

Service Manual



**TDS 410, 420 & 460
Digitizing Oscilloscopes**

070-8036-03

Instrument Serial Numbers

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

B010000	Tektronix, Inc., Beaverton, Oregon, USA
E200000	Tektronix United Kingdom, Ltd., London
J300000	Sony/Tektronix, Japan
H700000	Tektronix Holland, NV, Heerenveen, The Netherlands

Instruments manufactured for Tektronix by external vendors outside the United States are assigned a two digit alpha code to identify the country of manufacture (e.g., JP for Japan, HK for Hong Kong, IL for Israel, etc.).

Tektronix, Inc., P.O. Box 500, Beaverton, OR 97077

Printed in U.S.A.

Copyright © Tektronix, Inc., 1993. All rights reserved. Tektronix products are covered by U.S. and foreign patents, issued and pending. The following are registered trademarks: TEKTRONIX, TEK, TEKPROBE, and SCOPE-MOBILE.

WARRANTY

Tektronix warrants that this product will be free from defects in materials and workmanship for a period of three (3) years from the date of shipment. If any such product proves defective during this warranty period, Tektronix, at its option, either will repair the defective product without charge for parts and labor, or will provide a replacement in exchange for the defective product.

In order to obtain service under this warranty, Customer must notify Tektronix of the defect before the expiration of the warranty period and make suitable arrangements for the performance of service. Customer shall be responsible for packaging and shipping the defective product to the service center designated by Tektronix, with shipping charges prepaid. Tektronix shall pay for the return of the product to Customer if the shipment is to a location within the country in which the Tektronix service center is located. Customer shall be responsible for paying all shipping charges, duties, taxes, and any other charges for products returned to any other locations.

This warranty shall not apply to any defect, failure or damage caused by improper use or improper or inadequate maintenance and care. Tektronix shall not be obligated to furnish service under this warranty a) to repair damage resulting from attempts by personnel other than Tektronix representatives to install, repair or service the product; b) to repair damage resulting from improper use or connection to incompatible equipment; or c) to service a product that has been modified or integrated with other products when the effect of such modification or integration increases the time or difficulty of servicing the product.

THIS WARRANTY IS GIVEN BY TEKTRONIX WITH RESPECT TO THIS PRODUCT IN LIEU OF ANY OTHER WARRANTIES, EXPRESSED OR IMPLIED. TEKTRONIX AND ITS VENDORS DISCLAIM ANY IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE. TEKTRONIX' RESPONSIBILITY TO REPAIR OR REPLACE DEFECTIVE PRODUCTS IS THE SOLE AND EXCLUSIVE REMEDY PROVIDED TO THE CUSTOMER FOR BREACH OF THIS WARRANTY. TEKTRONIX AND ITS VENDORS WILL NOT BE LIABLE FOR ANY INDIRECT, SPECIAL, INCIDENTAL, OR CONSEQUENTIAL DAMAGES IRRESPECTIVE OF WHETHER TEKTRONIX OR THE VENDOR HAS ADVANCE NOTICE OF THE POSSIBILITY OF SUCH DAMAGES.

Table of Contents

Safety Summary	xvii
Preface	xxi
Manual Structure	xxi
Manual Conventions	xxii
Modules	xxii
Safety	xxii
Symbols	xxii
Related Manuals	xxii
Introduction	xxiii
Before Servicing	xxiii
Strategy for Servicing	xxiii
Tektronix Service	xxiv
Warranty Repair Service	xxiv
Repair or Calibration Service	xxiv
Self Service	xxv

Specifications

Product Description	1-1
General	1-1
User Interface	1-1
Menus	1-2
Indicators	1-2
General Purpose Knob	1-2
GUI	1-2
Signal Acquisition System	1-2
Horizontal System	1-3
Trigger System	1-4
Acquisition Control	1-4
On-Board User Assistance	1-4
Help	1-4
Autoset	1-4
Measurement Assistance	1-5
Cursor	1-5
Measure	1-5
Digital Signal Processing (DSP)	1-5
Storage and I/O	1-5
Display	1-6

Zoom	1-6
Nominal Traits	1-7
Warranted Characteristics	1-12
Performance Conditions	1-12
Typical Characteristics	1-18

Operating Information

Installation	2-1
Supplying Operating Power	2-1
Power Cord Information	2-2
Operating Voltage	2-2
Memory Backup Power	2-2
Operating Environment	2-4
Operating Temperature	2-4
Ventilation Requirements	2-4
Applying and Interrupting Power	2-4
Power-Up	2-4
Power-Down	2-5
Repackaging Instructions	2-6
Installed Options	2-6
Operating Information	2-7
Screen Layout	2-7
Basic Procedures	2-7
How to Power Up	2-7
How to Use Help	2-8
How to Use the Status Menu	2-8
How to Set Functions	2-9
How to Set Complex Functions	2-12

Theory of Operation

Circuit Description	3-1
Logic Conventions	3-1
Module Overview	3-1

Performance Verification

Brief Procedures	4-1
General Instructions	4-1

Conventions	4-2
Self Tests	4-4
Verify Internal Adjustment, Self Compensation, and Diagnostics	4-4
Functional Tests	4-6
Verify All Input Channels	4-6
Verify the Time Base	4-8
Verify the Main and Delayed Trigger Systems	4-9
Performance Tests	4-13
Prerequisites	4-13
Equipment Required	4-13
Test Record	4-15
Signal Acquisition System Checks	4-18
Check Offset Accuracy	4-18
Check DC Voltage Measurement Accuracy (Averaged)	4-20
Check Analog Bandwidth	4-22
Check Delay Match Between Channels	4-27
Time Base System Checks	4-31
Check Accuracy for Long-Term Sample Rate, Delay Time, and Delta Time Measurements	4-31
Trigger System Checks	4-35
Check Accuracy, Trigger Level or Threshold, DC Coupled ..	4-35
Sensitivity, Edge Trigger, DC Coupled	4-38
Maximum Input Frequency, Auxiliary Trigger	4-42
Check Video Trigger Sensitivity (Option 05 Equipped Models Only)	4-44
Output Signal Check	4-48
Check Probe Adjust Output	4-48

Adjustment Procedures

Adjustment Procedures	5-1
Requirements for Performance	5-1
Personnel	5-1
Warm-up Period	5-1
Access	5-1
System	5-2
Test Equipment	5-2
Usage	5-2
Performing the Adjustments	5-2
Complete Adjustment	5-3
Individual Adjustments	5-3
Partial Adjustment	5-3
Adjustment After Repair	5-3
Adjustment Dependencies	5-4

Equipment Required	5-5
Adjustment Instructions	5-6
Hardware Installation	5-6
Software Installation	5-7
Software-Based Adjustments	5-8
Probe Adjustment	5-9
Compensate the Probe	5-9
Measure the Probe Bandwidth	5-11
Adjust the Probe — High Frequency Response	5-14
Monitor Assembly Adjustment	5-20

Maintenance

Maintenance Information	6-1
Procedures Not In This Section	6-1
Preventing ESD	6-2
Precautions	6-2
Susceptibility to ESD	6-2
Inspection and Cleaning	6-5
General Care	6-5
Inspection and Cleaning Procedures	6-5
Inspection — Exterior	6-6
Cleaning Procedure — Exterior	6-6
Inspection — Interior	6-7
Cleaning Procedure — Interior	6-8
Lubrication	6-8
Removal and Installation Procedures	6-9
Preparation — Please Read	6-9
List of Modules	6-10
Cable Removal	6-10
General Instructions	6-10
Summary of Procedures	6-10
Access Procedure	6-13
Procedures for Module Removal and Installation	6-21
Front-Panel Knobs and Shafts	6-21
Line Fuse and Line Cord	6-23
Front Cover, Rear Cover, Cabinet, Rear EMI Gasket, and Cabinet Handle and Feet	6-24
Trim Ring, Menu Elastomer, Menu Buttons, and Front EMI Gaskets	6-28
A06 Front-Panel Assembly, ESD Shield, and Menu Flex and Probe Code Flex Circuits	6-31
A05 Attenuator Assembly and Shield	6-34
A26 Monitor Assembly	6-37

A08 Jumper Board Assembly, D1 Bus, and Board Supports	6-40
A03 CPU Assembly	6-41
A02 Display Assembly	6-43
A09 DSP Assembly	6-45
A01 Backplane Assembly and its Mount	6-46
Back-up Batteries	6-49
A25 Low Voltage Power Supply and its Mount	6-51
Fan and Fan Mount	6-54
Line Filter	6-56
A07 Auxiliary Power Supply	6-58
A04 Acquisition Assembly	6-60
Main Chassis	6-62
Disassembly for Cleaning	6-62
Troubleshooting	6-65
Diagnostics	6-65
Firmware Updates	6-66
Troubleshooting Equipment	6-67
Console Port Set Up	6-67

Options

Options and Accessories	7-1
Options	7-1
Standard Accessories	7-4
Optional Accessories	7-5

Electrical Parts List

Replaceable Electrical Parts List	8-1
--	------------

Diagrams

Diagrams	9-1
Symbols	9-1

Mechanical Parts List

Replaceable Parts List	10-1
Parts Ordering Information	10-1
Using the Replaceable Parts List	10-2

List of Illustrations

Figure 2-1: Power-Cord Plug Identification	2-3
Figure 2-2: Map of Display Functions	2-8
Figure 4-1: Map of Display Functions	4-3
Figure 4-2: Verifying Adjustments and Signal Path Compensation ..	4-5
Figure 4-3: Universal Test Hookup for Functional Tests	4-7
Figure 4-4: Initial Test Hookup	4-18
Figure 4-5: Initial Test Hookup	4-20
Figure 4-6: Initial Test Hookup (TDS 410 and TDS 420)	4-23
Figure 4-7: Initial Test Hookup (TDS 460)	4-23
Figure 4-8: Measurement of Analog Bandwidth	4-26
Figure 4-9: Initial Test Hookup	4-28
Figure 4-10: Measurement of Channel Delay	4-30
Figure 4-11: Initial Test Hookup	4-31
Figure 4-12: Measurement of Accuracy — Long-Term and Delay-Time	4-33
Figure 4-13: Initial Test Hookup	4-35
Figure 4-14: Initial Test Hookup	4-38
Figure 4-15: Measurement of Trigger Sensitivity	4-40
Figure 4-16: Initial Test Hookup	4-42
Figure 4-17: Confirming Auxiliary Triggering at Maximum Triggering Frequency	4-43
Figure 4-18: Initial Test Hookup	4-44
Figure 4-19: Adjusting Sync Pulse Amplitude	4-45
Figure 4-20: Measurement of Video Sensitivity	4-46
Figure 4-21: Initial Test Hookup	4-48
Figure 4-22: Measurement of Probe Compensator Limits	4-49
Figure 5-1: Hookup for Probe Compensation	5-9
Figure 5-2: Performing Probe Compensation	5-10
Figure 5-3: Proper and Improper Probe Compensation	5-10
Figure 5-4: Exposing the Inner Probe Tip	5-11
Figure 5-5: Initial Test Hookup (TDS 410 and TDS 420 Only)	5-12
Figure 5-6: Initial Test Hookup (TDS 460 Only)	5-12
Figure 5-7: Exposing the Probe Body	5-14
Figure 5-8: Initial Test Hookup (TDS 410 and TDS 420 Only)	5-15
Figure 5-9: Initial Test Hookup (TDS 460 Only)	5-15
Figure 5-10: Probe Test Hookup (TDS 410 and TDS 420 Only)	5-17
Figure 5-11: Probe Test Hookup (TDS 460 Only)	5-17
Figure 5-12: Locations of Probe Adjustments	5-18

Figure 5-13: Adjustments vs. Front-Corner Response	5-19
Figure 5-14: Monitor Adjustment Locations	5-21
Figure 5-15: Five and Ten Percent Luminance Patches	5-22
Figure 5-16: Composite Pattern for Focusing	5-23
Figure 5-17: External Graticule Limit Lines	5-25
Figure 6-1: Oscilloscope Orientation	6-11
Figure 6-2: Cabinet and Front-Panel Mounted Modules	6-15
Figure 6-3: Internal Modules	6-17
Figure 6-4: Cables and Cable Routing	6-20
Figure 6-5: Knob and Shaft Removal	6-22
Figure 6-6: Line Fuse and Line Cord Removal	6-23
Figure 6-7: Front Cover, Rear Cover, Cabinet, EMI Gasket, and Cabinet Handle and Feet Removal	6-25
Figure 6-8: Trim Ring, Menu Elastomer, and Menu Buttons Removal	6-28
Figure 6-9: EMI Gasket Removal and Installation	6-30
Figure 6-10: A06 Front-Panel Assembly, ESD Shield, and Menu Flex and Probe Code Flex Circuits Removal	6-32
Figure 6-11: Disassembly of the Front-Panel Assembly	6-33
Figure 6-12: A05 Attenuator Removal	6-35
Figure 6-13: A26 Monitor Assembly Removal	6-39
Figure 6-14: A08 Jumper Board Assembly, D1 Bus, and Board Supports Removal	6-41
Figure 6-15: A03 CPU Removal	6-42
Figure 6-16: A02 Display Assembly Removal	6-44
Figure 6-17: A09 DSP Assembly Removal	6-46
Figure 6-18: A01 Backplane Assembly and its Mount Removal	6-48
Figure 6-19: Battery Removal	6-50
Figure 6-20: A25 Low Voltage Power Supply Removal	6-52
Figure 6-21: Fan and Fan Mount Removal	6-55
Figure 6-22: Line Filter Removal	6-56
Figure 6-23: Auxiliary Power Supply Removal	6-59
Figure 6-24: A04 Acquisition Board Removal	6-61
Figure 6-25: Accessing the Protection Switch	6-66
Figure 6-26: Console Port Connections	6-69
Figure 6-27: Primary Troubleshooting Procedure	6-70
Figure 6-28: A03 CPU Board Connector P1	6-71
Figure 6-29: Module Isolation Troubleshooting Procedure	6-72
Figure 6-30: Low Voltage Power Supply Troubleshooting Procedure	6-74
Figure 6-31: Power Supply Overload Troubleshooting Procedure	6-76
Figure 6-32: A25 Low Voltage Power Supply Module (Right Side)	6-77
Figure 6-33: Monitor Troubleshooting Procedure	6-78
Figure 6-34: Horizontal and Vertical Sync Signals	6-79

Figure 6-35: A Video Signal with White, Black, and Blanking Levels	6-79
Figure 6-36: A26 Monitor Connector J440	6-80
Figure 6-37: A07 Auxiliary Power Connectors J4 and J7	6-80
Figure 6-38: A02 Display Connector J2	6-81
Figure 6-39: Processor/Front Panel Troubleshooting Procedure	6-82
Figure 6-40: A06 Front Panel Board Power Connectors J101 and J106	6-83
Figure 6-41: Attenuator/Acquisition Troubleshooting Procedure	6-84
Figure 6-42: A08 Jumper and A05 Attenuator Boards Signal Locations	6-85
Figure 6-43: Acquisition and Attenuator Power Troubleshooting Procedure	6-86
Figure 6-44: A04 Acquisition Board Power Connector	6-87
Figure 6-45: Backplane Troubleshooting Procedure	6-88
Figure 6-46: A01 Backplane Module	6-90
Figure 6-47: I2C Isolation Troubleshooting Procedure	6-91
Figure 6-48: Console Troubleshooting Procedure	6-92
Figure 9-1: TDS 400 Interconnections	9-2
Figure 9-2: TDS 400 Block Diagram	9-4
Figure 10-1: External and Front Panel Modules	10-7
Figure 10-2: Internal Modules	10-11
Figure 10-3: Cables and Routing	10-13

List of Tables

Table 1-1: Record Length vs. Divisions per Record	1-3
Table 1-2: Nominal Traits — Signal Acquisition System	1-7
Table 1-3: Nominal Traits — Time Base System	1-8
Table 1-4: Nominal Traits — Triggering System	1-9
Table 1-5: Nominal Traits — Display System	1-9
Table 1-6: Nominal Traits — Data Storage	1-9
Table 1-7: Nominal Traits — GPIB Interface, Video Output, and Power Fuse	1-10
Table 1-8: Nominal Traits — Mechanical	1-10
Table 1-9: Warranted Characteristics — Signal Acquisition System .	1-12
Table 1-10: Warranted Characteristics — Time Base System	1-14
Table 1-11: Warranted Characteristics — Triggering System	1-15
Table 1-12: Warranted Characteristics — Probe Compensator Output	1-16
Table 1-13: Power Requirements	1-16
Table 1-14: Warranted Characteristics — Environmental, Safety, and Reliability	1-17
Table 1-15: Typical Characteristics — Signal Acquisition System ...	1-18
Table 1-16: Typical Characteristics — Time Base System	1-19
Table 1-17: Typical Characteristics — Triggering System	1-19
Table 1-18: Typical Characteristics — Data Handling	1-20
Table 2-1: Power Cord Conductor Identification	2-2
Table 2-2: Effects of Corrupted Data	2-5
Table 4-1: Test Equipment	4-14
Table 4-2: DC Offset Accuracy	4-19
Table 4-3: Analog Bandwidth (TDS 410 and TDS 420)	4-25
Table 4-4: Analog Bandwidth (TDS 460)	4-25
Table 5-1: Adjustments Required for Module Replaced	5-3
Table 5-2: Adjustments and Dependencies	5-4
Table 5-3: Test Equipment, Fixtures, and Supplies	5-5
Table 5-4: GPIB Board Configuration	5-7
Table 6-1: Relative Susceptibility to Static-Discharge Damage	6-3
Table 6-2: External Inspection Check List	6-6
Table 6-3: Internal Inspection Check List	6-7
Table 6-4: Tools Required for Module Removal	6-12
Table 6-5: Access Instructions for Modules in Figure 6-2	6-14
Table 6-6: Access Instructions for Modules in Figure 6-3	6-16
Table 6-7: Access (and Removal) Instructions for Cables in Figure 6-4	6-18

Table 6-8: Troubleshooting Test Equipment, Fixtures, and Supplies	6-67
Table 6-9: Connections for a 9 to 25 Pin Null Modem Cable	6-68
Table 6-10: Diagnostic Failure Priority List	6-73
Table 6-11: Normal Output Voltage	6-75
Table 6-12: Power Supply Maximum Current	6-77
Table 6-13: Front Panel Connector Voltages	6-83
Table 6-14: Channel and P1 Signal Locations	6-85
Table 6-15: A05 Attenuator Board Power	6-86
Table 6-16: A04 Acquisition Board Power	6-86
Table 6-17: Regulator Voltages	6-89
Table 6-18: J7 Voltages	6-89
Table 6-19: J8 Front Panel Voltages	6-89
Table 7-1: International Power Cords	7-2
Table 7-2: Standard Accessories	7-4
Table 7-3: Probe Accessories	7-4
Table 7-4: Optional Accessories	7-5
Table 7-5: Probe Accessories	7-6
Table 7-6: Accessory Software	7-7

Service Safety Summary

Please take a moment to review these safety precautions. They are provided for your protection and to prevent damage to the digitizing oscilloscope. This safety information applies to all operators and service personnel.

Symbols and Terms

These two terms appear in manuals:

-  statements identify conditions or practices that could result in damage to the equipment or other property.
-  statements identify conditions or practices that could result in personal injury or loss of life.

These two terms appear on equipment:

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

This symbol appears in manuals:



Static-Sensitive Devices

These symbols appear on equipment:



DANGER
High Voltage



Protective
ground (earth)
terminal



ATTENTION
Refer to
manual

Specific Precautions

Observe all of the following precautions to ensure your personal safety and to prevent damage to either the digitizing oscilloscope or the equipment connected to it.

Do Not Perform Service While 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 before removing protective panels, soldering, or replacing components.

Power Source

The digitizing oscilloscope is intended to operate from a power source that will not apply more than 250 V_{RMS} between the supply conductors or between either supply conductor and ground. A protective ground connection, through the grounding conductor in the power cord, is essential for safe system operation.

Grounding the Digitizing Oscilloscope

The digitizing oscilloscope is grounded through the power cord. To avoid electric shock, plug the power cord into a properly wired receptacle where earth ground has been verified by a qualified service person. Do this before making connections to the input or output terminals of the digitizing oscilloscope.

Without the protective ground connection, all parts of the digitizing oscilloscope are potential shock hazards. This includes knobs and controls that may appear to be insulators.

Use the Proper Power Cord

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

Use the Proper Fuse

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

Do Not Remove Covers or Panels

To avoid personal injury, do not operate the digitizing oscilloscope without the panels or covers.

Do Not Operate in Explosive Atmospheres

The digitizing oscilloscope provides no explosion protection from static discharges or arcing components. Do not operate the digitizing oscilloscope in an atmosphere of explosive gasses.

Electric Overload

Never apply a voltage to a connector on the digitizing oscilloscope that is outside the range specified for that connector.

Preface

This service manual provides service information for the TDS 410, TDS 420, and TDS 460 Digitizing Oscilloscopes.



If servicing a TDS 410, follow the procedures for the TDS 420, but ignore all references to CH 3 and CH 4.

Manual Structure

This manual is divided into sections, such as *Specifications and Theory of Operation*. Further, it is divided into subsections, such as *Product Description* and *Removal and Installation Procedures*.

Sections containing procedures also contain introductions to those procedures. Be sure to read these introductions, because they provide information needed to do the service correctly and efficiently. The following is a brief description of each manual section.

- *Specifications* — contains a product description of the digitizing oscilloscope and tables of the characteristics and descriptions that apply to it.
- *Operating Information* — is this section. It includes a description of how this manual is structured, as well as general information and operating instructions at the level needed to safely power up and service this oscilloscope. A statement of the service strategy that this manual supports, as well as instructions for shipment of the digitizing oscilloscope, are found in this section.
- *Theory of Operation* — contains circuit descriptions that support general service and fault isolation.
- *Performance Verification* — contains a collection of procedures for confirming that this digitizing oscilloscope functions properly and meets warranted limits.
- *Adjustment Procedures* — contains a collection of procedures for adjusting this digitizing oscilloscope to meet warranted limits.
- *Maintenance* — contains information and procedures for doing preventive and corrective maintenance of the digitizing oscilloscope. Instructions for cleaning, for module removal and installation, and for fault isolation to a module are found here.
- *Options* — contains information on servicing any of the factory-installed options that may be present in your oscilloscope.
- *Electrical Parts List* — contains a statement referring you to the *Mechanical Parts List*, where both electrical and mechanical modules are listed. See below.
- *Diagrams* — contains a block diagram and an interconnection diagram useful for isolating failed modules.

- *Mechanical Parts List* — includes a table of all replaceable modules, their descriptions, and their Tektronix part numbers.

Manual Conventions

This manual uses certain conventions which you should become familiar with before doing service.

Modules

Throughout this manual, any replaceable component, assembly, or part of this digitizing oscilloscope is referred to generically as a module. In general, a module is an assembly, like a circuit board, rather than a component, like a resistor or an integrated circuit. Sometimes a single component is a module; for example, the chassis of the oscilloscope is a module.

Safety

Symbols and terms related to safety appear in the Safety Summary found at the beginning of this manual.

Symbols

Besides the symbols related to safety, this manual uses the following symbols:



The “stop sign” icon labels information which must be read in order to correctly do service and to avoid incorrectly using or applying service procedures.



The clock icon labels procedure steps which require a pause to wait for the oscilloscope to complete some operation before you can continue.



Various icons such as the example icon at the left are used in procedures to help identify certain readouts and menu functions on screen.

Related Manuals

These other manuals are available for the TDS 410, TDS 420, and TDS 460 Digitizing Oscilloscopes.

- The *Reference* gives you a quick overview of how to operate your oscilloscope.
- The *User* provides instructions on how to operate your oscilloscope.
- The *Programmer Manual* provides complete information on programming and remote control of the oscilloscope through the GPIB.

Introduction

This section contains general information critical to safe and effective servicing of this oscilloscope, the manual service strategy, and a description of repair and warranty services available from Tektronix.

Before Servicing

This manual is for servicing the TDS 410, TDS 420, & TDS 460 Digitizing Oscilloscopes. To prevent injury to yourself or damage to the oscilloscope, do the following before you attempt service:

- Be sure you are a qualified service person;
- Read the Safety Summary found at the beginning of this manual;
- Read *Strategy for Servicing and Supplying Operating Power* in this section.

When using this manual for servicing, be sure to heed all warnings, cautions, and notes.



If servicing a TDS 410, follow the procedures for the TDS 420, but ignore all references to CH 3 and CH 4.

Strategy for Servicing



Throughout this manual, any field-replaceable component, assembly, or part of this oscilloscope is referred to generically as a module.

This manual contains all the information needed for periodic maintenance of your oscilloscope. (Examples of such information are procedures for checking performance and for readjustment.) Further, it contains all information for corrective maintenance down to the module level. This means that the procedures, diagrams, and other troubleshooting aids help isolate failures to a specific module, rather than to components of that module. Once a failure is isolated, replace the module with a fully tested module obtained from the factory.

All modules are listed in Section 10, *Mechanical Parts List*. To isolate a failure to a module, use the fault isolation procedures found in Section 6, *Maintenance*. To remove and replace any failed module, follow the instructions in *Removal and Installation Procedures*, also found in Section 6.

Tektronix Service

Tektronix provides service to cover repair under warranty as well as other services that may provide a cost-effective answer to your service needs.

Whether providing warranty repair service or any of the other services listed below, Tektronix service technicians, trained on Tektronix products, are best equipped to service your digitizing oscilloscope. Tektronix technicians are apprised of the latest information on improvements to the product as well as the latest new options to the product.

Warranty Repair Service

Tektronix warrants this product for three years from date of purchase, excluding probes for which the warranty is one year. (The warranty appears on the back of the title page in this manual.) Tektronix technicians provide warranty service at most Tektronix service locations worldwide. Your Tektronix product catalog lists all service locations worldwide.

Repair or Calibration Service

The following services may be purchased to tailor repair and/or calibration of your digitizing oscilloscope to fit your requirements.

Option 9C — When you order your digitizing oscilloscope with option 9C, it is shipped with a *Certificate of Calibration and Test Data*. This certificate provides traceability to the National Institute of Standards and Technology (NIST). It certifies procedures used to calibrate the oscilloscope comply with U. S. Military Standard 45662A.

At-Depot Service — Tektronix offers several standard-priced adjustment (calibration) and repair services:

- A single repair and/or adjustment.
- Calibrations using equipment and procedures that meet the traceability standards specific to the local area.
- Annual maintenance agreements that provide for either calibration and repair or calibration only of the oscilloscope.

Of these services, the annual maintenance agreement offers a particularly cost-effective approach to service for many owners of the TDS 420 & TDS 460 Digitizing Oscilloscopes. Such agreements can be purchased to span several years.

On-Site Service — The annual maintenance agreement can be purchased with on-site service, with repair and calibration done at your facility. This service reduces the time your oscilloscope is out of service when calibration or repair is required.

Self Service

Tektronix supports repair to the module level by providing *Module Exchange* and *Module Repair and Return*.

Module Exchange — This service reduces down time for repair by allowing you to exchange most modules for remanufactured ones. Tektronix ships you an updated and tested exchange module from the Beaverton, Oregon service center, typically within 24 hours. Each module comes with a 90-day service warranty.

Module Repair and Return — This service returns to you within 10 days the same module that you shipped to Tektronix. The module shipped is repaired, tested, and returned to you from the Beaverton, Oregon service center. It is *not* updated to match current modules of the same type. Again, each module comes with a 90-day service warranty.

For More Information — Contact your local Tektronix service center or sales engineer for more information on any of the repair or adjustment services just described.

Product Description

This subsection begins with a general description of the traits of the TDS 400 Digitizing Oscilloscopes. Three subsections follow, one for each of three classes of traits: *nominal traits*, *warranted characteristics*, and *typical characteristics*.

General

Tektronix TDS 400 Digitizing Oscilloscopes are portable instruments suitable for use in a variety of test and measurement applications and systems. Key features include:

- Four input channels on the TDS 420 and TDS 460 (two input channels on the TDS 410), each with a record length of 500 to 15,000 points and 8-bit vertical resolution. (Option 1M extends the maximum record length to 60,000 points.)
- Simultaneous acquisition of waveforms in all channels at the maximum digitizing rate of 100 Megasamples/second. All channels acquire at the full analog bandwidth of 150 MHz (TDS 410 and TDS 420) or 350 MHz (TDS 460) and all have the same features.
- Video triggering capabilities (with Option 5, Video Trigger).
- Full programmability and printer/plotter output.
- Advanced functions, such as continuously updated measurements.
- Specialized display modes, such as infinite and variable persistence.
- A unique graphical user interface (GUI), an on-board help mode, and a logical front-panel layout which combine to deliver a new standard in usability.
- Advanced waveform math (with Option 2F, Advanced DSP Math). Compute and display the integral of a waveform, the differential of a waveform, and the FFT (Fast Fourier Transform) of a waveform.

User Interface

This digitizing oscilloscope uses a combination of front-panel buttons, knobs, and on-screen menus to control its many functions. The front-panel controls are grouped according to function: vertical, horizontal, trigger, and special. Within each group, any function likely to get adjusted often, such as vertical positioning or the time base setting, is set directly by its own front-panel knob.

Menus

Those functions for which control settings are usually changed less often, such as vertical coupling and horizontal mode, are set indirectly. That is, pressing one (sometimes two) front-panel button, such as vertical menu, displays a menu of functions at the bottom of the screen that are related to that button. (For the button vertical menu, the menu displayed contains functions such as coupling and bandwidth.) Using the buttons below this *main* menu to select a function, such as coupling, displays a *side* menu of settings for that function, such as AC, DC, or GND (ground) coupling, at the right side of the screen. Use the buttons to the right of the menu to select a setting, such as DC.

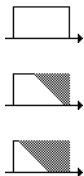
Indicators

Several on-screen readouts help you keep track of the settings for various functions, such as vertical and horizontal scale and trigger level. There are also readouts to display the results of measurements made using cursors or using the automatic parameter extraction feature (called measure) and readouts to display the status of the instrument.

General Purpose Knob

Menus can also be used to assign the general purpose knob to adjust a selected parameter function. The method employed is the same as for *selecting* a function, except the final selection in the side menu causes the general purpose knob to *adjust* some function, such as the position of measurement cursors on screen, or the setting for the fine gain of a channel.

GUI



The user interface also makes use of a GUI, or Graphical User Interface, to make setting functions and interpreting the display more intuitive. Some menus and status are displayed using iconic representations of function settings such as those shown here for full, 100 MHz, and 20 MHz bandwidth. Such icons allow you to more readily determine status or the available settings.

Signal Acquisition System

The signal acquisition system provides vertical channels with calibrated vertical scale factors from 1 mV to 10 V per division. All input channels can be acquired simultaneously.

You can display, vertically position, and offset each input channel. You can also limit their bandwidth (to either 100 MHz or 20 MHz), specify their vertical coupling, and adjust their fine gain.

Besides the input channels, up to three math waveforms and four reference waveforms are available for display. (A math waveform results when you specify operations, such as add or invert; a reference waveform results when you save a live waveform in a reference memory.)

Horizontal System

There are three horizontal display modes: main only, main intensified, and delayed only. You can select among various horizontal record length settings (see Table 1-1).

Table 1-1: Record Length vs. Divisions per Record

Record Length^{1, 2}	Divisions per Record (50 Points/Division)
60,000	1200 divs
30,000	600 divs
15,000	300 divs
5,000	100 divs
2,500	50 divs
1,000	20 divs
500	10 divs

¹The 30,000 and 60,000 point record lengths are available only with Option 1M.

²The maximum record length of 60,000 points for oscilloscopes equipped with Option 1M reduces to 15,000 points when operating in Hi Res or Average acquisition mode.

Both the delayed only display and the intensified zone on the main intensified display can be delayed by time with respect to the main trigger. Both can be set to display immediately after the delay (delayed runs after main mode); the delayed display can also be set to display at the first valid trigger after the delay (delayed triggerable mode).

The delayed display (or the intensified zone) can also be delayed by a selected number of events. In such a case, the events source is the delayed trigger source. For any events signal, the delayed-trigger system conditions the signal by determining the source, coupling, etc., of that signal.

At time base settings of 20 ms per division or slower the records are displayed using Roll mode. Both untriggered roll and triggered roll modes are available.

Trigger System

The triggering system comprises a complete set of features for triggering the signal-acquisition system. In edge trigger mode, you can select the source, slope, coupling, mode (auto or normal), and holdoff.

Oscilloscopes ordered with Option 5 also have the video trigger mode. This trigger mode allows triggering on NTSC-standard, PAL-standard, SECAM-standard, or custom video waveforms. You can configure the triggering for interlaced or non-interlaced scanning, different scan rates, field selection, line selection, and for delay by line or time.

You can choose where the trigger point is located within the acquired waveform record by selecting the amount of pretrigger data displayed. Presets of 10%, 50%, and 90% of pretrigger data can be selected in the horizontal menu, or the General Purpose knob can be assigned to set pretrigger data to any value within the limits of trigger position resolution.

