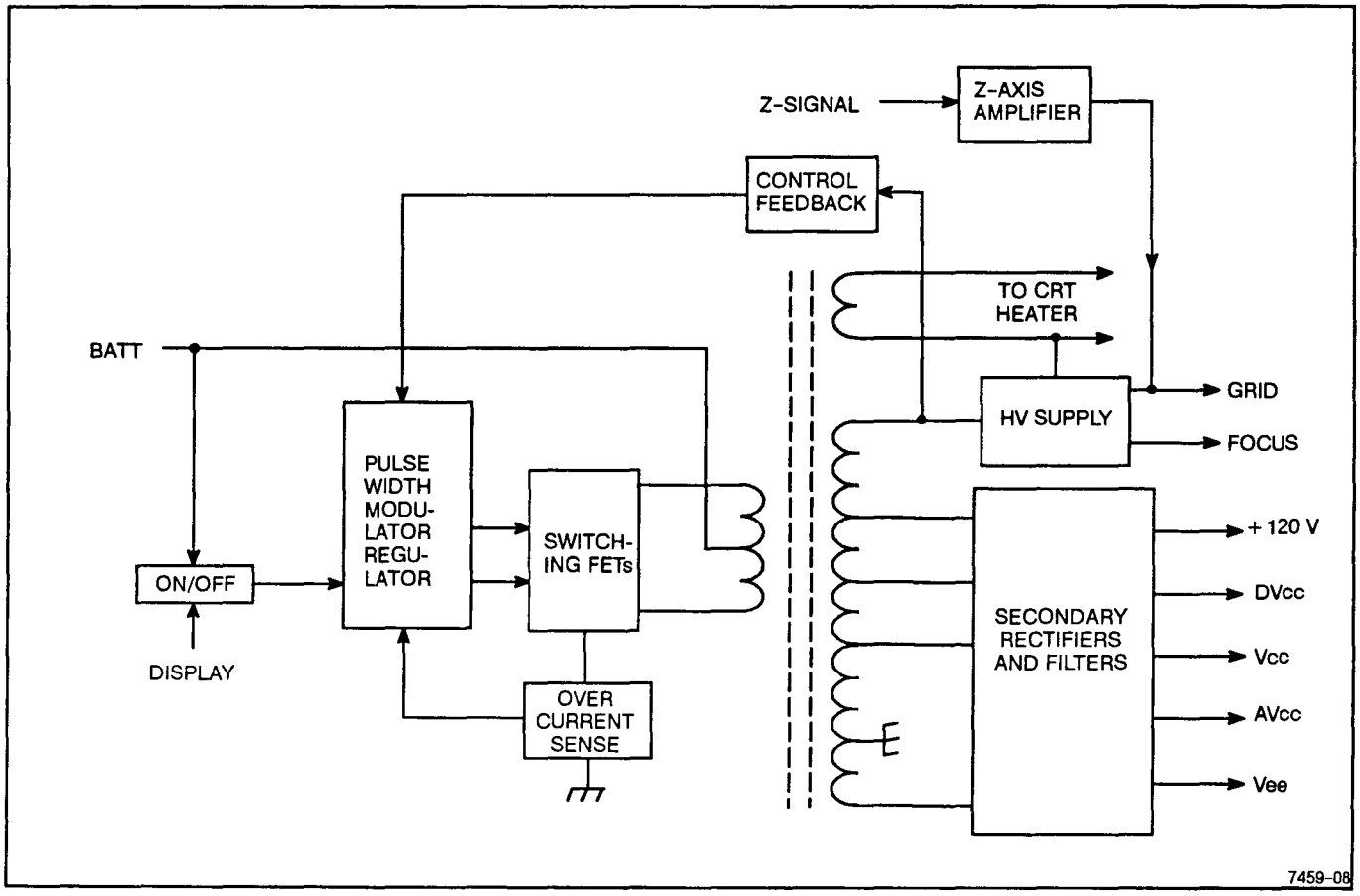


Figure 3-7. Power Supply block diagram.

PERFORMANCE CHECK PROCEDURE

INTRODUCTION

This performance check procedure verifies the performance requirements of the instrument listed in Section 1. These checks may be used as an acceptance test or as a preliminary troubleshooting aid to help determine the need for repair or readjustment.

You do not have to remove the instrument cabinet to do these checks. All checks can be made with operator-accessible controls and connectors.

TEST EQUIPMENT REQUIRED

Table 4–1 lists the test equipment required to do the performance check procedure and the adjustment procedure. It also includes the tools needed for disassembly and assembly of the instrument. Test equipment specifications described are the minimum necessary to provide accurate results. For test equipment operation information, refer to the appropriate test equipment instruction manual.

When you use equipment other than that recommended, you may have to make some changes to the test setups. If the exact example equipment in Table 4–1 is not available, use the Minimum Specification column to determine if any other available test equipment is adequate to do the check.

PERFORMANCE CONDITIONS

The performance limits in this performance check are valid under the following conditions: the instrument was self calibrated within ±5°C of the present ambient operating temperature and the instrument is checked at an ambient temperature between +15°C and +35°C.

PERFORMANCE CHECK INTERVAL

It is recommended that a complete performance check be done on the instrument at least once each year. A more frequent interval is advised if the instrument is used under severe conditions.

PREPARATION

This procedure is divided into subsections to let you check individual sections of the instrument when it is not necessary to do the complete performance check. An Equipment Required block at the beginning of each subsection lists the equipment from Table 4–1 that is needed to do the checks in that subsection.

The initial control settings at the beginning of each subsection prepare the instrument for the first step of the subsection. Do each of the steps in a subsection completely and in order to ensure the correct control settings for the steps that follow. Let the test equipment warm up for 20 minutes to obtain a valid performance check to the accuracies stated in the Performance Characteristics (Section 1).

Set-Up

a. Plug the External Power ac Adapter into the ac power source.

b. Plug in the low voltage ac power cord from wall transformer to the **EXT POWER INPUT** connector on the rear panel of the oscilloscope.

c. Open the zipper on the probe pouch and remove the probes. If disconnected, connect the probes through the oval opening in the upper rear corner of the pouch to the connectors on the oscilloscope.

d. Press the **ON** button of the oscilloscope to toggle it into the operating mode.

Table 4-1
Test Equipment Required

Item and Description	Minimum Specification	Use	Example of Test Equipment
Leveled Sine-Wave Generator	Frequency: 50 kHz to above 20 MHz. Output amplitude: variable from 10 mV to 5 V p-p. Output impedance: 50 Ω. Amplitude accuracy: constant within 1.5% of reference frequency to 20 MHz.	Vertical, triggering, and bandwidth checks.	TEKTRONIX SG 503 Leveled Sine-Wave Generator.[a]
Calibration Generator	Standard-amplitude signal levels (dc and square wave): 5 mV to 50 V. Accuracy: ±0.25%. High-amplitude signal levels: 1 V to 60 V. Repetition rate: 1 kHz. Fast-rise signal level: 1 V. Repetition rate: 1 MHz. Rise time: 1 ns or less. Flatness: ±0.5%.	Gain and transient response checks.	TEKTRONIX PG 506A Calibration Generator.[a]
Time-Mark Generator	Marker outputs: 5 ns to 0.5 s Marker accuracy: ±0.1%.	Horizontal checks.	TEKTRONIX TG 501A Time-Mark Generator.[a]
Coaxial Cable	Impedance: 50 Ω. Length: 42 in. Connectors: BNC.	External trigger checks.	Tektronix Part Number 012-0057-01.
Termination	Impedance: 50 Ω. Connectors: BNC.	Signal termination.	Tektronix Part Number 011-0049-01.
Adapter (2 required)	Connectors: BNC-to-miniature-probe tip.	Signal interconnection.	Tektronix Part Number 013-0084-03.
Open-end Wrench	3/16 inch.	Assembly and disassembly.	
Torx Screwdriver Tip and Handle	#T-15 Torx Tip and Screwdriver Handle.	Assembly and disassembly.	
Hex Wrench	.050 inch.	Assembly and disassembly.	
Adapter	Connectors: BNC female-to-dual-banana.	External trigger check.	Tektronix Part Number 103-0090-00.
T-Connector	Connectors: BNC.	Signal interconnection.	Tektronix Part Number 103-0030-00.

[a]**Requires a TM500-series power module.**

Table 4-1 (cont)

Item and Description	Minimum Specification	Use	Example of Test Equipment
Small, Flat-tip screwdriver	Length: 3-in shaft. Bit size: 1/8 inch.	Adjust intensity and focus controls.	
Alignment Tool	Length: 1-in shaft. Bit size: 3/32 in. Low capacitance; insulated.	Make internal adjustments.	
Short Jumper Wire	Connectors: Banana; length 3 inches or more.	External trigger self calibration.	
3.0 V Calibration Reference Voltage	3.0 V ±0.5%; no ripple.	CH1 and CH2 offset calibration.	Fluke DMM Calibrator.

e. Before the performance check procedure is made, the oscilloscope must be self calibrated. Press the **AUX FUNCT** button to bring up the AUX menu.

f. Select SELF CAL from the menu.

NOTE

Disconnect both the Channel 1 and Channel 2 probes from any signal source before performing the self calibration routines.

g. Select CH1 from the SELF CAL submenu. This starts the Channel 1 self calibration. When PASS/FAIL message is displayed, the first routine is done.

h. Select CH2 from the SELF CAL submenu. This starts the Channel 2 self calibration. When PASS/FAIL message is displayed, the second routine is done.

i. Select EXT TRIG to bring up the sub menu for running the external trigger self calibration.

NOTE

*For this self calibration, the **EXT TRIG COMM** and **EXT TRIG INPUT** connectors must be connected together. A short jumper with banana plug connectors may be used to make the connection.*

j. Select CAL to start the external trigger self calibration routine after the **EXT TRIG COMM** and **EXT TRIG INPUT** connectors are joined. A PASS/FAIL message is displayed when the routine is done. Remove jumper.

k. Press the **CLEAR** button at the completion of the self calibration routines to return to normal oscilloscope operation. You are now ready to make the performance checks.

If a self calibration step fails, the currently stored calibration constants are not changed. Run the failed routine again.

If the failure persists, further information about the nature of the failure may be found by connecting the RS-232 interface port to a terminal or host computer and rerunning the failed self calibration routine. A coded error message is output when the error occurs.

Refer to "Troubleshooting" in the Maintenance section of this manual and the *222 Series RS-232 Interfacing Guide* for explanations of the error codes.

An RS-232 interconnection cable for use with this product is available as an optional accessory (see Section 10 for ordering information). The cable wiring diagram is shown in Figure 4-1. Setting the communication baud rate is described in Section 4 of the Operators Manual.

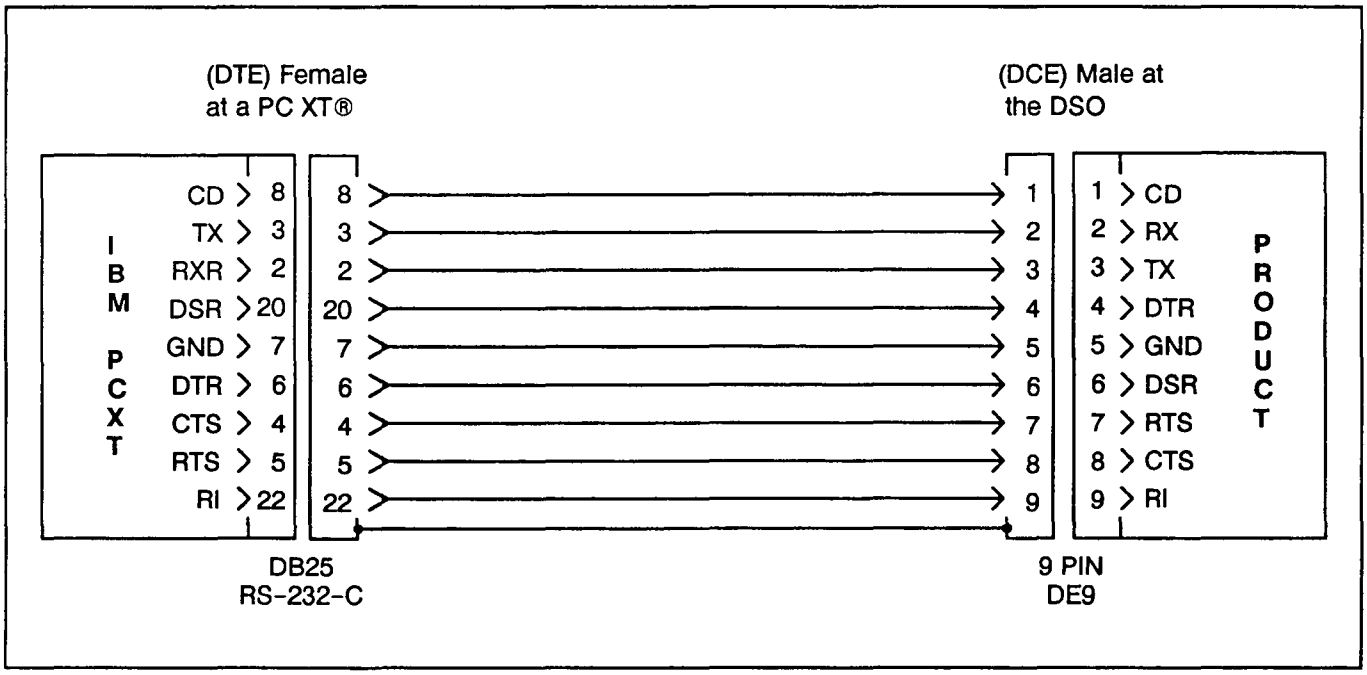


Figure 4-1. RS-232 interconnection cable wiring between a PC XT® (or compatible) and the product.

INDEX TO PERFORMANCE CHECKS

DISPLAY

Equipment Required (See Table 4-1)

External Power ac Adapter (wall transformer)

Small Flat-blade Screwdriver

INITIAL CONTROL SETTINGS

Power and Display

External Power	External Power ac Adapter Connected
Power	**ON**

Front-Panel Controls

Auto Setup	Press for initial setup

PROCEDURE

1. **Check/Adjust Intensity Control**

   a. Adjust the **INTEN** control (located on the rear panel) fully counterclockwise (CCW).

   b. CHECK – that the CRT beam cuts off (no intensity).

   c. Adjust the **INTEN** control clockwise for normal viewing.

2. **Adjust FOCUS Control**

   a. Press the **AUX FUNCT** button on the top panel.

   b. Select the ALIGN menu choice, then the XY menu choice. This displays a test pattern on the CRT.

   c. Adjust the **FOCUS** control (located on the rear panel) for the best definition of the pattern.

   d. Press the **CLEAR** button to remove the display pattern and return to normal operation.

VERTICAL

Equipment Required (See Table 4-1)

- Leveled Sine Wave Generator
- Calibration Generator
- 50 Ω BNC Termination
- BNC-to-probe-tip Adapter
- External Power ac Adapter (wall transformer)

INITIAL CONTROL SETTINGS

Power and Display

External Power	External Power ac Adapter Connected
Power	**ON**

Vertical

CH 2 Coupling	GND
CH 2 **VOLTS/DIV**	500 mV
CH 2 Variable	CAL
CH 1 Coupling	GND
CH 1 **VOLTS/DIV**	500 mV
CH 1 Variable	CAL

Horizontal

SEC/DIV	1 ms
X10 MAG	OFF

Trigger

Trigger **MODE**	AUTO BL
Trigger **SOURCE**	VERT
Trigger **SLOPE**	+

Top Panel Controls

Trigger **POS**	POST
STORE	STORE
DISPL	
INV1	OFF
INV2	OFF
XY	OFF
RO OFF	OFF (not selected)
ACQ	NORM
AUX FUNCT	
MOTOR TRIG	OFF

1. Check Input Current

a. Press the **CLEAR** button to clear the display.

b. Vertically position the Channel 1 trace to the center horizontal graticule line.

c. Set the CH 1 Coupling to DC.

d. CHECK – for 0.5 division or less shift from center horizontal graticule line.

e. Set CH 1 Coupling to CH1 OFF.

f. Repeat parts b, c, and d for Channel 2.

2. Check Input Coupling

a. SET: **SEC/DIV** 0.5 ms; Trigger **MODE** AUTO LVL

b. Connect the Calibration Generator AMPL output via a BNC-to-probe-tip adapter to the Channel 2 probe tip.

c. Set the Calibration Generator for a standard-amplitude output at 2.0 V.

d. Vertically position the bottom of the signal to the center horizontal graticule line.

e. Set the CH 2 Coupling to AC.

f. CHECK – that the display moves to approximately vertical center screen.

g. SET: CH 2 Coupling CH2 OFF; CH 1 Coupling DC

h. Disconnect the Channel 2 probe tip from the test equipment and connect the Channel 1 probe tip.

i. Repeat parts d, e, and f for Channel 1.

