TEK SERVICE MANUAL

070-7459-00
Product Group 41

# 222 Digital Storage Oscilloscope Service

***WARNING***

**THE FOLLOWING SERVICING INSTRUCTIONS ARE FOR USE BY QUALIFIED PERSONNEL ONLY. TO AVOID PERSONAL INJURY, DO NOT PERFORM ANY SERVICING OTHER THAN THAT CONTAINED IN OPERATING INSTRUCTIONS UNLESS YOU ARE QUALIFIED TO DO SO. REFER TO OPERATORS SAFETY SUMMARY AND SERVICE SAFETY SUMMARY PRIOR TO PERFORMING ANY SERVICE.**

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# PERFORMANCE CHARACTERISTICS

## INTRODUCTION

Performance characteristics given in the Electrical Specifications apply when the instrument has been self calibrated within ±5°C of the ambient temperature, has warmed up at least 20 minutes, and is operating in an ambient temperature between −10°C and +55°C (unless otherwise noted).

Environmental and Mechanical Specifications are listed after the Electrical Specifications.

## 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 repairs are made, affected circuits may need to be readjusted.

## ELECTRICAL SPECIFICATIONS

### VERTICAL DEFLECTION SYSTEM

#### Deflection Factor

5 mV per division to 50 V per division in a 1–2–5 sequence.[1]

#### Vertical Resolution

8-bits, 25 levels per division. 10.1 divisions of dynamic range.[1]

#### DC Accuracy

| | |
|---|---|
| +15°C to +35°C | ±3%.[2] |
| −15°C to +15°C | ±4%.[2] |
| +35°C to +55°C | ±4%.[2] |

[1]Performance Requirement not checked in manual.
[2]When the self calibration has been done within ±5°C of the ambient temperature.

#### VOLTS/DIV Variable Control

Increases the deflection factor by 2.5 to 1.

#### Aberrations

+6%, −6%, 6% p-p or less.[1]

Measured with a 5-division reference signal from a 50-Ω source driving a 50-Ω load at the probe tip. Vertically center the top of the reference signal.

#### Useful Rise Time

$$\frac{\text{SEC/DIV} \times 1.6}{10}$$ [1]

Rise time is limited to 35 ns by the vertical amplifier response.

#### Useful Bandwidth

SAMPLE $\frac{5}{\text{SEC/DIV}}$ Hz.[1]

Useful-storage bandwidth is limited to the frequency where there are 10 samples per sine-wave 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 6-division, 50-kHz sine wave.

REPETITIVE

| | |
|---|---|
| 0.5 µs/div to 50 µs/div | 10 MHz. |
| 1 µs/div | 5 MHz.[1] |
| 2 µs/div | 2.5 MHz.[1] |

Repetitive bandwidth is limited to 10 MHz by the analog system.

# OPERATING INFORMATION

## SAFETY

Refer to the Operator's Safety Summary at the front of this manual for safety information about the use of this instrument. Before connecting the instrument to a power source, read this section and the Safety Summary.

## BATTERY-CHARGER ADAPTER

Instruments are shipped with a detachable battery-charger 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 charge the oscilloscope's internal battery. Use the battery-charger adapter to operate the oscilloscope when an ac line voltage source is available to maintain battery charge for use when totally portable operation of the oscilloscope is needed. Use the appropriate battery charger adapter for the available power source voltage (115 Vac and 230 Vac). The adapter plugs into the instrument's external power receptacle as shown in Figure 2-1.

## EXTERNAL SUPPLY VOLTAGE

The 222 operates on an external supply voltage range 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 the charging battery from the supplied battery-charger adapter (wall transformer) is current limited, and the crt display may not be stable. If this effect is seen, either charge the battery for 1 hour before operating the oscilloscope or operate without the battery installed until it can be charged.