Acquisition Control

Depending on your measurement requirements, you can specify the mode and manner in which signals are acquired and processed:

- You can select equivalent-time sampling on repetitive signals or interpolation of points sampled on non-repetitive signals. Both can increase the apparent sample rate on the waveform when maximum real-time rates are reached.
- Peak-detect, high-resolution, sample, envelope, and average modes can be used to acquire signals.
- The acquisition can be set to stop after a single acquisition (or sequence of acquisitions if acquiring in average or envelope modes).

On-Board User Assistance

Two features that help you set up this digitizing oscilloscope to make your measurements are help and autoset.

Help

Help displays operational information about any front-panel control. When help mode is in effect, manipulating any front-panel control causes the digitizing oscilloscope to display information about that control. When help is first invoked, an introduction to help is displayed on screen.

Autoset

Autoset automatically sets up the digitizing oscilloscope for a viewable display based on the input signal.

Measurement Assistance

Once you have set up to make your measurements, the features cursor and measure can help you quickly make those measurements.

Cursor

Two types of cursors are provided for making parametric measurements on the displayed waveforms. Voltage can be measured between the positions of H Bar (horizontal) cursors, and time can be measured between V Bar (vertical) cursors. These are delta measurements; that is, measurements based on the difference between two cursors.

Both V Bar and H Bar cursors can also be used to make absolute measurements—measurements relative to a defined level or event. In the case of the H Bars, either cursor can be selected to read out its voltage with respect to the ground reference level of any channel; in the case of the V Bars, its time with respect to the trigger point (event) of the acquisition.

For time measurements, units can be either seconds or Hertz (for 1/time).

Measure

Measure can automatically extract parameters from the signal input to the digitizing oscilloscope. Any four out of the more than 20 parameters available can be displayed to the screen. The displayed parameters are extracted continuously and the results updated on-screen as the digitizing oscilloscope continues to acquire waveforms.

Digital Signal Processing (DSP)

An important component of the multiprocessor architecture of this digitizing oscilloscope is Tektronix proprietary digital signal processor, the DSP. This dedicated processor supports advanced analysis of your waveforms when doing such compute-intensive tasks as interpolation, waveform math, and signal averaging. It also teams with a custom display system to deliver specialized display modes (see *Display*, later in this description).

Storage and I/O

You can save acquired waveforms in any of four nonvolatile REF (reference) memories. Any or all of the saved waveforms can be displayed for comparison with the waveforms being currently acquired.

You can choose the source and destination of waveforms to be saved. You can save any of the input channels to any REF memory or move a stored reference from one REF memory to another. You can also write reference waveforms into a REF memory location via the GPIB interface.

The digitizing oscilloscope is fully controllable and capable of sending and receiving waveforms over the GPIB interface (IEEE Std 488.1-1987/IEEE Std 488.2-1987 standard). This feature makes the instrument ideal for making automated measurements in a production or research and development

environment that calls for repetitive data taking. Self-compensation and self-diagnostic features built into the digitizing oscilloscope to aid in fault detection and servicing are also accessible using commands sent from a GPIB controller.

Another standard feature is hardcopy. This feature allows you to output waveforms and other on-screen information to a variety of graphic printers and plotters from the digitizing oscilloscope front panel, providing hard copies without requiring you to put the digitizing oscilloscope into a system-controller environment. The hard copies obtained are WYSIWYG (What-You-See-Is-What-You-Get), based on what is displayed at the time hardcopy is invoked.

A VGA-compatible video output, available at the rear panel, is also standard with the TDS 400 digitizing oscilloscope.

Display

The TDS 400 Digitizing Oscilloscopes offer flexible display options. You can customize the following attributes of your display:

- Intensity: waveforms, readouts, graticule, etc.
- Style of waveform display(s): vectors or dots, intensified or non-intensified samples, and infinite or variable persistence
- Display format: XY or YT and graticule type

Zoom

This digitizing oscilloscope also provides an easy way to focus in on those waveform features you wish to examine up close. By invoking zoom, you can magnify the waveform parameter using the vertical and horizontal controls to expand (or contract) and position it for viewing.

Nominal Traits

Nominal traits are described using simple statements of fact such as “Four, all identical” for the trait “Input Channels, Number of,” rather than in terms of limits that are performance requirements.

Table 1-2: Nominal Traits — Signal Acquisition System

Name	Description								
Bandwidth Selections	20 MHz, 100 MHz, and FULL (TDS 410 and TDS 420: 150 MHz, TDS 460: 350 MHz)								
Digitizers, Number of	TDS 410: Two, both identical TDS 420 and TDS 460: Four, all identical								
Digitized Bits, Number of	8 bits ¹								
Input Channels, Number of	TDS 410: Two, both identical, called CH 1 and CH 2 TDS 420 and TDS 460: Four, all identical, called CH 1 through CH 4								
Input Coupling	DC, AC, or GND								
Input Resistance Selections	1 M Ω or 50 Ω								
Ranges, Offset, All Channels	<table> <tr> <th>Volts/Div Setting</th><th>Offset Range</th></tr> <tr> <td>1 mV/div to 99.5 mV/div</td><td>± 1 V</td></tr> <tr> <td>100 mV/div to 995 mV/div</td><td>± 10 V</td></tr> <tr> <td>1 V/div to 10 V/div</td><td>± 100 V</td></tr> </table>	Volts/Div Setting	Offset Range	1 mV/div to 99.5 mV/div	± 1 V	100 mV/div to 995 mV/div	± 10 V	1 V/div to 10 V/div	± 100 V
Volts/Div Setting	Offset Range								
1 mV/div to 99.5 mV/div	± 1 V								
100 mV/div to 995 mV/div	± 10 V								
1 V/div to 10 V/div	± 100 V								
Range, Position	± 5 divisions								
Range, Sensitivity ²	1 mV/div to 10 V/div								

¹Displayed vertically with 25 digitization levels (DLs) per division and 10.24 divisions dynamic range with zoom off. A DL is the smallest voltage level change resolved by the 8-bit A-D Converter, with the input scaled to the volts/division setting of the channel used. Expressed as a voltage, a DL is equal to 1/25 of a division times the volts/division setting.

²The sensitivity ranges from 1 mV/div to 10 V/div in a 1–2–5 sequence of coarse settings. Between consecutive coarse settings, the sensitivity can be finely adjusted with a resolution of 1% of the more sensitive setting. For example, between 50 mV/div and 100 mV/div, the volts/division can be set with 0.5 mV resolution.

Nominal Traits

Table 1-2: Nominal Traits — Signal Acquisition System (Cont.)

Name	Description	
Rise Time ³ (TDS 410 and TDS 420)	Volts/Div Setting	Rise Time
	5 mV/div–10 V/div	2.3 ns
	2 mV/div–4.98 mV/div	3.2 ns
	1 mV/div–1.99 mV/div	3.9 ns
Rise Time ³ (TDS 460)	Volts/Div Setting	Rise Time
	5 mV/div–10 V/div	1.0 ns
	2 mV/div–4.98 mV/div	1.4 ns
	1 mV/div–1.99 mV/div	3.5 ns

³Rise time is defined by the following formula:

$$\text{Rise Time (ns)} = \frac{350}{\text{BW (MHz)}}$$

Table 1-3: Nominal Traits — Time Base System

Name	Description
Range, Sample-Rate ^{1,3}	2.5 Samples/s to 100 MSamples/s
Range, Equivalent Time or Interpolated Waveform Rate ^{2,3}	200 MSamples/s to 50 GSamples/s
Range, Seconds/Division	1 ns/div to 20 s/div
Range, Time Base Delay Time	0 to 20 seconds (settings of 20 μ s and slower are displayed in roll mode)
Reference Frequency, Time Base	100 MHz
Record Length Selection	500 points, 1,000 points, 2,500 points, 5,000, and 15,000 points. Record lengths of 30,000 and 60,000 points are available with Option 1M. ⁴

¹The range of real-time rates, expressed in samples/second, at which a digitizer samples signals at its inputs and stores the samples in memory to produce a record of time-sequential samples

²The range of waveform rates for equivalent time or interpolated waveform records.

³The Waveform Rate (WR) is the equivalent sample rate of a waveform record. For a waveform record acquired by real-time sampling of a single acquisition, the waveform rate is the same as the real-time sample rate; for a waveform created by interpolation of real-time samples from a single acquisition or by equivalent-time sampling of multiple acquisitions, the waveform rate is faster than the real time sample rate. For all three cases, the waveform rate is 1/(Waveform Interval) for the waveform record, where the waveform interval (WI) is the time between the samples in the waveform record.

⁴The maximum record length of 60,000 points available with Option 1M is selectable with all acquisition modes except Hi Res and Average. In Hi Res and Average, the maximum record length is 15,000 points.

Table 1-4: Nominal Traits — Triggering System

Name	Description	
Range, Events Delay	1 to 9,999,999	
Ranges, Trigger Level or Threshold	Source	Range
	Any Channel	±12 divisions from center of screen
	Line	±400 Volts

Table 1-5: Nominal Traits — Display System

Name	Description
Video Display Resolution	640 pixels horizontally by 480 pixels vertically in a display area of 5.04 inches horizontally by 3.78 inches vertically
Waveform Display Graticule	A single graticule 401 × 501 pixels (8 × 10 divisions, with divisions that are 1 cm by 1 cm)
Waveform Display Grey Scale	16 levels in infinite-persistence and variable-persistence display styles

Table 1-6: Nominal Traits — Data Storage

Name	Description
Capacity, Nonvolatile Waveform Memory	Standard Instrument: Total capacity is 60,000 points. Option 1M Equipped Instrument: Total capacity is 60,000 points (one to four waveforms acquired with any combination of record lengths that add up to 60,000 points). For available record lengths, see “Record Length Selection” on page 1-8 of this section.
Capacity, Nonvolatile Setup Memory	Ten setups.
Batteries ¹ Required	Two lithium poly-carbon monofluoride. Both are type BR2/3A, UL listed. Both are rated at 3.0 volt, 1.2 amp-hour.

¹Batteries are not accessible from the outside of the instrument; therefore, they can only be replaced by a service technician.

Table 1-7: Nominal Traits — GPIB Interface, Video Output, and Power Fuse

Name	Description
Interface, GPIB	GPIB interface complies with IEEE Std 488.1-1987 and IEEE Std 488.2-1987.
Output, Video	Provides a video signal, non-interlaced, with levels that comply with ANSI RS343A. For oscilloscopes SN B030099 and below, output is through a rear-panel DB-9 connector. For oscilloscopes SN B030100 and above, output is through a rear-panel DB-15 connector.
Fuse Rating	Either of two fuses ¹ may be used: a .25" × 1.25" (UL 198.6, 3AG): 5 A FAST, 250 V, or a 5 mm × 20 mm, (IEC 127): 4 A (T), 250 V.

¹Each fuse type requires its own fuse cap.

Table 1-8: Nominal Traits — Mechanical

Name	Description
Cooling Method	Forced-air circulation with no air filter.
Construction Material	Chassis parts constructed of aluminum alloy; front panel constructed of plastic laminate; circuit boards constructed of glass-laminate. Plastic parts are polycarbonate.
Finish Type	Tektronix Blue textured finish on aluminum cabinet.
Weight	Standard digitizing oscilloscope 8.6 kg (19.0 lbs), oscilloscope only. 10.2 kg (22.5 lbs), with front cover, accessories, and accessories pouch installed. 14.5 kg (32.0 lbs), when packaged for domestic shipment. Rackmount digitizing oscilloscope 8.2 kg (18.0 lbs) plus the weight of rackmount parts, for the rackmounted digitizing oscilloscope (Option 1R). 16.3 kg (36.0 lbs), when the rackmounted digitizing oscilloscope is packaged for domestic shipment. Rackmount conversion kit 4.5 kg (10.0 lbs), parts only; 7.9 kg (17.5 lbs), parts plus package for domestic shipping.

Table 1-8: Nominal Traits — Mechanical (Cont.)

Name	Description
Overall Dimensions	Standard digitizing oscilloscope
	Height 191 mm (7.5 in), when feet and accessories pouch are installed. 165 mm (6.5 in), without the accessories pouch installed.
	Width 362 mm (14.25 in), with handle.
	Depth 471 mm (18.55 in), oscilloscope only; 490 mm (19.28 in), with optional front cover installed; 564 mm (22.2 in), with handle fully extended.
	Rackmount digitizing oscilloscope
	Height 178 mm (7.0 in).
	Width 483 mm (19.0 in).
	Depth 472 mm (18.6 in), without front-panel handles; 517 mm (20.35 in), with front-panel handles installed.

Warranted Characteristics

This subsection lists the various *warranted characteristics* that describe the TDS 400 Digitizing Oscilloscopes. Included are electrical and environmental characteristics.

Warranted characteristics are described in terms of quantifiable performance limits which are warranted. This subsection lists only warranted characteristics. A list of *typical characteristics* starts on page 1-18.

NOTE

In these tables, those warranted characteristics that are checked in the procedure Performance Tests, found in Section 4, appear in boldface type under the column Name.

Performance Conditions

The electrical characteristics found in these tables of warranted characteristics apply when the oscilloscope is adjusted at an ambient temperature between +20° C and +30° C, has had a warm-up period of at least 20 minutes, and is operating at an ambient temperature between 0° C and +50° C (unless otherwise noted).

Table 1-9: Warranted Characteristics — Signal Acquisition System

Name	Description
Accuracy, DC Voltage Measurement, Averaged	Measurement Type Average of ≥ 16 waveforms
	DC Accuracy $\pm(1.5\% \times (\text{reading} - \text{Net Offset}^1) + \text{Offset Accuracy} + 0.06 \text{ div})$
	Delta volts between any two averages of ≥ 16 waveforms ² $\pm(1.5\% \times \text{reading} + 0.1 \text{ div} + 0.3 \text{ mV})$
Accuracy, DC Gain ³	$\pm 1.5\%$

¹Net Offset = Offset – (Position x Volts/Div). Net Offset is the voltage level at the center of the A-D converter dynamic range. Offset Accuracy is the accuracy of this voltage level.

²The samples must be acquired under the same setup and ambient conditions.

³DC Gain Accuracy is confirmed in the Performance Verification Procedure by passing the checks for Offset Accuracy and DC Voltage Measurement Accuracy (Averaged).

Table 1-9: Warranted Characteristics — Signal Acquisition System (Cont.)

Name	Description	
Accuracy, Offset	Volts/Div Setting	Offset Accuracy
	1 mV/div–9.95 mV/div	$\pm(0.4\% \times \text{Net Offset}^1 + 0.9 \text{ mV} + 0.1 \text{ div})$
	10 mV/div–99.5 mV/div	$\pm(0.4\% \times \text{Net Offset}^1 + 1.5 \text{ mV} + 0.1 \text{ div})$
	100 mV/div–995 mV/div	$\pm(0.4\% \times \text{Net Offset}^1 + 15 \text{ mV} + 0.1 \text{ div})$
	1 V/div–10 V/div	$\pm(0.4\% \times \text{Net Offset}^1 + 150 \text{ mV} + 0.1 \text{ div})$
Accuracy, Position ⁴	$\pm(1.5\% \times (\text{Position} \times \text{Volts/div}) + \text{Offset Accuracy} + 0.04 \text{ div})$	
Analog Bandwidth, DC-50 Ω Coupled and DC-1 M Ω with Standard-accessory Probe Attached (TDS 410 and TDS 420)	Volts/Div	Bandwidth⁵
	5 mV/div–10 V/div	DC–150 MHz
	2 mV/div–4.98 mV/div	DC–110 MHz
	1 mV/div–1.99 mV/div	DC–90 MHz
Analog Bandwidth, DC-50 Ω Coupled and DC-1 M Ω with Standard-accessory Probe Attached (TDS 460)	Volts/Div	Bandwidth⁵
	5 mV/div–10 V/div	DC–350 MHz
	2 mV/div–4.98 mV/div	DC–250 MHz
	1 mV/div–1.99 mV/div	DC–100 MHz
Cross Talk (Channel Isolation)	Volts/Div	Isolation
	> 500 mV/div	$\geq 40:1$ at 50 MHz for any two channels having equal volts/division settings
	$\leq 9.95 \text{ mV/div}$	$\geq 40:1$ at 50 MHz for any two channels having equal volts/division settings
	10 mV/div–500 mV/div	$\geq 80:1$ at 100 MHz and $\geq 30:1$ at full bandwidth for any two channels having equal volts/division settings
Delay Between Channels, Full Bandwidth, Equivalent Time	$\leq 200 \text{ ps}$ between CH 1 and CH 2 (all models) and between CH 3 and CH 4 (TDS 420 and TDS 460) when both channels have equal volts/division and coupling settings	
	$\leq 450 \text{ ps}$ for any other combination of two channels with equal volts/division and coupling settings (TDS 420 and TDS 460).	

¹Net Offset = Offset – (Position x Volts/Div). Net Offset is the voltage level at the center of the A-D converter's dynamic range. Offset Accuracy is the accuracy of this voltage level.

⁴Position Accuracy is confirmed in the Performance Verification Procedure (Section 4) by passing the checks for Offset Accuracy and DC Voltage Measurement Accuracy (Averaged).

⁵The limits given are for the ambient temperature range of 0°C to +30°C. Reduce the upper bandwidth frequencies by 2.5 MHz for each °C above +30°C.

Table 1-9: Warranted Characteristics — Signal Acquisition System (Cont.)

Name	Description	
Input Impedance, DC-1 M Ω Coupled	1 M Ω $\pm$ 0.5% in parallel with 15 pF $\pm$ 2.0 pF. Matched between channels to within $\pm$ 1% for resistance and $\pm$ 1.0 pF for capacitance	
Input Impedance, DC-50 Ω Coupled (TDS 410 and TDS 420)	50 Ω $\pm$ 1% with VSWR $\leq$ 1.2:1 from DC–150 MHz	
Input Impedance, DC-50 Ω Coupled (TDS 460)	50 Ω $\pm$ 1% with VSWR $\leq$ 1.6:1 from DC–350 MHz	
Input Voltage, Maximum, DC-1 M Ω , AC-1 M Ω , or GND Coupled	Volt/Div 0.1 V/div–10 V/div	Rating $\pm$ 400 V (DC + peak AC); derate at 20 dB/decade above 10 MHz until the minimum rating of $\pm$ 5 V (DC + peak AC) is reached
	1 mV/div–9.99 mV/div	$\pm$ 400 V (DC + peak AC); derate at 20 dB/decade above 10 kHz until the minimum rating of $\pm$ 5 V (DC + peak AC) is reached
Input Voltage, Maximum, DC-50 Ω or AC-50 Ω Coupled	5 V rms, with peaks less than or equal to $\pm$ 30 V	
Lower Frequency Limit, AC Coupled	$\leq$ 10 Hz when AC–1 M Ω coupled; $\leq$ 200 kHz when AC-50 Ω coupled ⁶	

⁶The AC Coupled Lower Frequency Limits are reduced by a factor of 10 when 10X, passive probes are used.

Table 1-10: Warranted Characteristics — Time Base System

Name	Description
Accuracy, Long Term Sample Rate and Delay Time	$\pm$ 150 ppm over any $\geq$ 1 ms interval
Accuracy, Absolute Time and Delay Time Measurements ^{1, 2}	For single-shot acquisitions using sample or high-resolution acquisition modes and a bandwidth limit setting of 100 MHz: $\pm$ (1 WI + 150 ppm of Reading + 450 ps)
	For single-shot acquisitions using sample or high-resolution acquisition modes and a bandwidth limit setting of 20 MHz: $\pm$ (1 WI + 150 ppm of Reading + 1.3 ns)
	For repetitive acquisitions using average acquisition mode with $\geq$ 8 averages and a bandwidth limit setting of FULL: $\pm$ (1 WI + 150 ppm of Reading + 200 ps)

¹For input signals $\geq$ 5 divisions in amplitude and a slew rate of $\geq$ 2.0 divisions/ns at the delta time measurement points. Signal must have been acquired at a volts/division setting $\geq$ 5 mV/division and not in Events mode.

²The WI (waveform interval) is the time between the samples in the waveform record. Also, see the footnotes for *Sample Rate Range* and *Equivalent Time or Interpolated Waveform Rates* in Table 1-3 on page 1-8.

Table 1-10: Warranted Characteristics — Time Base System (Cont.)

Name	Description
Accuracy, Delta Time Measurement^{1, 2}	For single-shot acquisitions using sample or high-resolution acquisition modes and a bandwidth limit setting of 100 MHz: $\pm (1 \text{ WI} + 150 \text{ ppm of } \text{Reading} + 650 \text{ ps})$ For repetitive acquisitions using average acquisition mode with ≥ 8 averages and a bandwidth limit setting of FULL: $\pm (1 \text{ WI} + 150 \text{ ppm of } \text{Reading} + 300 \text{ ps})$

¹For input signals ≥ 5 divisions in amplitude and a slew rate of ≥ 2.0 divisions/ns at the delta time measurement points. Signal must have been acquired at a volts/division setting ≥ 5 mV/division and not in Events mode.

²The WI (waveform interval) is the time between the samples in the waveform record. Also, see the footnotes for *Sample Rate Range* and *Equivalent Time or Interpolated Waveform Rates* in Table 1-3 on page 1-8.

Table 1-11: Warranted Characteristics — Triggering System

Name	Description
Accuracy, Trigger Level or Threshold, DC Coupled	$\pm (2\% \text{ of } \text{Setting} - \text{Net Offset}^1 + 0.2 \text{ div} \times \text{volts/div setting} + \text{Offset Accuracy})$ for any channel as trigger source and for signals having rise and fall times ≥ 20 ns.
Sensitivity, Edge-Type Trigger, DC Coupled²	0.35 division from DC to 50 MHz, increasing to 1 division at 350 MHz (TDS 410 and TDS 420) or 500 MHz (TDS 460) for any channel as trigger source
Sensitivity, Video-Type, TV Field and TV Line²	0.6 division of video sync signal
Pulse Width, minimum, Events-Delay	5 ns
Auxiliary Trigger Input	Connector: BNC at rear panel Input Load: equivalent to three TTL gate loads Input Voltage (maximum): -5 VDC to $+10$ VDC
Auxiliary Trigger, Maximum Input Frequency	10 MHz Duty Cycle High and low levels must be stable for ≥ 50 ns

¹Net Offset = Offset – (Position x Volts/Div). Net Offset is the voltage level at the center of the A-D converter dynamic range. Offset Accuracy is the accuracy of this voltage level.

²The minimum sensitivity for obtaining a stable trigger. A stable trigger results in a uniform, regular display triggered on the selected slope. The trigger point must not switch between opposite slopes on the waveform, and the display must not “roll” across the screen on successive acquisitions. The TRIG'D LED stays constantly lighted when the SEC/DIV setting is 2 ms or faster but may flash when the SEC/DIV setting is 10 ms or slower.

Table 1-12: Warranted Characteristics — Probe Compensator Output

Name	Description	
Output Voltage and Frequency, Probe Compensator	Characteristic	Limits
	Voltage	0.5 V (base-top) $\pm 5\%$ into a 1 M Ω load
	Frequency	1 kHz $\pm 5\%$

Table 1-13: Warranted Characteristics — Power Requirements

Name	Description
Source Voltage and Frequency	90 to 132 VAC rms, continuous range, for 48 Hz through 62 Hz
	100 to 132 VAC rms, continuous range, for 48 Hz through 440 Hz
	180 to 250 VAC rms, continuous range, for 48 Hz through 440 Hz
Power Consumption	≤ 240 Watts (370 VA)

Table 1-14: Warranted Characteristics — Environmental, Safety, and Reliability

Name	Description
Atmospherics	Temperature: 0° C to +50° C, operating; –40° C to +75° C, non-operating Relative humidity: 0 to 95%, at or below +30° C; 0 to 75%, +31° C to +50° C Altitude: To 15,000 ft. (4570 m), operating; to 40,000 ft. (12190 m), non-operating
Emissions ^{1,2}	Meets or exceeds the requirements of the following standards: Vfg. 243/1991 Amended per Vfg 46/1992 FCC 47 CFR, Part 15, Subpart B, Class A EN50081-1 European Community Requirements EN55022 Radiated Emissions Class B EN55022 Conducted Emissions Class B
Susceptibility	Meets or exceeds the requirements of the following standards: EN50082-1 European Community Requirements IEC 801-3 Radiated Susceptibility 3 V/meter from 27 MHz to 500 MHz unmodulated. Performance Criteria: < + 0.2 division waveform displacement, or < 0.2 division increase in p-p noise when the oscilloscope is subjected to the EMI specified in the standard. IEC 801-2 Electrostatic Discharge, Performance Criteria B
Dynamics	Random vibration ³ : 0.31 g rms, from 5 to 500 Hz, 10 minutes each axis, operating; 2.46 g rms, from 5 to 500 Hz, 10 minutes each axis, non-operating

¹To maintain emission requirements when connecting to the IEEE 488 GPIB interface of this oscilloscope, use only a high-quality, double-shielded (braid and foil) GPIB cable. The cable shield must have low impedance connections to both connector housings. Acceptable cables are Tektronix part numbers 012-0991-00, -01, -02, and -03.

²To maintain emission requirements when connecting to the VGA-compatible video output of this oscilloscope, use only a high-quality double-shielded (braid and foil) video cable with ferrite cores at either end. The cable shield must have low impedance connections to both connector housings. An acceptable cable is NEC® part number 73893013. (Use an appropriate adapter when other than a 9-pin monitor connection is needed.)

³Does not apply to rackmounted instrument

Typical Characteristics

This subsection contains tables that list the various *typical characteristics* that describe the TDS 400 Digitizing Oscilloscopes.

Typical characteristics are described in terms of typical or average performance. Typical characteristics are not warranted.

This subsection lists only typical characteristics. A list of warranted characteristics starts on page 1-12.

Table 1-15: Typical Characteristics — Signal Acquisition System

Name	Description				
Accuracy, DC Voltage Measurement, Not Averaged	Measurement Type	DC Accuracy			
	Any Sample	$\pm (1.5\% \times (\text{reading} - \text{Net Offset}^{11}) + \text{Offset Accuracy} + 0.13 \text{ div} + 0.6 \text{ mV})$			
	Delta Volts between any two samples ²	$\pm (1.5\% \times \text{reading} + 0.26 \text{ div} + 1.2 \text{ mV})$			
Frequency Limit, Upper, 100 MHz Bandwidth Limited	100 MHz				
Frequency Limit, Upper, 20 MHz Bandwidth Limited	20 MHz				
Nonlinearity	< 1 DL, differential; ≤ 1 DL, integral, independently based ³				
Step Response Settling Error	Volts/Div Setting	Step Amplitude	Settling Error (%)⁴		
			20 ns	500 ns	20 ms
	1 mV/div–99.5 mV/div	≤2 V	≤0.5	≤0.2	≤0.1
	100 mV/div – 995 mV/div	≤20 V	≤2.0	≤0.5	≤0.2
	1 V/div–10 V/div	≤200 V	≤2.0	≤0.5	≤0.2

¹Net Offset = Offset – (Position x Volts/Div). Net Offset is the voltage level at the center of the A-D converter dynamic range. Offset Accuracy is the accuracy of this voltage level.

²The samples must be acquired under the same setup and ambient conditions.

³A DL (digitization level) is the smallest voltage level change that can be resolved by the 8-bit A-D Converter, with the input scaled to the volts/division setting of the channel used. Expressed as a voltage, a DL is equal to 1/25 of a division times the volts/division setting.

⁴The values given are the maximum absolute difference between the value at the end of a specified time interval after the mid-level crossing of the step, and the value one second after the mid-level crossing of the step, expressed as a percentage of the step amplitude.

Table 1-16: Typical Characteristics — Time Base System

Name	Description
Aperture Uncertainty	For real-time or interpolated records having duration ≤ 1 minute: $\leq (50 \text{ ps} + 0.03 \text{ ppm} \times \text{Record Duration}) \text{ RMS}$ For equivalent time records: $\leq (50 \text{ ps} + 0.06 \text{ ppm} \times \text{WI}^1) \text{ RMS}$
Fixed Error in Sample Time	$\leq 50 \text{ ps}$

¹The WI (waveform interval) is the time between the samples in the waveform record. Also, see the footnotes for *Sample Rate Range* and *Equivalent Time or Interpolated Waveform Rates* in Table 1-3 on page 1-8.

Table 1-17: Typical Characteristics — Triggering System

Name	Description		
Error, Trigger Position, Edge Triggering	Acquire Mode	Trigger-Position Error^{1,2}	
	Sample, Hi-Res, Average	±(1 WI + 1 ns)	
	Peak Detect, Envelope	±(2 WI + 1 ns)	
Holdoff, Variable, Main Trigger	Main Horizontal Scale	Minimum Holdoff	Maximum Holdoff
	≤100 ns/div	1 μs	5 × Min Holdoff
	≥100 ms/div	1 s	5 × Min Holdoff
	Otherwise	10 × sec/div	5 × Min Holdoff
Lowest Frequency for Successful Operation of “Set Level to 50%” Function	20 Hz		
Sensitivity, Edge Trigger, Not DC Coupled ³	Trigger Coupling	Typical Signal Level for Stable Triggering	
	AC	Same as DC-coupled limits ⁴ for frequencies above 60 Hz. Attenuates signals below 60 Hz.	
	Noise Reject	Three and one-half times the DC-coupled limits. ⁴	
	High Frequency Reject	One and one-half times the DC-coupled limits ⁴ from DC to 30 kHz. Attenuates signals above 30 kHz.	
	Low Frequency Reject	One and one-half times the DC-coupled limits ⁴ for frequencies above 80 kHz. Attenuates signals below 80 kHz.	

¹The trigger position errors are typically less than the values given here. These values are for triggering signals having a slew rate at the trigger point of ± 0.5 division/ns.

²The waveform interval (WI) is the time between the samples in the waveform record. Also, see the footnote for the characteristics *Sample Rate Range* and *Equivalent Time or Interpolated Waveform Rates* in Table 1-3 on page 1-8.

³The minimum sensitivity for obtaining a stable trigger. A stable trigger results in a uniform, regular display triggered on the selected slope. The trigger point must not switch between opposite slopes on the waveform, and the display must not "roll" across the screen on successive acquisitions. The TRIG'D LED stays constantly lighted when the SEC/DIV setting is 2 ms or faster but may flash when the SEC/DIV setting is 10 ms or slower.

⁴See the characteristic *Sensitivity, Edge-Type Trigger, DC Coupled* in Table 1-11, which begins on page 1-15.

Table 1-17: Typical Characteristics — Triggering System (Cont.)

Name	Description
Frequency, Maximum for Events Delay ⁵	90 MHz
Width, Minimum Pulse and Rearm, Events Delay ⁶	5 ns
Video Mode (Option 05 Equipped Instruments Only)	Line Rate Class: Four classes are provided as follows. ■ NTSC, which provides a default line rate compatible with the NTSC standard (525/60) ■ PAL, which provides a default line rate compatible with the PAL standard (625/50) ■ SECAM, which provides a default line rate compatible with the SECAM standard (625/50) ■ Custom, which provides user selectable line rate ranges (see “Custom Line Rate Ranges” below) Custom Line Rate Ranges: 15 kHz–20 kHz, 20 kHz–25 kHz, 25 kHz–35 kHz, and 35 kHz–64 kHz Holdoff: Automatically adjusts to 50 ms (nominal) for NTSC class; to 140 ms (nominal) for PAL and SECAM Triggerable on Field Selections: Odd, Even, or Both Delayed Acquisition: Settable for delay by line number or runs after time delay

⁵The maximum frequency for a delaying events input.

⁶The minimum pulse width and rearm width required for recognizing a delaying event.

Table 1-18: Typical Characteristics — Data Handling

Name	Description
Time, Data-Retention, Nonvolatile Memory ^{1,2}	Internal batteries, installed at time of manufacture, have a life of ≥5 years when operated and/or stored at an ambient temperature from 0° C to 50° C. Retention time of the nonvolatile memories is equal to the remaining life of the batteries.

¹The time that reference waveforms, stored setups, and calibration constants are retained when there is no power to the oscilloscope.

²Data is maintained by lithium poly-carbon monofluoride.

Installation

This section contains information about supplying operating power, the operating environment, applying and interrupting power, repackaging for shipment, and installed options.

Supplying Operating Power



Read all information and heed all warnings in this section before connecting the digitizing oscilloscope to a power source.

WARNING

AC POWER SOURCE AND CONNECTION. The digitizing oscilloscope operates from a single-phase power source. It has a three-wire power cord and a two-pole three-terminal grounding type plug. The voltage to ground (earth) from either pole of the power source must not exceed the 250 V rms maximum rated operating voltage.

Before making connection to the power source, be sure the digitizing oscilloscope has a suitable two-pole three-terminal grounding-type plug.

GROUNDING. This instrument is safety Class 1 equipment (IEC designation). All accessible conductive parts are directly connected through the grounding conductor of the power cord to the grounded (earthing) contact of the power plug.

WARNING

The power input plug must be inserted only in a mating receptacle with a grounding contact where earth ground has been verified by a qualified service person. Do not defeat the grounding connection. Any interruption of the grounding connection can create an electric shock hazard.