3. **Check Variable VOLTS/DIV Range**

a. SET: CH 1 Coupling DC
CH 2 Coupling CH2 OFF

b. Position the bottom of the signal on the center vertical graticule line.

c. Press in and rotate the vertical **POS** knob (this activates the **VAR VOLTS/DIV** control) counter-clockwise until the display amplitude stops decreasing.

NOTE

*The variable knob must be held in as it is rotated or it reverts to its vertical **POS** function.*

d. CHECK—for less than 1.6 division of signal amplitude.

e. Set the CH 2 **VAR VOLTS/DIV** to CAL (press and hold in the vertical **POS** knob while rotating it clockwise until a beep is heard and the uncal indicator is cleared from in front of the volts per division readout).

f. SET: CH 1 Coupling CH1 OFF
CH 2 Coupling DC

g. Disconnect the Channel 1 probe tip from the test equipment and connect the Channel 2 probe tip.

h. Repeat parts c, d, e, and f for Channel 2.

4. **Check VOLTS/DIV Accuracy**

a. Set Calibration Generator for a standard-amplitude output signal of 200 mv.

b. Set the CH 2 **VOLTS/DIV** control to 50 mV.

c. Vertically center the display.

d. CHECK—all positions of the volts per division settings for correct signal-to-graticule accuracy using the **VOLTS/DIV** control and Calibration Generator settings and amplitude limits given in Table 4-2.

e. Return the Calibration Generator output to 200 mV.

f. SET: CH 2 Coupling CH2 OFF
CH 1 Coupling DC
CH 1 **VOLTS/DIV** 50 mV

g. Disconnect the Channel 2 probe tip from the test equipment and connect the Channel 1 probe tip.

h. Repeat part d for Channel 1.

i. Disconnect the test equipment from the oscilloscope and return the Calibration Generator output to 20 mV.

5. **Check Probe Compensation**

a. SET: CH 1 **VOLTS/DIV** 50 mV
SEC/DIV 0.2 ms
TRIG POS MID

b. Connect the Calibration Generator positive-going, FAST-RISE output via a 50 Ω termination and a BNC-to-probe-tip adapter to the Channel 1 probe tip.

c. Set the Calibration Generator to output a fast rise signal with a 1 ms period.

d. Vertically position the top of the square wave on the second horizontal graticule line above the center.

e. Adjust the Calibration Generator output for a five division display amplitude.

f. Position the rising edge at the trigger position to the center vertical graticule line.

g. CHECK—for 0.15 division or less of rolloff or overshoot at the front corner.

h. SET: CH 1 Coupling CH1 OFF
CH 2 Coupling DC
CH 2 **VOLTS/DIV** 50 mV

i. Disconnect the Channel 1 probe tip from the test equipment and connect the Channel 2 probe tip.

j. Vertically center the display.

k. Repeat part g for Channel 2.

l. Disconnect the Channel 2 probe tip from the test equipment.

Table 4-2
VOLTS/DIV Accuracy Settings

VOLTS/DIV	CALIBRATION GENERATOR	AMPLITUDE LIMITS
5 mV[1]	20 mV	3.84 div–4.16 div
10 mV[1]	50 mV	4.80 div–5.20 div
20 mV[1]	0.1 V	4.80 div–5.20 div
50 mV	0.2 V	3.84 div–4.16 div
0.1 V	0.5 V	4.80 div–5.20 div
0.2 V	1 V	4.80 div–5.20 div
0.5 V	2 V	3.84 div–4.16 div
1 V	5 V	4.80 div–5.20 div
2 V	10 V	4.80 div–5.20 div
5 V	20 V	3.84 div–4.16 div
10 V	50 V	4.80 div–5.20 div
20 V	100 V	4.80 div–5.20 div
50 V	100 V	1.92 div–2.08 div
100 V[2]	– –	– –
200 V[2]	– –	– –
500 V[2]	– –	– –

[1] **These ranges available only with a P400 X1 probe (optional).**

[2] **P850 probe only; not practical to check due to calibration generator limitation. To verify attenuator accuracy in these positions, substitute a P400 X1 probe and check the 10, 20, and 50 V per division settings.**

6. Check Analog Bandwidth

a. SET: CH 2 **VOLTS/DIV** 0.5 V
SEC/DIV 5 μs

b. Connect the Leveled Sine Wave Generator output via a 50 Ω termination and BNC-to-probe-tip adapter to the Channel 2 probe tip.

c. Set the Leveled Sine Wave Generator for a display amplitude of 6 divisions at 50 kHz.

d. Set the **SEC/DIV** control to 50 ns.

e. Set the Leveled Sine Wave Generator output frequency to 10 MHz.

f. CHECK—for at least 4.2 divisions of display amplitude.

g. Return the Sine Wave Generator output frequency back to 50 kHz.

h. SET: CH 2 Coupling CH2 OFF
CH 1 Coupling DC
CH 1 **VOLTS/DIV** 0.5 V
SEC/DIV 5 μs

i. Disconnect the Channel 2 probe tip from the test equipment and connect the Channel 1 probe tip.

j. Vertically center the display.

k. Repeat parts c, d, e, and f for Channel 1.

l. Disconnect the Channel 1 probe tip from the test equipment.

HORIZONTAL

Equipment Required (See Table 4-1)

Time-Mark Generator
50 Ω BNC Termination
BNC-to-probe-tip Adapter
External Power ac Adapter (wall transformer)

INITIAL CONTROL SETTINGS

Power and Display

External Power	External Power ac Adapter Connected
Power	**ON**

Vertical

CH 2 Coupling	CH2 OFF
CH 1 Coupling	DC
CH 1 **VOLTS/DIV**	0.1 V
CH 1 **VAR**	CAL

Horizontal

SEC/DIV	1 ms
X10 MAG	OFF

Trigger

Trigger **MODE**	AUTO LVL
Trigger **SOURCE**	VERT
Trigger **SLOPE**	+

Top Panel Controls

Trigger **POS**	POST
STORE	STORE
DISPL	
INV1	OFF
INV2	OFF
XY	OFF
RO OFF	OFF (not selected)
ACQ	NORM
AUX FUNCT	
MOTOR TRIG	OFF

PROCEDURE

1. **Check X1 SEC/DIV Accuracy**

   a. Press the **CLEAR** button to clear the display.

   b. Connect the Time Mark Generator via a 50 Ω termination and BNC-to-probe-tip adapter to the Channel 1 probe tip.

   c. Set the Time Mark Generator to output 1 ms time markers.

   d. Vertically position the baseline of the time-mark signal to the center horizontal graticule line.

   e. Horizontally position the left time marker with the first vertical graticule line.

   f. CHECK—that the leading edge of each time marker is aligned to a vertical graticule line within 2% (±0.1 division).

   g. Disconnect the test equipment from the oscilloscope.

TRIGGER

Equipment Required (See Table 4-1)

- Leveled Sine Wave Generator
- Calibration Generator
- BNC-female-to-dual-banana Adapter
- BNC T-connector
- BNC-to-probe-tip Adapter
- 50 Ω BNC Termination
- External Power ac Adapter (wall transformer)
- BNC Coaxial Cable

INITIAL CONTROL SETTINGS

Power and Display

External Power	External Power ac Adapter Connected
Power	**ON**

Vertical

CH 2 Coupling	CH2 OFF
CH 2 **VAR**	CAL
CH 1 Coupling	DC
CH 1 **VOLTS/DIV**	50 mV
CH 1 **VAR**	CAL

Horizontal

X10 MAG	OFF
SEC/DIV	50 ns

Trigger

Trigger **MODE**	AUTO LVL
Trigger **SLOPE**	+
Trigger **SOURCE**	VERT

Top Panel Controls

Trigger **POS**	POST
STORE	STORE
DISPL	
INV1	OFF
INV2	OFF
XY	OFF
RO OFF	OFF (not selected)
ACQ	NORM
AUX FUNCT	
MOTOR TRIG	OFF

PROCEDURE

1. Check Trigger Sensitivity

a. Connect the Leveled Sine Wave Generator via a 50 Ω termination and a BNC-to-probe-tip adapter to the Channel 1 probe tip.

b. Set the Sine Wave Generator for a 5 division display amplitude at 10 MHz.

c. Set the CH 1 **VOLTS/DIV** control to 0.5 V for a 0.5 division display amplitude.

d. CHECK—for a stable display with the **TRIG'D** indicator on.

2. Check Trigger LEVEL Control

a. SET: CH 1 **VOLTS/DIV** 0.2 V; **SEC/DIV** 5 µs; Trigger **MODE** AUTO BL

b. Set the Sine Wave Generator for a 5 division display amplitude at the 50 kHz reference frequency.

c. Adjust the trigger **LEVEL** control for a stable trigger.

d. CHECK—that the signal remains triggered while the trigger point indicator "+" is on the positive slope when rotating the trigger **LEVEL** control through its range.

e. Set the trigger SLOPE to "-."

f. CHECK—that the signal remains triggered while the trigger point indicator "+" is on the negative slope when rotating the trigger **LEVEL** control through its range.

g. Set the CH 1 **VOLTS/DIV** to 50 mV.

h. Set the trigger **LEVEL** control to position the trigger indicator (+) to 1 division below the positive peak of the signal. (Use the vertical **POS** control to bring the peak of the signal on screen to see the trigger position on the waveform.)

i. Position the waveform vertically to place the bottom of the signal one division above the center horizontal graticule line.

j. CHECK—that the signal remains triggered with the **TRIG'D** indicator light on.

k. Use the trigger **LEVEL** control to place the trigger indicator one division above the negative peak of the signal while maintaining a stable, triggered display.

l. Position the waveform vertically to place the top of the signal one division below the center horizontal graticule line.

m. CHECK—that the signal remains triggered with the **TRIG'D** indicator light on.

n. Disconnect the Channel 1 probe tip from the BNC-to-probe-tip adapter and connect the Channel 2 probe tip.

o. SET:

CH 1 Coupling	CH1 OFF
CH 2 Coupling	DC
CH 2 **VOLTS/DIV**	0.2 V
Trigger **SLOPE**	+
Trigger **LEVEL**	For a stable display

p. Repeat parts d through m for Channel 2.

q. Disconnect the Channel 2 probe tip from the test equipment.

3. Check External Trigger Sensitivity

a. SET:

CH 2 Coupling	GND
CH 1 Coupling	DC
CH 1 **VOLTS/DIV**	50 mV
Trigger **SOURCE**	EXT
STORE	OFF (not selected)

b. Connect the Leveled Sine Wave Generator output via a 50 Ω termination, a BNC T-connector, and a BNC-to-probe-tip adapter to the Channel 1 probe tip.

c. Connect the other side of the T-connector via a 50 Ω coaxial cable and BNC-female-to-dual banana connector to the **EXT TRIG INPUT** and **EXT TRIG COMM** input jacks on the rear panel.

d. Vertically center the display.

e. Set the Sine Wave Generator to display 5 divisions of amplitude at 50 kHz.

f. Set the **SEC/DIV** control to 50 ns.

g. Set the Sine Wave Generator to 10 MHz.

h. CHECK—for a triggered display (**TRIG'D** indicator light on).

4. Check External Trigger Level Range

a. SET:

CH 1 **VOLTS/DIV**	1 V
SEC/DIV	5 μs

b. Adjust the Leveled Sine Wave Generator for maximum output at 50 kHz (just over a 5 division display amplitude).

c. Vertically center the display and horizontally position the beginning of the sweep at the second vertical graticule line.

d. Set the SEC/DIV to 1.0 μs.

e. CHECK—that the beginning of the signal moves at least 2.0 divisions below the center horizontal graticule line as the trigger **LEVEL** control is rotated counterclockwise.

f. CHECK—that the beginning of the signal moves at least 2.0 divisions above the center horizontal graticule line as the trigger **LEVEL** control is rotated clockwise.

g. Disconnect the probe tip from the test equipment.

5. Check Trigger Jitter

a. SET: Trigger **SOURCE** VERT

b. Press the **AUX FUNCT** button on the top panel.

c. Select ALIGN to display the ALIGN submenu.

d. Press the third button (the one below the XY menu choice; it is a hidden menu choice that is not labeled) to start the clock calibration procedure.

e. CHECK – that the trigger position indicator (+) remains within the center two horizontal divisions (see Figure 4-2). An occasional jump outside the center two divisions is normal.

f. Press **CLEAR** when finished with the trigger jitter check procedure.

6. Check Motor Trigger

a. Set:

CH 1 **VOLTS/DIV**	0.1
SEC/DIV	1 ms
Trigger **SOURCE**	VERT
Trigger **MODE**	AUTO BL
TRIG POS	MID
MOTOR TRIG	ON

b. Connect the fast rise output of the Calibration Generator through the BNC-to-probe-tip adapter to the Channel 1 probe tip.

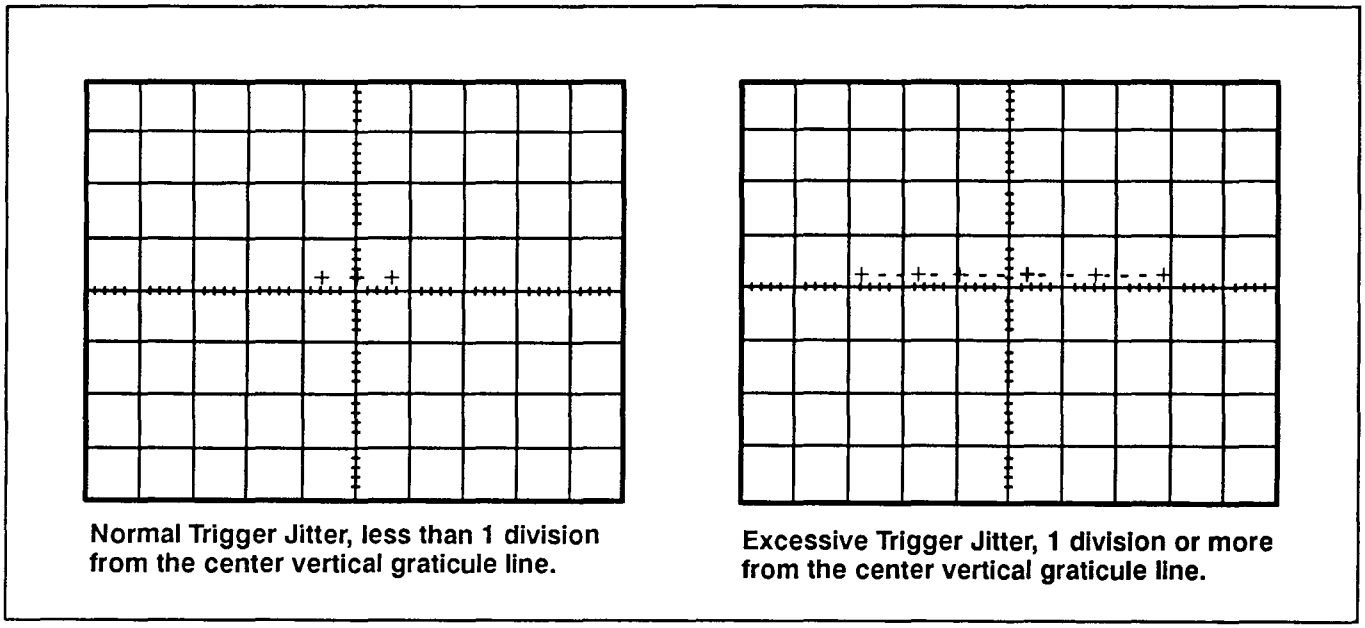
c. Set the Calibration Generator frequency to 1 kHz.

d. Press the **AUTO LVL: PUSH** button to center the trigger level on the waveform.

e. Adjust the Calibration Generator frequency to the point where the trigger of the waveform is just able to be maintained.

f. Verify that the negative portion of the displayed square wave is between 1.5 and 3.0 ms.

g. Disconnect the test equipment from the instrument.



Normal Trigger Jitter, less than 1 division from the center vertical graticule line.

Excessive Trigger Jitter, 1 division or more from the center vertical graticule line.

Figure 4-2. Trigger jitter check.

ADJUSTMENT PROCEDURE

INTRODUCTION

The adjustment procedure is a set of sequenced instructions intended to return the instrument to conformance with the performance characteristics given in section 1. Adjustments contained in this procedure should be done only after checks from the "Performance Check Procedure", Section 4, have indicated a need for readjustment or after repairs have been made to the instrument.

TEST EQUIPMENT

Table 4–1 is a complete list of the test equipment required to accomplish the adjustment procedure in this section. To ensure accurate measurements, it is important that test equipment used for making the adjustments in this section meets or exceeds the specifications described in Table 4–1. When considering use of equipment other than that recommended, use the Minimum Specification column in Table 4–1 to determine whether available test equipment will work.