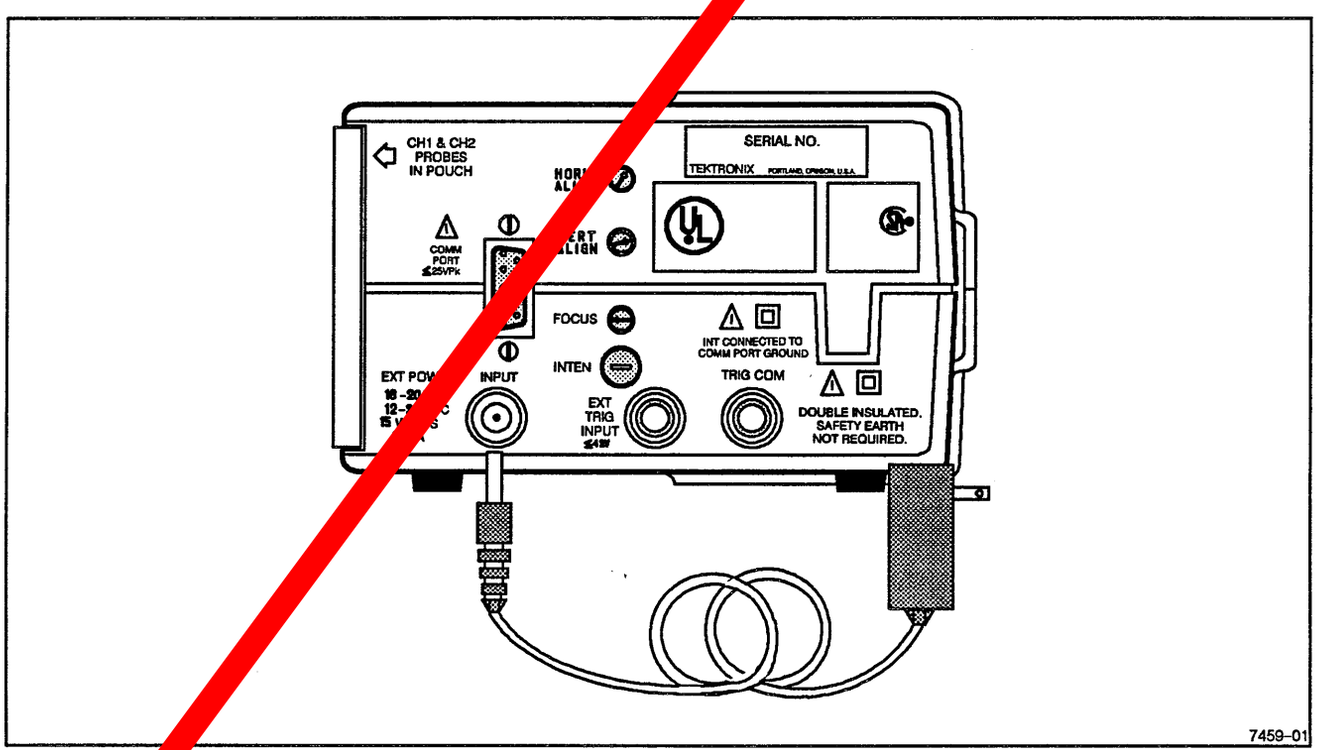


Figure 2-1. External Power Input.

# BLOCK DIAGRAM OVERVIEW

## INTRODUCTION

The 222 Digital Storage Oscilloscope 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-232C 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 222 may be changed or queried.

In the Display System the digital waveform data is 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 attenuator 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 SEC/DIV 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 SEC/DIV setting.

The Acquisition Memory is a FIFO (first in, first out) 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 SEC/DIV 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.

# PERFORMANCE CHECK PROCEDURE

## INTRODUCTION

This Performance Check Procedure verifies the Performance Requirements of the 222 DSO as listed in the Specifications (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 all the test equipment required to do the Performance Check Procedure, the Adjustment Procedure and the tools needed for disassembly and assembly. 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 setup. If the exact 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 verification document are valid under the following conditions:

The instrument must have been self calibrated within ±5°C of the ambient operating temperature.

The instrument must be checked at an ambient temperature between +5°C and +55°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 a 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 following steps. Let the instrument and test equipment warm up for 10 minutes to obtain a valid performance check to the accuracies stated in the Performance Characteristics (Section 1).

### Set-Up

a. Plug the wall transformer into the ac power source.

b. Plug the low voltage ac power cord from the wall transformer into the EXT POWER INPUT jack on the rear of the oscilloscope.

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

d. Turn on the test equipment and allow a 10-minute warm-up period to obtain a stable operating temperature.

# ADJUSTMENT PROCEDURE

## INTRODUCTION

The Adjustment Procedure is a set of sequenced instructions intended to return the instrument to conformance with the Performance Characterisitcs 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 both the Performance Check Procedure in Section 4 and 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 of Section 1. Tolerances given are applicable only to the instrument undergoing adjustment and do not include test equipment error. The instrument must have a warm-up period of at least 10 minutes before making adjustments.

The operating temperature range is between –10°C and +55°C. To meet the stated Performance Specifications, the instrument must be operating at an ambient temperature within ±5°C of the last "Self Cal." A complete "Self Cal" 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 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.

# MAINTENANCE

This section of the manual contains information on static-sensitive components, preventive maintenance, troubleshooting, and corrective maintenance. General information regarding the care and handling of semiconductor devices is provided in "Static-Sensitive Components," 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 hints, and soldering techniques.