For electric shock protection, the grounding connection must be made before making connection to the oscilloscope input or output terminals.

Power Cord Information

A power cord with appropriate plug configuration is supplied with each digitizing oscilloscope. Table 2-1 gives the color coding of the conductors in the power cord. If you require a power cord other than the one supplied, refer to Figure 2-1.

Table 2-1: Power Cord Conductor Identification

Conductor	Color	Alternate Color
Ungrounded (Line)	Brown	Black
Grounded (Neutral)	Light Blue	White
Grounded (Earthing)	Green/Yellow	Green

Operating Voltage

The line voltage ranges and their associated line frequency ranges over which this oscilloscope operates are listed in Section 1 *Specification*. See *Source Voltage and Frequency* on page 1-16 for those ranges.



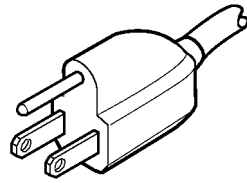
Before stepping the source line voltage from one range to a higher range, set the principal power switch (rear panel) to its OFF position. Failure to do so can damage the oscilloscope.

There are two fuses. Either fuse may be used throughout the line voltage and frequency ranges. These two fuses are not totally interchangeable as each requires a different fuse cap. The fuses and their caps are listed by part number in Section 10, *Mechanical Parts List*.

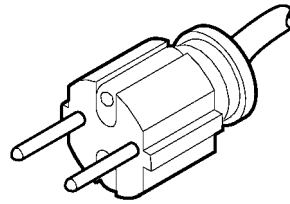
Memory Backup Power

Replaceable lithium batteries maintain internal memory modules to allow the digitizing oscilloscope to retain the following data upon loss of the AC power source: stored adjustment constants, saved front-panel settings, current front-panel settings (instrument status), and saved waveforms.

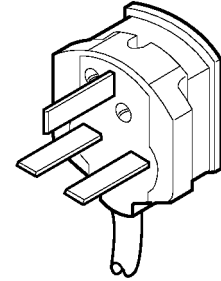
These batteries have a shelf life of about five years. Partial or total loss of stored settings upon power-up may indicate that you need to replace the batteries.



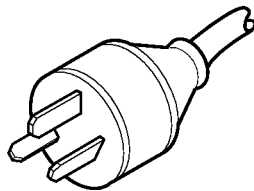
Standard*
North American
115V



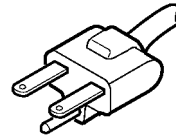
Option A1
Universal Euro
230V



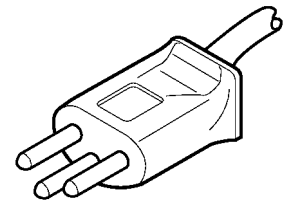
Option A2
UK
230V



Option A3
Australian
230V



Option A4*
North American
230V



Option A5
Switzerland
230V

** Canadian Standards Association certification
includes these power plugs for use in the
North American power network*

Figure 2-1: Power-Cord Plug Identification

Operating Environment

The following environmental requirements are provided to ensure proper operation and long oscilloscope life.

Operating Temperature

Operate the oscilloscope where the ambient air temperature is between 0° C and +50° C, and store the oscilloscope at an ambient temperature from –40° C to +75° C. After storage at temperatures outside the operating limits, allow the chassis to stabilize at a safe operating temperature before applying power.

Ventilation Requirements

The digitizing oscilloscope is cooled by air drawn in and exhausted through its cabinet side panels by an internal fan. To ensure proper cooling of the oscilloscope, allow at least two inches clearance on both sides and ¾ inch on the bottom of the digitizing oscilloscope. (The feet on the bottom of the oscilloscope provide the required clearance when set on flat surfaces.) The top of the oscilloscope does not require ventilation clearance.



If air flow is restricted, the power supply of the digitizing oscilloscope may temporarily shut down.

Applying and Interrupting Power

Consider the following information when you power up or power down the oscilloscope, or when power is interrupted due to an external power failure.

Power-Up

Upon power-up, the oscilloscope runs its power-on self check. If the self check passes, the oscilloscope displays a “passed” status message and a prompt to press CLEAR MENU to continue. If the self check fails, the oscilloscope displays a diagnostic log that identifies the area(s) that failed and a prompt to press CLEAR MENU to continue. See Section 6, *Maintenance*, for information on diagnostics and fault isolation.

Power-Down

CAUTION

DO NOT power down the oscilloscope when either running a signal path compensation or when doing any of the adjustments described in Section 5, Adjustment Procedures. To do so might result in the loss of internally stored adjustment constants.

In general, do not power down the oscilloscope when doing operations that affect the data types listed in Table 2-2. Wait for the oscilloscope to finish the operation when doing adjustments, saving waveforms, or saving setups. After operations complete, wait at least four more seconds before turning the power off.

Improper power-down or unexpected loss of power to the oscilloscope can result in corruption of non-volatile RAM (NVRAM). The following table describes the messages displayed when power is restored after an abnormal power-down.

Table 2-2: Effects of Corrupted Data

Corrupted Data Type	Results
<i>Adjustment Constants:</i>	
■ Signal Path Compensation	A signal path compensation is required.
■ Voltage Reference	A voltage reference adjustment is required (Section 5).
■ Low or High Frequency Response	A frequency response adjustment is required (Section 5).
■ Trigger Skew	A trigger skew adjustment is required (Section 5).
<i>Error Log</i>	Errors logged are lost.
<i>Reference Waveforms</i>	Waveforms Lost.
<i>Saved Setups</i>	Setups Lost.

Repackaging Instructions

Use a corrugated cardboard shipping carton having a test strength of at least 275 pounds and with an inside dimension at least six inches greater than the oscilloscope dimensions. (If available, use the original shipping carton, which meets these requirements.)

If the instrument is being shipped to a Tektronix Service Center, enclose the following information: the owner's address, the name and phone number of a contact person, the type and serial number of the oscilloscope, the reason for returning, and a complete description of the service required.

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

Mark the address of the Tektronix Service Center and also your own return address on the shipping carton in two prominent locations.

Installed Options

Your oscilloscope may be equipped with one or more options. Except for the line-cord options described by Table 2-1 (on page 2-3 of this section), all options and optional accessories are listed and described in Section 7, *Options*. For further information and prices of oscilloscope options, see your Tektronix Products catalog or contact your Tektronix Field Office.

Operating Information

Before doing service, read the following operating instructions. These instructions are at the level appropriate for servicing this digitizing oscilloscope. The complete operators instructions are found in the user manual.

Additional instructions are integrated into the service procedures found in later sections of this manual. For instance, the procedures found in the section *Performance Verification* contain instructions for making the front-panel settings required to check each oscilloscope characteristic included there. Also, the general instructions for operating the internal diagnostic routines are found in Section 6, *Maintenance*. You may also find the *Product Description* in Section 1 useful for understanding how the oscilloscope functions.

Screen Layout

The screen layout is illustrated in Figure 2-2 on page 2-8. Note that the figure illustrates a full graticule; you may also select a grid, crosshair, or frame graticule from the display menu.

Basic Procedures

How to Power Up

Push the principal power switch found on the rear panel of the digitizing oscilloscope, then push the **ON/STBY** (standby) switch to toggle the digitizing oscilloscope into operation. The switch at the rear panel is the true power disconnect switch. The **ON/STBY**(standby) switch simply toggles operation on and off.

WARNING

*The principal power switch at the rear panel is the true power disconnect switch. The **ON/STBY** (standby) switch simply toggles operation on and off. When connected to a power source and when the principal power switch is on, the some power supply circuitry in this digitizing oscilloscope is energized regardless of the setting of the **ON/STBY** switch.*

When connecting or disconnecting the line cord to or from the power source, the principal power switch should be off.

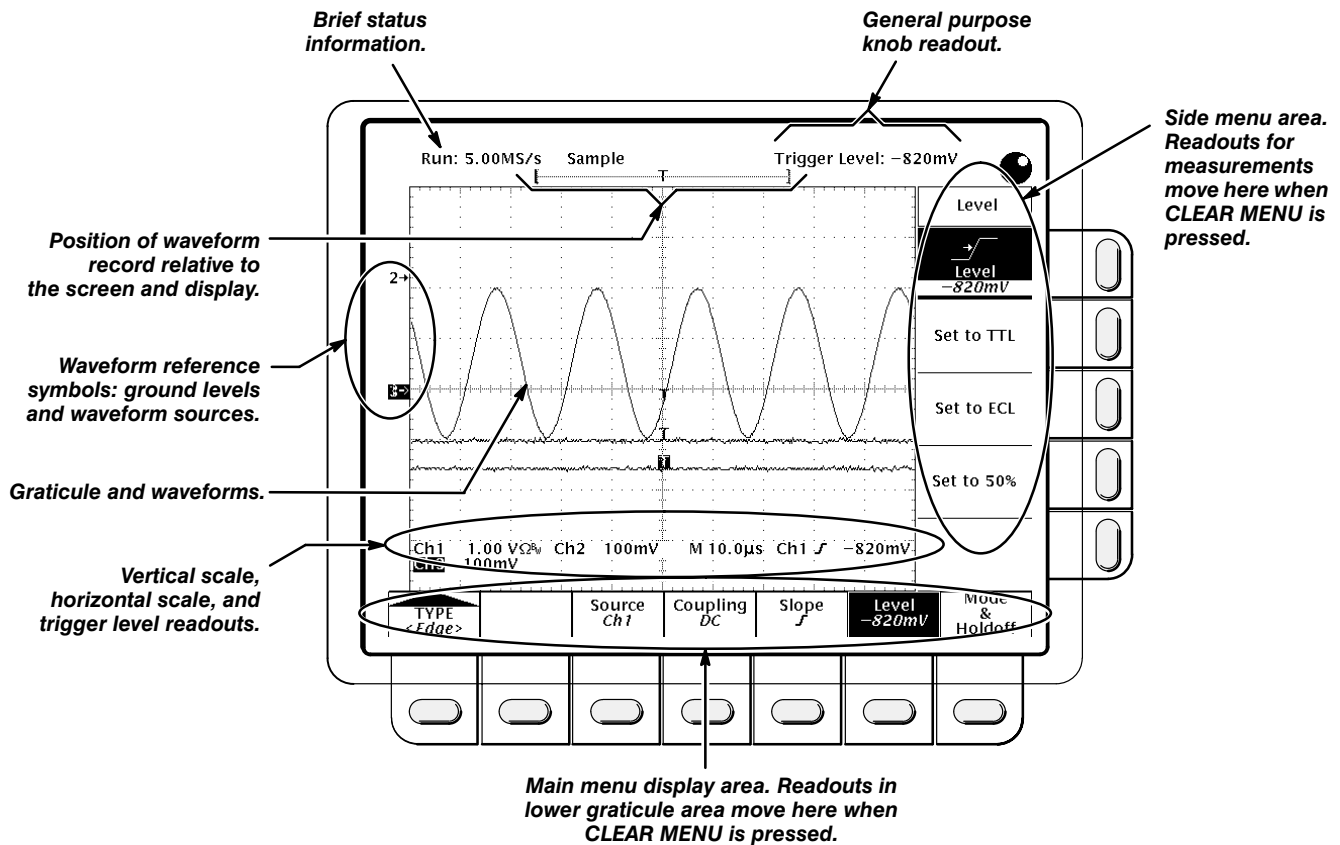


Figure 2-2: Map of Display Functions

How to Use Help

Push the **HELP** front-panel button to enter help mode. Front-panel knobs and buttons now display information about their function when turned or pushed. Push **HELP** again to exit help mode.

To get help information on a menu item, display the menu desired (if you are in help mode, exit help first). Push **HELP**. Now the menu buttons display information about their function when pushed.

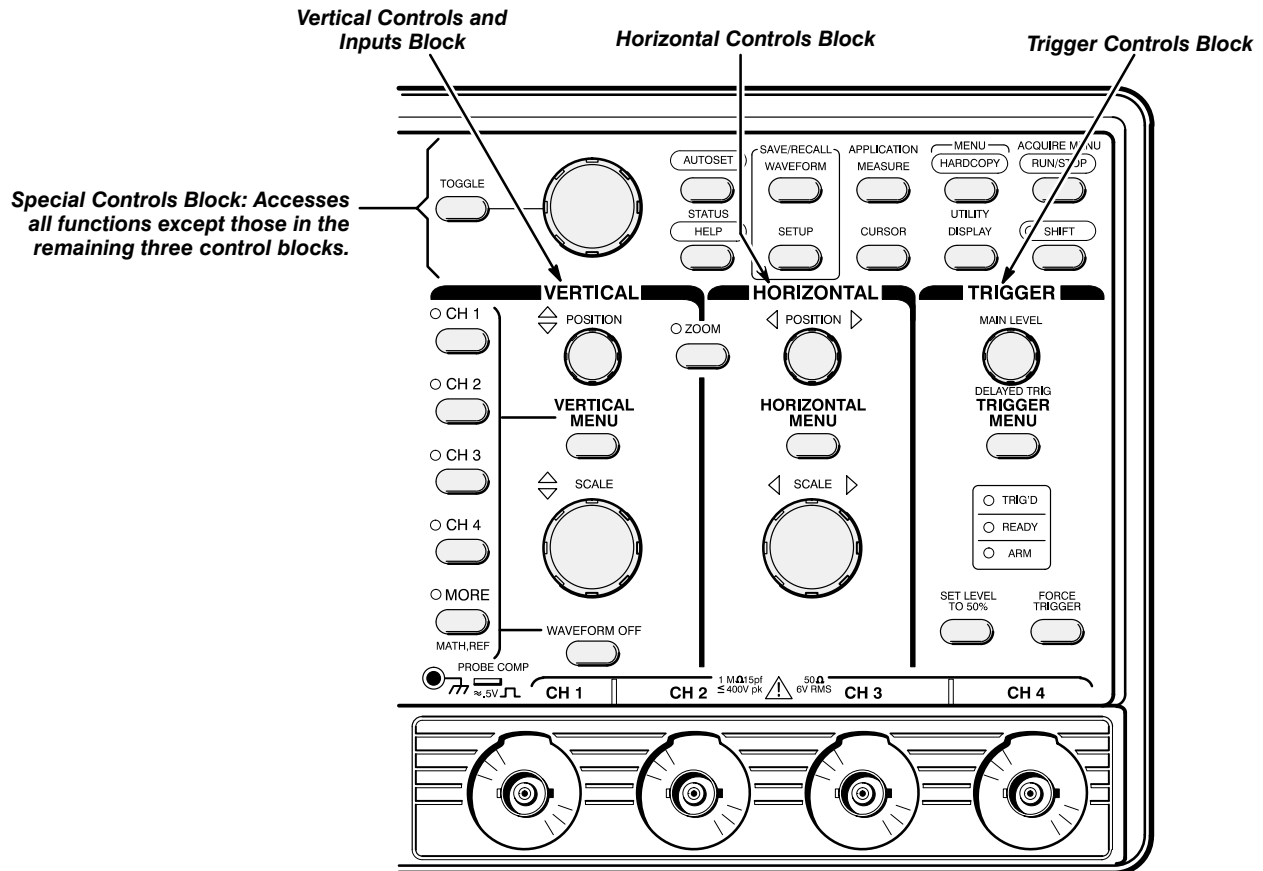
How to Use the Status Menu

Push the **SHIFT** button, and then press the **STATUS** front-panel button to display the status menu. The messages reflect the state of the acquisition system, whether it is running or stopped (and if it is stopped, why), as well as setup-related information.

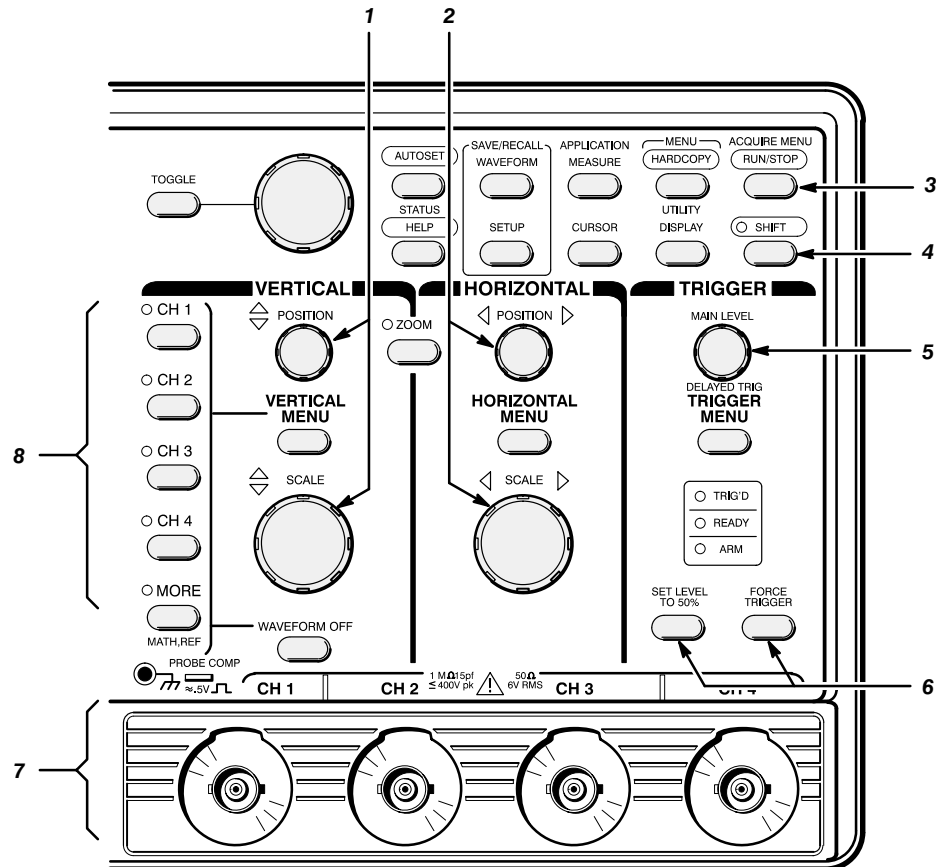
How to Set Functions

Most functions are set either by using one or two front-panel buttons or knobs, or by pushing a front-panel button to use a main menu, and then a side menu to set the function. The following steps illustrate both procedures.

1. Locate the block that contains the function to be set.

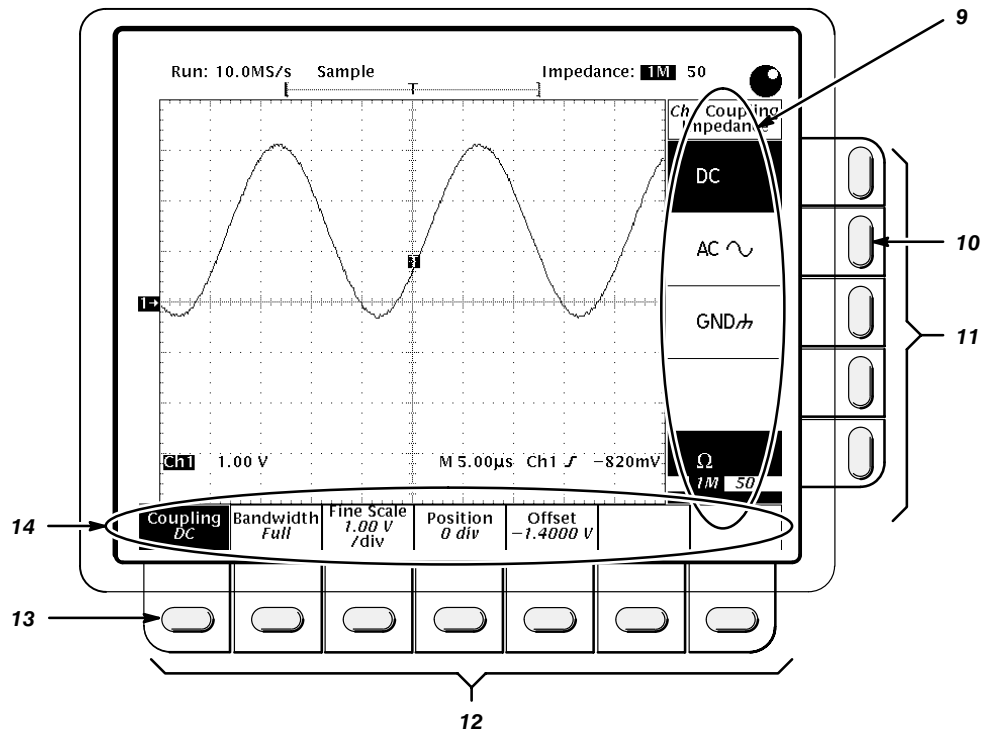


2. Select the waveform source(s). Position, scale, and set trigger level for waveform source(s) directly from the front-panel. (Note that parentheses-enclosed numbers appear within the following steps. Each number refers to the control(s) labeled with the same number in the figure that precedes the step.)



- a. Input waveforms into these channels (7). Example: **CH 1**.
- b. Push any channel button (8) to display its waveform. The last channel selected determines which waveform is positioned and scaled. The indicator above the channel last selected is lighted. Example: Push **CH 1**; then **CH 2**.
- c. Vertically (1) and horizontally (2) scale and position the waveform(s) selected. Example: Set the scale to 100 mV/div, and center the waveform on screen.
- d. Stop and start acquiring waveforms (3). Example: Push **RUN/STOP** if not acquiring.
- e. Adjust trigger level (5) to trigger the waveform(s) selected, or use these buttons (6) to either set a trigger level at the mid-amplitude level of the selected waveform or to force a single trigger. Example: Push **SET LEVEL TO 50%**.

3. Set all other functions using menus.
 - a. Choose the waveform source (8) first if setting a vertical function; else skip to step b. Example: Push **CH 2**.
 - b. Push **SHIFT** (4) if the function to be set is highlighted in blue; else skip to step c.



- c. Push the front-panel button that corresponds to the menu containing the function. A main menu (14) for selecting among related functions appears. Example: Push **VERTICAL MENU**.

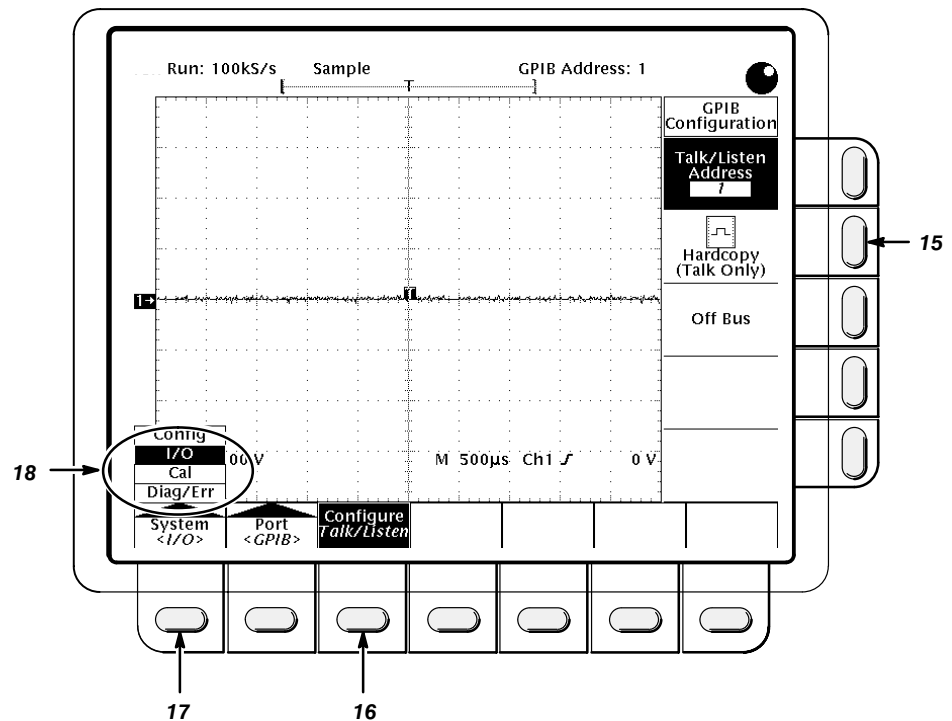
Note the two labels: the top label is a function to choose from; the bottom label tells you the current setting for that function. **Offset** is currently set to **-1.4 V**.

- d. Select a function from the main menu using the main menu buttons (12). A side menu for selecting among the available settings for that function appears. Example: Push **Coupling** (13).
- e. Select the setting for the function from the side menu (9) using the side menu buttons (11). Example: Push **AC** (10).

How to Set Complex Functions

A few functions require more than just two levels (main and side) of menus to completely specify their settings. In such cases, either the main menu, the side menu, or both are modified to supply additional choices. The procedures that follow show both schemes.

1. Set up a function using pop-up menus:

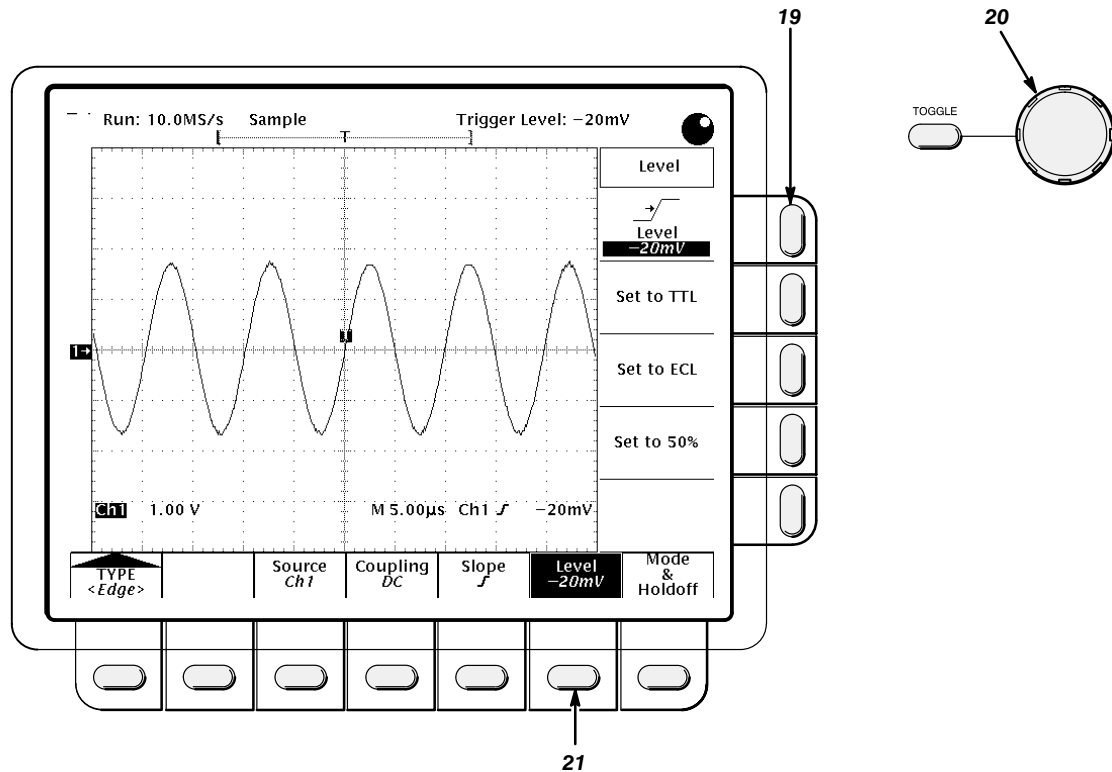


- a. For some selections, pushing a main menu button pops up a menu (18) of subfunctions. Example: Push **SHIFT**; then push **UTILITY**. Now push **System** (17).

Note the pop-up menu for **System** is set to **I/O** (input/output). All the main menu buttons to the right of the pop-up menu are labeled with subfunctions of **I/O**.

- b. Pushing the button that popped up the menu (17) toggles through the pop-up menu choices. Example: Repeatedly push **System** to toggle through the pop-up menu. Notice the other main-menu button labels change accordingly. Toggle back to **I/O**.
- c. Complete the setting of the desired mode by selecting from the main menu and the side menu that results. Example: Push **Configure** (16), and then push **Hardcopy (Talk only)** (15).

2. Set up a function using the general purpose knob (20). (The examples of possible menu selections in the substeps that follow assume you have pushed **TRIGGER MENU**.)



- a. Pushing some main menu buttons displays a side menu with labels containing readouts that you can vary. Example: Push **Level** (21).
- b. Pushing the side-menu button assigns the knob to control the readout appearing in the button label. It also copies the readout to the general purpose knob readout area in the right corner of the screen. Example: Push **Level** (19).
- c. Use the general purpose knob (20) to adjust the trigger level to the setting desired. Example: Turn the knob to **-20 mV**.

More About the General Purpose Knob — As you have just seen, the general purpose knob is used to extend the number of choices available to a side menu button. The general purpose knob can also be assigned to control the following functions:

- Cursor positioning
- Display intensities
- Delay time
- Number of events
- Trigger position

- Holdoff
- Offset
- Variable persistence

In all cases, the menus are used to select the function to which the general purpose knob is assigned. The following attributes apply to this knob:

- Depending on the function it is assigned to control, the general purpose knob varies numerical readouts, positions objects (cursors) on screen, or selects between icon-label settings that show up in side-menu labels.
- The general purpose knob has a readout area at the upper-right corner of the screen. (See Figure 2-2.) This readout always reflects the name and value of the function that the general purpose knob is currently controlling.
- The general purpose knob is affected by the **SHIFT** button. Pressing shift toggles the knob between its fine and coarse modes. Fine mode is used for most adjustments; coarse mode is used to traverse large parts of the adjustment range in less time.
- Whenever the general purpose knob assignment is changed, a knob icon appears immediately to the left of the general purpose knob readout to notify you of the assignment change. The icon is removed as soon as you use the general purpose knob to change the value of the function it is assigned to.
- To assign the general purpose knob to control a function, display the menu containing the function; then select the function. (Note that not all functions can be controlled by the general purpose knob.)
- Whenever the menu is removed, the general purpose knob is not assigned and does not control a function. (An exception is the cursor function. If cursors are turned on, removing the menu leaves the knob assigned to control the cursors until reassigned by selecting another menu and function that uses the knob.)
- The general purpose knob also has a **TOGGLE** button. The toggle button is used to toggle the knob between the control of either of the two cursors displayed when H-bar or V-bar cursors are turned on in the cursor menu.

Display and Utility Menus — Using the techniques described for using menus, you can access and change functions in the display menu and utilities menu. In the Display menu, you can set the following functions:

- Intensity: waveforms, readouts, graticule, etc.
- Style of waveform display(s): vectors or dots, intensified or non-intensified samples, and infinite or variable persistence.
- Display format: XY or YT.
- Graticule format: full, grid, crosshair, and frame.
- Waveform interpolation filter and readout options.

From the Utility menu, you can configure the GPIB port (talk/listen, address, etc.) and access internal routines for self diagnostics and self compensation. Instructions for setting up communication over the GPIB are found in Section 5, *Adjustment Procedures*.

Circuit Description

This section describes the electrical operation of the Tektronix TDS 410, TDS 420, & TDS 460 Digitizing Oscilloscopes using the major circuit blocks or modules.

This section has two main parts:

- **Logic Conventions** describes how logic functions are discussed and represented in this manual.
- **Module Overview** describes circuit operation from a functional-circuit block perspective.

Logic Conventions

The digitizing oscilloscope contains many digital logic circuits. This manual refers to these circuits with standard logic symbols and terms. Unless otherwise stated, all logic functions are described using the positive-logic convention: the more positive of the two logic levels is the high (1) state, and the more negative level is the low (0) state. Signal states may also be described as “true” meaning their active state or “false” meaning their non-active state. The specific voltages that constitute a high or low state vary among the electronic devices.

Active-low signals are indicated by a tilde prefixed to the signal name (~RESET). Signal names are either active-high, active-low, or have both active-high and active-low states.

Module Overview

This module overview describes the basic operation of each functional circuit block as shown in Figure 9-2.

General

The digitizing oscilloscope is a portable, multichannel instrument. Each channel provides a calibrated vertical scale factor. All channels can be acquired simultaneously.

Input Signal Path

A signal enters the oscilloscope through a probe connected to a BNC on the A05 Attenuator board.

Attenuators — Circuitry in the attenuator selects the input coupling, the termination, and the attenuation factor. The processor system controls the attenuators. For example, if 50 Ω input termination is selected and the input is overloaded, the processor system switches the input to the 1 M Ω position. The preamplifier in the A05 Attenuator amplifies the input signals.

Probe Coding Interface — Probe coding interface signals pass through the A06 Front Panel to the processor system which in turn controls the A05 Attenuator and the A04 Acquisition boards.

Jumper — Signals from the attenuators pass through the A08 Jumper board to the acquisition system.

Acquisition System — The acquisition system converts the input signals to digital signals and controls the acquisition process under direction of the processor system. The acquisition system includes the trigger, acquisition timing, and acquisition mode generation and control circuitry.

D1 Bus — The acquisition system passes the digital values representing the acquired waveform through the D1 bus to the A09 DSP board (TriStar). This happens after a waveform acquisition is complete if the digital signal processor (DSP) requests the waveform.