Detailed operating instructions for test equipment are not given in this procedure. If more operating information is required, refer to the appropriate test-equipment instruction manual.

LIMITS AND TOLERANCES

The limits and tolerances stated in this procedure are instrument specifications only if they are listed in the performance characteristics listed in section 1. Tolerances given are applicable only to the instrument undergoing adjustment and do not include test equipment error.

The operating temperature range is between −10°C and +55°C. To meet the performance characteristics, the instrument must be operating at an ambient temperature within ±5°C of the last self calibration. A complete self calibration is done as part of the adjustment procedure.

ADJUSTMENTS AFFECTED BY CIRCUIT BOARD REPLACEMENT

Replacement of a circuit board to repair an instrument may affect one or more adjustment settings. Due to the interactions possible between boards, it is recommended that a complete adjustment be done if circuit boards are replaced.

PREPARATION FOR ADJUSTMENT

Before performing this procedure, do not preset any internal adjustments. Only change an internal adjustment setting if a performance characteristic cannot be met with the original setting.

PROCEDURE STEPS

Equipment Required (see Table 4-1)

External Power ac Adapter (wall transformer)	Alignment Tool
Calibration Generator	Torx Driver, T-15 Tip
50-Ω BNC Termination	Hex Wrench, 0.050 inch
BNC T-Connector	Open-end Wrench, 3/16 inch
BNC-to-probe-tip Adapter (2 required)	50-Ω BNC Coaxial Cable
Dual-Male-Banana-to-Female-BNC- Adapter	DMM Calibrator
Shorting Jumper	Banana Tip Connectors

See Figures 5-2, 5-3, and 5-4 for the Adjustment Locations.

PREPARATION

1. Turn on the test equipment and allow a 20 minute warm-up period before beginning the procedure.
2. Remove the front case piece and the top case half from the instrument. (See the "Front and Top Case Removal" procedure in " Maintenance", Section 6.)
3. Swing the front panel out from the left side to allow the CRT to be viewed directly when the display adjustments are made.
4. Lay the top case half down on the right side of the instrument with the front of the case facing the instrument. Reconnect the top keypad cable to its front panel connector.
5. Connect the wall transformer to an appropriate source of ac power and connect the power supply cable to the **EXT POWER INPUT** connector on the rear panel.
6. Press the front-panel **ON** button to toggle into the operating mode.

ADJUSTMENTS

1. **Display Adjust**

   a. Press the **AUX FUNCT** button on the top panel.

   b. Select the ALIGN submenu to bring up the menu choice.

   c. Select XY to display a test pattern.

   d. ADJUST—**INTEN** control (R413, the larger control shaft located on the rear panel of the instrument) for a viewable display.

   e. ADJUST—**FOCUS** control (R415, located on the rear panel) and ASTIG (R424) for the best focused display over the entire graticule area.

   f. ADJUST—VPOS (R456) and HPOS (R448) to center the ALIGN XY calibration pattern on the CRT.

   g. ADJUST—HORIZ ALIGN (R426) and VERT ALIGN (R431) for best horizontal and vertical alignment of the box pattern to the graticule lines.

   h. ADJUST—VGAIN (R455) for a display 4 vertical divisions high and HGAIN (R447) for a display 8 horizontal divisions wide on the outer box pattern.

   NOTE

   Make sure the midpoint of each outside trace of the calibration pattern is exactly centered over its respective graticule line. See Figure 5-1.

   i. RECHECK—All the display controls for best adjustment.

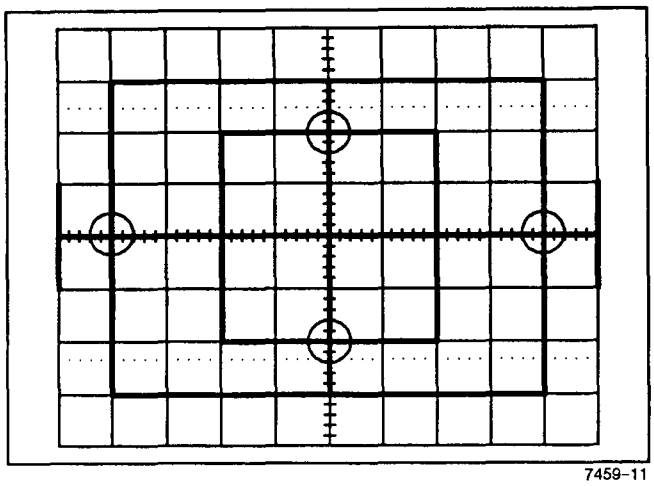


Figure 5-1. Locations at which horizontal and vertical gains are adjusted.

2. Sweep Length and Vector Generator Adjust

a. ADJUST—SWP (R255) to set the end of the sweep just to the vertical line on the right side of the display pattern.

b. ADJUST—XVECT (R259) and YVECT (R260) for the best corner at the lower left of the display pattern.

c. Press CLEAR to remove the display pattern.

3. CH1 and CH2 Reference Self Calibration

a. Set up the DMM Calibrator to provide a 3.0 volt reference voltage.

b. Connect a BNC T-connector and two BNC-to-probe tip adapters to the 3.0 volt output from the DMM calibrator via a 50Ω BNC coaxial cable and BNC-female-to-dual-banana-tip adapter. Insert both probe tips into the probe tip adapters.

c. Press the **AUX FUNCT** button on the top panel.

d. Select SELF CAL to call up the calibration menu.

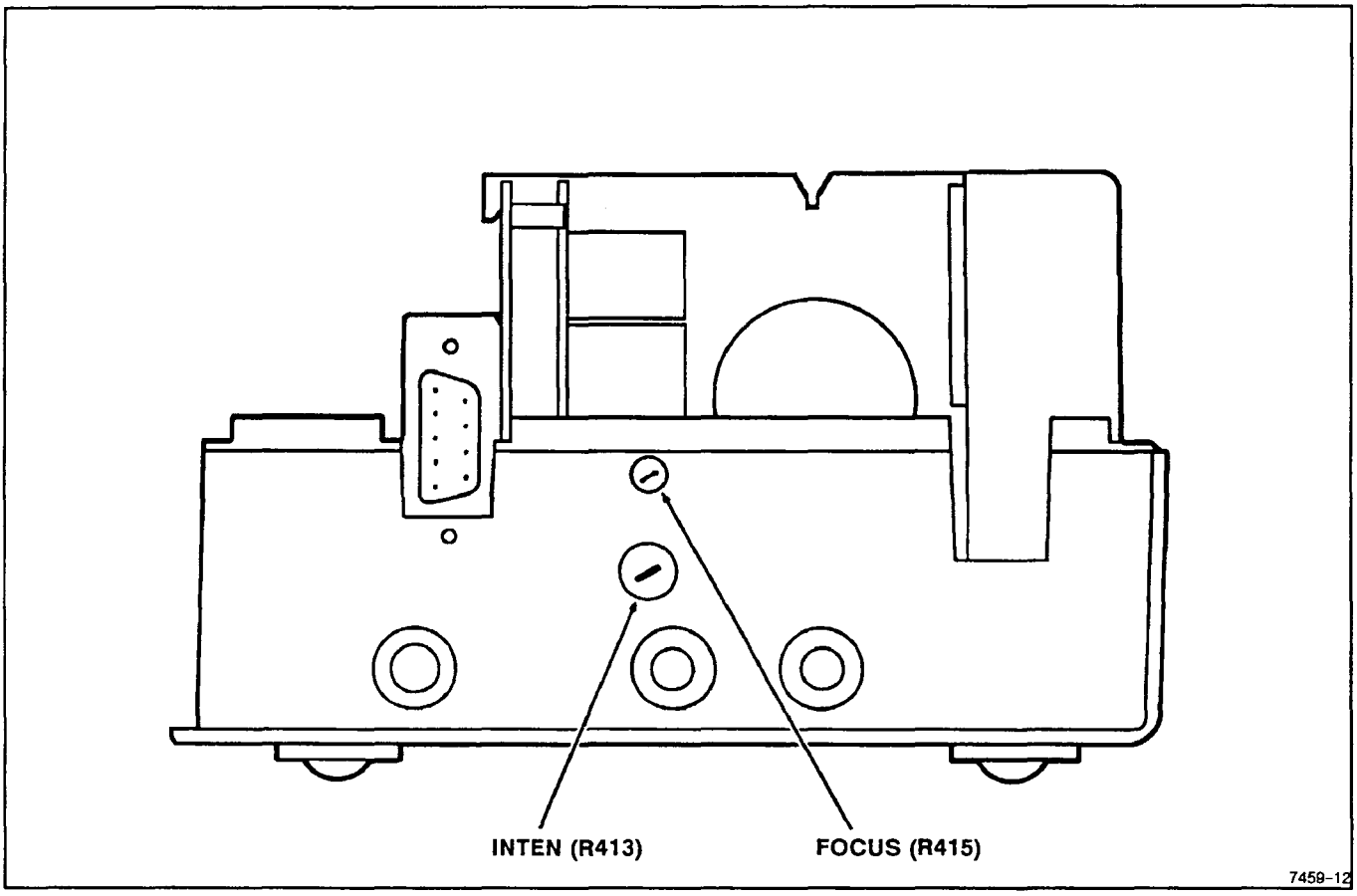


Figure 5-2. Rear Panel adjustments.

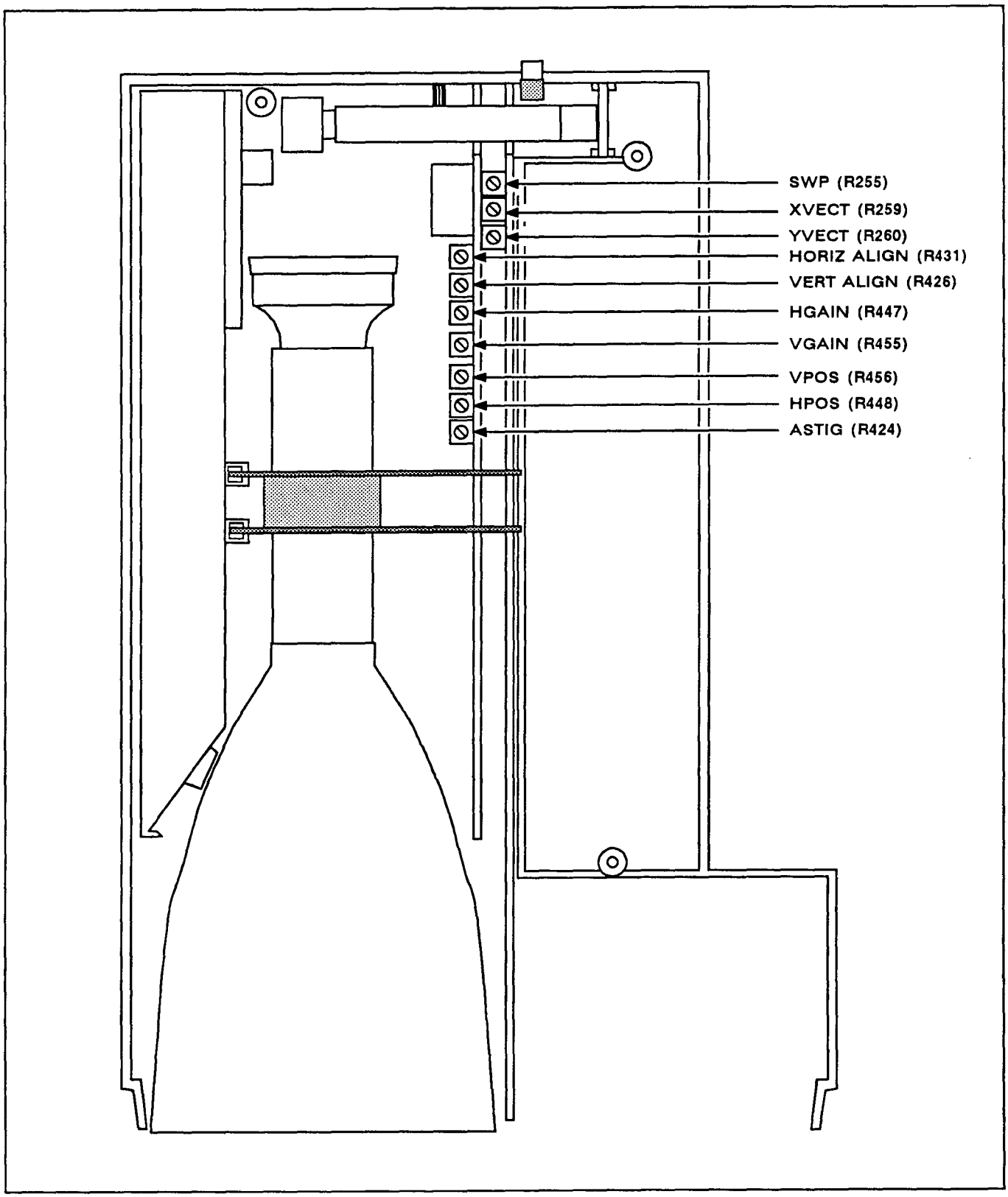


Figure 5-3. Top accessible adjustments.

e. Select PROBE to display the APPLY REF menu.

f. Select CH 1 to run the CH 1 REFERENCE Self Cal.

g. Select CH 2 to run the CH 2 REFERENCE Self Cal.

h. When the calibration routine has finished, disconnect the T-connector, with the two probe tips remaining connected, from the 3.0 volt reference voltage.

4. Channel 1 and Channel 2 Gain Self Calibration

a. Press the **AUX FUNCT** button on the top panel.

b. Select SELF CAL to call up the calibration menu.

c. Select CH 1 to start the channel 1 self calibration.

d. Select CH 2 to start the Channel 2 self calibration.

NOTE

*The PASS/FAIL message is not self-clearing and will remain on the display either until it is updated with the results of the next self calibration process or until the **CLEAR** button is pressed.*

5. Clock Delay Adjust

a. Press the **AUX FUNCT** button on the top panel.

b. Select ALIGN to display the ALIGN menu.

c. Press the third button (the one below the XY menu choice; it is not labeled) to start the clock calibration procedure.

d. ADJUST – CLOCK DELAY (R308), located below the front of the CRT (see Figure 5-4), until the trigger position indicator (+) remains within the center two horizontal divisions (an occasional jump outside the center divisions may occur).

e. Press **CLEAR** when finished with the interactive portion of the clock delay adjustment procedure.

6. External Trigger Offset Calibration

NOTE

*The **TRIG COM** and **EXT TRIG INPUT** jacks on the rear panel must be connected together before running the external trigger offset self calibration.*

a. Use the banana plug shorting fixture to short the **TRIG COM** and **EXT TRIG INPUT** jacks together.

b. Press the **AUX FUNCT** button on the top keypad.

c. Select SELF CAL to display the SELF CAL menu.

d. Select EXT TRIG to display the next menu.

e. Press the CAL button to run the external trigger self calibration routine.

f. When the routine finishes, disconnect the shorting fixture from the **TRIG COM** and **EXT TRIG INPUT** jacks.

g. Disconnect the external power and reassemble the instrument.

Check the instrument for proper operation after reassembling it.

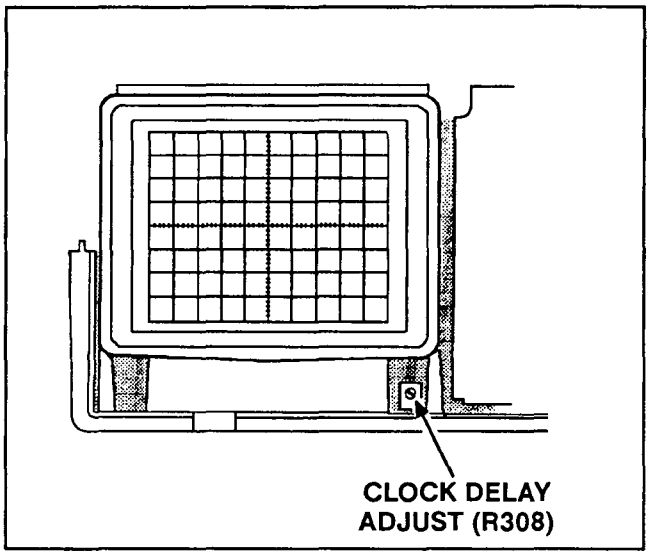


Figure 5-4. Clock Delay adjustment.

MAINTENANCE

This section of the manual contains information on static-sensitive assemblies, preventive maintenance, troubleshooting, and corrective maintenance. General information regarding the care and handling of semiconductor devices is provided in "Static-Sensitive Assemblies", and routine cleaning and inspection are covered in "Preventive Maintenance". Internal testing capabilities and diagnostic test routines are included in the "Troubleshooting" subsection. The "Corrective Maintenance" part of this section includes circuit board removal procedures, maintenance aids, and soldering techniques.