## STATIC-SENSITIVE COMPONENTS

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 components.
2. Transport and store static-sensitive components or assemblies in their original containers or on a metal rail. Label any package that contains static-sensitive components or assemblies.
3. Discharge the static voltage from your body by wearing a grounded antistatic wrist strap while handling these components. Servicing static-sensitive components or 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. Keep the component leads shorted together whenever possible.
6. Pick up components by their bodies, never by their leads.
7. Do not slide the components over any surface.
8. Avoid handling components in areas that have a floor or work-surface covering capable of generating a static charge.
9. Use a soldering iron that is connected to earth ground.
10. 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**

# 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.

## OPTIONS

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.

## 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)


Assembly numbers are marked on the mechanical exploded views located in the mechanical 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.

# 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 whe possible.

## FIGURE AND INDEX NUMBERS

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

## INDENTATION SYSTEM

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

*1 2 3 4 5 Na & Description*

*Assembly and/or comp ent*
*Attaching parts for as mbly and/or component*

*EN ATTACHING PARTS*

*Detail part assembly and/or component*
*Attachin arts for detail part*

*END ATTACHING PARTS*

*arts 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.

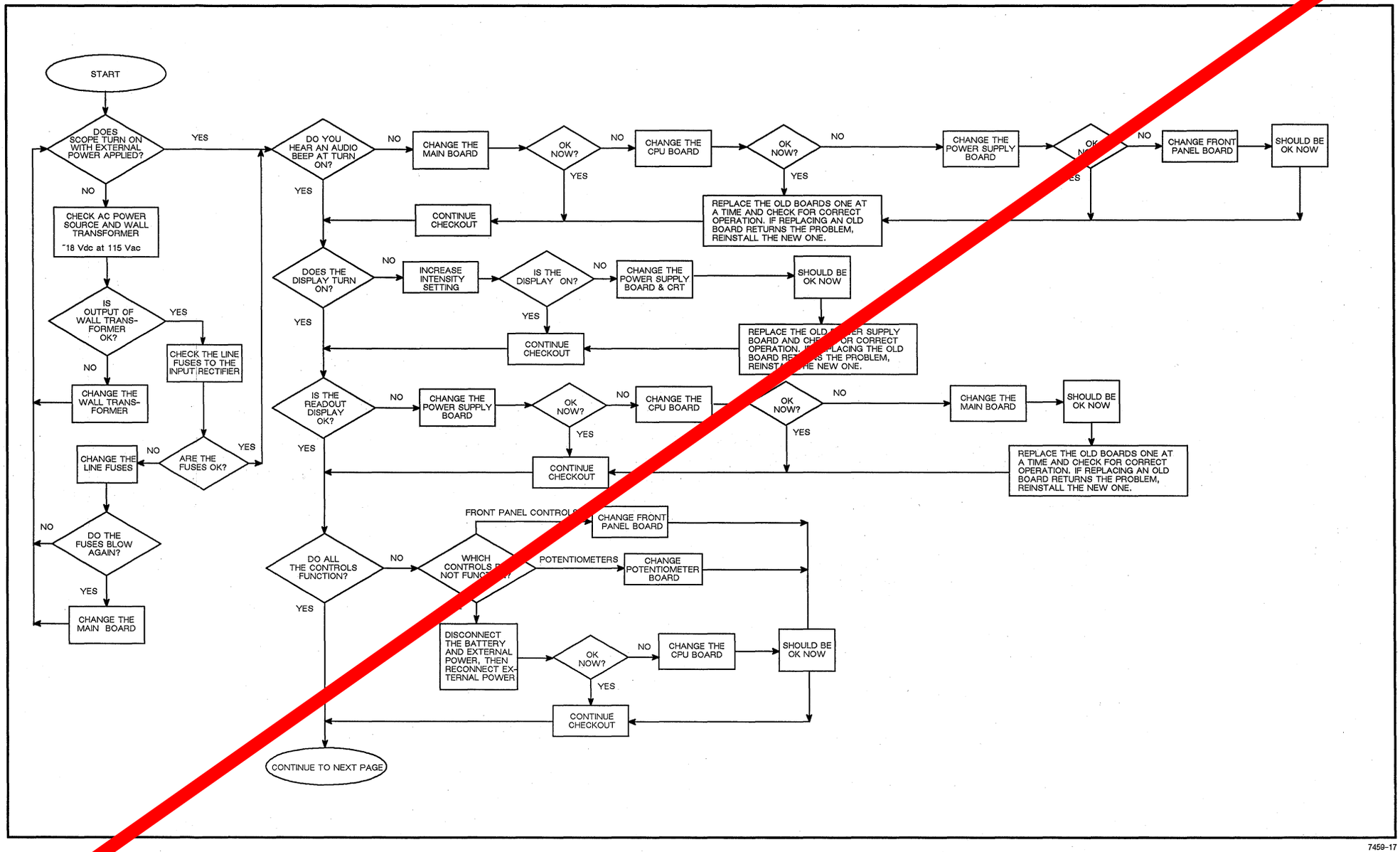


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**Figure 9-1. Troubleshooting chart.**