Processor System — The processor system consists of a 68020 micro-processor that controls the entire instrument. It includes the firmware program for the oscilloscope. The firmware can be reprogrammed by using the GPIB and an external software package. The processor system also includes a GPIB interface.

DSP — The digital signal processor processes each waveform as directed by software downloaded from the system processor. Waveforms and any text to be displayed are passed on to the A02 Display board.

Display — Text and waveforms are processed by different parts of the A02 Display circuitry. The display sends the text and waveform information to the A26 Monitor assembly as a video signal. The display circuitry also generates and sends vertical (VSYNC) and horizontal (HSYNC) sync signals to the A26 Monitor assembly. A VGA-compatible video output is available at the rear of the instrument.

Monitor Assembly

All information (waveforms, text, graticules, and pictographs) is displayed by the A20 CRT Driver. The driver generates the high voltages necessary to drive the CRT. It also contains the video amplifier, horizontal oscillator, and the vertical and horizontal yoke driver circuitry. The monitor gets its supply voltages from the A25 Low Voltage Power Supply through the A01 Back-plane and the A07 Auxiliary Power boards.

Front Panel

The processor system sends instructions to and receives information from the Front Panel Processor on the A06 Front Panel board. The Front Panel Processor reads the front-panel switches and pots. Any changes in their settings are reported to the processor system. The Front Panel Processor also turns the LEDs on and off, generates the bell signal, and generates the probe compensation signal PROBE ADJ. The Front Panel Processor also processes the probe coding interface signals.

Menu Switches — Front-panel menu switches are also read by the Front Panel Processor. The processor sends any changes in menu selections to the processor system.

ON/STBY Switch — This switch is not read by the Front Panel Processor. The signal passes through the A06 Front Panel board, the A03 CPU board, and the A01 Backplane board to the low voltage power supply.

Rear Panel

The GPIB connector provides access to stored waveforms and allows external control of the oscilloscope. Other connectors accessible from the rear panel are the AUX TRIGGER and VIDEO.

Aux Power

The A07 Auxiliary Power circuitry includes the principal power switch, fuse, line trigger transformer, and line filter. It also distributes power to the monitor and fan.

Low Voltage Power Supply

The low voltage power supply is a switching power converter. It supplies power to all oscilloscope circuitry. The low voltage power supply sends all of its power to the A01 Backplane where it is distributed to all other circuitry.

The principal POWER switch, located on the rear panel, controls all power to the oscilloscope including the low voltage power supply. The ON/STBY switch, located on the front panel, also controls all of the power to the oscilloscope except for part of the circuitry in the low voltage power supply.

Fan

The fan provides forced air cooling for the oscilloscope. It connects to +12 V on the A01 Backplane through the A07 Auxiliary Power board.

Brief Procedures

The *Self Tests* use internal routines to confirm basic functionality and proper adjustment. No test equipment is required to do these test procedures.

The *Functional Tests* utilize the probe-adjust output at the front panel as a test-signal source for further verifying that the oscilloscope functions properly. A standard-accessory probe, included with this oscilloscope, is the only equipment required.

General Instructions

These procedures verify the TDS 400 Digitizing Oscilloscopes.

Besides the *Brief Procedures*, the set of procedures that can be used to verify oscilloscope performance includes the *Performance Tests* found later in this section. You may not need to perform all of these procedures, depending on what you want to accomplish:

- To rapidly confirm that this oscilloscope functions and is adjusted properly, just do the procedures under *Self Tests*, which begin on page 4-4.

Advantages: These procedures are quick to do, require no external equipment or signal sources, and perform extensive functional and accuracy testing to provide high confidence that the oscilloscope will perform properly. Use these procedures as a quick check before making a series of important measurements.

- To further check functionality, first do the *Self Tests* just mentioned; then do the procedures under *Functional Tests* that begin on page 4-6.

Advantages: These procedures require minimal additional time to perform, require no additional equipment other than a standard-accessory probe, and more completely test the internal hardware of this oscilloscope. Use these procedures to quickly determine if the oscilloscope is suitable for putting into service, such as when it is first received.

- If more extensive confirmation of performance is desired, do the *Performance Tests*, beginning on page 4-13, after doing the *Functional and Self Tests* just referenced.

Advantages: These procedures add direct checking of warranted specifications. They require more time to perform and suitable test equipment is required. (See *Equipment Required* on page 4-13.)

If you are not familiar with operating this oscilloscope, read *General Operating Instructions* in Section 3 of this manual. These instructions will acquaint you with the use of the front-panel controls and the menu system.

Conventions

Throughout these procedures the following conventions apply:

- Each test procedure uses the following general format:

Title of Test

Equipment Required

Prerequisites

Procedure

- Each procedure consists of as many steps, substeps, and subparts as required to do the test. Steps, substeps, and subparts are sequenced as follows:

1. First Step

- a. First Substep

- First Subpart
- Second Subpart

- b. Second Substep

2. Second Step

- In steps and substeps, the lead-in statement in italics instructs you what to do, while the instructions that follow tell you how to do it: in the example step below, “*Initialize the oscilloscope*” by doing “Press save/recall **SETUP**. Now, press the main-menu button...”

Initialize the oscilloscope: Press save/recall **SETUP**. Now, press the main-menu button **Recall Factory Setup**; then the side-menu button **OK Confirm Factory Init**.

- Where instructed to use a front-panel button or knob, or select from a main or side menu, or verify a readout or status message, the name of the button or knob appears in boldface type: “press **SHIFT**; then **ACQUIRE MENU**,” “press the main-menu button **Coupling**,” or “verify that the status message is **Pass**.”



The symbol at the left is accompanied by information you must read to do the procedure properly.

- Refer to Figure 4-1: "Main menu" refers to the menu that labels the seven menu buttons under the display; "side menu" refers to the menu that labels the five buttons to the right of the display.

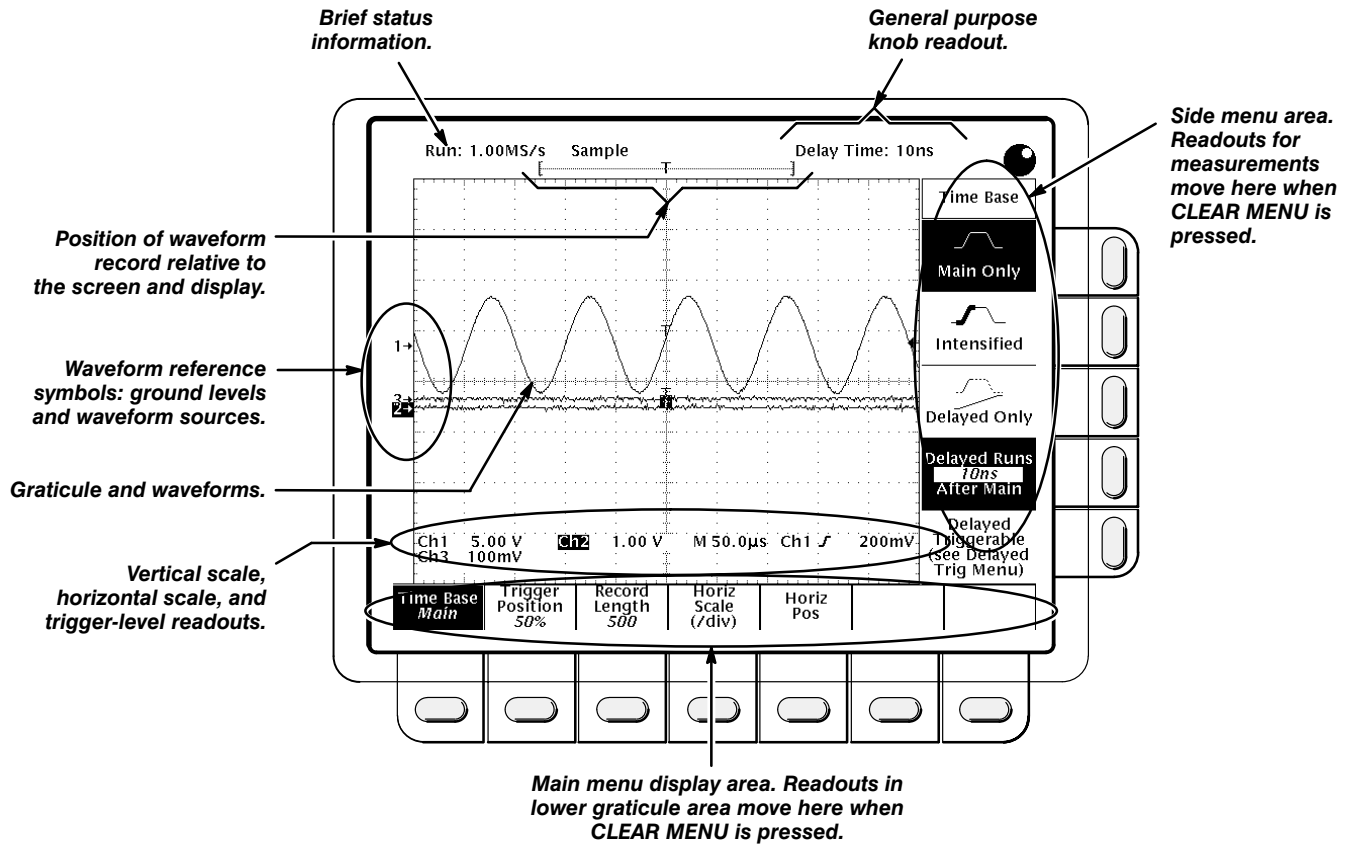


Figure 4-1: Map of Display Functions

Self Tests

This procedure uses internal routines to verify that this oscilloscope functions and passes its internal self tests and signal path compensations. It also confirms that the oscilloscope was adjusted properly at the time it was last adjusted. No test equipment or hookups are required.

Verify Internal Adjustment, Self Compensation, and Diagnostics

Equipment Required: None.

Prerequisites: Power on the digitizing oscilloscope and allow a 20 minute warm-up before doing this procedure.

Procedure:

1. *Verify that internal diagnostics pass:* Do the following substeps to verify that the internal diagnostics passed.
 - a. *Display the system diagnostics menu:*
 - Press **SHIFT**; then press **UTILITY**.
 - Repeatedly press the main-menu button **System** until **Diag/Err** is highlighted in the menu that pops up.
 - Repeatedly press the main-menu button **Area** until **All** is highlighted in the menu that pops up.
 - b. *Run the system diagnostics:* Press the main-menu button **Execute**; then press the side-menu button **OK Confirm Run Test**.
 - c. *Wait:* The internal diagnostics do an exhaustive verification of proper oscilloscope function. This verification takes up to a minute. While it progresses, a variety of test patterns flash on screen. When finished, the resulting status appears on the screen.
 - d. *Confirm no failures are found:* Verify that no failures are found and reported on-screen.
 - e. *Confirm the four adjustment sections have passed status:*
 - Press **SHIFT**; then press **UTILITY**.
 - Press the main menu button **System** until **Cal** is highlighted in the pop-up menu.
 - Verify that the word **Pass** appears in the main menu under the following menu labels: **Voltage Reference**, **High Frequency Response**, **Low Frequency Response**, and **Trigger Skew**. (See Figure 4-2.)

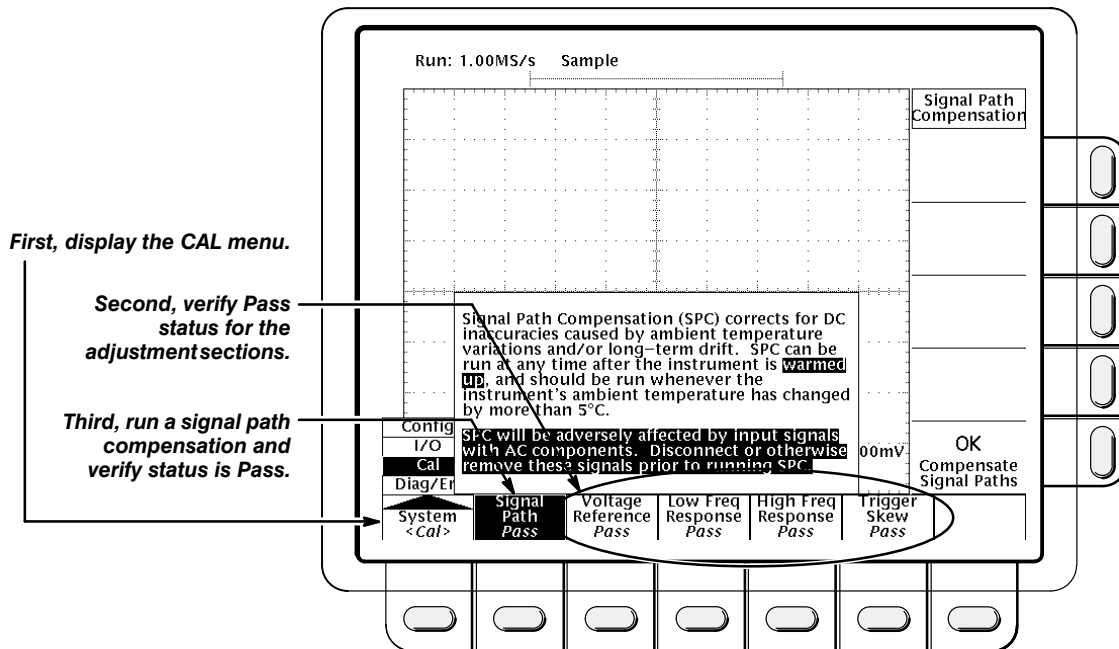


Figure 4-2: Verifying Adjustments and Signal Path Compensation

This oscilloscope lets you compensate the internal signal path used to acquire the waveforms you acquire and measure. By executing the signal path compensation feature (SPC), you optimize the oscilloscope capability to make accurate measurements based on the ambient temperature.

You *must* run an SPC anytime you wish to ensure that the measurements you make are made with the most accuracy possible. You should also run an SPC if the temperature has changed more than 5°C since the last SPC was performed.

- f. *Run the signal path compensation:* Disconnect all input signals. Press the main-menu button **Signal Path**; then press the side-menu button **OK Compensate Signal Paths**.

NOTE

Failure to run the signal path compensation may result in the oscilloscope not meeting warranted performance levels.



- g. *Wait:* signal path compensation runs in one to three minutes. While it progresses, a “clock” icon (shown at left) displays on-screen. When compensation completes, the status message updates to **Pass** or **Fail** in the main menu (see step h).
- h. *Confirm signal path compensation returns passed status:* Verify the word **Pass** appears under **Signal Path** in the main menu. (See Figure 4-2.)

2. *Return to regular service:* Press **CLEAR MENU** to exit the system menus.

Functional Tests

The purpose of these procedures is to confirm that this oscilloscope functions properly. The only equipment required is one of the standard-accessory probes.



These procedures verify functions; that is, they verify that oscilloscope features *operate*. They do *not* verify that they operate within limits.

Therefore, when the instructions in the functional tests that follow call for you to verify that a signal appears on-screen “that is about five divisions in amplitude” or “has a period of about six horizontal divisions,” etc., do **NOT** interpret the quantities given as limits. Operation within limits is checked in *Performance Tests*, which begin on page 4-13.



DO NOT make changes to the front-panel settings that are not called out in the procedures. Each verification procedure will require you to set the oscilloscope to certain default settings before verifying functions. If you make changes to these settings, other than those called out in the procedure, you may obtain invalid results. In this case, just redo the procedure from step 1.

When you are instructed to press a menu button, the button may already be selected (its label will be highlighted). If this is the case, it is not necessary to press the button.

Verify All Input Channels

Equipment Required: One P6138 probe.

Prerequisites: None.

Procedure:

1. *Install the test hookup and preset the oscilloscope controls:*

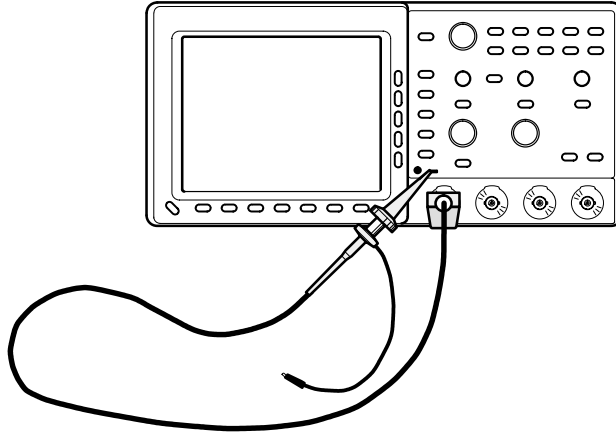


Figure 4-3: Universal Test Hookup for Functional Tests

- a. *Hook up the signal source:* Install the probe on **CH 1**. Connect the probe tip to **PROBE ADJ** on the front panel; leave the probe ground unconnected.
- b. *Initialize the oscilloscope:*
 - Press save/recall **SETUP**.
 - Press the main-menu button **Recall Factory Setup**.
 - Press the side-menu button **OK Confirm Factory Init**.
2. *Verify that all input channels operate:* Do the following substeps—test CH 1 first, *skipping substep a since CH 1 is already set up for verification from step 1*.
 - a. *Select an unverified channel:*
 - Press **WAVEFORM OFF** to remove from display the channel just verified.
 - Press the front-panel button that corresponds to the channel you are to verify.
 - Move the probe to the channel you selected.
 - b. *Set up the selected channel:*
 - Press **AUTOSET** to obtain a viewable, triggered display in the selected channel.
 - Set the vertical **SCALE** to 100 mV. Use the vertical **POSITION** knob to center the waveform vertically on screen.
 - Set the horizontal **SCALE** to 200 μ s.
 - Press **TRIGGER MENU**.
 - Press the main-menu button **Coupling**; then press the side menu-button **HF Rej**.

- c. *Verify that the channel is operational:* Confirm that the following statements are true.
- The vertical scale readout for the channel under test shows a setting of 100 mV, and a square-wave probe-compensation signal about five divisions in amplitude is on-screen. (See Figure 4-1 on page 4-3 to locate the readout.)
 - The vertical **POSITION** knob moves the signal up and down the screen when rotated.
 - Turning the vertical **SCALE** knob counterclockwise decreases the amplitude of the waveform on-screen, turning the knob clockwise increases the amplitude, and returning the knob to 100 mV returns the amplitude to about five divisions.
- d. *Verify that the channel acquires in all acquisition modes:* Press **SHIFT**; then press **ACQUIRE MENU**. Use the side menu to select, in turn, each of the five hardware acquire modes and confirm that the following statements are true. Refer to the icons at the left of each statement as you confirm those statements.



- **Sample** mode displays an actively acquiring waveform on-screen. (Note that there is noise present on the peaks of the square wave.)



- **Peak Detect** mode displays an actively acquiring waveform on-screen with the noise present in Sample mode “peak detected.”



- **Hi Res** mode displays an actively acquiring waveform on-screen with the noise that was present in Sample mode reduced.



- **Envelope** mode displays an actively acquiring waveform on-screen with the noise displayed.



- **Average** mode displays an actively acquiring waveform on-screen with the noise reduced like in Hi Res mode.

- e. *Test all channels:* Repeat substeps a through d until all input channels are verified.

3. *Remove the test hookup:* Disconnect the probe from the channel input and the probe-adjust terminal.

Verify the Time Base

Equipment Required: One P6138 probe.

Prerequisites: None.

Procedure:

1. *Install the test hookup and preset the oscilloscope controls:*
 - a. *Hook up the signal source:* Install the probe on **CH 1**. Connect the probe tip to **PROBE ADJ** on the front panel; leave the probe ground unconnected. (See Figure 4-3 on page 4-7.)

- b. *Initialize the oscilloscope:*
 - Press save/recall **SETUP**.
 - Press the main-menu button **Recall Factory Setup**; then press the side-menu button **OK Confirm Factory Init**.
 - c. *Modify default settings:*
 - Press **AUTOSET** to obtain a viewable, triggered display.
 - Set the horizontal **SCALE** to 200 μ s.
 - Press **VERTICAL MENU**.
 - Press the main-menu button **Bandwidth**. Then press the side-menu button **20 MHz**.
 - Press **CLEAR MENU** to remove the vertical menu from the screen.
2. *Verify that the time base operates:* Confirm the following statements.
 - a. One period of the square-wave probe-compensation signal is about five horizontal divisions on-screen for the 200 μ s horizontal scale setting (set in step 1c).
 - b. Rotating the horizontal **SCALE** knob clockwise expands the waveform on-screen (more horizontal divisions per waveform period), and that counterclockwise rotation contracts it, and that returning the horizontal scale to 200 μ s returns the period to about five divisions.
 - c. The horizontal **POSITION** knob positions the signal left and right on-screen when rotated.
 3. *Remove the test hookup:* Disconnect the probe from the channel input and the probe-adjust terminal.

Verify the Main and Delayed Trigger Systems

Equipment Required: One P6138 probe.

Prerequisites: None.

Procedure:

1. *Install the test hookup and preset the oscilloscope controls:*
 - a. *Hook up the signal source:* Install the probe on **CH 1**. Connect the probe tip to **PROBE ADJ** on the front panel; leave the probe ground unconnected. (See Figure 4-3 on page 4-7.)
 - b. *Initialize the oscilloscope:*
 - Press save/recall **SETUP**.
 - Press the main-menu button **Recall Factory Setup**.
 - Press the side-menu button **OK Confirm Factory Init**.
 - c. *Modify default settings:*

- Press **AUTOSET** to obtain a viewable, triggered display.
 - Set the horizontal **SCALE** for the **M** (main) time base to 200 μ s.
 - Press **VERTICAL MENU**.
 - Press the main-menu button **Bandwidth**. Then press the side-menu button **20 MHz**.
 - Press **TRIGGER MENU**.
 - Press the main-menu button **Mode & Holdoff**.
 - Press the side-menu button **Normal**.
 - Press **CLEAR MENU** to remove the menus from the screen.
2. *Verify that the main trigger system operates:* Confirm that the following statements are true.
- The trigger-level readout for the main trigger system changes with the trigger **MAIN LEVEL** knob.
 - The trigger-level knob can trigger and untrigger the square-wave signal as you rotate it. (Leave the signal *untriggered*.)
 - Pressing **SET LEVEL TO 50%** triggers the signal that you just left untriggered. (Leave the signal triggered.)
3. *Verify that the delayed trigger system operates:*
- a. *Select the delayed time base:*
- Press **HORIZONTAL MENU**.
 - Press the main-menu button **Time Base**.
 - Press the side-menu button **Delayed Triggerable**; then press the side-menu button **Delayed Only**.
 - Set the horizontal **SCALE** for the **D** (delayed) time base to 200 μ s.
- b. *Select the delayed trigger-level menu:*
- Press **SHIFT**; then press **DELAYED TRIG**.
 - Press the main-menu button **Level**; then press the side-menu button **Level**.
- c. *Confirm that the following statements are true:*
- The trigger-level readout for the delayed trigger system changes with the general purpose knob.
 - The general purpose knob can trigger and untrigger the square-wave probe-compensation signal as you rotate it. (Leave the signal *untriggered*.)
 - Pressing the side-menu button **Set to 50%** triggers the probe-compensation signal that you just left untriggered. (Leave the signal triggered.)

- d. *Verify the delayed trigger counter:*
 - Press the main-menu button **Delay by Time**.
 - Press the side-menu button **Events**, just below the **Triggerable after Time** selection.
 - Use the General Purpose knob to enter an event count of 325 events.
 - Verify that the trigger **READY** indicator on the front panel flashes about once every second as the waveform is updated on-screen.
4. *Remove the test hookup:* Disconnect the standard-accessory probe from the channel input and the probe-adjust terminal.

Performance Tests

This subsection contains a collection of procedures for checking that the TDS 400 Digitizing Oscilloscopes perform as warranted.

The procedures are arranged in four logical groupings: *Signal Acquisition System Checks*, *Time Base System Checks*, *Triggering System Checks*, and *Output Ports Checks*. They check all the characteristics that are designated as checked in Section 1, *Specification*. (The characteristics that are checked appear in **boldface** type under *Warranted Characteristics* in Section 1.) You can use form at the end of this section as a test record.



These procedures *extend* the confidence level provided by the basic procedures described on page 4-1. The basic procedures should be done first, then these procedures performed if desired.

Prerequisites

The tests in this subsection comprise an extensive, valid confirmation of performance and functionality when the following requirements are met:

- The cabinet must be installed on the digitizing oscilloscope.
- You must have performed and passed the procedures under *Self Tests*, found on page 4-4, and those under *Functional Tests*, found on page 4-6.
- A signal-path compensation *must* have been done within the recommended calibration interval and at a temperature within $\pm 5^{\circ}$ C of the present operating temperature. (If at the time you did the prerequisite *Self Tests*, the temperature was within the limits just stated, consider this prerequisite met.)
- The digitizing oscilloscope must have been last adjusted at an ambient temperature between $+20^{\circ}$ C and $+30^{\circ}$ C, must have been operating for a warm-up period of at least 20 minutes, and must be operating at an ambient temperature between 0° C and $+50^{\circ}$ C. (The warm-up requirement is usually met in the course of meeting the first prerequisite listed above.)

Related Information—Read *General Instructions* and *Conventions* that start on page 4-1. Also, if you are not familiar with operating this digitizing oscilloscope, read *General Operating Instructions* in Section 2 of this service manual before doing any of these procedures.

Equipment Required

These procedures use external, traceable signal sources to directly check warranted characteristics. The required equipment list follows this introduction.

Table 4-1: Test Equipment

Item Number and Description	Minimum Requirements	Example	Purpose
1 Attenuator, 10X (two required)	Ratio: 10X; impedance 50 Ω ; connectors: female BNC input, male BNC output	Tektronix part number 011-0059-02	Signal attenuation
2 Attenuator, 5X (two required)	Ratio: 5X; impedance 50 Ω ; connectors: female BNC input, male BNC output	Tektronix part number 011-0060-02	Signal attenuation
3 Termination, 50 Ω	Impedance 50 Ω ; connectors: female BNC input, male BNC output	Tektronix part number 011-0049-01	Checking delay match between channels
4 Termination, 75 Ω	Impedance 75 Ω ; connectors: female BNC input, male BNC output	Tektronix part number 011-0102-01	Used to test Video Option 05 equipped instruments only
5 Cable, Precision Coaxial (three required)	50 Ω , 36 in, male to male BNC connectors	Tektronix part number 012-0482-00	Signal interconnection
6 Cable, Coaxial	75 Ω , 36 in, male to male BNC connectors	Tektronix part number 012-1338-00	Used to test Video Option 05 equipped instruments only
7 Connector, Dual-Banana (two required)	Female BNC to dual banana	Tektronix part number 103-0090-00	Various accuracy tests
8 Connector, BNC "T"	Male BNC to dual female BNC	Tektronix part number 103-0030-00	Checking trigger sensitivity
9 Coupler, Dual-Input	Female BNC to dual male BNC	Tektronix part number 067-0525-02	Checking delay match between channels
10 Generator, DC Calibration	Variable amplitude to ± 110 V; accuracy to 0.1%	Data Precision 8200, with 1 kV option installed	Checking DC offset and measurement accuracy
11 Generator, Leveled Sine Wave, Medium Frequency	200 kHz to 250 MHz; Variable amplitude from 5 mV to 4 V p-p into 50 Ω	TEKTRONIX SG 503 Leveled Sine Wave Generator ¹	Checking analog bandwidth and trigger sensitivity at low frequencies
12 Generator, Leveled Sine Wave, High Frequency	250 MHz to 500 MHz; Variable amplitude from 5 mV to 4 V p-p into 50 Ω ; 6 MHz reference	TEKTRONIX SG 504 Leveled Sine Wave Generator ¹ with SG 504 Output Head	Checking analog bandwidth and trigger sensitivity at high frequencies

¹Requires a TM 500 or TM 5000 Series Power Module Mainframe.

Table 4-1: Test Equipment (Cont.)

Item Number and Description	Minimum Requirements	Example	Purpose
13 Generator, Time Mark	Variable marker frequency from 10 ms to 10 ns; accuracy within 2 ppm	TEKTRONIX TG 501 Time Mark Generator ¹	Checking sample-rate and delay-time accuracy
14 Probe, 10X, included with this instrument	A P6138 probe	Tektronix number P6138	Signal interconnection
15 Generator, Video Signal	Provides NTSC compatible outputs	TEKTRONIX TSG 1001	Checking video trigger sensitivity

¹Requires a TM 500 or TM 5000 Series Power Module Mainframe.

Test Record

Photocopy the next two pages and use them to record the performance test results for your instrument.

TDS 410, TDS 420, & TDS 460 Test Record

Instrument Serial Number: _____	Certificate Number: _____
Temperature: _____	RH %: _____
Date of Calibration: _____	Technician: _____

Performance Test		Minimum	Incoming	Outgoing	Maximum
Offset Accuracy					
CH1 Offset	+1 V	995 mV	_____	_____	+1.005 V
	+10 V	9.935 V	_____	_____	+10.065 V
	+99.9 V	99.2505 V	_____	_____	+100.5495 V
CH2 Offset	+1 V	995 mV	_____	_____	+1.005 V
	+10 V	9.935 V	_____	_____	+10.065 V
	+99.9 V	99.2505 V	_____	_____	+100.5495 V
CH3 Offset (TDS 420 & TDS 460)	+1 V	995 mV	_____	_____	+1.005 V
	+10 V	9.935 V	_____	_____	+10.065 V
	+99.9 V	99.2505 V	_____	_____	+100.5495 V
CH4 Offset (TDS 420 & TDS 460)	+1 V	995 mV	_____	_____	+1.005 V
	+10 V	9.935 V	_____	_____	+10.065 V
	+99.9 V	99.2505 V	_____	_____	+100.5495 V
DC Voltage Measurement Accuracy (Averaged)					
CH1	100 mV	-20.8 mV	_____	_____	+20.8 mV
CH2	100 mV	-20.8 mV	_____	_____	+20.8 mV
CH3	100 mV (TDS 420/460)	-20.8 mV	_____	_____	+20.8 mV
CH4	100 mV (TDS 420/460)	-20.8 mV	_____	_____	+20.8 mV
Analog Bandwidth					
CH1	100 mV	424 mV	_____	_____	N/A
CH2	100 mV	424 mV	_____	_____	N/A
CH3	100 mV (TDS 420/460)	424 mV	_____	_____	N/A
CH4	100 mV (TDS 420/460)	424 mV	_____	_____	N/A
Delay Between Channels					
Delay Between Channels		N/A	_____	_____	450 ps
Time Base System					
Long Term Sample Rate/ Delay Time @ 500 ns/10 ms		-3.0 Div	_____	_____	+3.0 Div
Delta Time @ 5 ns (100 MHz)		49.592 ns	_____	_____	50.408 ns

TDS 410, TDS 420, & TDS 460 Test Record (Cont.)

Performance Test	Minimum	Incoming	Outgoing	Maximum
Trigger System (DC Coupled Threshold)				
Main Trigger	-18 mV	_____	_____	+18 mV
Main Trigger – Falling	-18 mV	_____	_____	+18 mV
Delayed Trigger	-18 mV	_____	_____	+18 mV
Delayed Trigger – Falling	-18 mV	_____	_____	+18 mV
Probe Compensator Output Signal				
Frequency	950 Hz	_____	_____	1050 Hz
Voltage	475 mV	_____	_____	525 mV

Signal Acquisition System Checks

These procedures check those characteristics that relate to the signal-acquisition system and are listed as checked under *Warranted Characteristics* in Section 1, *Specification*.

Check Offset Accuracy

Equipment Required: Two dual-banana connectors (Item 7), one BNC T connector (Item 8), one DC calibration generator (Item 10), and two precision coaxial cables (Item 5).

Prerequisites: The oscilloscope must meet the prerequisites listed on page 4-13.

1. *Install the test hookup and preset the instrument controls:*

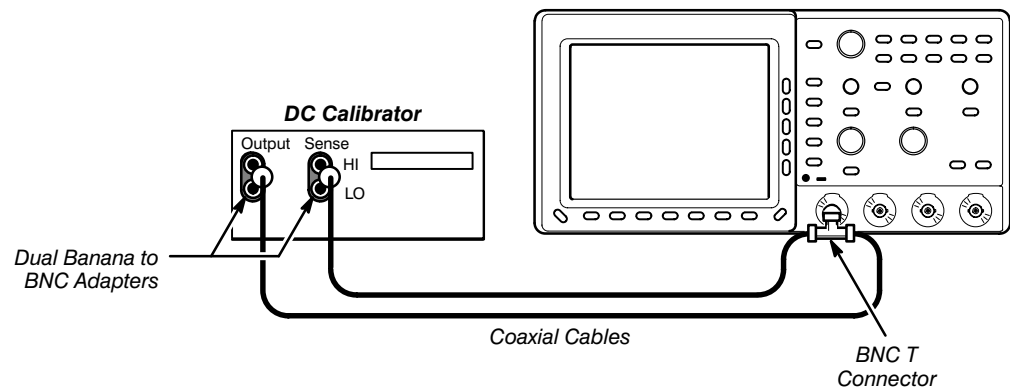


Figure 4-4: Initial Test Hookup

- a. *Hook up the test-signal source:*
 - Set the output of a DC calibration generator to 0 volts.
 - Connect the output of a DC calibration generator through a dual-banana connector followed by a 50 Ω precision coaxial cable to one side of a BNC T connector.
 - Connect the Sense output of the generator through a second dual-banana connector followed by a 50 Ω precision coaxial cable to the other side of the BNC T connector. Now connect the BNC T connector to **CH 1**.
- b. *Initialize the oscilloscope:*
 - Press save/recall **SETUP**.
 - Press the main-menu button **Recall Factory Setup**.
 - Press the side-menu button **OK Confirm Factory Init**.
- c. *Modify the default settings:*
 - Set the horizontal **SCALE** to 1 ms.