STATIC-SENSITIVE ASSEMBLIES

The following precautions apply when performing any maintenance involving internal access to the instrument.

CAUTION

Static discharge can damage any semiconductor component in this instrument.

This instrument contains electrical components that are susceptible to damage from static discharge. Table 6-1 lists the relative susceptibility of various classes of semiconductors. Static voltages of 1 kV to 30 kV are common in unprotected environments.

When performing maintenance, observe the following precautions to avoid component damage:

1. Minimize handling of static-sensitive assemblies.
2. Transport and store static-sensitive assemblies in their original containers. Label any package that contains static-sensitive assemblies.
3. Discharge the static voltage from your body by wearing a grounded antistatic wrist strap while handling these assemblies. Servicing static-sensitive assemblies should be performed only at a static-free work station by qualified service personnel.
4. Keep anything capable of generating or holding a static charge off the work station surface.
5. Pick up assemblies by their edges, never by their component leads.
6. Do not slide the assemblies over any surface.
7. Avoid handling assemblies in areas that have a floor or work-surface covering capable of generating a static charge.
8. Use a soldering iron that is connected to earth ground.
9. Use only approved antistatic, vacuum-type desoldering tools for component removal.

Table 6-1

Relative Susceptibility to Static-Discharge Damage

Semiconductor Classes	Relative Susceptibility Levels [a]
MOS or CMOS microcircuits or discretes, or linear microcircuits with MOS inputs (Most Sensitive)	1
ECL	2
Schottky signal diodes	3
Schottky TTL	4
High-frequency bipolar transistors	5
JFET	6
Linear microcircuits	7
Low-power Schottky TTL	8
TTL (Least Sensitive)	9

[a] Voltage equivalent for levels (voltage discharged from a 100-pF capacitor through a resistance of 100 Ω):

1 = 100 to 500 V
2 = 200 to 500 V
3 = 250 V
4 = 500 V
5 = 400 to 600 V
6 = 600 to 800 V
7 = 400 to 1000 V (est)
8 = 900 V
9 = 1200 V

PREVENTIVE MAINTENANCE

INTRODUCTION

Preventive maintenance consists of cleaning, inspecting, and checking instrument performance. Preventive maintenance on a regular basis may prevent instrument malfunction and improve instrument reliability. The required frequency of maintenance depends on the severity of the environment in which the instrument is used. A good time to do preventive maintenance is just before instrument adjustment.

INSPECTION AND CLEANING

Inspect and clean the instrument as often as operating conditions require. Accumulation of dirt in the instrument can cause overheating and component breakdown. Dirt on components acts as an insulating blanket, preventing efficient heat dissipation. It also provides an electrical conduction path that could result in instrument failure, especially under high-humidity conditions

CAUTION

To prevent damage to the plastics in this instrument, use a nonresidue-type cleaner, preferably isopropyl alcohol or a solution of 1% mild detergent and 99% water. Before using any other type of cleaner, consult your Tektronix Service Center or representative.

Exterior

INSPECTION. Inspect the external portions of the instrument for damage, wear, and missing parts; use Table 6-2 as a guide. Instruments that appear to have been dropped or otherwise abused should be checked thoroughly to verify correct operation and performance. Deficiencies that could cause personal injury or could lead to further instrument damage should be repaired immediately.

CAUTION

To prevent damage, do not allow moisture to get inside the instrument during external cleaning. Use only enough liquid to dampen the cloth or applicator.

CLEANING. Remove loose dust on the outside of the instrument with a soft cloth or small soft-bristle brush. The brush is particularly useful on and around the controls and connectors. Remove remaining dirt with a soft cloth dampened in a mild detergent-and-water solution. Do not use abrasive cleaners.

Clean the light filters and the CRT face with a soft, lint-free cloth dampened with either isopropyl alcohol or a mild detergent-and-water solution.

Interior

To clean or inspect the inside of the instrument, first refer to the Remove and Replace Procedures in this section.

Table 6-2
External Inspection Checklist

Item	Inspect For	Repair Action
Case and Front Panel	Cracks, scratches, deformations, damaged hardware or gaskets.	Replace defective components.
Front-panel Controls	Missing, damaged, or loose knobs, torn or damaged switch activators.	Repair or replace missing or defective items.
Connectors	Dirt in connectors.	Clean or wash out dirt.
Accessories	Missing items or parts of items, bent pins, broken or frayed cables, and damaged connectors.	Replace damaged or missing items, frayed cables, and defective parts.

INSPECTION. Inspect the internal parts of the instrument for damage and wear, using Table 6-3 as a guide. Repair any problems found immediately. The repair method for most visible defects is to replace the defective circuit board, but take particular care if heat-damaged components are found. Since overheating usually indicates other trouble in the instrument, the cause of overheating must be eliminated to prevent repeated damage.

If any circuit board is replaced, do a complete adjustment of the instrument (see Section 5 for the Adjustment Procedure).

CAUTION

To prevent damage from electrical arcing, ensure that circuit boards and components are dry before applying power to the instrument.

CLEANING. To clean the interior, blow off dust with dry, low-pressure air (approximately 9 psi). Remove any remaining dust with a soft brush or a cloth dampened with a solution of mild detergent and water. A cotton-tipped applicator is useful for cleaning in narrow spaces and on circuit boards. If these methods do not remove all the dust or dirt, the instrument may be spray washed using a solution of 1% mild detergent and 99% water as follows:

1. Remove covers and shields to reach parts to be cleaned (see Removal and Replacement Instructions).
2. Spray wash dirty parts with the detergent-and-water solution; then use clean water to thoroughly rinse them.

CAUTION

To prevent damage, do not wash the Potentiometer circuit board (A5) or the beeper on the Power Supply circuit board (A4).

3. Dry all parts with low-pressure air.
4. Dry all components and assemblies in an oven or drying compartment using low-temperature (125°F to 150°F) circulating air.

SWITCH CONTACTS. Switch contacts are permanently treated when assembled. Unless the switch board is contaminated during disassembly, neither cleaning nor other preventive maintenance is necessary.

Table 6-3
Internal Inspection Checklist

Item	Inspect For	Repair Action
Circuit Boards	Loose, broken, or corroded solder connections. Burned circuit boards. Burned, broken, or cracked circuit-run plating.	Replace defective circuit board.
Resistors	Burned, cracked, broken, blistered, or separated from the circuit board.	Replace defective circuit board.
Solder Connections	Cold solder or rosin joints on connectors.	Resolder joint and clean with isopropyl alcohol.
Capacitors	Damaged or leaking cases. Corroded solder on leads or terminals, or separated from the circuit board.	Replace defective circuit board.
Semiconductors	Separated from circuit board or cracked.	Replace defective circuit board.
Wiring and Cables	Loose plugs or connectors. Burned, broken, or frayed wiring.	Firmly seat connectors. Repair or replace defective wires or cables.

CAUTION

Residual body oils are corrosive to the contact material over time. Do not touch the switch pad contacts or the carbon tipped actuators with your fingers.

LUBRICATION

A regular lubrication program for the instrument is not necessary. The potentiometers used in this instrument are permanently sealed and do not require periodic lubrication. Rotary switches are sealed and do not require lubrication.

PERIODIC READJUSTMENT

To ensure accurate measurements, check the performance of this instrument every 2000 hours of operation or, if used infrequently, once each year. If you replace any circuit boards it will be necessary to readjust the instrument because of possible interactions between the circuit boards.

Complete performance check instructions are given in section 4 of this manual; adjustment instructions are given in section 5. The performance check procedure can be helpful in localizing certain troubles in the instrument. In some cases, minor problems may be revealed or corrected by readjustment.

TROUBLESHOOTING

INTRODUCTION

Preventive maintenance performed on a regular basis should reveal most potential problems before an instrument malfunctions. However, should troubleshooting be required, the following information is provided to aid in locating a fault. In addition, the material presented in the Block Diagram Description section of this manual may be helpful while troubleshooting.

TROUBLESHOOTING AIDS

Diagnostic Firmware

This instrument contains built-in diagnostic routines that can help in localizing certain failures. If a failure is detected during power on or self-calibration, an error message is sent over the RS-232 interface to a terminal or host computer. No error codes (other than the PASS/FAIL self calibration messages) appear on the CRT display. See the RS-232 Interfacing Guide for complete information regarding the error messages.

Troubleshooting Chart

A troubleshooting chart is provided in section 9 to help isolate problems to a circuit board.

Circuit Board Locations

The locations of circuit boards in the instrument are shown in "Removal and Replacement Procedures" Figure 6-1 in this section of the manual.

TROUBLESHOOTING TECHNIQUES

The following procedure is arranged in an order that enables checking simple trouble possibilities before requiring more extensive troubleshooting.

CAUTION

To prevent damage, do not use test equipment to make measurements on static-sensitive, current-sensitive, or voltage-sensitive components or assemblies unless you are certain that any voltage or current supplied by the test equipment does not exceed the limits of the component to be tested,.

1. Power-up and Self Calibration Tests

When instrument power is applied, the contents of the microprocessor EEPROMs are checked for false data that would indicate corrupted calibration constants. If the instrument fails the power-up tests, failure codes are sent via the RS-232 interface to a terminal or host computer. Refer to Table 6-4 for error codes, descriptions, and recommended corrective actions.

Table 6-4
Power Up Error Codes

Code	Bit Field	Description	Corrective Action
4001		EEPROM checksum bad.	Perform all self calibrations.
4002 FFFF		Initial self cal needed.	Perform all self calibrations.
4002 0001	0	CH 1 gain constant error.	Perform CH 1 gain self calibration.
4002 0002	1	CH 2 gain constant error.	Perform CH 2 gain self calibration.
4002 0004	2	CH 1 reference constant error.	Perform CH 1 reference self calibration.
4002 0008	3	CH 2 reference constant error.	Perform CH 2 reference self calibration.
4002 0010	4	CH 1 trigger constant error.	Perform CH 1 trigger gain self calibration.
4002 0020	5	CH 2 trigger constant error.	Perform CH 2 trigger gain self calibration.
4002 0040	6	External trigger constant error.	Perform ext trig self calibration.
4002 0080	7	Clock delay constant error.	Perform clock delay self calibration.

Any combination of power-up error codes may occur. The last two digits of the error code are a hexadecimal number that can be converted to an eight bit binary number. After converting to binary and determining which bits are high (set to1), use Table 6-4 to determine which self calibration procedures to perform.

For example, suppose the following error code is displayed on the CRT:

4002 0021

Converting the hexadecimal value of 21 to binary format results in the following:

Binary Number

Bit Field							
7	6	5	4	3	2	1	0
0	0	1	0	0	0	0	1

which is the binary number

0010 0001

The 0 bit and the 5th bit is high. Consult the Bit Field column in Table 6-4 and note that a CH 1 gain constant error and a CH 2 trigger constant error occurred. Perform the CH 1 gain and the CH 2 trigger gain self calibrations.

If there is a single failure, the description and corrective action may be determined directly from Table 6-4. For example, suppose the following error code appears on the display:

4002 0010

Referring to Table 6-4, it is noted that a CH 1 trigger constant error has occurred and that the CH 1 trigger gain self calibration should be performed.

At the end of a self calibration process, the instrument will display a "PASS" or "FAIL" message near the center of the CRT display area. If a process fails, the associated calibration constants are **not** updated. As the instrument is turned off and back on, it will continue to output calibration constant error codes. A successful self calibration will correct the calibration constants and eliminate the message.

When a self calibration process fails, it immediately outputs an error code corresponding to the cause of the failure. Several error messages may be given before the process stops. Descriptions of the possible error codes and corrective actions are listed in Table 6-5.

Table 6-5
Self Cal Error Codes

Code	Description
8009 XXXX[1]	Trigger search error.
8013 XXXX	External trigger offset range error.
8014 XXXX	External trigger hysteresis error.
8015 XXXX	Clock delay error
8101 XXXX[2]	CH 1 acquisition timeout error.
8102 XXXX	CH 1 mid position search error.
8103 XXXX	CH 1 mid position range error.
8104 XXXX	CH 1 offset search error.
8105 XXXX	CH 1 offset range error.
8106 XXXX	C H 1 offset gain error
8107 XXXX	CH 1 gain range error.
8108 XXXX	CH 1 gain search error.
8109 XXXX	CH 1 trigger search error.
8110 XXXX	CH 1 trigger offset range error.
8111 XXXX	CH 1 trigger gain error.
8112 XXXX	CH 1 trigger hysteresis error.
8116 XXXX	CH 1 acquisition delay error.
8201 XXXX[2]	CH 2 acquisition timeout error.
8202 XXXX	CH 2 mid position search error.
8203 XXXX	CH 2 mid position range error.
8204 XXXX	CH 2 offset search error.
8205 XXXX	CH 2 offset range error.
8207 XXXX	CH 2 gain range error.
8208 XXXX	CH 2 gain search error.
8209 XXXX	CH 2 trigger search error.
8210 XXXX	CH 2 trigger offset range error.
8211 XXXX	CH 2 trigger gain error.
8212 XXXX	CH 2 trigger hysteresis error.
8216 XXXX	CH 2 acquisition delay error.

[1] **To repair 80XX failures, first replace the Main circuit board (A3). If the problem still exists, then replace the CPU circuit board (A2).**

[2] **To repair 81XX and 82XX failures, replace the Acquisition circuit board (A1).**

A quick index to the self calibration procedures is provided in Table 6-6.

Table 6-6
Index To Self Cal Procedures

Procedure	Page Number
CH 1 and CH 2 GAIN	5-3
CH 1 and CH 2 REFERENCE	5-4
CLOCK DELAY	5-6
EXT TRIG	5-7

Under unusual circumstances, functional processes may be disrupted during normal operation, resulting in the transmission of error messages out the RS-232 port. See Table 6-7 for error codes, descriptions, and corrective actions.

Table 6-7
Error Codes Occurring During Normal Operation

Code	Description
8009[1]	Auto level trigger search error.
F000[2]	COP timeout error.
F001	Illegal opcode execution.
F002	Interrupt exception.
F003	Task exception.

[1] **Indicates a failure to locate and trigger on the signal. In Auto Level trigger mode, the error code will be output continuously until the signal can be located. If this condition occurs for all signals, perform the CH 1 and CH 2 self calibration procedures. Most likely, one of them will indicate a trigger system failure which should be corrected by replacing the Acquisition circuit board. If the problem still occurs, replace the Main circuit board.**

[2] **The FXXX codes result in a system reset. If the front panel settings appear to be corrupted, they are returned to the default values. If these error codes occur frequently, it is likely that a failure has occurred on the CPU circuit board; replace it to correct the problem.**

Incorrect control settings can give a false indication of instrument malfunction. If there is any question about the correct function or operation of any control, refer to the operating information in the Operators Manual.

2. Check Associated Equipment

Before proceeding, ensure that any equipment used with the instrument is operating correctly. Verify that input signals are properly connected and that the interconnecting cables are not defective. Check that the AC power-source voltage to all equipment is correct.

3. Visual Check

WARNING

To avoid electrical shock, disconnect the instrument from the ac power source and remove the battery before making a visual inspection of the internal circuitry.

Perform a visual inspection for loose or broken connectors and wires, damaged circuit boards and components, or other clues to the cause of an instrument malfunction.

4. Check Instrument Performance and Adjustment

Check the performance of either those circuits where trouble appears to exist or the entire instrument. An apparent trouble may be caused by misadjustment. The complete performance check is in section 4 of this manual and adjustment instructions are in section 5.

5. Isolate Trouble to a Circuit Board

To isolate problems, use any symptoms noticed when checking the instrument's operation to help localize the trouble to a particular circuit board (for example, no waveform acquisition, improper front-panel control operation, no display or improper display of the waveforms or readouts). The Troubleshooting Chart in section 9 will help isolate the problem to a circuit board. Also, the block diagrams may aid in determining signal flow and control line dependency for correct circuit operation.

6. Check Circuit Board Interconnections

After the trouble has been isolated to a particular circuit board, again check for loose or broken connections and improperly soldered or heat-damaged components. Damaged circuit boards must be replaced for repair of the instrument. (Refer to the appropriate instructions in the "Removal and Replacement Procedures" in this section.)

CORRECTIVE MAINTENANCE

INTRODUCTION

Corrective maintenance in the field consists of circuit board replacement by a qualified service person.

This instrument is covered by a standard Tektronix three year warranty. If it fails during the warranty period, return it to Tektronix for free servicing (subject to the conditions of the warranty statement). For a detailed warranty statement, refer to the "Customer Information" section of the Tektronix product catalog.

To make arrangements for warranty service (or to get an estimate for out-of-warranty repairs) within the United States, call the following toll-free customer service number between 8:00 A.M. and 4:30 P.M. Pacific Time:

1-800-937-6007

To make arrangements for warranty service (or to get an estimate for out-of-warranty repairs) outside of the United States, call your local Tektronix Sales Office or Service Center. They are fully equipped to service your oscilloscope.

If it is necessary to return your instrument for repair or service, refer to the "Repackaging for Shipment" information below.

REPACKAGING FOR SHIPMENT

We recommend that you save the original carton and packing material in the event it is necessary for the oscilloscope be reshipped using a commercial transport carrier. If the original materials are unfit or not available, then repackage the instrument using the following procedure.

1. Use a corrugated cardboard shipping carton with a test strength of at least 275 pounds and an inside dimension at least six inches greater than the instrument dimensions.
2. Enclose the following information: owner's address, name and phone number of a contact person, serial number of the instrument, reason for returning, and a complete description of the service required.
3. Completely wrap the instrument with polyethylene sheeting or equivalent to protect the outside finish and keep harmful substances out of the instrument.
4. Cushion the instrument on all sides with three inches of padding material or urethane foam, tightly packed between the carton and the instrument.
5. Seal the shipping carton with an industrial stapler or strapping tape.
6. Mark your return address on the shipping carton. Send the carton to the following address.

   Tektronix, Inc.
   4106 N. Vancouver Ave.
   Portland, OR 97217

   Attention: 222 Series Warranty Repair

NOTE

Most instruments will be returned within 24 hours of receipt at Tektronix, Inc.

MAINTENANCE PRECAUTIONS

To reduce the possibility of personal injury or instrument damage, observe the following precautions.

1. Disconnect the instrument from the ac-power source and remove the battery before removing or installing circuit boards.
2. Use care not to overtighten screws.

REMOVAL AND REPLACEMENT PROCEDURES

Table 6-8
Recommended tools for removal and replacement procedures

Description	Specification	Usage	Example
Hexagonal wrench	0.050 inch	Instrument disassembly	
Open-end wrench	3/16 inch	Instrument disassembly	
Torx head screwdriver	T-15 tip	Instrument disassembly	
Screwdriver	Small flat blade	Instrument disassembly	
Adhesive	PRISM 454 gel	Reassemble Keypad board and Front Panel board.	Loctite #45440
Accelerator	Tak Pak spray	Reassemble Keypad board and Front Panel board. Used with Loctite adhesive #45440.	Loctite #14647

Introduction

To prepare for calibration of the instrument and to further disassemble the instrument for circuit board replacement, the top half of the case must be removed.

CAUTION

All assembly and disassembly of the instrument must be done at an approved anti-static work station. The semiconductor devices in the instrument are highly susceptible to static discharge damage.

Front and Top Case

1. Unzip the probe pouch; unplug the probes (if attached) and remove the probes from the pouch.
2. Place the instrument on its side and slide the probe pouch and battery compartment cover assembly toward the rear of the instrument to disengage the locking tabs. The opening for the probe leads makes a convenient place to apply the needed force with your finger.
3. Lift the probe pouch and battery compartment cover up and off the instrument.
4. Disconnect the three-wire battery connector.
5. Remove the battery pack from the compartment.
6. Remove the front panel knob assemblies as follows.
   a. Remove the three smaller rubber knob shells labeled **POS** (two shells) and **AUTO LVL:PUSH**. This can easily be done by placing a small tipped object (such as a small flat blade screwdriver) between the bottom edge of the knob shell and gently pry the knob shell off the knob inserts.
   b. Using a 0.050 inch hexagonal wrench, loosen the setscrews in the exposed knob inserts and remove them.
   c. Remove the three larger, knob shells and inserts in the same manner as the smaller ones.
7. Remove the protective cap from the COMM PORT connector on the rear panel. Using a 3/16 inch open-end wrench or nutdriver, remove the upper hexagonal standoff post and washer from the COMM PORT connector. Do not remove the lower standoff at this time.
8. Place the instrument on its top case.

9. Lift the flip stand up; then using a T-15 Torx-head tip screwdriver, remove the two short screws at the front, the two long screws at the rear, and the long screw located under the flip stand. Return the flip stand to its storage position.

10. Turn the instrument over and set it down with the front panel facing you.

11. Pull the bottom of the front case piece out until it clears the bottom case half. Then disengage the top of the front case piece from the top case half and pull it away from the instrument, extending the connecting cables only about an inch.

12. Disconnect the six-wire cable (coming from the Keypad board attached to the top case half) from the Front Panel switch board. Note the orientation of the cable for reinstalling correctly.

13. Lift the top case half off the instrument.

NOTE

If you are removing the top case half for calibration only, do not disassemble the instrument any further. Do not separate the Front Panel or Keypad board from their attachments unless you intend to change the boards or the rubber pushbutton actuators.

Front Panel Board Removal and Installation

1. Disconnect the two 14-pin cables from the Front Panel board; lay the front case piece down on the work surface.

2. Remove the Front Panel board from the front case piece by gently breaking the glue off the guide posts that protrude through the board.

CAUTION

Do not attempt to melt the glue with a heat gun to remove it. Excess heat may damage the plastic front panel assembly.

3. Remove the the rubber pushbutton actuator mat.

CAUTION

Do not touch either the switch contact area on the Front Panel board or the carbon contact area on the pushbutton actuators with bare fingers. Body oils can cause the contact surfaces to corrode over time.

4. When reinstalling the rubber pushbutton actuator mat, align all the buttons with the appropriate holes in the front panel case piece.

NOTE

Installing the actuator mat will be easier to do if the front case piece is held off the work surface so the longer buttons can protrude through their holes without interference.

5. Reinstall the Front Panel board over the guide post and reglue the board to the front case piece using a small amount of glue on each guide post.

Keypad Board Removal and Installation

1. Lay the top case half down with the Keypad board visible.

2. Remove the Keypad board from the top case half by gently breaking the glue off the guide posts protruding through the board. Remove the board. Remove the rubber pushbutton actuator mat if replacement is necessary.

NOTE

Do not touch either the switch contact area on the Keypad board or the carbon contact area on the pushbutton actuators with bare fingers. Body oils can cause the contact surfaces to corrode over time.

3. When reinstalling the actuator mat, align all the buttons with the appropriate holes in the top case half. Check to insure that the text is oriented correctly.

NOTE

Do not glue the two guide posts nearest the side of the case in the next step.

4. Reinstall the Keypad board over the guide posts. While applying slight pressure to the board, reglue the board to the top case half at four of the guide posts using a small amount of glue.

Potentiometer Board

1. The Potentiometer board is mounted on a metal bracket. Once the front case piece and top case half are removed and the connecting cable from the Front Panel board is disconnected, lift the Potentiometer board assembly out of the bottom case half. Note that there are slots in the bottom of the case that align with slots in the metal bracket holding the Potentiometer board.

2. Use a long, T-15 Torx-head tip screwdriver to remove the mounting screw from the Potentiometer board; separate the Potentiometer board from the metal bracket.

NOTE

If replacing the Potentiometer board, remove the three o-rings from the potentiometer shafts for use on the replacement board.

Probe Receptacle Removal

1. Remove the front case piece and the top case half.

2. Lift the probe receptacle assembly straight up until it clears the guides in the bottom case half and lay it to the rear of the instrument.

3. Disconnect the two coaxial cables from the rear of the Acquisition board by pulling each one straight out. Remove the receptacle.

CRT and Power Supply Board Removal

1. Remove the front case piece, top case half, and the probe receptacle.

CAUTION

The CRT is a high-vacuum component. Wear the proper eye protection when handling the CRT. Use care not to place excessive strain on the neck or connector pins. Place the CRT in a protected location while it is out of the instrument.

2. Lift the front of the CRT out of the bottom case half. Then pull up and forward on the Power Supply board to disconnect it from the Main board. Lift the entire assembly (CRT, CRT neck support bracket, and Power Supply board) out of the bottom case half.

3. Gently disconnect the CRT socket harness from the CRT.

4. Place the CRT in a safe place if it is to be reinstalled or dispose of it safely if it is defective. If replacing the CRT, unsnap the bottom half of the support bracket from the top half and remove the brackets from the CRT (the support bracket may remain assembled on the CRT if the same CRT is to be reinstalled).

5. Remove the extension knob from the **INTEN** (intensity) control if the board is to be replaced. Retain the knob for use on the replacement board.

CPU/Display Board Removal

1. Remove the front case piece, top case half, probe receptacle, and CRT with Power Supply board.

2. Using a 0.050 inch open-end wrench or nutdriver, remove the lower hexagonal standoff post and washer from the COMM PORT connector .

3. Hold down on Main board and pull up on the center of the CPU/Display board to disconnect it from the Main board.

4. Lift the board out of the bottom case half.

Acquisition Board and Main Board Removal

NOTE

The and Acquisition board assembly Main board must be removed from the bottom case half together as a unit.

1. Remove the front case piece, top case half, probe receptacle, CRT with Power Supply board, and the CPU/Display board.

2. Using a T-15 Torx-head tip screwdriver, remove the screw (located by the External Trigger Inputs at the rear of the instrument) holding the Main board to the bottom case half.

3 Grasp the square black component on the Main board and pull the Main board forward and up slightly while pulling on the back of the bottom case. This releases the external trigger input connectors from the holes in the back of the case. Lift the Main board and Acquisition board assembly as a unit straight up out of the bottom case half.

4. Pull firmly and evenly on the front and lower edges of the Acquisition board assembly to separate it from the Main board.

Acquisition Board Replacement

After separating the Acquisition board assembly from the Main board, use the following procedure to remove the Acquisition board from its shielding case.

1. Place the Acquisition board assembly on the work surface with the probe jacks up. Unsnap the case halves using a small flat blade screwdriver. This is best done by starting with the two snaps in the middle of the assembly and then the two at the rear.

2. Turn the assembly over and remove the shield piece.

3. Remove the circuit board from the other half.

Acquisition Board and Main Board Reinstallation

1. Place the Acquisition board in the half of the shielding case with the probe jacks.

2. Position the other half of the shielding case in place and snap the halves together.

3 Align the pins on the Acquisition board with the connectors on the Main board and reconnect the two boards.

4. Position the Main board and Acquisition board assembly in the bottom case half, guiding the foam gasket strip on the back of the Acquisition board assembly past the edge of the bottom case half.

5. Replace the hold-down screw near the External Trigger Inputs at the rear of the Main board.

CPU/Display Board Reinstallation

1. Position the CPU/Display board into the bottom case half.

2. Align the connectors at the front end of the CPU/Display board with the pins on the Main board. You may have to guide the foam gasket strip on the back side of the board past the edge of the bottom case half.

3. Plug the CPU/Display board to the Main board.

4. Using one of the hexagonal standoff posts and washers removed previously, secure the lower end of the COMM PORT connector to the bottom case half . Tighten the standoff post finger tight at this time.

Power Supply Board with CRT Reinstallation

CAUTION

The CRT is a high-vacuum component. Wear the proper eye protection when handling the CRT. Use care not to place excessive strain on the neck or neck pins. Place the CRT in a protected location while it is out of the instrument.

1. If installing a new CRT, reassemble the support brackets to the CRT neck. If installing a new Power Supply board, reinstall the **INTEN** knob removed earlier to the **INTEN** potentiometer shaft at the rear of the board.

2. Reconnect the CRT harness from the Power Supply board to the CRT pins.

3. Position the CRT with Power Supply board assembly into the bottom case half with the front of the CRT tilted up slightly.

4. Guide the **INTEN** (Intensity) control shaft into the hole at the rear of the bottom case half, and align the two connectors near the front of the Power Supply board with the pins on the Main board.

5. Press down on the Power Supply board to mate the connectors.

6. Align the CRT neck support bracket with the alignment pin in the bottom case. Then align the top of the support bracket with the slots on the Power Supply and CPU/Display boards and the square holes on the Acquisition Board assembly and lower the CRT into place.

Probe Receptacle Reinstallation

NOTE

To distinguish between the CH 1 and CH 2 probes, CH 1 coax cable has a mark at the metal end and CH 2 does not.

1. Connect the lower coaxial cable (the unmarked end) to the lower jack on the Acquisition board assembly; connect the upper coaxial cable (the marked end) to the upper jack.
2. Position the toroid in the space over the trigger input shield on the Main board.
3. Slide the probe receptacle into position in the grooves in the lower case half.

Potentiometer Board Reinstallation

1. Align the Potentiometer board with the slot and mounting screw hole in the metal Potentiometer board bracket.
2. Using a T-15 Torx screwdriver tip, reinstall the mounting screw to hold the Potentiometer board to the bracket.
3. Position the Potentiometer board assembly into the bottom case half, aligning the bottom of the bracket and the board with the slots in the bottom case half.

Case Reassembly

1. Ensure that the circuit boards are all positioned correctly for reassembly of the instrument case.
2. Position the top case half on the bottom case half, carefully aligning the two halves while making sure the following items are all in place.
   a. The probe receptacle is in its grooves.
   b. The Keypad board guide posts fit in the holes of the Potentiometer board bracket.
   c. The handle strap is properly captured between the top and bottom clips in the case halves.
3. Hold the two halves of the case together and turn it over.
4. Reinstall the three long screws – two at the rear and one under the flip stand. Recommended torque is 4 in/lbs
5. Ensure that the CRT filter assembly is seated in the front case piece, then position the case piece into place for reinstallation.
6. Reconnect the three cables to the Front Panel board. Position the cables into the Potentiometer board bracket space as much as possible.
7. Guide the potentiometer shafts through the Front Panel board then angle the top of the front case piece toward the top case half. The five slots on the top of the front case piece must catch on the five tabs on the top case half.
8. With the top of the front case piece caught, press the bottom over the front edge of the bottom case half.
9. Install the two, short screws that hold the front case piece to the bottom case half. Recommended torque is 4 in/lbs.

CAUTION

Excessive tightening of the hexagonal stand-off posts that secure COMM PORT connector may damage the instrument case.

10. Reinstall the washer and hexagonal standoff post through the COMM PORT connector and into the top case half on the rear panel. Tighten both standoffs. Recommended torque is 0.25 in/lbs.
11. Reinstall the battery; push the on button to make sure the oscilloscope operates.
12. Plug in one of the probes to check that the channel matches the indicators.
13. Turn off the power and reinstall the front-panel knob assemblies as follows.

CAUTION

Do not overtighten the setscrews in the knob inserts. Excessive pressure can burr the potentiometer shafts and make the knobs difficult to remove. The recommended torque is 2 in/lbs.

a. Place the three large knob inserts on their potentiometer shafts with the smallest diameter surface towards the front panel. Align the outer surface of the inserts flush with the end of the larger shafts. Use a 0.050 inch hexagonal wrench to tighten the setscrew in each of the inserts.

b. Place the three small knob inserts on their potentiometer shafts with the smallest diameter surface towards the front panel. Align the outer surface of the inserts flush with the ends of the smaller shafts. Use a 0.050 inch hexagonal wrench to tighten the setscrew in each of the inserts.

c. Install the three large rubber knob shells onto the large inserts.

d. Install the three small rubber knob shells onto the small inserts (the knob shell labeled **AUTO LVL:PUSH** is installed on the knob insert nearest the CRT).