- Press **SHIFT**; then **ACQUIRE MENU**.
 - Press the main-menu button **Mode**; then press the side-menu button **Hi Res**.
 - Press **DISPLAY**.
 - Press the main-menu button **Graticule**; then press the side-menu button **Frame**.
 - Press **MEASURE**.
 - Press the main-menu button **Select Measurement for CHx**; then press the side-menu button **Mean**. (You will have to press **MORE** several times to access the **Mean** measurement.)
 - Press **CLEAR MENU**.
2. *Confirm input channels are within limits for offset accuracy: Do the following substeps—test CH 1 first, skipping substep a since CH 1 is already set up to be checked from step 1.*

WARNING

High voltages are used in this procedure. Before doing this or any other procedure in this manual, read the Safety Summary found at the beginning of this manual.

a. *Select an unchecked channel:*

- Press **WAVEFORM OFF** to remove the channel just confirmed from the display. Then, press the front-panel button that corresponds to the channel you are to confirm.
- Press **MEASURE**.
- Press the main-menu button **Select Measurement for CHx**; then press the side-menu button **Mean**. (You will have to press **MORE** several times to access the **Mean** measurement.)

Table 4-2: DC Offset Accuracy

Vertical Scale Setting	Vertical Position	Offset Setting	Generator Setting	Offset Accuracy Limits
1 mV	0	+1 V	+1 V	±5 mV
100 mV	0	+10 V	+10 V	±65 mV
1 V	0	+99.9 V	+99.9 V	±649.5 mV

- b. *Set the vertical scale:* Set the vertical **SCALE** to one of the settings listed in Table 4-2 that is not yet checked. (Start with the first setting listed.)
 - c. *Set the offset:* Press the **VERTICAL MENU** button and then the **Offset** main-menu button. Using the **General Purpose** knob, set the offset as dictated by Table 4-2. (Start with the first setting listed.)
 - d. *Set the generator:* Set the DC calibration generator to match the vertical scale as dictated by Table 4-2. (Start with the first setting listed.)
 - e. *Check against limits:* Do the following subparts in the order listed.
 - Subtract the measured mean from the generator setting. The result is the offset accuracy
 - CHECK that the offset accuracy is within the limits listed for the current vertical scale setting.
 - Repeat substeps b through e until all vertical scale settings listed in Table 4-2 are checked for the channel under test.
 - f. *Test all channels:* Repeat substeps a through e for all input channels.
3. *Disconnect the hookup:*
 - a. *Set the generator output to 0 V.*
 - b. Then disconnect the cable from the generator output at the input connector of the channel last tested.

Check DC Voltage Measurement Accuracy (Averaged)

Equipment Required: Two dual-banana connectors (Item 7), one BNC T connector (Item 8), one DC calibration generator (Item 10), and two precision coaxial cables (Item 5).

Prerequisites: The oscilloscope must meet the prerequisites listed on page 4-13.

Procedure:

1. *Install the test hookup and preset the instrument controls:*
 - a. *Hook up the test-signal source:*
 - Set the output of a DC calibration generator to 0 volts.
 - Connect the output of a DC calibration generator through a dual-banana connector followed by a 50 Ω precision coaxial cable to one side of a BNC T connector (see Figure 4-5).
 - Connect the Sense output of the generator through a second dual-banana connector followed by a 50 Ω precision coaxial cable to the other side of the BNC T connector. Now connect the BNC T connector to **CH 1**.

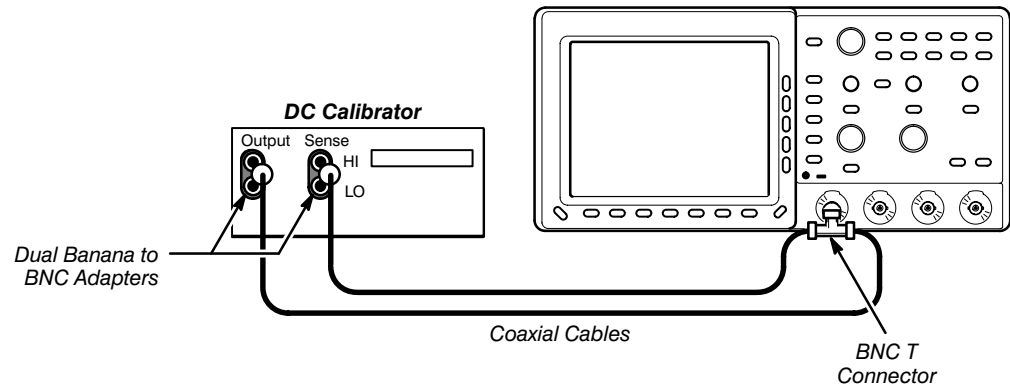


Figure 4-5: Initial Test Hookup

b. *Initialize the oscilloscope:*

- Press save/recall **SETUP**.
- Press the main-menu button **Recall Factory Setup**.
- Press the side-menu button **OK Confirm Factory Init**.

c. *Modify the default settings:*

- Press **SHIFT**; then **ACQUIRE MENU**.
- Press the main-menu button **Mode**; then press the side-menu button **Average 16**.
- Press **DISPLAY**.
- Press the main-menu button **Graticule**; then press the side-menu button **Frame**.
- Press **MEASURE**.
- Press the main-menu button **Select Measurement for CHx**; then press the side-menu button **Mean**. (You will have to press **MORE** several times to access the **Mean** measurement.)
- Set the vertical **SCALE** to 100 mV.
- Press the **VERTICAL MENU** button and then the **Offset** main-menu button. Set the offset to 0 V.
- Set the vertical **POSITION** to 0 V.

2. *Confirm input channels are within limits for DC delta voltage accuracy:*
Do the following substeps—test CH 1 first, *skipping substep a since CH 1 is already selected from step 1*.

a. *Select an unchecked channel:*

- Set the generator output to 0 V.
- Press **WAVEFORM OFF** to remove the channel just confirmed from the display.

- Press the front-panel button that corresponds to the next channel you are to confirm.
 - Press **MEASURE**.
 - Press the main-menu button **Select Measurement for CHx**; then press the side-menu button **Mean**. (You will have to press **MORE** several times to access the **Mean** measurement.)
 - Move the test hook up to the channel you select.
 - Set the vertical **SCALE** to 100 mV.
 - Set the vertical **POSITION** to 0 V.
 - Press the **VERTICAL MENU** button and then the **Offset** main-menu button. Set the offset to 0 V.
- b. *Set the generator:* Set the DC calibration generator to +0.35 V.
- c. *Record Measurement:* Read the mean at the measurement readout and record this number on a piece of scratch paper.
- d. *Set the generator:* Set the DC calibration generator to –0.35 V.
- e. *Check against limits:* Do the following subparts in the order listed.
- Use this formula to calculate voltage measurement accuracy.
- $$700 \text{ mV} - (\text{mean from step c} - (\text{present mean}))$$
- For example:
- $$700 \text{ mV} - (347 \text{ mV} - (-358 \text{ mV})) = -5 \text{ mV}$$
- CHECK that the voltage measurement accuracy is within $\pm 20.8 \text{ mV}$.
- f. *Test all channels:* Repeat substeps a through e for all channels.
3. *Disconnect the hookup:*
- a. *Set the generator output to 0 V.*
 - b. Then disconnect the cable from the generator output at the input connector of the channel last tested.

Check Analog Bandwidth

Equipment Required for TDS 410 and TDS 420: One medium-frequency leveled sine-wave generator (Item 11), one 50 Ω precision cable (Item 5), and two 10X attenuators (Item 1).

Equipment Required for TDS 460: One high-frequency leveled sine-wave generator and its leveling head (Item 12), one 50 Ω precision cable (Item 5), and two 10X attenuators (Item 1).

Prerequisites: See page 4-13.

Procedure:

1. *Install the test hookup and preset the instrument controls:*
 - a. *Initialize the oscilloscope:*
 - Press save/recall **SETUP**. Then press the main-menu button **Recall Factory Setup**.
 - Press the side-menu button **OK Confirm Factory Init**.
 - b. *Modify the default settings:*
 - Set the horizontal **SCALE** to 10 μ s (TDS 410 and TDS 420) or 50 ns (TDS 460).
 - Press **TRIGGER MENU**.
 - Press the main-menu button **COUPLING**; then press the side menu button **Noise Rej**.
 - Press **SHIFT**; then **ACQUIRE MENU**.
 - Press the main-menu button **Mode**; then press the side-menu button **Average 16**.
 - Press **Measure**. Now press the main-menu button **High–Low Setup**; then press the side-menu button **Min–Max**.

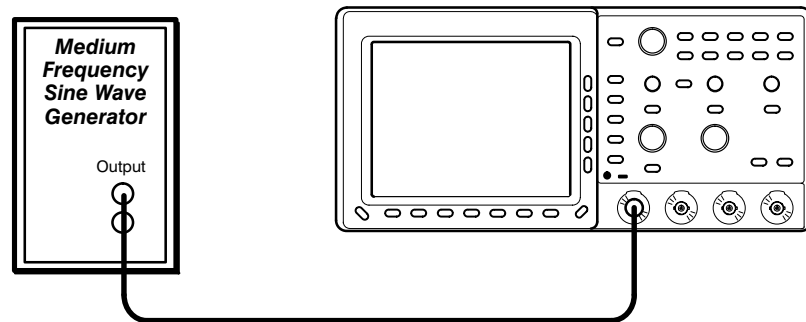


Figure 4-6: Initial Test Hookup (TDS 410 and TDS 420)

- c. **TDS 410 and TDS 420: Hook up the test-signal source:** Connect, through a 50 Ω precision cable, the sine-wave output of a medium-frequency leveled sine-wave generator to **CH 1**. Set the output of the generator to a reference frequency of 50 kHz.

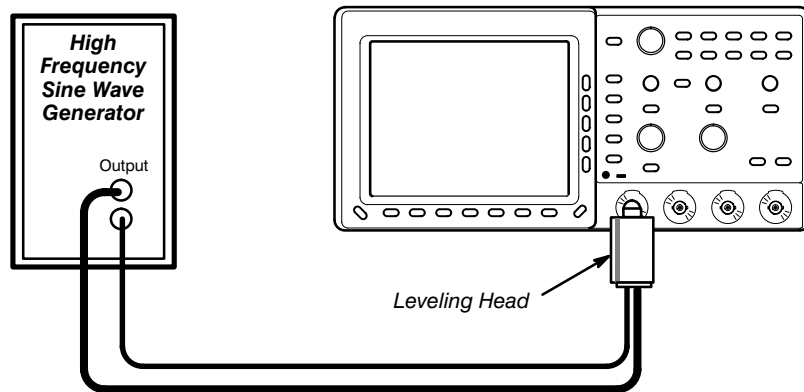


Figure 4-7: Initial Test Hookup (TDS 460)

- d. **TDS 460:** Hook up the test-signal source: Connect, through its leveling head, the sine-wave output of a high-frequency leveled sine-wave generator to **CH 1**. Set the output of the generator to a reference frequency of 6 MHz.
2. *Confirm the input channels are within limits for analog bandwidth:* Do the following substeps—test CH 1 first, *skipping substeps a and b since CH 1 is already set up for testing from step 1.*
 - a. *Select an unchecked channel:*
 - Press **WAVEFORM OFF** to remove the channel just confirmed from display.
 - Press the front-panel button that corresponds to the channel you are to confirm.
 - Move the leveling head to the channel you select.
 - b. *Match the trigger source to the channel selected:*
 - Press **TRIGGER MENU**.
 - Press the main-menu button **Source**.
 - Press the side-menu button that corresponds to the channel selected.
 - c. *Set its input impedance:*
 - Press **VERTICAL MENU**; then press the main-menu button **Coupling**.
 - Press the side-menu button Ω to toggle it to the 50 Ω setting.
 - d. *Set the vertical scale:* Set the vertical **SCALE** to one of the settings listed in Table 4-3 (TDS 410 and TDS 420) or Table 4-4 (TDS 460) not yet checked. (Start with the 100 mV setting.)

Table 4-3: Analog Bandwidth (TDS 410 and TDS 420)

Vertical Scale	Attenuators (10X)	Reference Amplitude (at 50 MHz)	Horizontal Scale	Test Frequency	Limits
100 mV	none	600 mV (6 divisions)	5 ns	150 MHz	≥ 424 mV
1 V	none	5 V (5 divisions)	5 ns	150 MHz	≥ 3.535 V
500 mV	none	3 V (6 divisions)	5 ns	150 MHz	≥ 2.121 V
200 mV	none	1.2 V (6 divisions)	5 ns	150 MHz	≥ 848 mV
50 mV	1	300 mV (6 divisions)	5 ns	150 MHz	≥ 212 mV
20 mV	1	120 mV (6 divisions)	5 ns	150 MHz	≥ 84 mV
10 mV	1	60 mV (6 divisions)	5 ns	150 MHz	≥ 42 mV
5 mV	2	30 mV (6 divisions)	5 ns	150 MHz	≥ 21 mV
2 mV	2	12 mV (6 divisions)	5 ns	110 MHz	≥ 8.4 mV
1 mV	2	6 mV (6 divisions)	5 ns	90 MHz	≥ 4.2 mV

Table 4-4: Analog Bandwidth (TDS 460)

Vertical Scale	Attenuators (10X)	Reference Amplitude (at 6 MHz)	Horizontal Scale	Test Frequency	Limits
100 mV	none	600 mV (6 divisions)	2 ns	350 MHz	≥ 424 mV
1 V	none	5 V (5 divisions)	2 ns	350 MHz	≥ 3.535 V
500 mV	none	3 V (6 divisions)	2 ns	350 MHz	≥ 2.121 V
200 mV	none	1.2 V (6 divisions)	2 ns	350 MHz	≥ 848 mV
50 mV	1	300 mV (6 divisions)	2 ns	350 MHz	≥ 212 mV
20 mV	1	120 mV (6 divisions)	2 ns	350 MHz	≥ 84 mV
5 mV	2	30 mV (6 divisions)	2 ns	350 MHz	≥ 21 mV
2 mV	2	12 mV (6 divisions)	2 ns	250 MHz	≥ 8.4 mV
1 mV	2	6 mV (6 divisions)	2 ns	100 MHz	≥ 4.2 mV

- e. *Display the test signal:* Do the following subparts to first display the reference signal and then the test signal.

- Press **MEASURE**; then press the main-menu button **Select Measurement for CHx**.
- Now press the side menu button **more** until the menu label **Pk-Pk** appears in the side menu (its icon is shown at the left). Press the side-menu button **Pk-Pk**.
- Press **CLEAR MENU**.



- Set the generator output so the CHx Pk-Pk readout equals the reference amplitude in Table 4-3 (TDS 410 and TDS 420) or Table 4-4 (TDS 460) that corresponds to the vertical scale set in substep d.
 - Press the front-panel button **SET LEVEL TO 50%** as necessary to trigger a stable display.
- f. *Measure the test signal:*
- Increase the frequency of the generator output to the test frequency in Table 4-3 (TDS 410 and TDS 420) or Table 4-4 (TDS 460) that corresponds to the vertical scale set in substep d.
 - Set the horizontal **SCALE** to 5 ns (TDS 410 and TDS 420) or 2 ns (TDS 460).
 - Press **SET LEVEL TO 50%** as necessary to trigger the display.
 - Read the results at the CHx Pk-Pk readout, which automatically measures the amplitude of the test signal. (See Figure 4-8.)

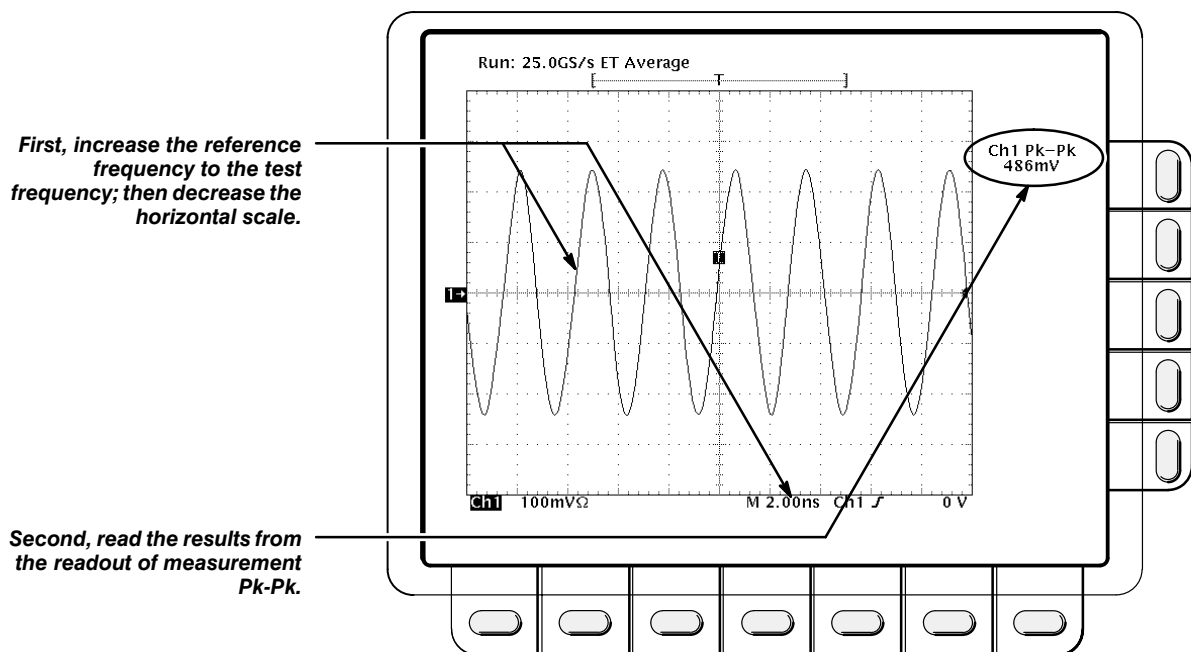


Figure 4-8: Measurement of Analog Bandwidth

- g. *Check against limits:*
- CHECK that the **Pk-Pk** readout on screen is within the limits listed in Table 4-3 (TDS 410 and TDS 420) or Table 4-4 (TDS 460) for the current vertical scale setting.
 - When finished checking, set the horizontal **SCALE** back to the 10 μ s (TDS 410 and TDS 420) or 50 ns (TDS 460) setting.



Checking the bandwidth of each channel at all vertical scale settings is time consuming and unnecessary. You may skip checking the remaining vertical scale settings in Table 4-3 (TDS 410 and TDS 420) or Table 4-4 (TDS 460) (that is, skip the following substep, h) if this digitizing oscilloscope has performed as follows:

- Passed the 100 mV vertical scale setting just checked in this procedure.
- Passed the *Verify Internal Adjustment, Self Compensation, and Diagnostics* procedure found under *Self Tests*, on page 4-4.

NOTE

Passing the signal path compensation confirms the signal path for all vertical scale settings for all channels. Passing the internal diagnostics ensures that the factory-set adjustment constants that control the bandwidth for each vertical scale setting have not changed.

h. *Check remaining vertical scale settings against limits (optional):*

- If desired, finish checking the remaining vertical scale settings for the channel under test by repeating substeps d through g for each of the remaining scale settings listed in Table 4-3 (TDS 410 and TDS 420) or Table 4-4 (TDS 460) for the channel under test.
- When doing substep e, skip the subparts that turn on the CHx Pk-Pk measurement until you check a new channel.
- Install/remove 10X attenuators between the generator leveling head and the channel input as is needed to obtain the six division reference signals listed in the table.

i. *Test all channels:* Repeat substeps a through g for all channels.

3. *Disconnect the hookup:* Disconnect the test hook up from the input connector of the channel last tested.

Check Delay Match Between Channels

Equipment Required: One medium-frequency leveled sine-wave generator (Item 11), one precision coaxial cable (Item 5), one 50 Ω terminator (Item 3), and a dual-input coupler (Item 9).

Prerequisites: See page 4-13.

Procedure:



DO NOT use the vertical position knob to reposition any channel while doing this check. To do so invalidates the test.

1. *Install the test hookup and preset the instrument controls:*

- a. *Initialize the front panel;*
 - Press save/recall **SETUP**.
 - Press the main-menu button **Recall Factory Setup**.
 - Press the side-menu button **OK Confirm Factory Init**.
- b. *Modify the initialized front-panel control settings:*
 - Do *not* adjust the vertical position of any channel during this procedure.
 - Set the horizontal **SCALE** to 1 ns.
 - Press **SHIFT**; then press **ACQUIRE MENU**.
 - Press the main-menu button **Mode**, and then press the side-menu button **Average 16**.
- c. *Hook up the test-signal source:*
 - Connect the sine wave output of a medium-frequency sine wave generator to a 50 Ω precision coaxial cable, a 50 Ω termination, and a dual-input coupler. (Refer to Figure 4-9.)
 - Connect the coupler to both **CH 1** and **CH 2**. *Ensure that the coupler cables are of equal length.*

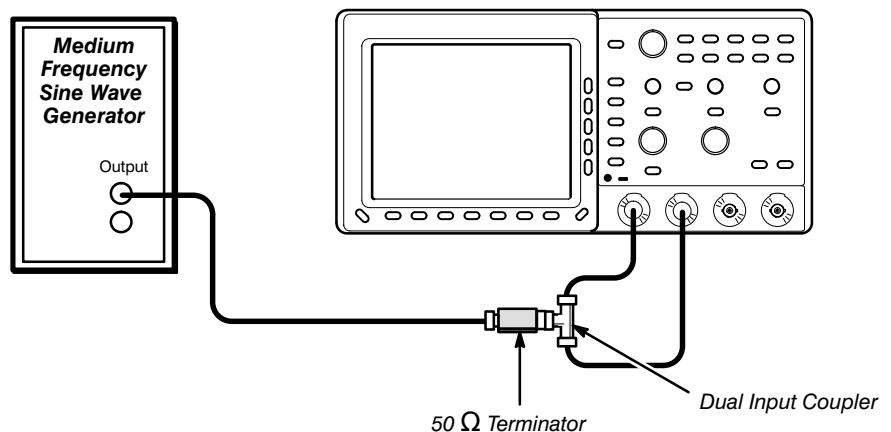


Figure 4-9: Initial Test Hookup

2. *Confirm all channels are within limits for channel delay:*
 - a. *Set up the generator:* Set the generator frequency to 250 MHz and the amplitude for about five divisions in CH 1.

Hint: as you are adjusting the generator amplitude, push **SET LEVEL TO 50%** frequently to speed up the updating of the waveform amplitude on screen.

- b. *Save a CH 2 waveform:* Press **CH 2**; then press save/recall **WAVEFORM**. Now, press the main-menu button **Save Waveform**; then press the side-menu button **To Ref 2**.
- c. If you are testing a TDS 410, skip to step h.
- d. *Save a CH 3 waveform:* Move the coupler from **CH 2** to **CH 3**, so that **CH 1** and **CH 3** are driven. Press **CH 3**; then press the side-menu button **To Ref 3**.
- e. *Display all test signals:*
 - Press **WAVEFORM OFF** twice to remove CH 2 and CH 3 from the display.
 - Move the coupler from **CH 3** to **CH 4**, so that CH 1 and CH 4 are driven. Press **CH 4** to display.
 - Now, press the front-panel button **MORE**. Press the main-menu buttons **Ref 2** and **Ref 3**.
- f. *Measure the test signal:*
 - Locate the point on the rising edge of the left-most waveform where it crosses the center horizontal graticule line. This is the *time reference point* for this waveform. Note the corresponding *time reference point* for right-most waveform. See Figure 4-10.
 - Press **CURSOR**; then press the side-menu button **V Bars**.
 - Press **CLEAR MENU**.
 - Rotate the General Purpose knob to align one cursor to the *time reference point* of the left-most waveform edge and the other cursor to the *time reference point* of the right-most waveform edge. (Press **TOGGLE** to switch between the two cursors.) See Figure 4-10.
 - Read the measurement results at the Δ : cursor readout, not the @: readout on screen.

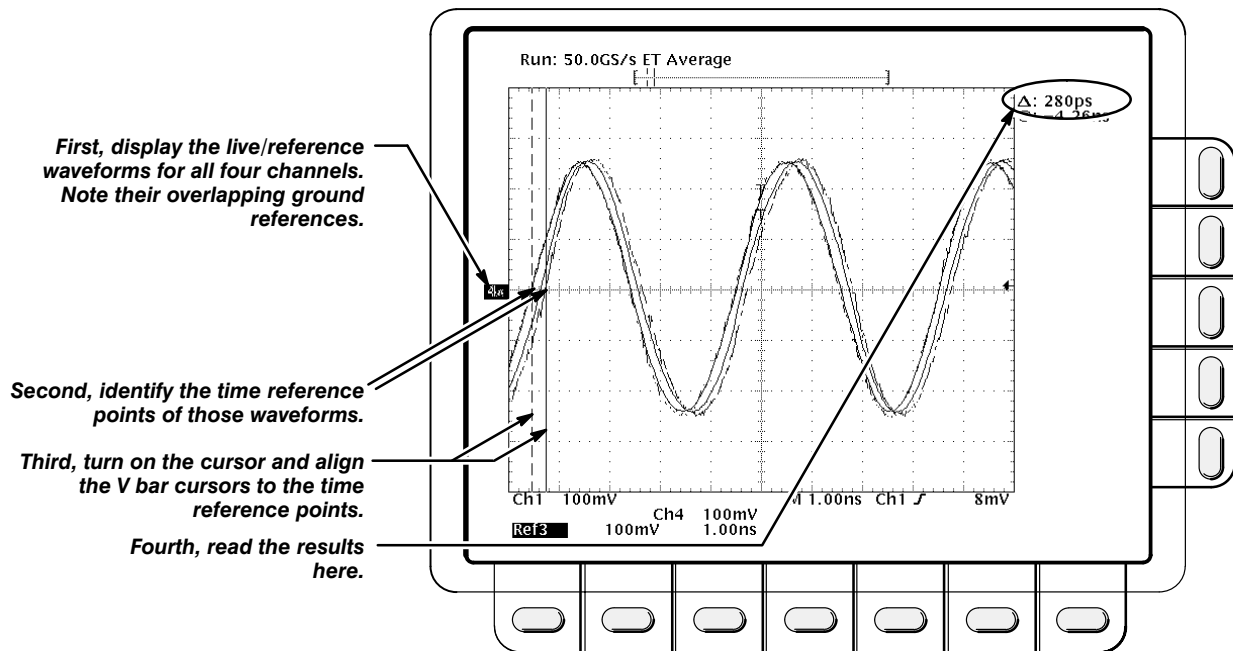


Figure 4-10: Measurement of Channel Delay

- g. *Check all channels against limit:* CHECK that the cursor readout on screen is ≤ 450 ps. If the cursor readout is ≤ 200 ps, skip substep h.
- h. *Check CH 1 to CH 2 and CH 3 to CH 4 against limit:*
 - Press **WAVEFORM OFF** four times to remove all waveforms.
 - Press **CH 1**.
 - Press **MORE**; then press the main-menu button **Ref 2**.
 - Measure the delay between CH 1 and Ref 2 using the method described in substep f above.
 - CHECK that the cursor readout on screen is ≤ 200 ps.
 - If you are testing a TDS 410, skip to step 3.
 - Press **WAVEFORM OFF** twice to turn off CH 1 and Ref 2; then press **CH 4** to turn on CH 4.
 - Press **MORE**; then press the main-menu button **Ref 3** to display the CH 3 waveform stored in Ref 3.
 - Measure the delay between Ref 3 and CH 4 using the method described in substep f above.
 - CHECK that the cursor readout on screen is ≤ 200 ps.
3. *Disconnect the hookup:* Disconnect the cable from the generator output at the input connectors of the channels.

Time Base System Checks

These procedures check those characteristics that relate to the Main and Delayed time base system and are listed as checked under *Warranted Characteristics* in Section 1, *Specification*.

Check Accuracy for Long-Term Sample Rate, Delay Time, and Delta Time Measurements

Equipment Required: One time-marker generator (Item 13) and one precision coaxial cable (Item 5).

Prerequisites: See page 4-13.

Procedure:

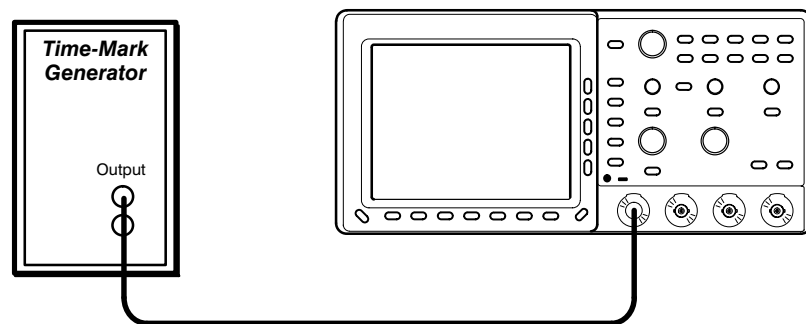


Figure 4-11: Initial Test Hookup

1. *Install the test hookup and preset the instrument controls:*
 - a. *Hook up the test-signal source:* Connect, through a 50 Ω precision coaxial cable, the time-mark output of a time-marker generator to **CH 1**. Set the output of the generator for 10 ms markers.
 - b. *Initialize the oscilloscope:*
 - Press save/recall **SETUP**.
 - Press the main-menu button **Recall Factory Setup**.
 - Press the side-menu button **OK Confirm Factory Init**.
 - c. *Modify the initialized front-panel control settings:*
 - Set the vertical **SCALE** to 500 mV.
 - Press **VERTICAL MENU**; then press the main-menu button **Coupling**. Press the side-menu button Ω to change the coupling setting to **50 Ω** .
 - Press **SET LEVEL TO 50%**.
 - Use the vertical **POSITION** knob to center the test signal on screen.

- Set the horizontal **SCALE** of the Main time base to 1 ms.
 - Press **TRIGGER MENU**; then press the main-menu button **Mode & Holdoff**. Now press the side-menu button **Normal**.
 - Press **SET LEVEL TO 50%**.
 - Press horizontal **MENU**. Press the main-menu button **Record Length**; then press the side-menu button **1000 points in 20 divs**.
 - Press the main-menu button **Trigger Position**. Press the side-menu button **Pretrigger**; then use the **General Purpose** knob to set pretrigger to 20%.
2. *Confirm Main and Delayed time bases are within limits for accuracies:*
- a. *Display the test signal:*
 - Adjust the horizontal **POSITION** to move the trigger **T** to the right and on to the screen. Continue to position the trigger **T** to align it to the center vertical graticule line.
 - Press the main-menu button **Time Base**.
 - Press the side-menu buttons **Delayed Only** and **Delayed Runs After Main**.
 - b. *Measure the test signal:*
 - First set the horizontal **SCALE** of the **D** (delayed) time base to 1 ms. Then use the **General Purpose** knob to set delayed time to 10 ms.
 - Set the horizontal **SCALE** of the **D** (delayed) time base to 500 ns.
 - c. *Check long-term sample rate and delay time accuracies against limits:* CHECK that the rising edge of the marker crosses the center horizontal graticule line at a point within ± 3.0 divisions of center graticule (see Figure 4-12).