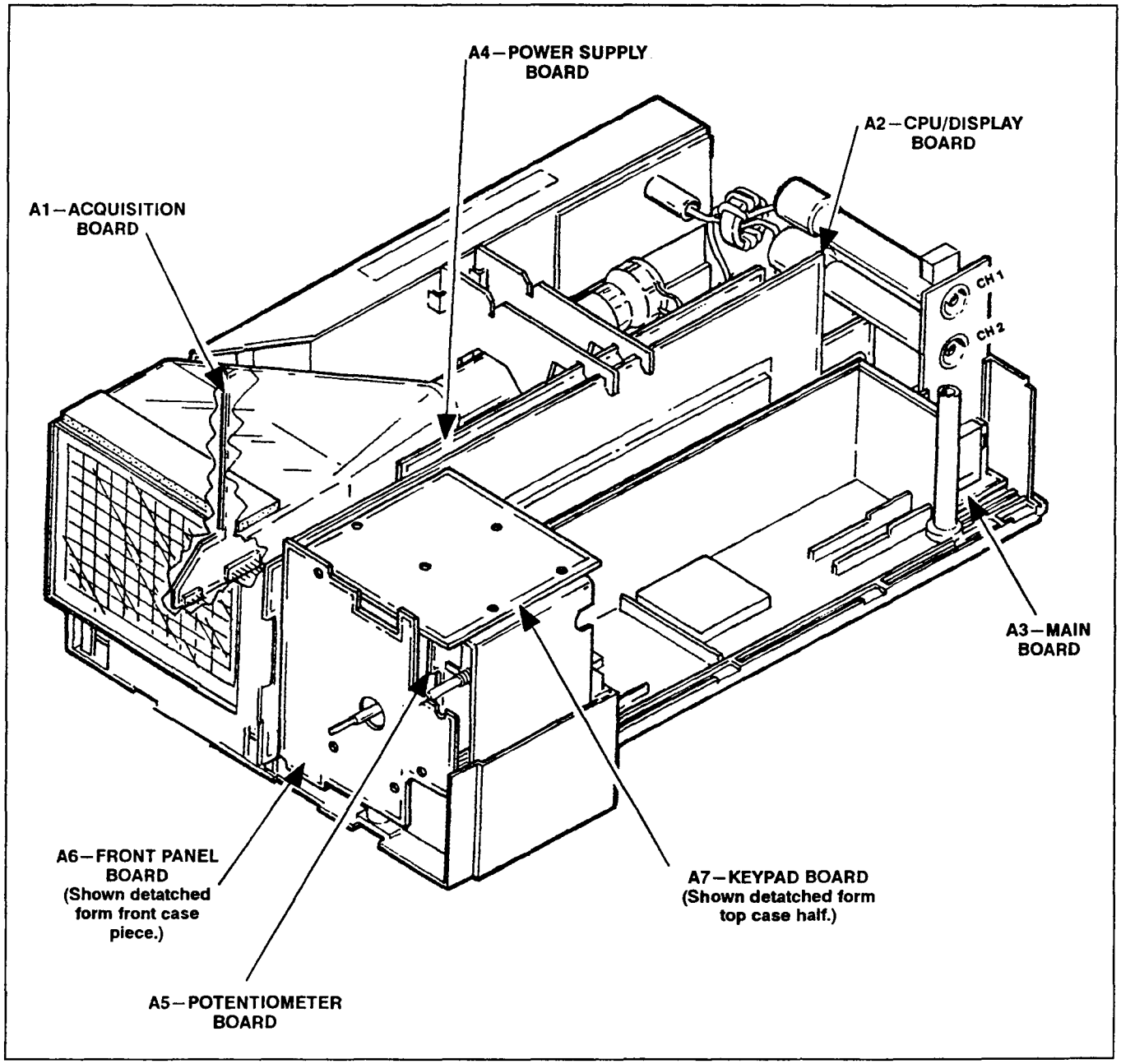


Figure 1-1. Circuit board locations.

OPTIONS

INTRODUCTION

This section contains a list of instrument options. Tektronix part numbers are provided. More information about instrument options and accessories can be obtained from the current Tektronix Product Catalog or your local Tektronix Field Office or representative. In the United States, instruments and accessories may also be ordered by calling the Tektronix National Marketing Center toll-free number, 1-800-427-2200.

The following Battery-Charger Adapter Options are available:

	Description	Part Number
Option 02	Instrument supplied without the battery-charger adapter	
Option A1	European 220V	120-1826-00
Option A2	UK 240V	120-1827-00

REPLACEABLE ELECTRICAL PARTS

PARTS ORDERING INFORMATION

Replacement parts are available from or through your local Tektronix, Inc. Field Office or representative.

When ordering parts, include the following information in your order: part number, instrument type or number, serial number, and modification number if applicable.

If a part you have ordered has been replaced with a new or improved part, your local Tektronix, Inc. Field Office or representative will contact you concerning any change in part number.

Change information, if any, is located at the rear of this manual.

LIST OF ASSEMBLIES

A list of assemblies can be found at the beginning of the electrical parts list. The assemblies are listed in numerical order. When the complete component number of a part is known, this list will identify the assembly in which the part is located.

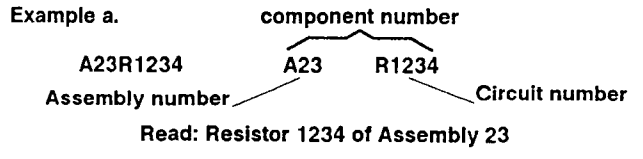
CROSS INDEX–MFR. CODE NUMBER TO MANUFACTURER

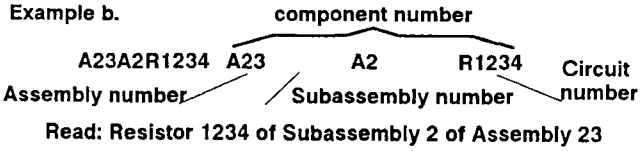
The Mfg. Code Number to Manufacturer Cross Index for the electrical parts list is located immediately after this page. The cross index provides codes, names, and addresses of manufacturers of components listed in the electrical parts list.

ABBREVIATIONS

Abbreviations conform to American National Standard Y1.1.

COMPONENT NUMBER (column one of the parts list)





The circuit component's number appears on the diagrams and circuit board illustrations. Each diagram and circuit board illustration is clearly marked with the assembly number. Assembly numbers are also marked on the mechanical exploded views located in the mechanical parts list. The component number is obtained by adding the assembly number prefix to the circuit number.

The electrical parts list is divided and arranged by assemblies in numerical sequence (e.g., assembly A1 with its subassemblies and parts, precedes assembly A2 with its subassemblies and parts).

Chassis-mounted parts have no assembly number prefix and are located at the end of the electrical parts list.

TEKTRONIX PART NO. (column two of the parts list)

Indicates part number to be used when ordering replacement part from Tektronix.

SERIAL NO. (columns three and four of the parts list)

Column three (3) indicates the serial number at which the part was first used. Column four (4) indicates the serial number at which the part was removed. No serial number entered indicates part is good for all serial numbers.

NAME & DESCRIPTION (column five of the parts list)

In the parts list, an item name is separated from the description by a colon (:). Because of space limitations, an item name may sometimes appear as incomplete. For further item name identification, the U.S. Federal Catalog handbook H6-1 can be utilized where possible.

MFR. CODE (column six of the parts list)

Indicates the code number of the actual manufacturer of the part. (Code to name and address cross reference can be found immediately after this page.)

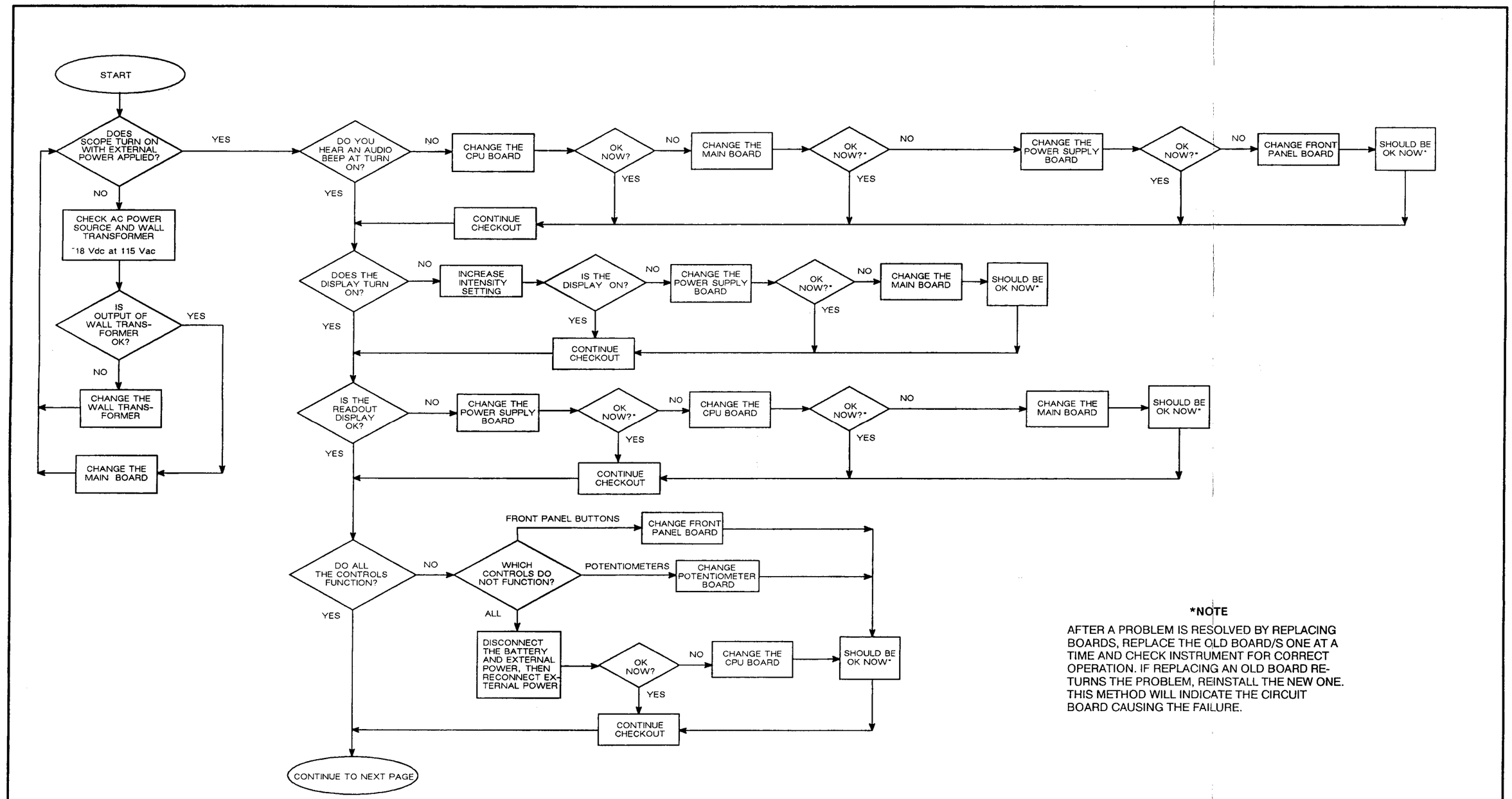
MFR. PART NO. (column seven of the parts list)

Indicates actual manufacturer's part number.

CROSS INDEX – MFR. CODE NUMBER TO MANUFACTURER

Mfr. Code	Manufacturer	Address	City, State, Zip Code
80009	TEKTRONIX INC	14150 SW KARL BRAUN DR PO BOX 500	BEAVERTON OR 97077–0001

Component Number	Tektronix Part No.	Serial No. Effective	Serial No. Dscont	Name & Description	Mfr. Code	Mfr. Part No.
A1	671–1987–00			CIRCUIT BD ASSY:ACQUISITION;	80009	671198700
A2	671–1988–00			CIRCUIT BD ASSY:CPU/DISPLAY;	80009	671198800
A3	671–1989–00			CIRCUIT BD ASSY:MAIN;	80009	671198900
A4	671–1990–00			CIRCUIT BD ASSY:POWER SUPPLY;	80009	671199000
A5	671–1991–00			CIRCUIT BD ASSY:POTENTIOMETER;	80009	671199100
A6	671–0063–01			CIRCUIT BD ASSY:FRONT PANEL;	80009	671006301
A7	671–0269–01			CIRCUIT BD ASSY:KEYPAD;	80009	671026901

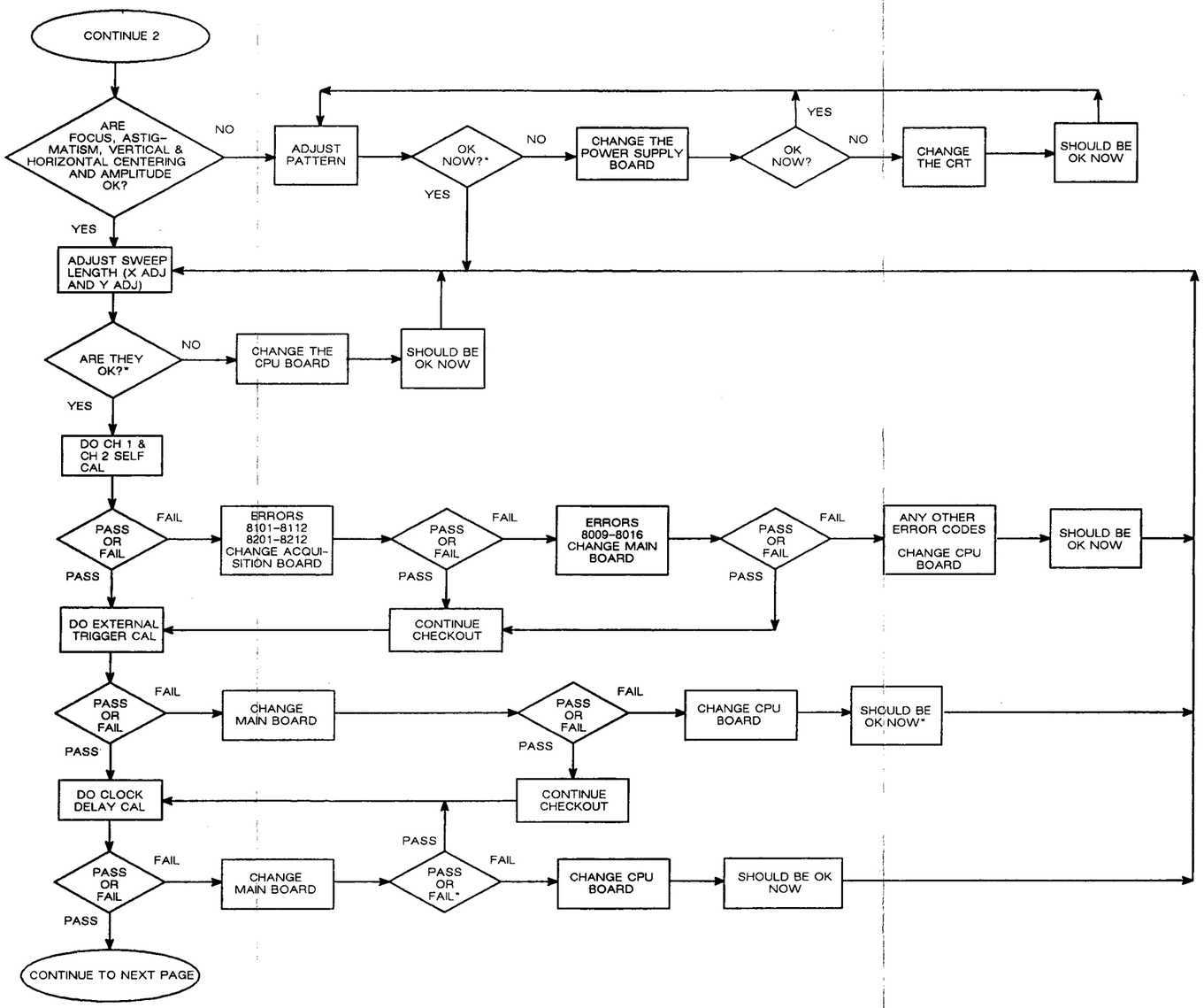


***NOTE**

AFTER A PROBLEM IS RESOLVED BY REPLACING BOARDS, REPLACE THE OLD BOARD/S ONE AT A TIME AND CHECK INSTRUMENT FOR CORRECT OPERATION. IF REPLACING AN OLD BOARD RE-TURNS THE PROBLEM, REINSTALL THE NEW ONE. THIS METHOD WILL INDICATE THE CIRCUIT BOARD CAUSING THE FAILURE.

(7459-17)8098-01

Figure 9-1. Troubleshooting chart.

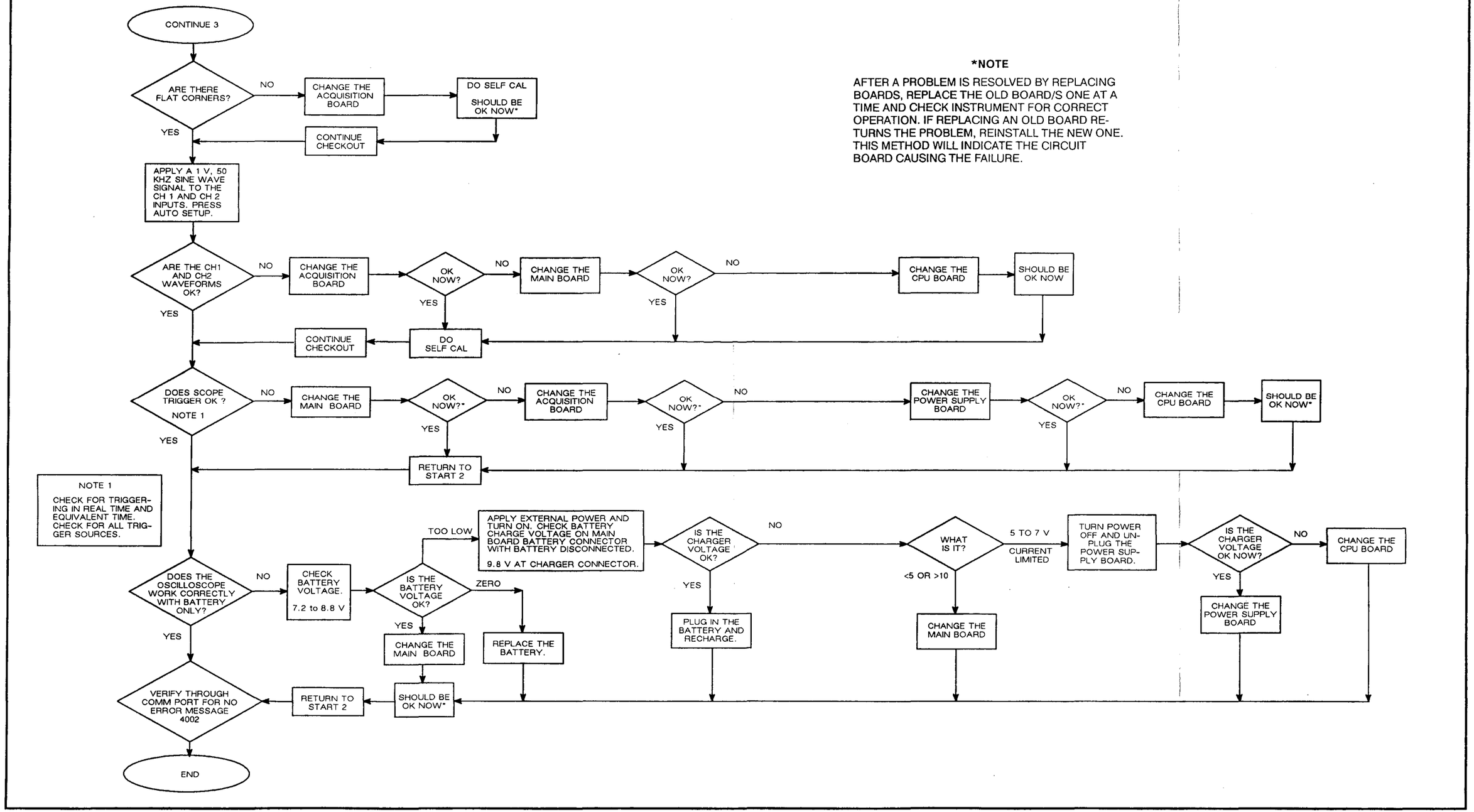


***NOTE**

AFTER A PROBLEM IS RESOLVED BY REPLACING BOARDS, REPLACE THE OLD BOARD/S ONE AT A TIME AND CHECK INSTRUMENT FOR CORRECT OPERATION. IF REPLACING AN OLD BOARD RE-TURNS THE PROBLEM, REINSTALL THE NEW ONE. THIS METHOD WILL INDICATE THE CIRCUIT BOARD CAUSING THE FAILURE.

(7459-18)8098-02

Figure 9-2. Troubleshooting chart (cont.)

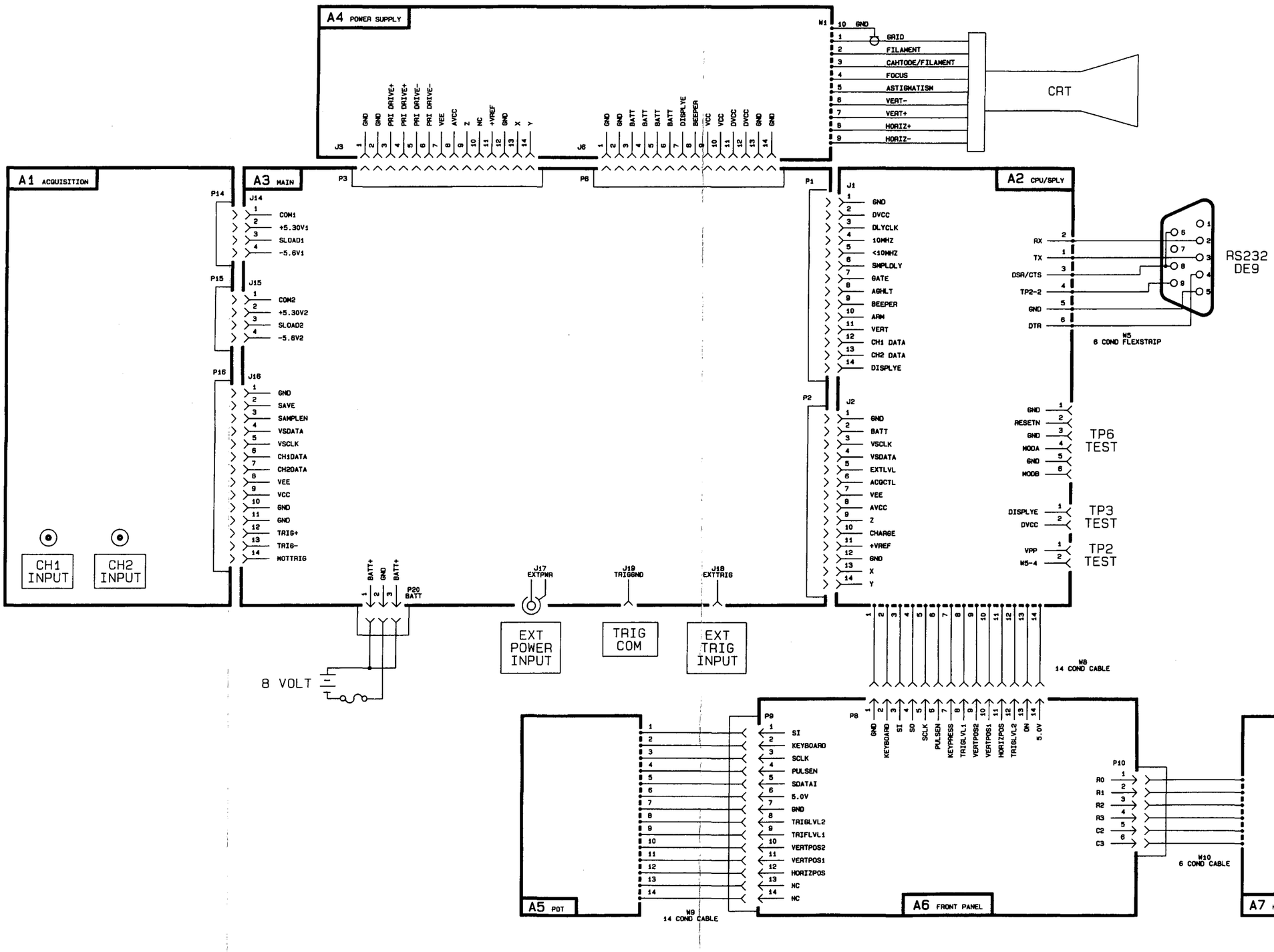


***NOTE**

AFTER A PROBLEM IS RESOLVED BY REPLACING BOARDS, REPLACE THE OLD BOARD/S ONE AT A TIME AND CHECK INSTRUMENT FOR CORRECT OPERATION. IF REPLACING AN OLD BOARD RETURNS THE PROBLEM, REINSTALL THE NEW ONE. THIS METHOD WILL INDICATE THE CIRCUIT BOARD CAUSING THE FAILURE.

(7459-19)8098-03

Figure 9-3. Troubleshooting chart (cont.)



8098-04

Figure 9-4. Interconnect diagram.

REPLACEABLE MECHANICAL PARTS

Replacement parts are available from or through your local Tektronix, Inc. Field Office or representative.

When ordering parts, include the following information in your order: part number, instrument type or number, serial number, and modification number if applicable.

If a part you have ordered has been replaced with a new or improved part, your local Tektronix, Inc. Field Office or representative will contact you concerning any change in part number.

Change information, if any, is located at the rear of this manual.

ITEM NAME

In the parts list, an item name is separated from the description by a colon(:). Because of space limitations, an item name may sometimes appear as incomplete. For further Item name identification, the U.S. Federal Cataloging Handbook H6-1 can be utilized where possible.

FIGURE AND INDEX NUMBERS

Items in this section are referenced by figure and index numbers to the illustrations.

INDENTATION SYSTEM

This mechanical parts list is indented to indicate item relationships. Following is an example of the indentations system used in the description column.

1 2 3 4 5 Name & Description

Assembly and/or component
Attaching parts for assembly and/or component

END ATTACHING PARTS

Detail part of assembly and/or component
Attaching parts for detail part

END ATTACHING PARTS

Parts of detail part
Attaching parts for parts or detail part

END ATTACHING PARTS

Attaching parts always appear in the same indentation as the item it mounts, while the detail parts are indented to the right. Indented items are part of, and included with, the next higher indentation.

Attaching parts must be purchased separately, unless otherwise specified.

ABBREVIATIONS

Abbreviations conform to American National Standard Y1.1.

CROSS INDEX – MFR. CODE NUMBER TO MANUFACTURER

Mfr. Code	Manufacturer	Address	City, State, Zip Code
TK0IK	MODERN METALS	UNIT A/K, 5/F GOLD KING IND. BLDG NO. 35–41 TAI LIN ROAD	KWAI–CHUNG N.T. HONG KONG
TK0435	LEWIS SCREW CO	4300 S RACINE AVE	CHICAGO IL 60609–3320
TK1035	HERMAN H SMITH INC	812 SNEDIKER AVE	BROOKLYN NY 11207
TK1163	POLYCAST INC	9898 SW TIGARD ST	TIGARD OR 97223
TK1908	PLASTIC MOLDED PRODUCTS	4336 SO ADAMS	TACOMA WA 98409
TK1967	SYNDETEK	3915 E MAIN	SPOKANE WA 99202
TK2415	FRIWO FRIEMANN & WOLF	GERATEAU GMBH POSTFOCH 1209 B–4412	OSTBEVENGERMANY
TK2465	PRECISION INTERCONNECTIONS INC	470 WINDSOR PARK DR	CENTERVILLE OH 45459
0DWW6	MICRO POWER ELECTRONICS	7973 SW CIRRUS DRIVE BLDG. #22	BEAVERTON OR 97005
0JRZ2	BADGLEY MFG CO	1620 NE ARGYLE	PORTLAND OR 97211
0J260	COMTEK MANUFACTURING OF OREGON (METALS)	PO BOX 4200	BEAVERTON OR 97076–4200
0KBZ5	MORELLIS Q & D PLASTICS	1812 16TH AVE	FOREST GROVE OR 97116
0KB01	STAUFFER SUPPLY	810 SE SHERMAN	PORTLAND OR 97214
14310	AULT INC	1600–H FREEWAY BLVD	MINNEAPOLIS MN 55430–1706
2K262	BOYD CORP	6136 NE 87th AVE PO BOX 20038	PORTLAND OR 97220
77824	SCHLEGEL CORP	1555 JEFFERSON RD PO BOX 23197	ROCHESTER NY 14692–3113
80009	TEKTRONIX INC	14150 SW KARL BRAUN DR PO BOX 500	BEAVERTON OR 97077–0001
95760	PROTECTIVE CLOSURES CO INC	2150 ELMWOOD AVE	BUFFALO NY 14207–1910
86928	SEASTROM MFG CO,INC.	701 SONORA AVE.	GLENDALE, CA 91201

Fig. & Index No.	Tektronix Part No.	Serial No. Effective	Dscont	Qty	12345 Name & Description	Mfr. Code	Mfr. Part No.
1 -1	390-1047-10			1	CABINET ASSY:FRONT,222PS,YELLOW,390-1047-11 W/ELECTRODAG,550 PAINT AND LABELS	80009	390104710
-2	366-2139-00			1	KNOB,SHELL:IVORY GRAY SANTOPRENE 221-73,W/B LACK AUTO LVL PUSH,0.26 ID X 0.42 OD 0.3 H	TK1163	ORDER BY DESCRI
-3	377-0613-00			3	INSERT,KNOB:0.080 ID X 0.310 OD X 0.255 H, W/4-40 SETSCREW,AL	0J260	ORDER BY DESCRI
-4	366-2137-00			3	KNOB,SHELL:IVORY GRAY SANTOPRENE 221-73,0.5 ID X 0.62 OD X 0.3 H,FLUTED SURFACE	TK1163	ORDER BY DESCRI
-5	377-0612-00			3	INSERT,KNOB:0.128 ID X 0.518 OD X 0.270 H, W/4-40 SETSCREW,AL	0J260	ORDER BY DESCRI
-6	366-2138-00			2	KNOB,SHELL:IVORY GRAY,SANTOPRENE 221-73,W/B LACK POS,FLUTED 0.42 OD X 0.26 ID X 0.3 H	TK1163	ORDER BY DESCRI
-7	378-0382-00			1	FILTER ASSY:CRT,GREEN W/FOAM STRIPS	80009	378038200
-8	260-2423-00			1	SWITCH,PUSH:12 BUTTON,2 POLE	TK0IK	ORDER BY DESCRI
-9	437-0428-00			1	CABINET,TOP:222 SERIES,YELLOW,390-1045-10 W/PAD FOR BATTERY ATTACHING PARTS	80009	437042800
-10	211-0744-00			3	SCREW,MACHINE:6-32 X 2.0,PNH,TORX,STL,CD END ATTACHING PARTS	TK0435	ORDER BY DESCRI
-11	200-3932-00			1	DOOR,ACCESS:BATTERY,W/POUCH & LABEL,YELLOW	80009	200393200
-12	346-0251-00			1	STRAP,HANDLE:HAND/CARRY GRIP ASSY	0JRZ2	ORDER BY DESCRI
-13	260-2422-00			1	SWITCH,PUSH:8 BUTTON,2 POLE	TK0IK	ORDER BY DESCRI
-14	146-0075-00			1	BATTERY PACK AS:RECHARGABLE,2 X 4V	0DWW6	ORDER BY DESCRI
-15	342-0889-01			1	INSUL,CKT BD:POLYESTER,0.010 THK,222PS	2K262	ORDER BY DESCRI
-16	437-0429-00			1	CABINET,BOTTOM:222 SERIES,YELLOW,390-1046-10 W/PAD FOR BATTERY ATTACHING PARTS	80009	437042900
-17	211-0721-00			2	SCREW,MACHINE:6-32 X 0.375,PNH,STL END ATTACHING PARTS	0KB01	ORDER BY DESCRI
-18	348-1059-10			1	STAND,TILT:MOBAY MAKROLON 6455,SUNRISE YELLOW	TK1163	PER TEK DOCUMEN

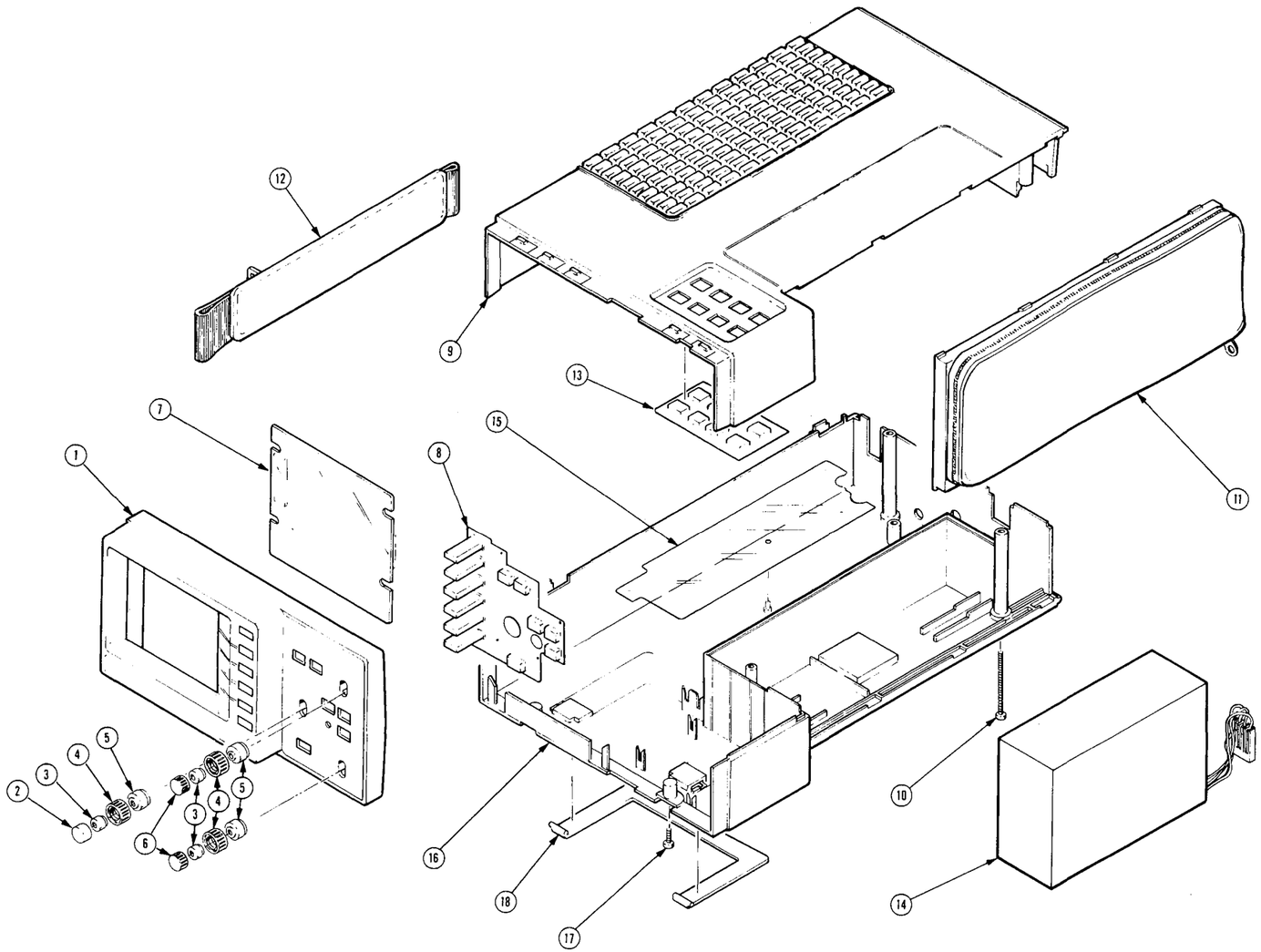


Figure 10-1. Cabinet.