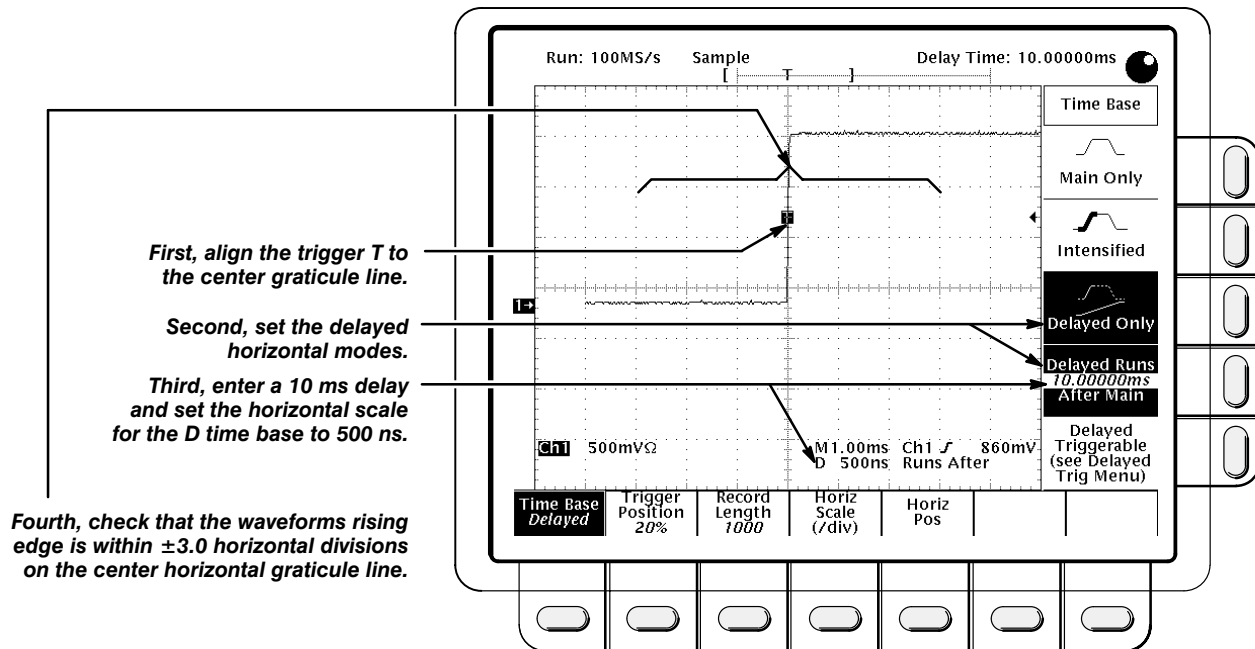


Figure 4-12: Measurement of Accuracy — Long-Term and Delay-Time

d. Check delta-time accuracy against limits:

- Press the side-menu button **Main Only**. Set horizontal **SCALE** to 5 ns.
- Set the output of the generator for 50 ns markers.
- Press **SET LEVEL TO 50%**.
- Press **VERTICAL MENU**.
- Press the main-menu button **Bandwidth**; then press the side-menu button 100 MHz.
- Press **SHIFT**; then **ACQUIRE MENU**. Now press the main-menu button **Mode**; then press the side-menu button **Average**.
- Use the **General Purpose** knob to set the number of averages to 8.
- Press **MEASURE**.
- Press the main-menu button **High-Low Setup**; then press the side-menu button **Min-Max**.
- Press the main-menu button **Select Measurement for Ch1**.
- Press the side-menu button **—more—**, until **PERIOD** appears in the side menu. Press **PERIOD**.
- Press **CLEAR MENU**.

- CHECK that the readout for **CH 1 Per** is within 49.592 ns to 50.408 ns.
3. *Disconnect the hookup:* Disconnect the cable from the generator output at the input connector of **CH 1**.

Trigger System Checks

These procedures check those characteristics that relate to the Main and Delayed trigger systems and are listed as checked under *Warranted Characteristics* in Section 1, *Specification*.

Check Accuracy, Trigger Level or Threshold, DC Coupled

Equipment Required: One DC calibration generator (Item 10), one BNC T connector (Item 8), and two precision coaxial cables (Item 5).

Prerequisites: The oscilloscope must meet the prerequisites listed on page 4-13.

Procedure:

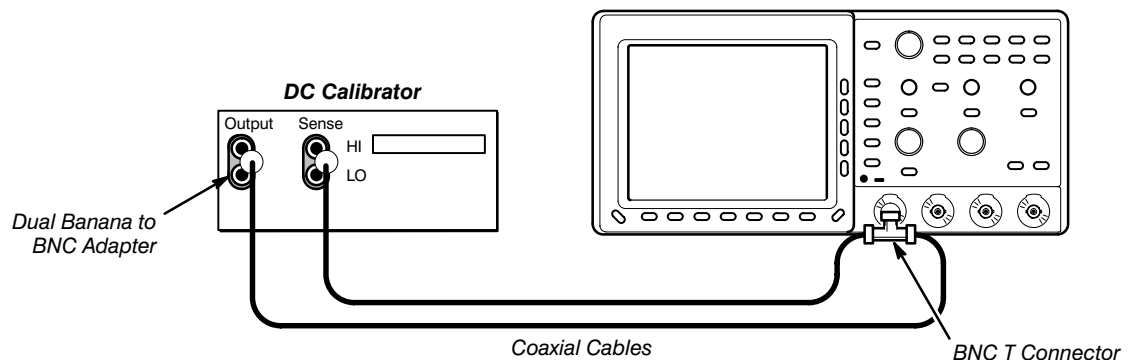


Figure 4-13: Initial Test Hookup

1. *Install the test hookup and preset the instrument controls:*
 - a. *Hook up the test-signal source:*
 - Set the output of a DC calibration generator to 0 volts.
 - Connect the output of a DC calibration generator through a dual-banana connector followed by a 50 Ω precision coaxial cable to one side of a BNC T connector.
 - Connect the Sense output of the generator, through a second dual-banana connector followed by a 50 Ω precision coaxial cable, to the other side of the BNC T connector. Now connect the BNC T connector to **CH 1**.
 - b. *Initialize the oscilloscope:*
 - Press save/recall **Setup**.
 - Press the main-menu button **Recall Factory Setup**.
 - Press the side-menu button **OK Confirm Factory Init**.

2. *Confirm Main trigger system is within limits for Trigger-level/Threshold accuracy:*
 - a. *Display the test signal:*
 - Set the vertical **SCALE** to 50 mV.
 - Set the standard output of a DC calibration generator to +0.3 V.
 - b. *Measure the test signal:*
 - Press **SET LEVEL TO 50%**.
 - Press **TRIGGER MENU**.
 - Read the measurement results from the readout below the label **Level** in the menu rather than from the trigger readout in the graticule area.
 - c. *Check against limits:*
 - Subtract the trigger level readout from the DC calibration generator setting. The result is the trigger level accuracy.
 - CHECK that the trigger level is accurate to within ± 18 mV.
 - Press **TRIGGER MENU**. Press the main-menu button **Slope**; then press the side-menu button for negative slope. (See icon at left.) Repeat substep b.
 - Subtract the trigger level readout from the DC calibration generator setting. The result is the trigger level accuracy.
 - CHECK that the trigger level is accurate to within ± 18 mV.
3. *Confirm Delayed trigger system is within limits for Trigger-level/Threshold accuracy:*
 - a. *Select the Delayed time base:*
 - Press **HORIZONTAL MENU**.
 - Press the main-menu button **Time Base**.
 - Press the side-menu buttons **Delayed Only** and **Delayed Triggerable**.
 - Set **D** (delayed) horizontal **SCALE** to 500 μ s.
 - b. *Select the Delayed trigger system:*
 - Press **SHIFT**; then press the front-panel button **DELAYED TRIG**.
 - Press the main-menu button **Level**.
 - c. *Measure the test signal:* Press the side-menu button **SET TO 50%**. Read the measurement results in the side menu below the label **Level**.
 - d. *Check against limits:* Do the following subparts in the order listed.





- Subtract the trigger level readout from the DC calibration generator setting. The result is the trigger level accuracy.
 - CHECK that the trigger level is accurate to within ± 18 mV.
 - Press **TRIGGER MENU**. Press the main-menu button **Slope**; then press the side-menu button for negative slope. (See icon at left.)
 - Subtract the trigger level readout from the DC calibration generator setting. The result is the trigger level accuracy.
 - CHECK that the trigger level is accurate to within ± 18 mV.
4. *Disconnect the hookup:*
- a. *First set the output of the DC calibration generator to 0 volts.*
 - b. Then disconnect the cable from the generator output at the input connector of **CH 1**.

Sensitivity, Edge Trigger, DC Coupled

Equipment Required: One medium-frequency leveled sine-wave generator (Item 11), one high-frequency leveled sine-wave generator (Item 12), one precision 50 Ω coaxial cable (Item 5), one 10X attenuator (Item 1), and one 5X attenuator (Item 2).

Prerequisites: See page 4-13.

Procedure:

1. *Install the test hookup and preset the instrument controls:*
 - a. *Initialize the oscilloscope:*
 - Press save/recall **SETUP**.
 - Press the main-menu button **Recall Factory Setup**.
 - Press the side-menu button **OK Confirm Factory Init**.
 - b. *Modify the initialized front-panel control settings:*
 - Set the horizontal **SCALE** for the **M** (main) time base to 20 ns.
 - Press **HORIZONTAL MENU**; then press the main-menu button **Time Base**.
 - Press the side-menu button **Delayed Only**; then press the side-menu button **Delayed Triggerable**.
 - Set the horizontal **SCALE** for the **D** (delayed) time base to 20 ns; then press the side-menu button **Main Only**.
 - Press **TRIGGER MENU**; then press the main-menu button **Mode & Holdoff**. Now press the side-menu button **Normal**.
 - Press **VERTICAL MENU**; then press the main-menu button **Coupling**. Now press the side-menu button Ω to select the 50 Ω setting.
 - Press **SHIFT**; then press **ACQUIRE MENU**. Now press the main-menu button **Mode**; then press the side-menu button **Average 16**.

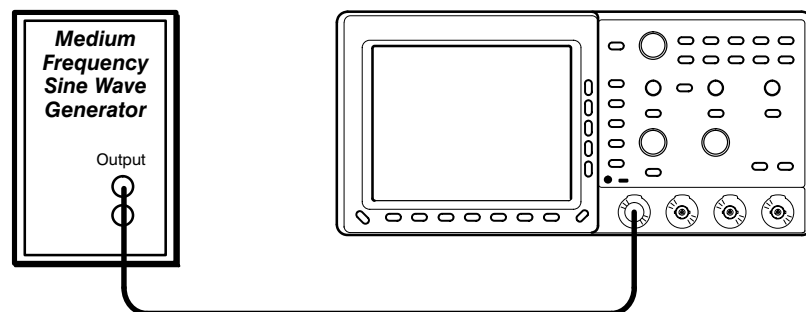


Figure 4-14: Initial Test Hookup

- c. *Hook up the test-signal source:* Connect, through a 50 Ω precision coaxial cable, the signal output of a medium-frequency sine wave generator to **CH 1**.
2. *Confirm Main and Delayed trigger systems are within sensitivity limits (50 MHz):*
- a. *Display the test signal:*
- Set the generator frequency to 50 MHz.
 - Press **MEASURE**.
 - Press the main-menu button **High-Low Setup**; then press the side-menu button **Min-Max**.
 - Press the main-menu button **Select Measurement for Ch1**.
 - Press the side-menu button **—more—** until **Amplitude** appears in the side menu (its icon is shown at the left). Press the side-menu button **Amplitude**.
 - Adjust the trigger **MAIN LEVEL** knob to obtain stable triggered waveform.
 - Press **CLEAR MENU**.
 - Set the test signal amplitude for about three and a half divisions on screen. Now fine adjust the generator output until the **CH 1 Amplitude** readout indicates the amplitude is 350 mV. (Readout may fluctuate around 350 mV.)
 - Disconnect the 50 Ω precision coaxial cable at **CH 1** and reconnect it to **CH 1** through a 10X attenuator.
- b. *Check for Main trigger system for stable triggering at limits:*
- Read the following definition: A stable trigger is one that is consistent; that is, one that results in a uniform, regular display triggered on the selected slope (positive or negative). This display should *not* have its trigger point switching between opposite slopes, nor should it “roll” across the screen. At horizontal scale settings of 2 ms/division and faster, **TRIG'D** remains constantly lit. It flashes for slower settings.
 - Press **TRIGGER MENU**; then press the main-menu button **Slope**.
 - Press **SET LEVEL TO 50%**. CHECK that a stable trigger is obtained for the test waveform on both the positive and negative slopes. (Use the side menu to switch between trigger slopes; use the trigger **MAIN LEVEL** knob to stabilize the trigger if required.)
 - Leave the Main trigger system triggered on the positive slope of the waveform before continuing to the next step.



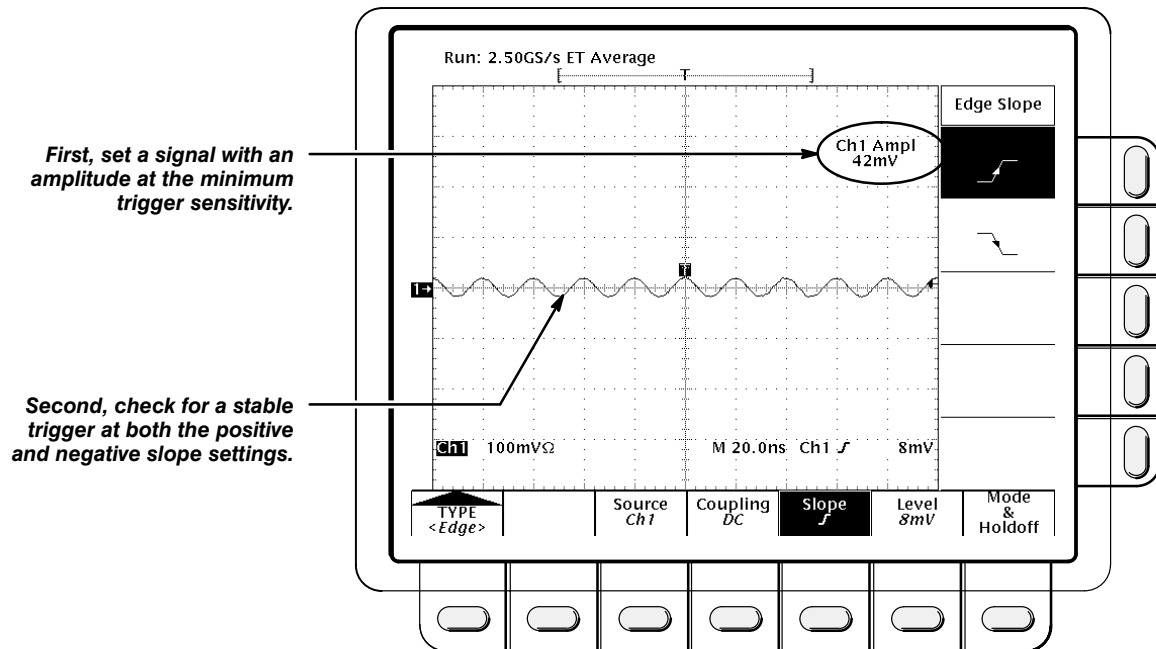


Figure 4-15: Measurement of Trigger Sensitivity

- c. *Check delayed trigger system for stable triggering at limits:* Do the following subparts in the order listed.
 - Press **HORIZONTAL MENU**; then press the main-menu button **Time Base**. Now press the side-menu button **Delayed Only**.
 - Press **SHIFT**; then press **DELAYED TRIG**. Press the main-menu button **Level**.
 - Press the side-menu button **SET TO 50%**. CHECK that a stable trigger is obtained for the test waveform for both the positive and negative slopes of the waveform. (Use the General Purpose knob to stabilize the trigger if required.) Press the main-menu button **Slope**; then use the side menu to switch between trigger slopes.
 - Leave the delayed trigger system triggered on the positive slope of the waveform before continuing to the next step. Also, return to the main time base: Press **HORIZONTAL MENU**; then press the main-menu button **Time Base**. Now press the side-menu button **Main Only**.
3. *Confirm that the Main and Delayed trigger systems are within sensitivity limits (at upper frequency limits):*
 - a. *Hook up the test-signal source:* Disconnect the hookup installed in step 1. Connect, through its leveling head, the signal output of a high-frequency leveled sine-wave generator to **CH 1**.

- b. *Set the Main and Delayed Horizontal Scales:*
 - Set the horizontal **SCALE** to 5 ns for the **M** (Main) time base.
 - Press the side-menu button **Delayed Only**.
 - Set the horizontal **SCALE** to 2 ns for the **D** (Delayed) time base. Press the side-menu button **Main Only**.
 - c. *Display the test signal:*
 - Set the generator frequency to 350 MHz (TDS 410 and TDS 420) or 500 MHz (TDS 460).
 - Set the test signal amplitude for about five divisions on screen. Now fine adjust the generator output until the **CH 1 Amplitude** readout indicates the amplitude is 500 mV. (Readout may fluctuate around 500 mV.)
 - Disconnect the leveling head at **CH 1** and reconnect it to **CH 1** through a 5X attenuator.
 - d. Repeat step 2, substeps b and c only.
4. *Confirm that the Main and Delayed trigger systems couple trigger signals from all channels:* Doing the procedure *Check Analog Bandwidth*, which begins on page 4-22, checks coupling. If you have not done that procedure, do so after finishing this procedure. See the following note.

NOTE

Steps 1 through 3 confirmed trigger sensitivity for the Main and Delayed triggering systems using the CH 1 input. Doing the procedure Check Analog Bandwidth ensures that trigger signals are coupled from all channels.

5. *Disconnect the hookup:* Disconnect the cable from the generator output at the input connector of the channel last tested.

Maximum Input Frequency, Auxiliary Trigger

Equipment Required: One medium-frequency leveled sine-wave generator (Item 11), two precision 50 Ω coaxial cables (Item 5), and a BNC T connector (Item 8).

Prerequisites: See page 4-13.

Procedure:

1. *Install the test hookup and preset the instrument controls:*

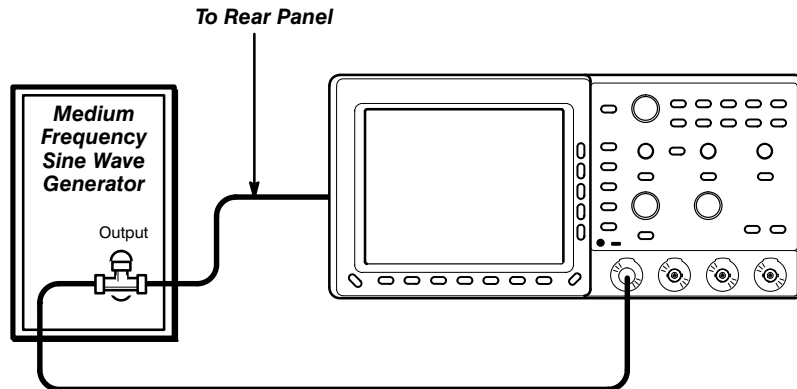


Figure 4-16: Initial Test Hookup

- a. *Initialize the oscilloscope:*
 - Press save/recall **SETUP**.
 - Press the main-menu button **Recall Factory Setup**.
 - Press the side-menu button **OK Confirm Factory Init**.
- b. *Modify the initialized front-panel control settings:*
 - Set the vertical **SCALE** to 1 volt; set the horizontal **SCALE** to 20 ns.
 - Press **VERTICAL MENU**.
 - Press the main-menu button **Coupling**. Press the side-menu button Ω to toggle it to the 50 Ω setting.
 - Press **TRIGGER MENU**. Press the main-button **SOURCE**; then press the side-menu button **—more—** until **Auxiliary** appears in the side menu. Press the side-menu button **Auxiliary**.
 - Press the **Coupling** main-menu button; then press the **AC** side-menu button.
- c. *Hook up the test-signal source:*
 - Connect a BNC T connector to the output of the sine-wave generator.

- Connect one 50 Ω cable to one side of the BNC T connector; connect a second 50 Ω cable to the other side of the BNC T connector.
 - Connect one of the cables just installed to **CH 1**; connect the other cable just installed to the **AUX TRIGGER** input at the rear panel.
2. *Confirm the Trigger input:*
- a. *Display the test signal:*
 - Set the generator for a 10 MHz, four division signal.
 - b. *Check the Main trigger system for stable triggering at limits:*
 - Read the following definition: A stable trigger is one that is consistent; that is, one that results in a uniform, regular display triggered on the selected slope (positive or negative). This display should *not* have its trigger point switching between opposite slopes, nor should it “roll” across the screen.

First, set a signal with a four division amplitude and a 10 MHz frequency.

Second, check for a stable trigger at both the positive and negative slope settings.

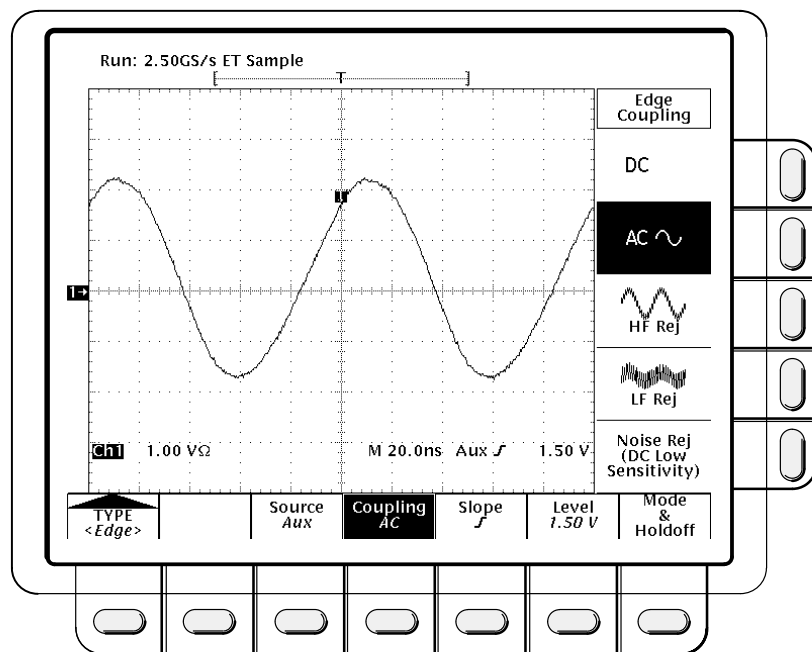


Figure 4-17: Confirming Auxiliary Triggering at Maximum Triggering Frequency

3. *Disconnect the hookup:* Disconnect the cable from the generator output at the input connector of the channel last tested.

Check Video Trigger Sensitivity (Option 05 Equipped Models Only)

Equipment Required: One NTSC format video generator (Item 15), 75 Ω coaxial cable (Item 6), and one 75 Ω terminator (Item 4).

Prerequisites: See page 4-13.

Procedure:

1. *Install the test hookup and preset the instrument controls:*
 - a. *Initialize the instrument:*
 - Press save/recall **SETUP**.
 - Press the main menu button **Recall Factory Setup**.
 - Press the side menu button **OK Confirm Factory Init**.
 - b. *Modify the default setup:*
 - Set the vertical **SCALE** to 500 mV.
 - Set the horizontal **SCALE** to 20 μ s.
 - Press **HORIZONTAL MENU**.
 - Press the main menu button **Record Length**.
 - Press the side menu button **5000 points in 100 divs**.

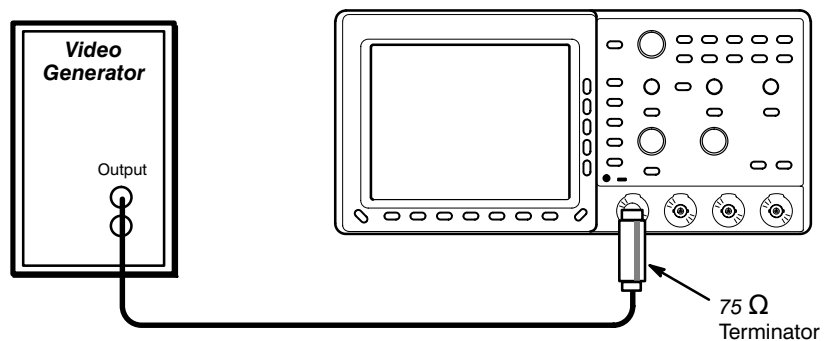


Figure 4-18: Initial Test Hookup

- c. *Hook up the test-signal source:* Connect, through a 75 Ω precision coaxial cable, followed by a 75 Ω terminator, the output of a NTSC format video generator to CH 1 (see Figure 4-18).
2. *Confirm the video trigger system is within limits:*
 - a. *Display the test signal:*
 - Set video generator to NTSC format.
 - Set the output of the generator for a five step ramp with color burst.

- Press **SET TO 50%**. Use the trigger **MAIN LEVEL** knob to stabilize the display as required.
 - Press **TRIGGER MENU**.
 - Press the main menu button **Mode & Holdoff**. Then press the side menu button **Normal**.
- b. *Fine adjust the sync pulse amplitude:* The amplitude of the TV waveform should now be about 2 divisions pk-pk. Do the following sub-parts to fine adjust the vertical gain until the sync pulses measure exactly 0.6 divisions peak-to-peak using the graticule:
- Press **VERTICAL MENU**.
 - Press the main menu button **Fine Scale**.
 - Use the General Purpose knob, adjust the fine gain until the sync pulse amplitude is 0.6 divisions measured using the graticule (see Figure 4-19).

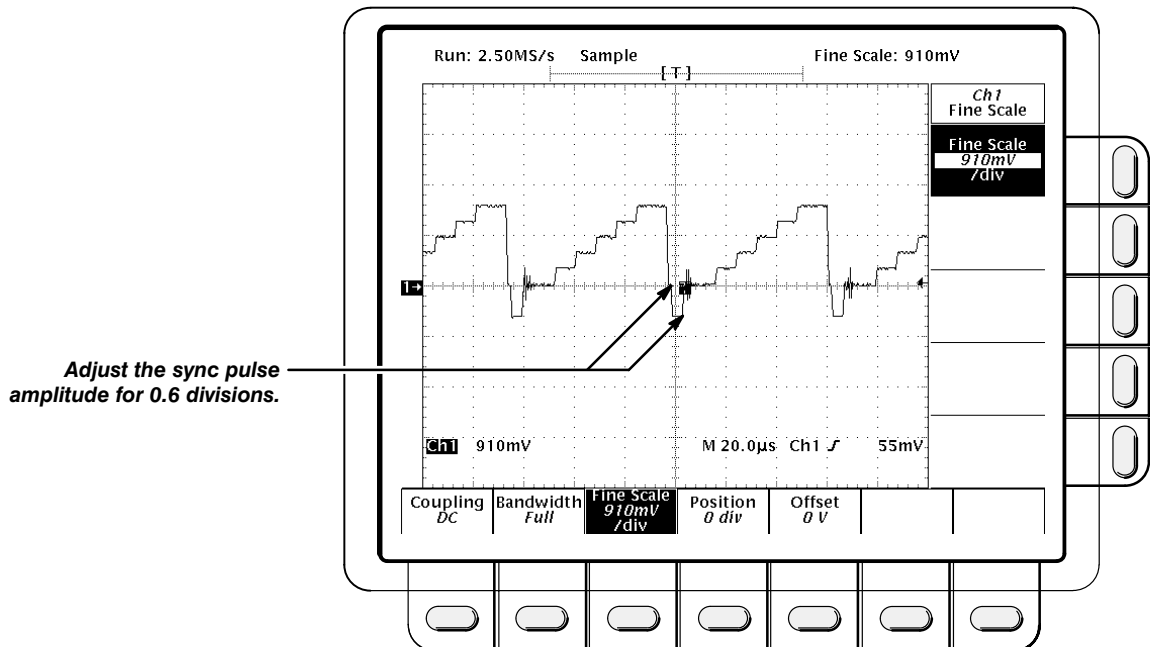


Figure 4-19: Adjusting Sync Pulse Amplitude

- c. *Check for stable triggering against limits:*
- Read the following definition: A stable trigger is one that is consistent; that is, one that results in a uniform, regular display triggered on the selected slope (positive or negative). This display should *not* have its trigger point switching between opposite slopes, nor should it “roll” across the screen. At horizontal scale settings appropriate for viewing video waveforms, the **TRIG'D** light remains constantly lit.

- Press **TRIGGER MENU**. Press the main menu button **Type** twice—first to pop up its menu and then to toggle it to **Video**.
- Press the main menu button **Class** to pop up its menu. Press it again as needed to toggle it to **NTSC**.
- Press the main menu button **Scan** to pop up its menu.
- Press the side menu button **Interlaced Field One**. Center the display at mid screen.
- CHECK that a stable trigger is obtained with the last two lines of TV field 2 and the beginning of TV field 1 displayed. (If the last line is a full TV line duration ($63.5\ \mu\text{s}$), then it is the end of field 2—see waveform R1 in Figure 4-20.)
- Press the side menu button **Interlaced Field Two**. Center the display at mid screen.
- CHECK that a stable trigger is obtained with the last of TV field 1 and the beginning of TV field 2 displayed. (If the last line is a $\frac{1}{2}$ TV line duration ($31.75\ \mu\text{s}$), then it is the end of field 1 — see waveform R2 in Figure 4-20.)
- Press the side menu button **Non Interlaced Both Fields**.
- Press the main menu button **Mode and Holdoff**. Then press the side menu button **Holdoff**.
- Use the **General Purpose** knob to set the holdoff to 1.

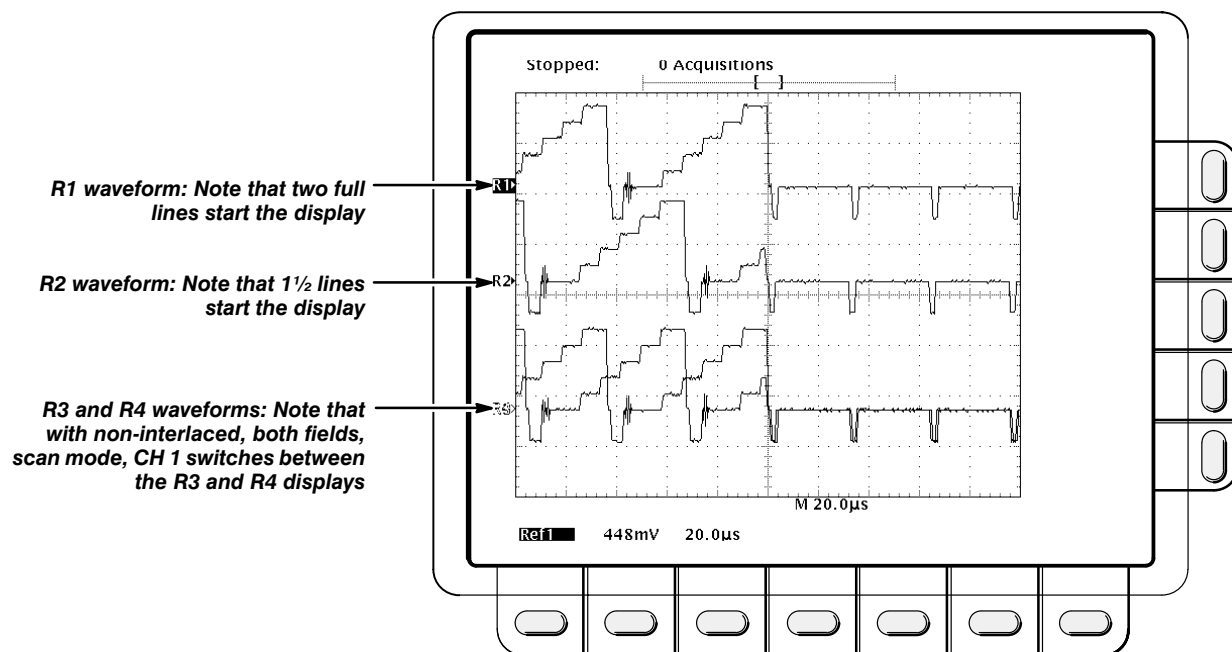


Figure 4-20: Measurement of Video Sensitivity

- Rotate the horizontal **POSITION** control clockwise to move the ends of both fields to the center of the display.
 - CHECK that a stable trigger is obtained while alternating between field 1 and field 2. (If the last line is alternating between a full TV line and $\frac{1}{2}$ a line in duration ($63.5\ \mu\text{s}$ and $31.75\ \mu\text{s}$ respectively), then triggering is occurring on both fields—see waveforms R3 and R4 in Figure 4-20.)
- d. *Check delay by lines:*
- Press the main-menu button **Scan**.
 - Press the side-menu button **Interlaced Field One**.
 - Rotate the horizontal **POSITION** control counter clockwise and align the trigger “T” to center screen
 - Press the main-menu button **TV Delay Mode**.
 - Press the side-menu button **Delay by Lines**.
 - Use the General Purpose knob to set the line count to **10**.
 - CHECK that the selected line is the first line that has the color burst signal.
- e. *Check sync trigger:*
- Using the Vertical **POSITION** knob, move the video waveform from the top to the bottom of the display.
 - CHECK that the **TRIG'D** LED stays on and the waveform is stable.
 - Using the Vertical **POSITION** knob return the waveform to the center of the display.
3. *Disconnect the hookup:* Disconnect the cable from the generator output at the input connector of **CH 1**.

Output Signal Check

The procedure that follows checks the characteristics of the probe compensation signal that are listed as checked under *Warranted Characteristics* in Section 1, *Specification*.

Check Probe Adjust Output

Equipment Required: One standard-accessory 10X probe (Item 14).

Prerequisites: See page 4-13. Also, this digitizing oscilloscope must have passed *Check Accuracy — Long-Term Sample Rate, Delay time, Time Measurement* on page 4-31, and *Check DC Voltage Measurement Accuracy (Averaged)* on page 4-20.

Procedure:

1. *Install the test hookup and preset the instrument controls:*

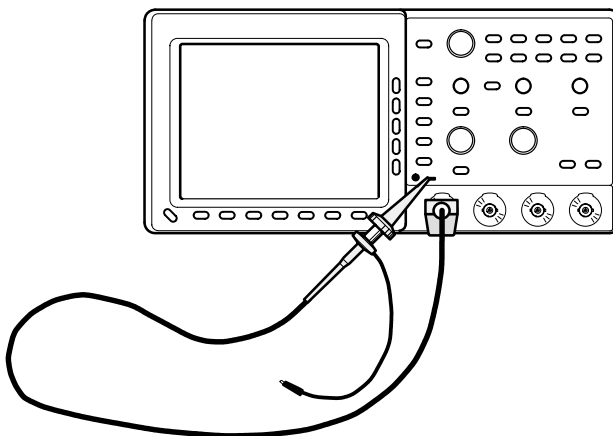


Figure 4-21: Initial Test Hookup

- a. *Hook up test-signal:* Install the standard-accessory probe on **CH 1**. Connect the probe tip to **PROBE ADJ** on the front panel; leave the probe ground unconnected.
- b. *Initialize the oscilloscope:*
 - Press save/recall **SETUP**.
 - Press the main-menu button **Recall Factory Setup**.
 - Press the side-menu button **OK Confirm Factory Init**.
- c. *Modify the initialized front-panel control settings:*
 - Press **AUTOSET**. Set the horizontal **SCALE** to 200 μ s.
 - Press **SHIFT**; then press **ACQUIRE MENU**.
 - Press the main-menu button **Mode**; then press the side-menu button **Hi Res**.

2. Confirm that the Probe Compensator signal is within limits for amplitude and frequency:

a. Measure the amplitude and frequency of the probe compensation signal:

- Press **MEASURE**; then press the main-menu button **Select Measurement for Ch1**.
- Now repeatedly press the side-menu button **—more—** until **Amplitude** appears in the side menu (its icon is shown at the left). Press the side-menu button **Amplitude**.
- Repeatedly press the side-menu button **—more—** until **Frequency** appears in the side menu (its icon is shown at the left). Press the side-menu button **Frequency**.
- Press **CLEAR MENU** to remove the menus from the display. See Figure 4-22.

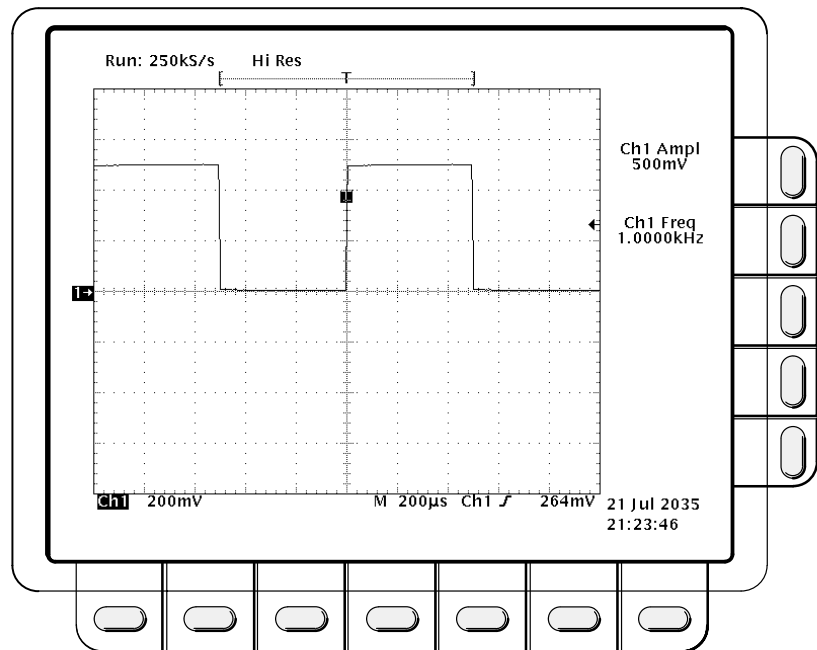


Figure 4-22: Measurement of Probe Compensator Limits

- b. *Check against limits:* CHECK that the **CH 1 Freq** readout is within 950 Hz to 1.050 kHz, inclusive, and that the readout for **Ch1 Ampl** is within 475 mV to 525 mV, inclusive.
- c. *Disconnect the test hookup:* Remove the test probe as desired.

Adjustment Procedures

This section contains information needed to adjust the TDS 410, TDS 420, & TDS 460 Digitizing Oscilloscopes.

Description — The *Adjustment Procedures* are divided into three parts:

- This general information about adjusting this oscilloscope and the written procedures for installing and using the adjustment software.
- The TDS 410, *TDS 420*, & *TDS 460 Adjustment Software* included with this manual. Read the material in this section before using the adjustment software.
- Two written procedures for manually adjusting the probe and the monitor assembly.

Purpose — Use this procedure to return the oscilloscope to conformance with its *Warranted Characteristics* as listed in Section 1, *Specification*. You can also use this procedure to optimize the performance of the oscilloscope.

This procedure is *not* required to verify the oscilloscope conforms with its warranted characteristics; performance verification procedures are found in Section 4.

Adjustment Interval — As a general rule, these adjustments should be done every 2,000 hours of operation or once a year if used infrequently.

Requirements for Performance

Before you do this procedure, you need to address the following requirements.

Personnel

This procedure is only to be performed by trained service technicians.

Warm-up Period

This oscilloscope requires a 20 minute warm-up period in a 20° C to 30° C environment before it is adjusted. Adjustments done before the operating temperature has stabilized may cause errors in performance.

Access

Except when adjusting the monitor assembly, the cabinet is not removed. (A monitor adjustment is not done as part of a routine adjustment — see *Complete Adjustment* on page 5-3.)

System

The following computer and peripherals are required to adjust this oscilloscope; the adjustment software does not run on systems that do not meet *all* requirements listed:

- The *minimum* computer required is an IBM® PC™ or a strict compatible with an eight MHz clock speed or faster (a Intel® 286 processor minimum). PCs or compatibles that are based on older processors (Intel® 8086 and 8088) are not acceptable.
- The *recommended* computer is a PC or compatible with at least a 16 MHz clock speed (Intel® 386sx™) or better with a math coprocessor installed. When obtained with its optional math coprocessor installed, the Tektronix RIC 386 controller, listed in the equipment list on page 5-5, is an example of a recommended computer.
- MSDOS® 3.2 or higher.
- 640K Resident RAM, with 580K available.
- A hard drive.
- A high-density floppy drive: 3.5 inch (1.44 M) or 5.25 inch (1.2 M).
- A GPIB board — National Instruments® GPIB-PCII, GPIB-PCIIA or GPIB-PCII/IIA. (A PC-GPIB package that includes the PCII/IIA is available — Tektronix part number S3FG210).
- Suitable keyboard and monitor.

Test Equipment

The equipment list on page 5-5 lists all test equipment required to adjust this oscilloscope.

Usage

The following topics cover what is required of you when adjusting the oscilloscope and what is done by the software. Also, the performance of individual adjustments is discussed.

Performing the Adjustments

When using the adjustment software, you are not required to manually adjust any circuits. The software adjusts the circuits using external standards you provide in response to prompts on the computer screen. Your role is to provide those test signals and to prompt the computer to continue.

Since the probe and monitor-assembly adjustments require manual adjustment of circuit components, they are not part of the adjustment software. Written procedures for these adjustments begin on page 5-9.

Complete Adjustment

A complete adjustment is the performance of all adjustments contained in the Adjustment Software plus the probe adjustment on page 5-9. Therefore to do a complete adjustment, *do all adjustments in the software, completely and in sequence, then do the written probe adjustment procedure.*

Throughout this section, “complete adjustment” is used as just defined. Note that the procedure *Monitor Adjustment* (page 5-20) is *not* required to do a complete adjustment.

Individual Adjustments

The adjustment software contains a sequence of individual adjustments. The list of those adjustments follows.

- Signal Path Compensation
- Voltage Reference Adjustment
- High Frequency Response Adjustment (TDS 460 only)
- Low Frequency Response Adjustment
- Trigger Skew Adjustment

All these software-based adjustments are made internally by the adjustment software, and all adjustments are done without removal of the oscilloscope cabinet.

Partial Adjustment

The adjustment software allows you to make individual adjustments. However, usually all adjustments are made unless you are adjusting circuits in the course of troubleshooting the oscilloscope. Read the information under *Complete Adjustment*, *Adjustment After Repair*, and *Adjustment Dependencies* before doing an individual adjustment.

Adjustment After Repair

After the removal and replacement of a module due to electrical failure, you either must do a complete adjustment or no adjustment is required, depending on the module replaced. See Table 5-1.

Table 5-1: Adjustments Required for Module Replaced

Module Replaced	Adjustment Required
Acquisition Board	Complete Adjustment
Attenuator Board	Complete Adjustment
Front Panel Assembly	None Required
Low Voltage Power Supply	Complete Adjustment

Table 5-1: Adjustments Required for Module Replaced (Cont.)

Module Replaced	Adjustment Required
CPU Assembly ¹	Complete Adjustment
DSP Assembly	None Required
Display Assembly	None Required
Auxiliary Power Supply	None Required
Backplane Assembly	None Required
Monitor Assembly	None Required

¹If a firmware update is done, a complete adjustment must be done.

Adjustment Dependencies

Some adjustments depend on the successful prior completion of other adjustments. For example, the Voltage Reference Adjustment must pass before any other adjustments can be successfully completed. The following table lists the adjustments and their dependencies.

Table 5-2: Adjustments and Dependencies

Adjustment	Prior Completion Requirements
Voltage Reference Adjustment	None
Low Frequency Response Adjustment	Voltage Reference
High Frequency Response Adjustment (TDS 460 only)	Voltage Reference
Trigger Adjustment	Voltage Reference
Probe Adjustment	Voltage Reference, Low Frequency Response, and High Frequency Response
Monitor Adjustment	None

Equipment Required

The test equipment required to adjust the TDS 410, TDS 420, & TDS 460 Digitizing Oscilloscopes is listed here.

Table 5-3: Test Equipment, Fixtures, and Supplies

Item Number and Description	Minimum Requirements	Example	Purpose
1 Computer system	See description under <i>System</i> on page 5-2 for minimum and recommended requirements	Tektronix RIC 386	Software based adjustments
2 Adapter, BNC female to BNC female	Tektronix 103-0028-00	Tektronix 103-0028-00	Probe adjustment
3 Adapter, probe tip to BNC, 50 Ω termination	Tektronix 013-0227-00	Tektronix 013-0227-00	Probe adjustment
4 Adjustment tool	0.1 inch hex on both ends	GC Electronics #8606	A26 Monitor adjustment
5 Attenuator, 10X (two required)	Ratio: 10X; impedance 50 Ω ; connectors: female BNC input, male BNC output	Tektronix part number 011-0059-02	Software-based adjustments and probe adjustment
6 Attenuator, 2X	Ratio: 2X; impedance 50 Ω ; connectors: female BNC input, male BNC output	Tektronix part number 011-0069-02	Software-based adjustments
7 Cable GPIB	IEEE Std 488.1-1987/ IEEE Std 488.2-1987	Tektronix part number 002-0991-01	Software-based adjustments
8 Coupler, dual input	Female BNC to dual male BNC	Tektronix part number 067-0525-02	Software-based adjustments
9 Cable, precision coaxial	50 Ω , 36 in, male-to-male BNC connectors	Tektronix part number 012-0482-00	Software-based adjustments
10 Connector, dual-banana	Female BNC to dual banana	Tektronix part number 103-0090-00	Software-based adjustments
11 Generator, DC calibration	Variable amplitude to ± 10 V; accuracy to 0.05%	Data Precision 8200	Software-based adjustments

Table 5-3: Test Equipment, Fixtures, and Supplies (Cont.)

Item Number and Description	Minimum Requirements	Example	Purpose
12 Generator, leveled sine wave, medium-frequency	200 kHz to 250 MHz; Variable amplitude from 5 mV to 4 V _{p-p} into 50 Ω; flatness ≤3 %; harmonic content: 2 nd harmonic down –30 dB from fundamental; all others down –40 dB	TEKTRONIX SG 503 ¹ or SG5030 ² Leveled Sine Wave Generator	Software-based adjustments
13 Generator, leveled sine wave, high-frequency	250 MHz to 500 MHz; Variable amplitude from 5 mV to 4 V _{p-p} into 50 Ω; 6 MHz reference; harmonic content: 2 nd harmonic down –30 dB from fundamental; all others down –40 dB	TEKTRONIX SG 504 ¹ Leveled Sine Wave Generator with its leveling head or a TEKTRONIX SG 5030 ² Programmable Leveled Sine Wave Generator with its leveling head	Software based adjustments
14 Probe, 10X, included with this instrument	A P6138 probe	Tektronix number P6138	Signal interconnection
15 Photometer	0.1 to 200 Footlamberts (0.343 to 686 Candelas)	TEKTRONIX J16 Photometer with J6503 Luminance Probe	Contrast adjustment
16 Graticule, external	TEKTRONIX 067-0206-00	TEKTRONIX 067-0206-00	A26 Monitor linearity check
17 Generator, pulse	High amplitude pulse with variable amplitude of 60 V to 100 V.	TEKTRONIX PG 506A Calibration Generator ¹	Software based adjustments and probe adjustment
18 Pulser, tunnel diode	TEKTRONIX 067-0681-01	TEKTRONIX 067-0681-01	Probe adjustment

¹Requires a TM 500 or TM5000 Series Power Module Mainframe.

²Requires a TM5000 Series Power Module Mainframe.

Adjustment Instructions

The following instructions guide you through installing the software on your system, setting up the oscilloscope for adjustment, and starting the adjustment of the oscilloscope by the software.

Hardware Installation

1. *Install the proper GPIB card (see System on page 5-2):* Use the manual accompanying your GPIB card to install and configure that card.

2. Configure the GPIB card:

- a. This software is compatible with cards configured for PCII and PCIIA operation. The following table lists the default card settings.
- b. If these setting conflict with your hardware setup, see your GPIB card manual for alternate settings.

Table 5-4: GPIB Board Configuration

Board Settings	GPIB-PCII ¹	GPIB-PCIIA ¹
Base I/O Address (hex)	2B8	2E1
Interrupt Line	7	7
DMA Channel	1	1

¹Systems using the combination card (GPIB-PCII/IIA) can be configured as either a GPIB-PCII or GPIB-PCIIA.

- c. If you have more than one GPIB card installed, this adjustment software assumes the first card (referenced 0). See your GPIB card manual for information on how to determine which card is your "0" card.

Software Installation



ALWAYS use this installation procedure when installing this software on a new computer. This installation program uses parameters you supply (see step 2, substep c) to create a custom start-up file on your hard disk directory. After installation, you will be instructed to run this start-up batch file whenever you do software-based adjustments, so it can configure your computer properly before it runs the adjustment program. Do *not* simply copy the software files from one computer to another, since the start-up batch file you copy might not match the computer you copy it to.

1. *Create a working disk:* Using the proper DOS commands, copy the adjustment software for your digitizing oscilloscope to a working disk.
2. *Install the software to hard disk:*
 - a. Install your working disk in a floppy drive and switch to that drive.
 - b. Use the appropriate commands to display the file called *README*. Read this file before continuing with this procedure.
 - c. Type *install*. *install* asks you to specify the hard disk on which to install the adjustment software. It also prompts you to specify several GPIB-card configuration parameters.
 - d. The adjustment software is installed in a directory called *TDS400.ADJ*.

3. *Store your installation disk:* Remove your installation disk and store it in a secure place.

Software-Based Adjustments

Equipment Required: All items that are listed for “Software-based Adjustments” under “Purpose” in Table 5-3 on page 5-5.

1. *Hook up the oscilloscope:*
 - a. Connect the GPIB cable (Item 7) to the GPIB port at the computer rear panel. (When multiple GPIB cards are installed, connect to the GPIB0 card.)
 - b. Connect the GPIB cable (Item 7) to the GPIB port at the oscilloscope rear panel.
 - c. Power on the oscilloscope.
 - d. Power on and boot your system.
 2. *Set up the oscilloscope:*
 - a. Press **SHIFT**; then press **UTILITY**.
 - b. Repeatedly press the main-menu button **System** until **I/O** is highlighted in the pop up menu.
 - c. Press the side-menu button **TALK/LISTEN**.
 - d. Use the General Purpose knob to set any address between 0 and 29.
 3. *Let the oscilloscope warm up:* Allow a 20 minute warm up period before you begin step 4.
 4. *Start the adjustment software:*
 - a. Change drives to your hard drive.
 - b. Change directories to TDS400.ADJ.
 - c. Type ADJ400.
 - d. Follow the instructions as prompted on your computer screen.
- 

The adjustment software prompts you to enter the ambient temperature. *Enter the exact ambient temperature, within $\pm 1^{\circ}$ C.* Failure to enter the temperature as just specified results in an adjustment of the oscilloscope that can degrade oscilloscope performance across the specified operating temperature range.
5. *When adjustment is completed:*
 - a. To do a complete adjustment as defined on page 5-3, do the procedure *Probe Adjustment* on page 5-9.

Probe Adjustment

Probe adjustment is divided into three parts: *Compensate the Probe*, *Measure the Probe Bandwidth*, and *Adjust the Probe — High Frequency Response*. If probe bandwidth is within required limits, you are instructed to *not* do the high frequency response adjustment.

Compensate the Probe

Equipment Required: The P6138 probe (Item 14) and the probe adjustment tool included as a probe accessory.

Procedure:

1. *Install the test hookup and preset the oscilloscope controls:*

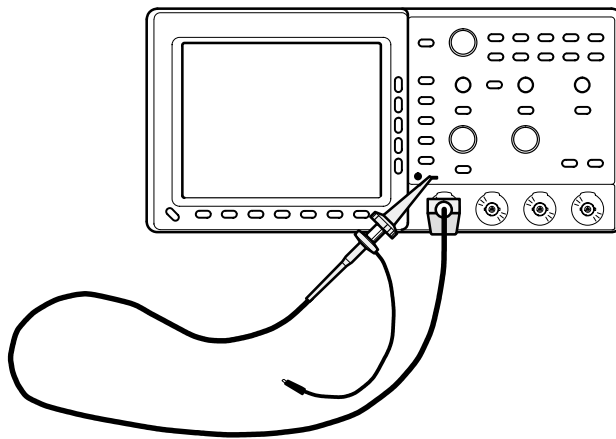


Figure 5-1: Hookup for Probe Compensation

- a. *Hook up test-signal source:* Install the standard-accessory probe to **CH 1**. Connect the probe tip to **PROBE ADJ** on the front panel; leave the probe ground unconnected.
- b. *Initialize the oscilloscope:*
 - Press save/recall **SETUP**.
 - Press the main-menu button **Recall Factory Setup**.
 - Press the side-menu button **OK Confirm Factory Init**.
- c. *Modify the initialized front-panel control settings:*
 - Press **AUTOSET**. Set the horizontal **SCALE** to 200 μ s.
 - Press **SET LEVEL TO 50%**.
 - Press **VERTICAL MENU**.
 - Push the main-menu button **Bandwidth**. Then push the side-menu button **20 MHz**.
 - Press **SHIFT**. Then press **ACQUIRE MENU**.

- Press the main-menu button **Mode**. Then press the side-menu button **Hi Res**.

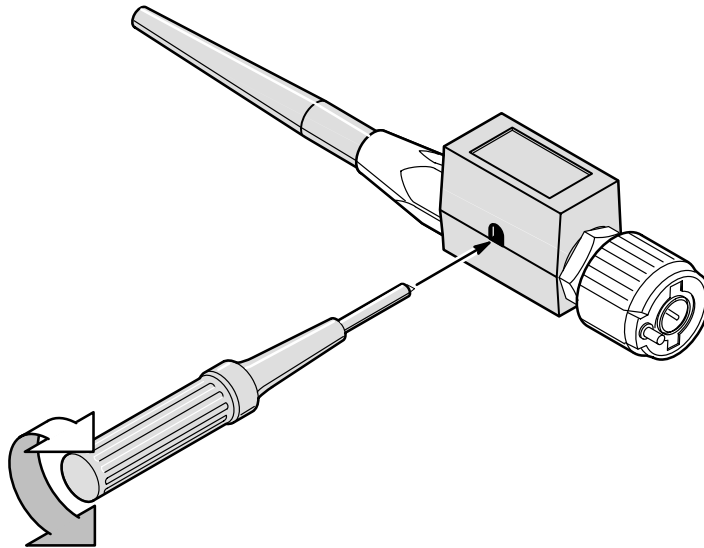


Figure 5-2: Performing Probe Compensation

2. *Compensate the Probe:*

- Locate the probe compensation hole in the side of the probe body.
- Using the probe compensation tool, adjust the probe for best square wave compensation (flat as possible across the top of the waveform).

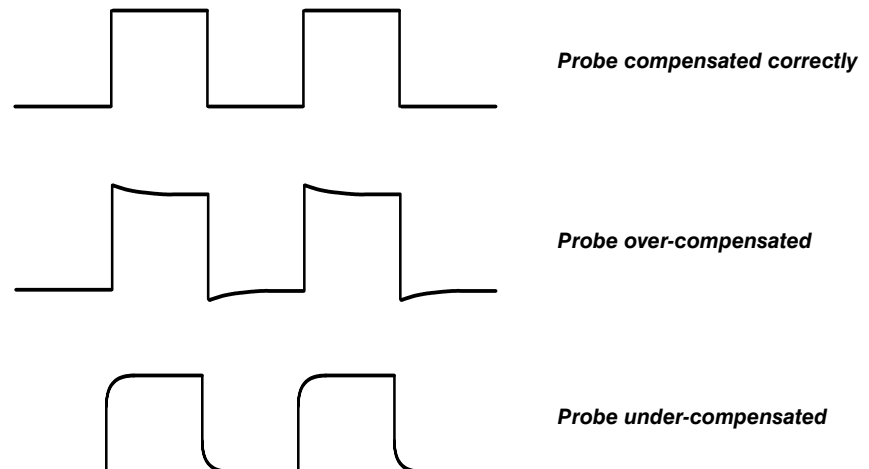


Figure 5-3: Proper and Improper Probe Compensation

3. *Disconnect the hookup:* Disconnect the probe from the probe adj (adjust) terminals; leave probe installed on CH 1 and leave the oscilloscope control setup as is for doing the next part of the probe adjustment.

Measure the Probe Bandwidth

Equipment Required (TDS 410 and TDS 420 Only): One medium-frequency sine wave generator (Item 12), one 50 Ω precision coaxial cable (Item 9), one BNC female to female BNC adapter (Item 2), one 50 Ω BNC to probe tip adapter (Item 3), and one P6138 10X probe (Item 14).

Equipment Required (TDS 460 Only): One high-frequency sine wave generator with its leveling head (Item 13), one BNC female to female BNC adapter (Item 2), one 50 Ω BNC to probe tip adapter (Item 3), and one P6138 10X probe (Item 14).

Procedure:

1. *Install the test hookup and preset the oscilloscope controls:*

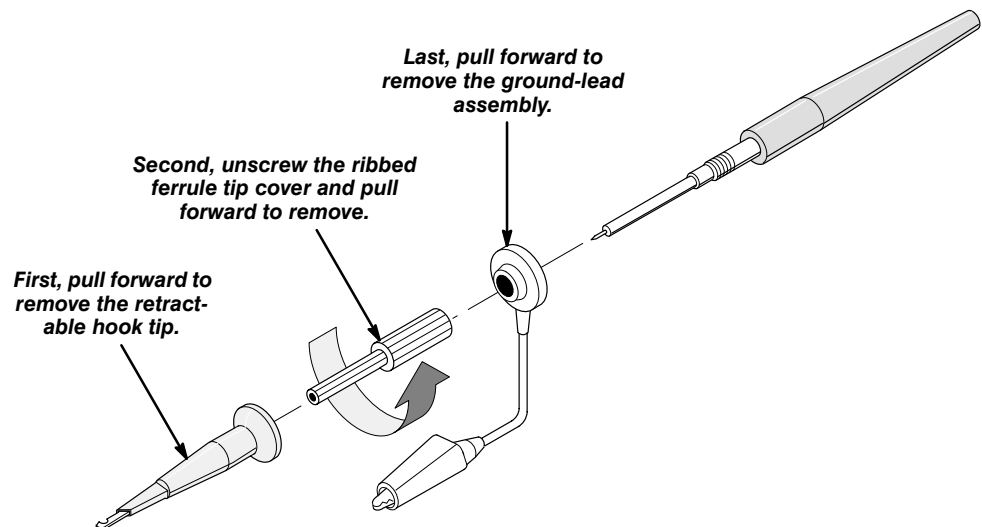


Figure 5-4: Exposing the Inner Probe Tip

- a. *Expose the Inner Probe Tip:* Follow the instructions in Figure 5-4.

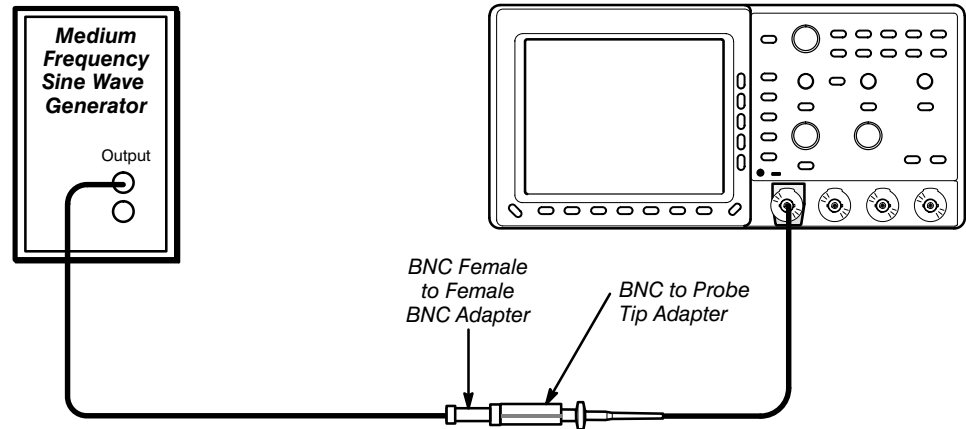


Figure 5-5: Initial Test Hookup (TDS 410 and TDS 420 Only)

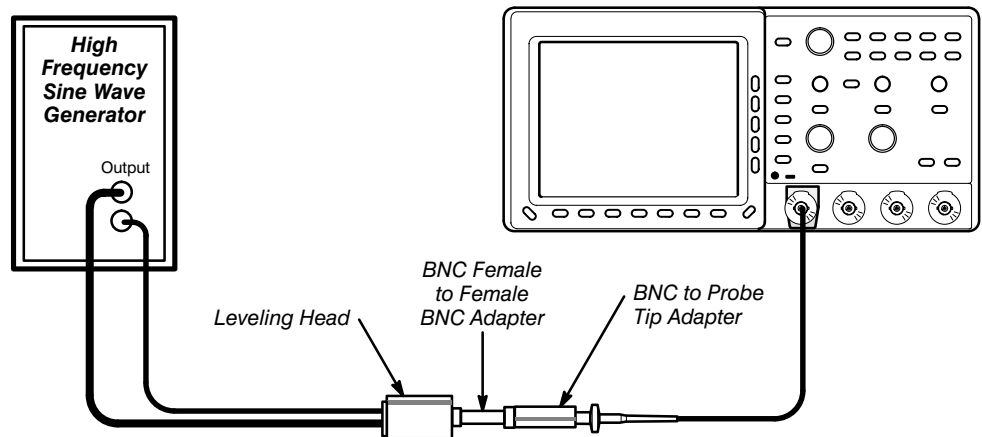


Figure 5-6: Initial Test Hookup (TDS 460 Only)

b. *Hook up test-signal source:*

- (TDS 410 and TDS 420 Only) Connect the output of a medium-frequency sine wave generator, through a 50 Ω precision cable, to a BNC female to female BNC adapter (see Figure 5-5).
- (TDS 460 Only) Connect the output of a high-frequency sine wave generator, through its leveling head, to a BNC female to female BNC adapter (see Figure 5-6).
- Connect the BNC female to female BNC adapter to a BNC to probe tip adapter.
- Plug the probe tip from the probe on CH 1 into the BNC to probe tip adapter.

c. *Initialize the oscilloscope:*

- Press save/recall **SETUP**.
- Press the main-menu button **Recall Factory Setup**.
- Press the side-menu button **OK Confirm Factory Init**.

d. *Modify the initialized front-panel control settings:*

- Press **Autoset**.
- Set the vertical **SCALE** to 100 mV.
- (TDS 410 and TDS 420 Only) Set the horizontal **SCALE** to 10 μ s.
- (TDS 460 Only) Set the horizontal **SCALE** to 100 ns.
- Press **SHIFT**. Then press **ACQUIRE MENU**.
- Press the main-menu button **Mode**. Then press the side-menu button **Hi Res**.
- Press **MEASURE**.
- Press the main-menu button **Hi-Low Setup**. Then press the side-menu button **Min-Max**.
- Press the main-menu button **Select Measurement for Ch1**.
- Repeatedly press the side-menu button **—more—** until **Pk-Pk** appears in the side menu. Press the side-menu button **Pk-Pk**.
- Press **CLEAR MENU**.

2. *Confirm probe bandwidth:*

a. *Display and measure the test signal:*

- (TDS 410 and TDS 420 Only) Monitor the **CH 1 Pk-Pk** readout while you set the output of the generator for a 600 mV (6 division), 50 kHz reference signal.
- (TDS 460 Only) Monitor the **CH 1 Pk-Pk** readout while you set the output of the generator for a 600 mV (6 division), 6 MHz reference signal.
- (TDS 410 and TDS 420 Only) Set the horizontal **SCALE** to 2 ns and set the frequency of the generator to 150 MHz.
- (TDS 460 Only) Set the horizontal **SCALE** to 1 ns and set the frequency of the generator to 350 MHz.
- Read the measurement results at the CH 1 Pk-Pk readout on screen.

b. *Check against limits:* CHECK that the **CH 1 Pk-Pk** readout is greater than or equal to 420 mV.

3. *Disconnect the hookup:*
 - a. Unplug the probe from BNC to probe tip adapter.
 - b. If substep 2b was passed, the probe adjustment is finished. Reverse the instructions in Figure 5-4, page 5-11, to reinstall the retractable hook probe tip.
 - c. If substep 2b was *not* passed, leave the probe tip exposed. Remove the probe from CH 1 and go on to the next procedure *Adjust the Probe — High Frequency Response*.

Adjust the Probe — High Frequency Response

Do not perform this procedure until you have first completed the procedures *Compensate the Probe* and *Measure Probe Bandwidth* on pages 5-9 and 5-11, respectively.

Do not perform this procedure if you have successfully completed *Measure the Probe Bandwidth*. Probe adjustment is complete.

Equipment Required (TDS 410 and TDS 420 Only): One pulse generator (Item 17), one 50 Ω precision cable (Item 9), one BNC female to female BNC adapter (Item 2), one 50 Ω BNC to probe adapter (Item 3), and one P6138 10X probe (Item 14). Also required is the probe adjustment tool included with the P6138 probe accessories.

Equipment Required (TDS 460 Only): One pulse generator (Item 17), one 50 Ω precision cable (Item 9), one tunnel diode pulser (Item 18), one BNC female to female BNC adapter (Item 2), one 50 Ω BNC to probe adapter (Item 3), one P6138 10X probe (Item 14), and one 10X attenuator (Item 5). Also required is the probe adjustment tool included with the P6138 probe accessories.

Procedure:

1. *Install the test hookup and preset the oscilloscope controls:*

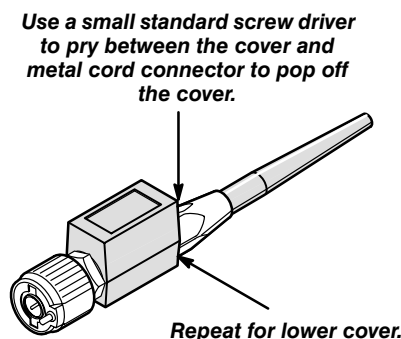


Figure 5-7: Exposing the Probe Body

a. *Access Inner Probe Tip and Adjustment Ports:*

- The probe tip should be exposed from the procedure *Measure Probe Bandwidth*. If not, follow the instructions in Figure 5-4 to expose the probe tip.
- Follow the instructions in Figure 5-7 to remove the probe body covers.