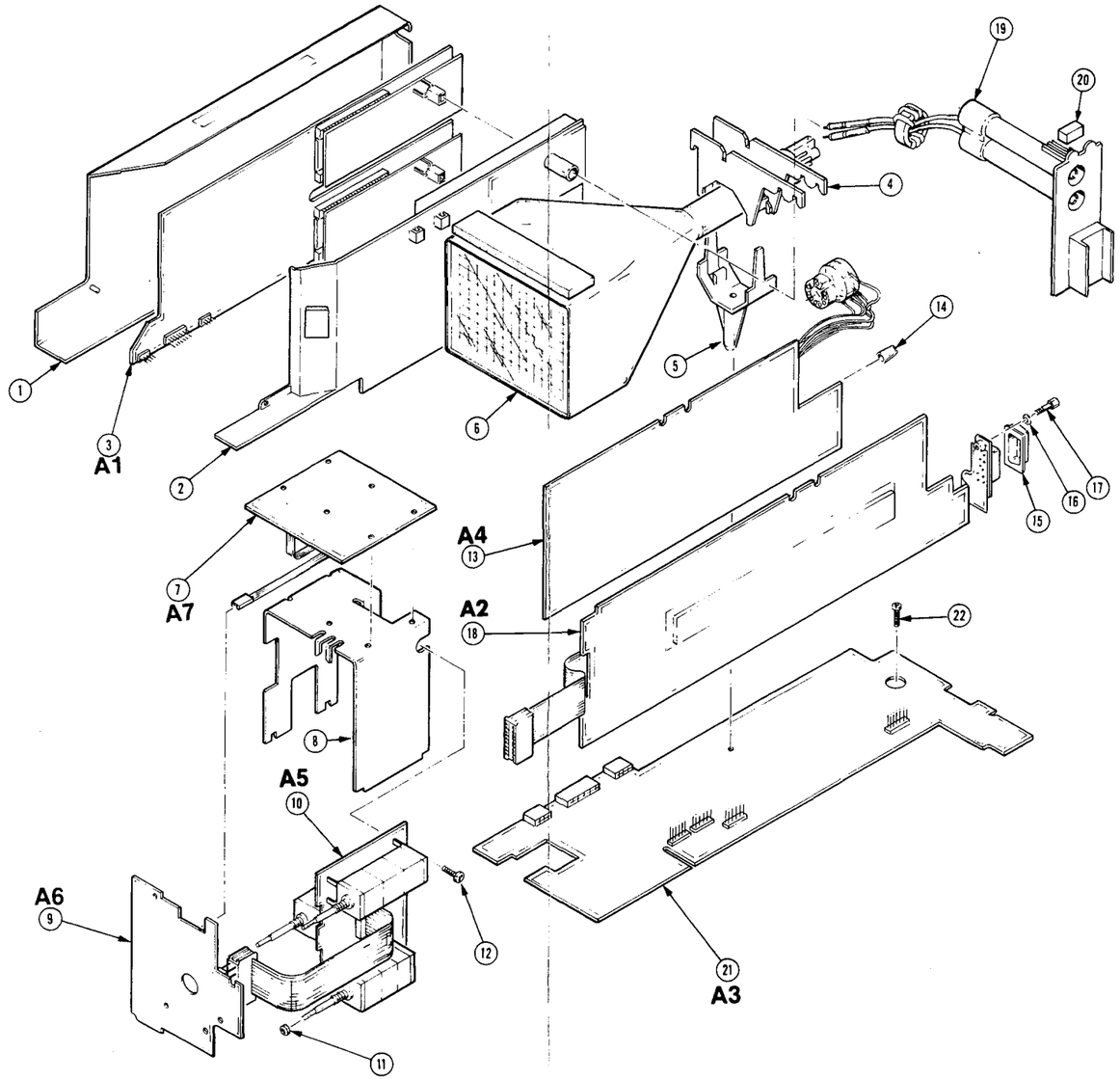


Figure 10-2. Circuit Boards.

Fig. & Index No.	Tektronix Part No.	Serial No. Effective	Serial No. Dscont	Qty	12345 Name & Description	Mfr. Code	Mfr. Part No.
2 –1	380–1004–00			1	HOUSING ASSY:380–0970–00 W/EMI GASKET STRIP AND WARNING LABEL	80009	380100400
–2	200–3931–00			1	COVER ASSEMBLY:200–3845–00 W/EMI GASKET PAD	80009	200393100
–3	--------				CICUIT BD ASSY:ACQUISITION (SEE A1)		
–4	386–5781–00			1	SUPPORT,TOP:POLYCARBONATE	TK1908	ORDER BY DESCRI
–5	386–5782–01			1	SUPPORT,BOTTOM:CRT SHIELD,LEXAN	TK1163	ORDER BY DESCRI
–6	119–3547–00			1	CRT ASSEMBLY:222 CRT W/SHIELD & EMI GASKET	80009	119354700
–7					CIRCUIT BD ASSY:KEYPAD (SEE A7)		
–8	407–3734–00			1	BRACKET,KEYPAD:ALUMINUM	0J260	ORDER BY DESCRI
–9	--------				CIRCUIT BD ASSY:FRONT PANEL (SEE A6)		
–10	--------				CIRCUIT BD ASSY:POTENTIOMETER (SEE A5) ATTACHING PARTS		
–11	354–0716–00			3	RING,ELASTOMER:0.110 ID X 0.280 OD X 0.125 THK,SILICON/GRAPHITE BLEND	80009	354071600
–12	211–0721–00			1	SCREW,MACHINE:6–32 X 0.375,PNH,STL END ATTACHING PARTS	0KB01	ORDER BY DESCRI
–13	--------				CIRCUIT BD ASSY:PWR SPLY (SEE A4)		
–14	366–2110–10			1	KNOB,EXTENSION:INTENSITY,BLACK,MONSANTO SANTOPRENE	0KBZ5	ORDER BY DESCRI
–15	200–3750–00			1	CAP,PROTECTIVE:POLYETHYLENE,BLACK,CONDUCTIVE, D SUB,9 PIN	95760	ORDER BY DESCRI
–16	129–1390–01			2	SPACER,POST:0.250 L,4–40 THD,NI PL STEEL,0.188X0.2 L	80009	129139001
–17	210–1494–00			2	WASHER,FLAT:0.122 ID X 0.228 OD X 0.016 THK ,STAINLESS STEEL	80009	210149400
–18	--------				CIRCUIT BD ASSY:CPU/DSPLY (SEE A2)		
–19	131–4656–00			1	CONN,RCPT,ELEC:PROBE TO INSTR ASSY,X2	80009	131465600
–20	348–1102–00			1	SHLD GSKT,ELEK:EMI,0.250 X 0.5 X 0.375 L	77824	5725–191V–3C
–21	--------				CIRCUIT BD ASSY:MAIN (SEE A3) ATTACHING PARTS		
–22	211–0721–00			1	SCREW,MACHINE:6–32 X 0.375,PNH,STL END ATTACHING PARTS	0KB01	ORDER BY DESCRI

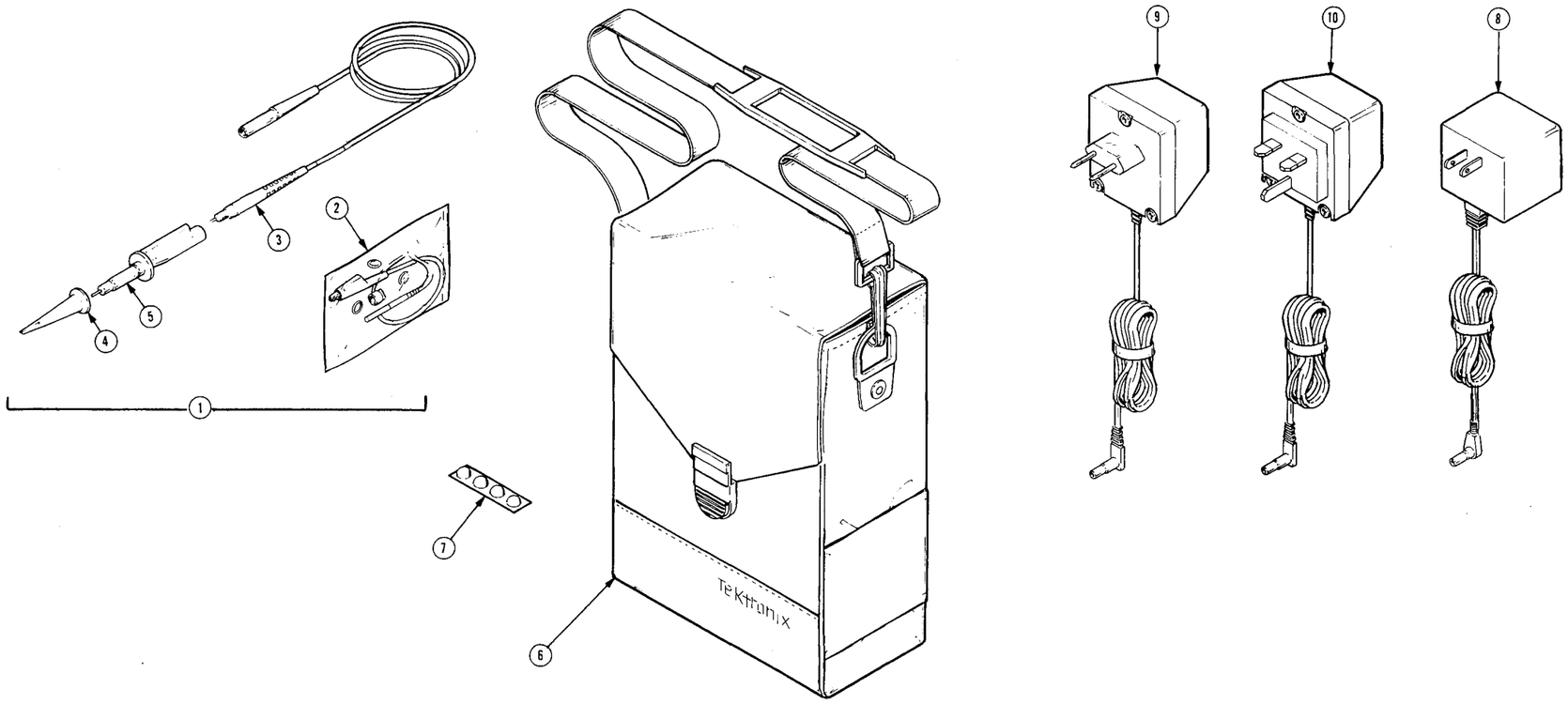


Figure 10-3. Accessories

Fig. & Index No.	Tektronix Part No.	Serial No. Effective	Dscont	Qty	12345 Name & Description	Mfr. Code	Mfr. Part No.
3 –							
					STANDARD ACCESSORIES		
	070–8097–00			1	MANUAL,TECH:OPERATORS,222PS,HAND HELD DSO	80009	070809700
	070–8099–00			1	MANUAL,TECH:INTERFACE GUIDE,222 SERIES,RS232 CARD,INFO:USERS QUICK REFERENCE,222PS,HAND	80009	070809900
	070–8100–00			1	HELD DSO	80009	070810000
–1	P850			2	PROBE PASSIVE: 10K 850V PEAK MAX	80009	P850
					EACH P850 PROBE CONTAINS:		
–2				1	.ACCESSORY,PKG:P400 & P850		
	015–0201–06			1	.TIP,PROBE:IC TEST	80009	015020106
	~~196–3332–00~~ 196-3337-00			1	.LEAD,ELECTRICAL:26 AWG,1.5 L	TK1967	ORDER BY DESCRI
	334–2794–00			1	.BAND,MARKER:0.371 DIA,BLACK,PLASTIC	80009	334279400
	334–2994–00			1	.SLEEVE,MKR,CA:MKD INTERCONNECTING CABLE	80009	334299400
–3	175–3766–04			1	.CABLE ASSY,RF:70 OHM,71.5 L,SLATE GRAY	80009	175376604
–4	013–0107–06			1	.TIP,PROBE:MINIATURE/COMPACT SIZE,RETRACTABLE HOOK ASSY	80009	013010706
–5	206–0427–00			1	.PROBE,HEAD:P850,X30	80009	206042700
–6	016–1024–00			1	CASE,CARRYING:BLACK CLOTH	0JRZ2	ORDER BY DESCRI
–7	020–1752–00			1	ACCESSORY KIT:FOUR RUBBER FEET IN BAG W/ INSTRUCTION	2K262	ORDER BY DESCRI
–8	120–1807–00			1	TRANSFORMER,PWR:POWER SUPPLY,WALL MOUNT, PLUG IN, IN 120VAC,OUT 18 VAC,TOTAL 16 VAC	14310	3281059001
					OPTIONAL ACCESSORIES		
	070–8098–00			1	MANUAL,TECH:SERVICE,222PS,HAND HELD DSO	80009	070809800
	146–0075–00			1	BATTERY PACK AS:RECHARGABLE,2 X 4V	0DWW6	ORDER BY DESCRI
	016–0993–00			1	POUCH,ACCESSORY:222 DSO,3.25 W X 5.75 H X	0JRZ2	ORDER BY DESCRI
	174–1453–00			1	CA ASSY,SP,ELEC:RS232 SERIAL,36 0 L,DB9	TK2465	CBI 5840
	103–0090–00			1	ADAPTER,CONN:BNC FEM	TK1035	1686
	BAT200			1	EXT.BATTERY CHARGER W/OTHER ACC.	80009	BAT200
	P6122			1	PROBE: W/ACCESSORIES	80009	P6122
	013–0084–03			1	ADAPTER,CONN:PROBE TO BNC	80009	013008403
	CAT200			1	VIRTUAL SOFTWARE PACKAGE	80009	CAT200
	P400			1	PROBE PASSAVE 1X 850V PEAK MAX	80009	P400
					EACH P400 PROBE CONTAINS:		
	020–1908–00			1	.ACCESSORY,PKG:P400 & P850	80009	020190800
	175–3766–04			1	.CABLE ASSY,RF:70 OHM,71.5 L,SLATE GRAY	80009	175376604
	013–0107–06			1	.TIP,PROBE:MINIATURE/COMPACT SIZE,RETRACTABLE HOOK ASSY	80009	013010706
	206–0426–00			1	.PROBE HEAD:P400,X3	80009	206042600
					OPTIONS		
–9	120–1826–00			1	TRANSFORMER:220VAC/50HZ INPUT (OPTION A–1)	TK2415	ORDER BY DESCRI
–10	120–1827–00			1	TRANSFORMER:240VAC/50HZ INPUT (OPTION A–2)	TK2415	ORDER BY DESCRI

Tektronix®
COMMITTED TO EXCELLENCE

MANUAL CHANGE INFORMATION

Date: 8-13-92 Change Reference: C1/0892

Product: 222PS SERVICE Manual Part Number: 070-8098-00

DESCRIPTION Product Group 40

EFFECTIVE ALL SERIAL NUMBERS

Replaceable Mechanical Parts List Changes

CHANGE TO:

FIG. #	Tektronix Part No.	Effective Serial Number	Description
3-2 (2)	196-3337-00	ALL	LEAD, ELECTRICAL: 26 AWG, 1.5 L