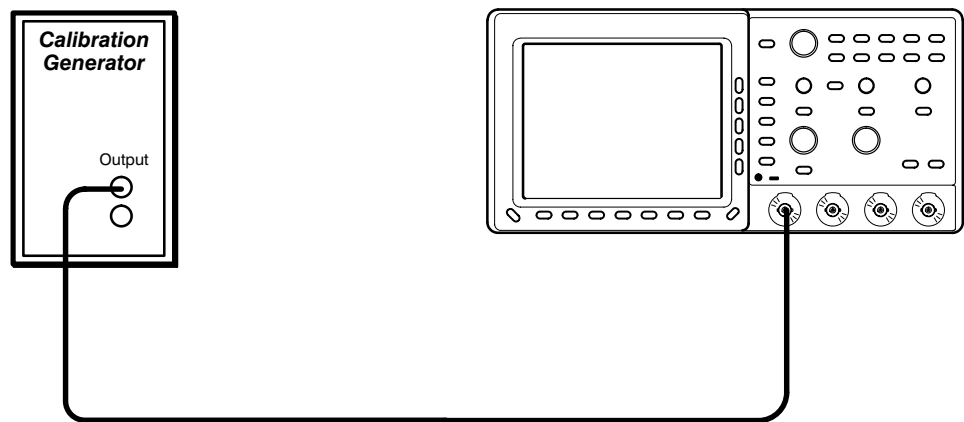


Figure 5-8: Initial Test Hookup (TDS 410 and TDS 420 Only)

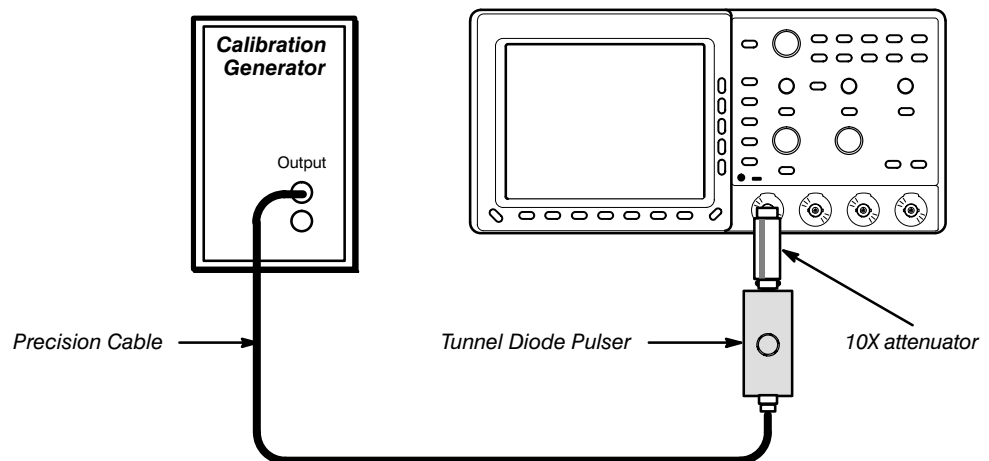


Figure 5-9: Initial Test Hookup (TDS 460 Only)

b. *Hook up test-signal source (TDS 410 and TDS 420 Only):*

- Connect the high-amplitude output of a calibration generator, through a 50 Ω precision cable to the **CH 1** input (see Figure 5-8).

c. *Hook up test-signal source (TDS 460 Only):*

- Connect the high-amplitude output of a calibration generator, through a 50 Ω precision cable to the input of a tunnel diode pulser (see Figure 5-9).
- Connect the output of the tunnel diode pulser through a 10X attenuator to CH 1.
- Set the triggering level of the tunnel diode pulser to minimum.

d. *Initialize the oscilloscope:*

- Press save/recall **SETUP**.
- Press the main-menu button **Recall Factory Setup**.
- Press the side-menu button **OK Confirm Factory Init**.

e. *Modify the initialized front-panel control settings:*

- Set vertical **SCALE** to 5 mV.
- Press **VERTICAL MENU**. Then press the main-menu button **Coupling**. Press the side-menu button Ω to toggle to 50 Ω coupling.
- Press **SHIFT**. Then press **ACQUIRE MENU**.
- Press the main-menu button **Mode**. Then press the side-menu button **Hi Res**.
- Press **CLEAR MENU**.

2. *Adjust the Probe:*a. *Display and store the reference signal:*

- (TDS 410 and TDS 420 Only) Set the high-amplitude output of the generator for a six division square wave on screen (see Figure 5-10).
- (TDS 460 Only) Set the high-amplitude output of the generator for 60 to 100 V at the input to the tunnel diode pulser (see Figure 5-11).
- (TDS 460 Only) Advance the triggering level of the tunnel diode pulser until a five to six division square wave appears on screen.
- Push **SET LEVEL TO 50%** as required to trigger the signal.
- Advance the horizontal **SCALE** to 5 ns.
- Press **HORIZONTAL MENU**.
- Press the main-menu button **Trigger Position**; and press the side-menu button **10%**.
- Push **SHIFT**. Then press **SAVE WAVEFORM**.
- Press the main-menu button **Save Waveform**. Then press the side-menu button **To Ref 1**.

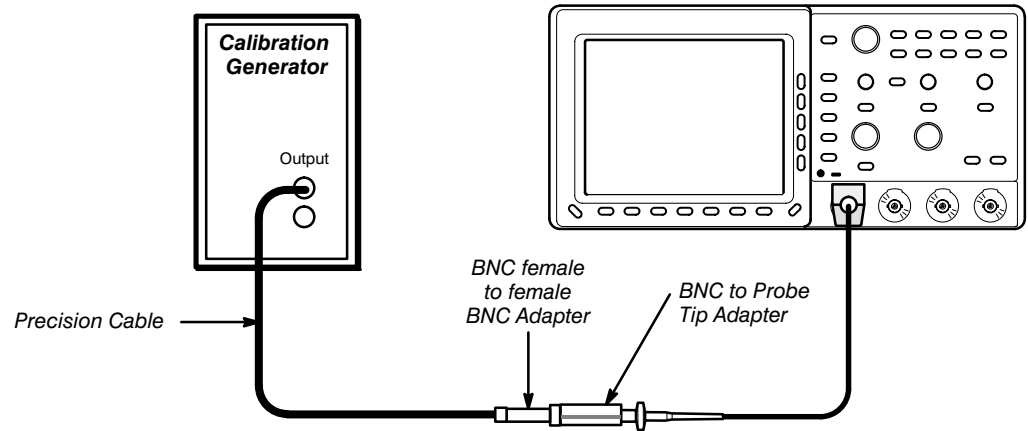


Figure 5-10: Probe Test Hookup (TDS 410 and TDS 420 Only)

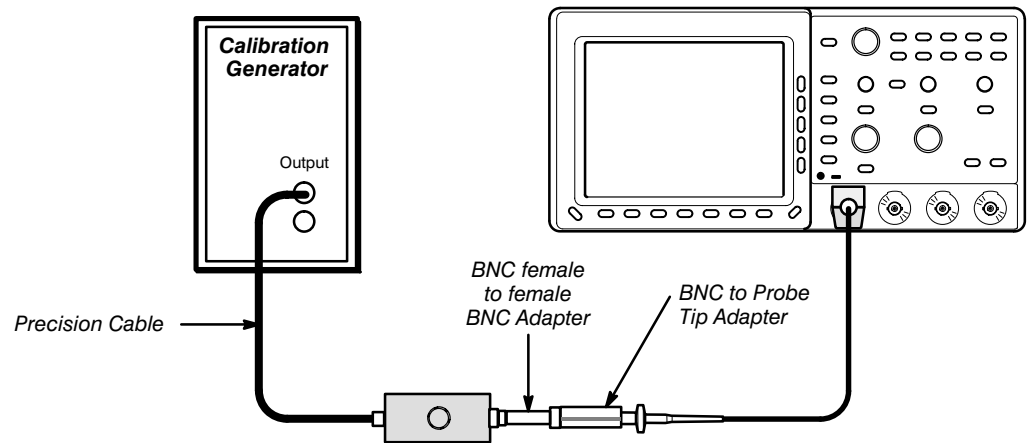


Figure 5-11: Probe Test Hookup (TDS 460 Only)

- Press **MORE**. Then push the main-menu button **Ref 1**.
- b. *Display the test signal:*
 - (TDS 460 Only) Disconnect the tunnel diode pulser at CH 1 and remove the 10X attenuator.
 - (TDS 460 Only) Connect the output of the tunnel diode pulser through a BNC female to BNC female adapter to a BNC to probe tip adapter.
 - (TDS 410 and TDS 420 Only) Disconnect the calibration generator at CH 1.
 - (TDS 410 and TDS 420 Only) Connect the output of the calibration generator through a BNC female to BNC female adapter to a BNC to probe tip adapter.

- Install the probe on CH 1.
 - Plug the probe tip from the probe into the BNC to probe tip adapter.
 - Press the main-menu button **Coupling**. Then press the side-menu button Ω to toggle to 1 M Ω coupling.
 - Press **HORIZONTAL MENU**.
 - Press the main-menu button **Trigger Position**; press the side-menu button **10%**.
- c. *Make the adjustments:*
- Locate the various adjustments in Figure 5-12.
 - Manually adjust the front-corner response of the probe to best match the response of the Ref 1 waveform. Note that it is more important to match the response during the first 5 ns than during the entire first 20 ns the adjustments affect.
 - See Figure 5-13 to see what areas on the front corner that the various adjustments affect.

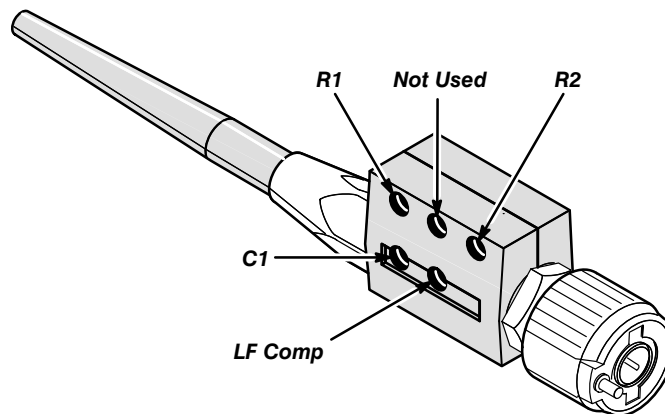


Figure 5-12: Locations of Probe Adjustments

- d. *Recheck Probe Bandwidth:*
- Redo the procedure *Measure the Probe Bandwidth* to check if the probe now meets its bandwidth requirement.
 - If bandwidth is met, adjustment is complete. Skip to step 3.
 - If bandwidth is *not* met, redo this procedure, increasing front corner overshoot slightly relative to the stored waveform.
 - Repeat this step (d) until bandwidth is met.

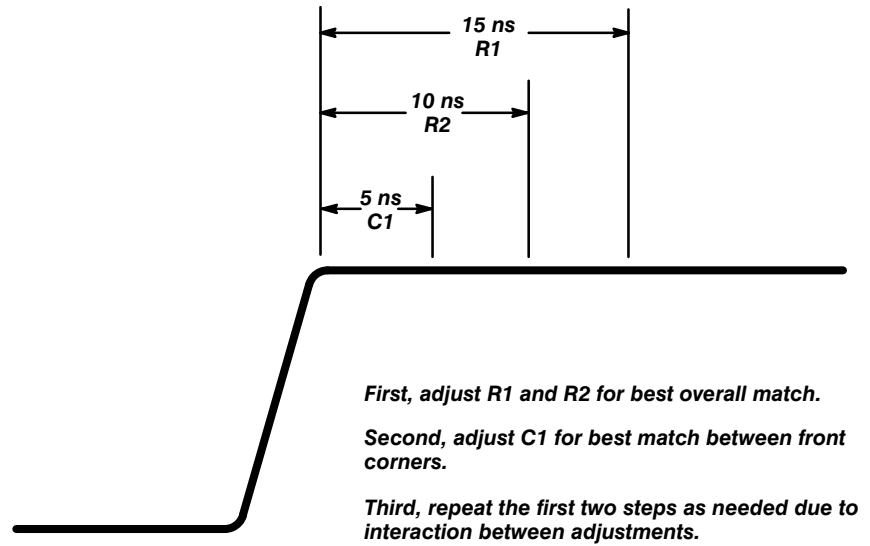


Figure 5-13: Adjustments vs. Front-Corner Response

3. *Disconnect the hookup:* Unplug the probe from the BNC to probe tip adapter. Reverse the instructions in Figure 5-4, page 5-11, to reinstall the retractable probe tip.

Monitor Assembly Adjustment



Do not do this procedure when performing a routine adjustment. Only do this procedure if the display on the monitor assembly has become unsatisfactory. See *Complete Adjustment* on page 5-3.

CAUTION

High voltages are accessible on the A26 Monitor assembly. Do not touch the circuit board when the power is on. Do not touch the CRT anode button even if the power is off. Wear safety glasses when working with the CRT.

WARNING

Static electricity can damage this circuitry. When standing the CRT on its front panel place it on a clean padded surface.

The equipment required to do this procedure is listed in Table 5-3.

Equipment Required: One J16 Photometer with a J6503 Luminance Probe (Item 15), one monitor adjustment tool (Item 4), and an external graticule (Item 16).

Procedure:

1. *Access the inside of the oscilloscope:* See *Removal and Installation Procedures* in Section 6 to remove the cabinet.
2. *Adjust the vertical and horizontal sync:*
 - a. If the display rolls vertically adjust V. SYNC (R453) to the center of the stable display range. (See Figure 5-14.)
 - b. If diagonal lines are present on the display adjust H. SYNC (R473) to the center of the stable display range.
3. *Adjust the display brightness:*
 - a. *Display the Circle test pattern:*
 - Disconnect the power plug from the oscilloscope.
 - Set the DIP switch (S1), located near the front of the A03 CPU board, as follows:

Switch No.	1	2	3	4	5	6	7	8
Open						X	X	
Closed	X	X	X	X	X			X

- Reconnect the power plug to the oscilloscope.
 - Power on the oscilloscope.
 - Allow 15 to 20 minutes for the oscilloscope to warm up.
 - Press **SHIFT** and **UTILITY**.
 - Repeatedly press the main-menu button **System** until **Diag/Err** is highlighted in the pop up menu.
 - Repeatedly press the main-menu button **Area** until **Display** is highlighted in the pop up menu.
 - Repeatedly press the side-menu button **—more—** until **Circle** appears in the side menu. Push **Circle**.
 - Press the main-menu button **EXECUTE**. Then press the side-menu button **Ok Confirm Run Test**.
- b. *Make the brightness adjustment:*
- Locate R482 (BRITE) (see Figure 5-14).

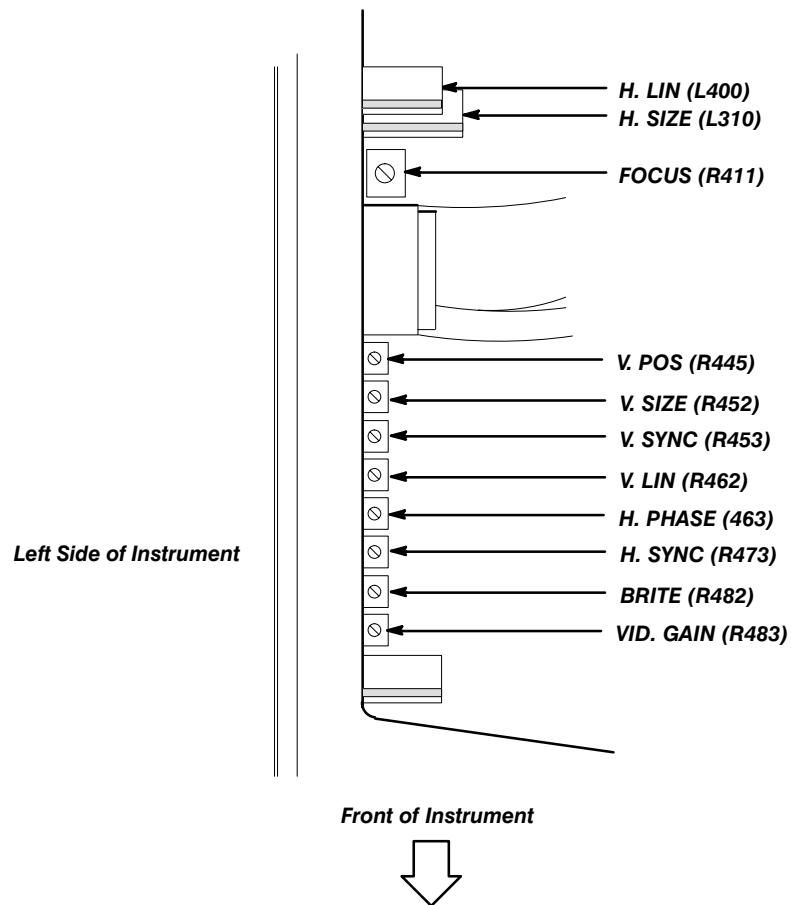


Figure 5-14: Monitor Adjustment Locations

- Adjust R482 until the background raster lines in the 5% luminance patch (see Figure 5-15) disappear while the lines in the 10% luminance patch are visible.
4. *Adjust the display contrast:*
- a. *Display the White Box test pattern:*
- Press the center main-menu button to display the main-menu.
 - Press the main-menu button **Tests**.
 - Repeatedly press the side-menu button **—more—** until **White Box** appears in the side menu. Push **White Box**.
 - Press the main-menu button **EXECUTE**. Then press the side-menu button **Ok Confirm Run Test**.

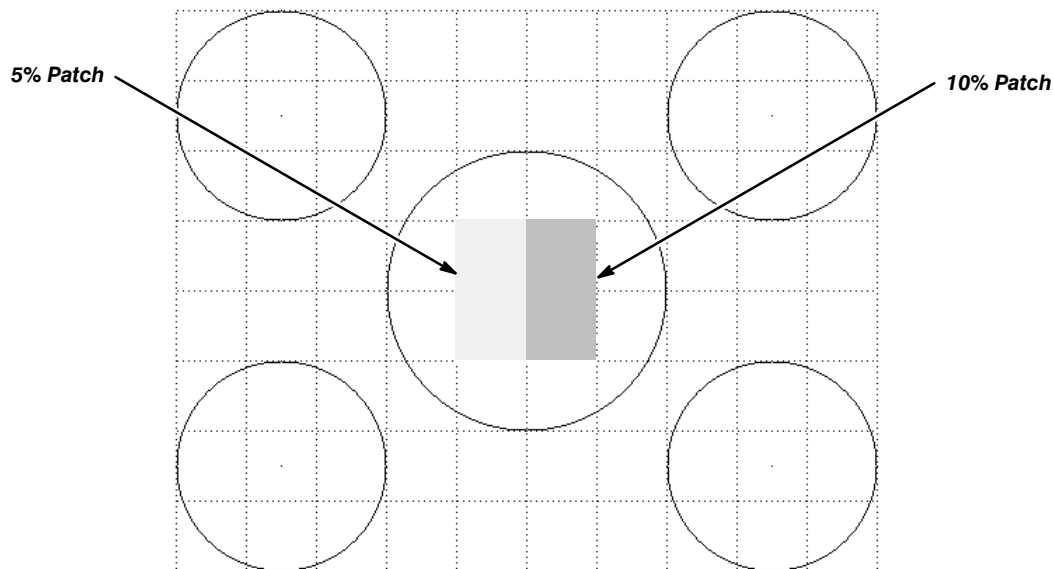


Figure 5-15: Five and Ten Percent Luminance Patches

- b. *Make the contrast adjustment:*
- Locate R483 (VID. GAIN) on the A26 Monitor assembly (see Figure 5-14).
 - Monitor the luminance at center screen using a J16 photometer and a luminance probe.
 - Adjust R483 (VID. GAIN) for a reading of 100 foot-lamberts (343 candelas).
 - If R483 needed a large adjustment, perform the brightness adjustment again.

5. *Adjust the display focus:*

a. *Display the Composite test pattern:*

- Press the center main-menu button to display the main-menu.
- Press the main-menu button **Tests**.
- Repeatedly press the side-menu button **—more—** until **Composite** appears in the side menu. Push **Composite**.
- Press the main-menu button **EXECUTE**. Then press the side-menu button **Ok Confirm Run Test**.

b. *Make the focus adjustment:*

- Locate R411 (FOCUS) (see Figure 5-14).
- Adjust R411 for best overall focusing at all four corners and at the center of the screen (see Figure 5-16).

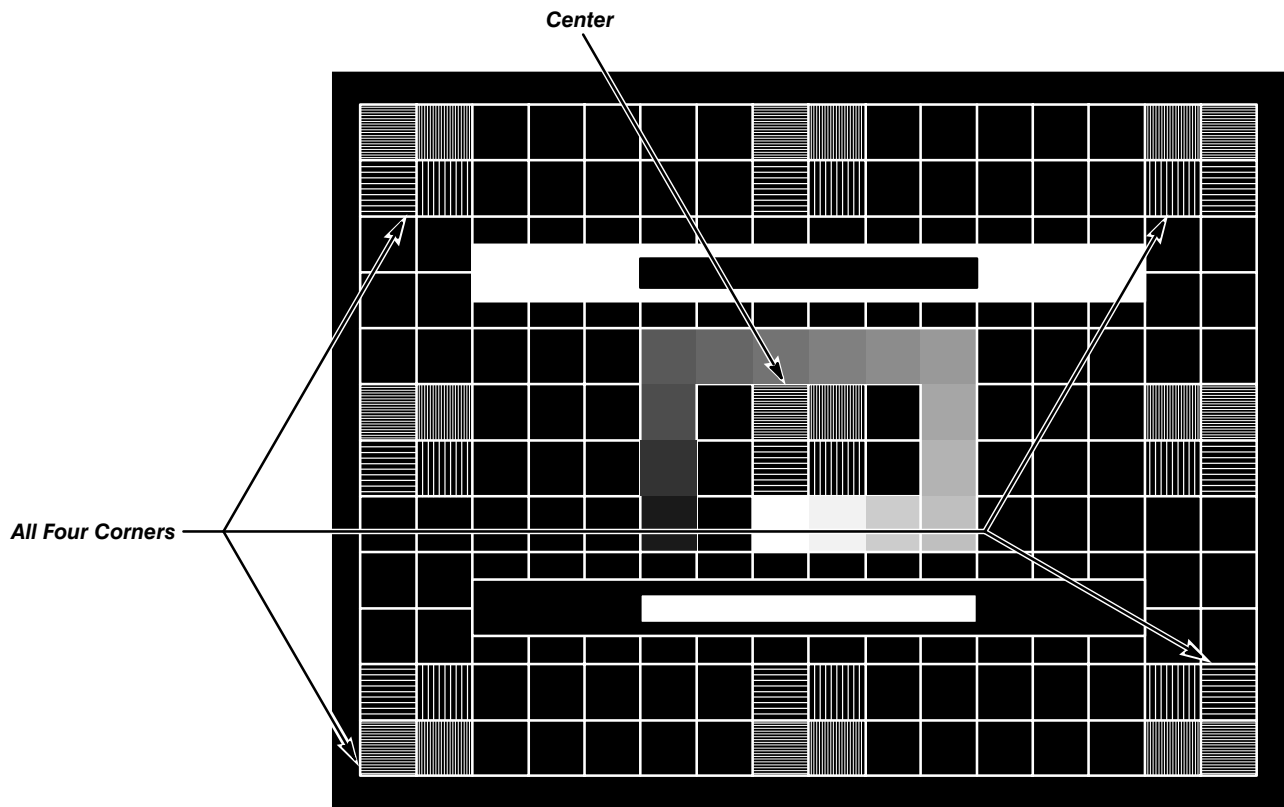


Figure 5-16: Composite Pattern for Focusing

6. *Adjust the display position and size:*

a. *Display the 16 × 12 test pattern:*

- Press the center main-menu button to display the main-menu.
- Press the main-menu button **Tests**.

- Repeatedly press the side-menu button **—more—** until **16x12** appears in the side menu. Push **16x12**.
 - Press the main-menu button **EXECUTE**. Then press the side-menu button **Ok Confirm Run Test**.
- b. *Make the position and size adjustment:*
- Place the external graticule (16) over the front of the CRT.
 - Locate the R443 (V. POS), R452 (V. SIZE), R463 (H. PHASE), and L310 (H. SIZE) controls (see Figure 5-14).
 - Adjust the external graticule horizontally and vertically, and if necessary R443, R452, R463, and L310, so that the centers of the outer boundaries of the displayed 16×12 test pattern are within the limits marked on the external graticule.

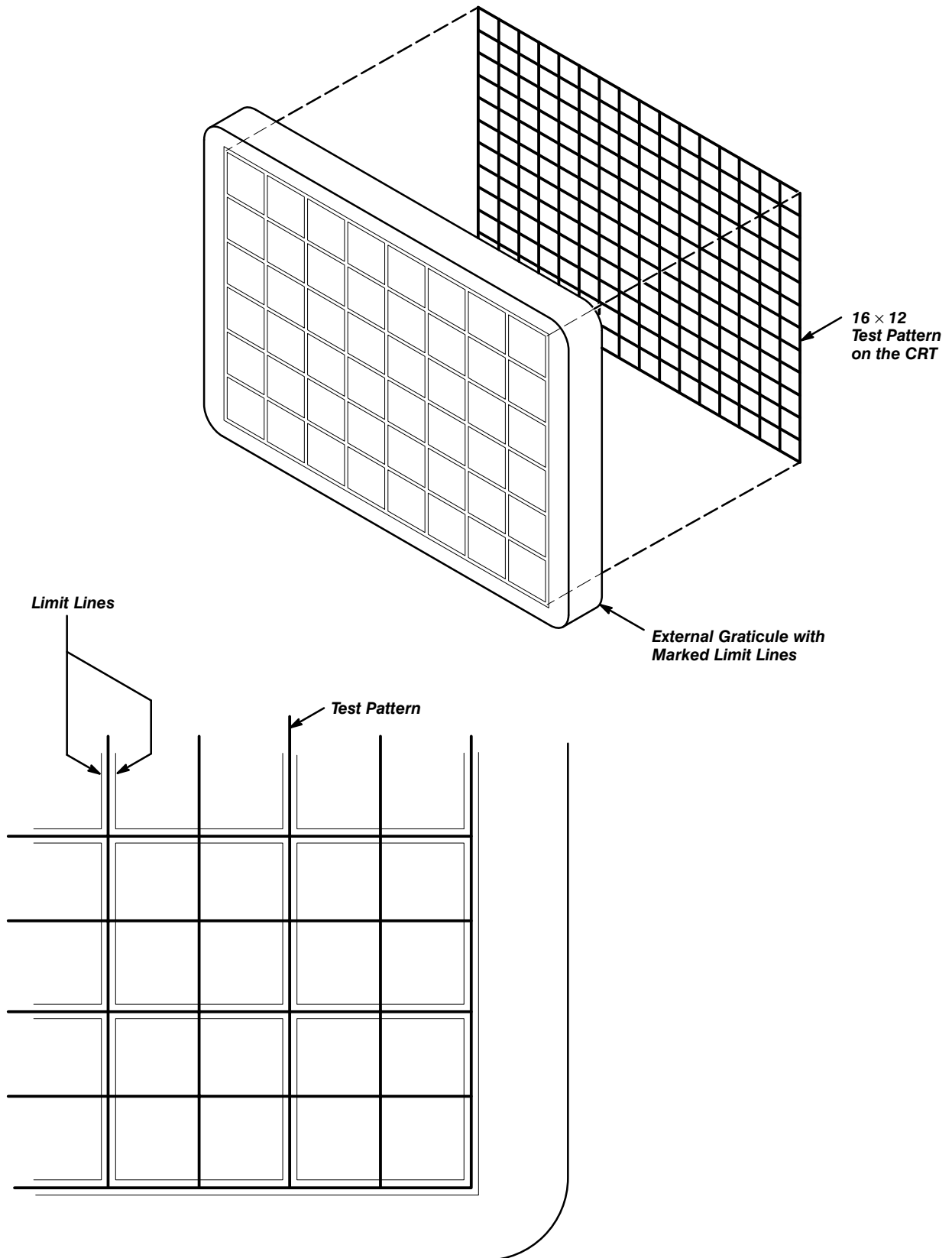


Figure 5-17: External Graticule Limit Lines

7. *Adjust geometry and linearity:*

- a. *Set up for geometry and linearity adjustment:* If you have not performed the display position adjustment, perform step 6.
- b. *Make the linearity adjustment:*
 - Locate R462 (V. LIN) (see Figure 5-14).
 - Adjust R462 so that alternate vertical lines of the displayed 16 × 12 test pattern are within the limits marked on the external graticule. If the lines can not be adjusted within those limits, replace the A26 Monitor assembly module.
 - If necessary perform step 6 again.

8. *Restore the oscilloscope to normal operation:*

- a. Restore the dip switch to the settings that follow:

Switch No.	1	2	3	4	5	6	7	8
Open								
Closed	X	X	X	X	X	X	X	X

- b. Power off the oscilloscope.
- c. See *Removal and Installation Procedures* in Section 6 to reinstall the cabinet and other modules removed in step 1.

Maintenance Information

This section contains the information needed to do periodic and corrective maintenance on the TDS 410, TDS 420, & TDS 460 Digitizing Oscilloscopes. Specifically, the following subsections are included:

- **Maintenance Information** — This subsection. It includes this introduction plus general information on preventing damage to internal modules when doing maintenance.
- **Inspection and Cleaning** — Information and procedures for inspecting the oscilloscope and cleaning its external and internal modules.
- **Removal and Installation Procedures** — Procedures for the removal of defective modules and replacement of new or repaired modules. Also included is a procedure for disassembly of the oscilloscope for cleaning.
- **Troubleshooting** — Information for isolating failed modules. Included are instructions for operating the oscilloscope internal diagnostic routines and troubleshooting trees. Most of the trees make use of these internal diagnostic routines to speed fault isolation to a module.

Service personnel must be prepared to safely service the oscilloscope. This manual is for qualified service personnel only. Read the *Safety Summary* at the front of this manual. If you are unfamiliar with the operation of this oscilloscope, read *Operating Information* before servicing the oscilloscope. To prevent electro-static damage (ESD), read *Preventing ESD*, on page 6-2, before servicing the oscilloscope.

Procedures Not In This Section

The following sections contain information and procedures related to doing maintenance.

- Section 2, *Operating Information*, covers instructions useful when operating the oscilloscope in order to troubleshoot it. The section also details the service strategy and lists options for obtaining maintenance service and for replacing failed modules.
- Section 3, *Theory of Operation*, contains a circuit description at the module, or block, level.
- Section 4, *Performance Verification*, contains procedures that are useful in isolating problems to modules by testing oscilloscope performance.
- Section 5, *Adjustment Procedures*, addresses after repair adjustment and the interval between periodic adjustments. It contains a procedure for adjusting the internal circuits of the oscilloscope.

- Section 9, *Diagrams*, contains a block diagram using individual modules as blocks and an interconnection diagram showing connections between the modules.
- Section 10, *Mechanical Parts List*, lists all field replaceable modules by part number.

Preventing ESD



Static discharge can damage any semiconductor component in this oscilloscope.

Precautions

When performing any service which requires internal access to the oscilloscope, adhere to the following precautions to avoid damaging internal modules and their components due to electrostatic discharge (ESD).

1. Minimize handling of static-sensitive modules.
2. Transport and store static-sensitive modules in their static protected containers. Label any package that contains static-sensitive modules.
3. Discharge the static voltage from your body by wearing a grounded antistatic wrist strap while handling these modules. Do service of static-sensitive modules only at a static-free work station.
4. Do not remove the oscilloscope cabinet unless you have met precaution number 3, above. Consider all internal modules static-sensitive.
5. Nothing capable of generating or holding a static charge should be allowed on the work station surface.
6. Handle circuit boards by their edges when possible.
7. Do not slide the modules over any surface.
8. Avoid handling modules in areas that have a floor or work-surface covering capable of generating a static charge.
9. Do not use high-velocity compressed air when cleaning dust from modules.

Susceptibility to ESD

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.

Table 6-1: Relative Susceptibility to Static-Discharge Damage

Semiconductor Classes	Relative Susceptibility Levels¹
MOS or CMOS microcircuits or discrete circuits, 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

¹Voltage equivalent for levels (voltage discharged from a 100 pF capacitor through resistance of 100 ohms):

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

Inspection and Cleaning

Inspection and Cleaning describes how to inspect for dirt and damage on, and how to clean the exterior and interior of, the TDS 410, TDS 420, & TDS 460 Digitizing Oscilloscopes. Inspection and cleaning are done as preventive maintenance. Preventive maintenance, when done regularly, may prevent oscilloscope malfunction and enhance its reliability.

Preventive maintenance consists of visually inspecting and cleaning the oscilloscope and using general care when operating it.

How often to do maintenance depends on the severity of the environment in which the oscilloscope is used. A proper time to perform preventive maintenance is just before oscilloscope adjustment.

General Care

The cabinet helps keep dust out of the oscilloscope, and it is a major component of the oscilloscope cooling system. The cabinet should normally be in place when operating the oscilloscope. The front cover protects the front panel and display from dust and damage. Install the front cover when storing or transporting the oscilloscope.

Inspection and Cleaning Procedures

Inspect and clean the oscilloscope as often as operating conditions require. The collection of dirt on components inside can cause them to overheat and breakdown. (Dirt acts as an insulating blanket, preventing efficient heat dissipation.) Dirt also provides an electrical conduction path that could cause an oscilloscope failure, especially under high-humidity conditions.



CAUTION

Avoid the use of chemical cleaning agents which might damage the plastics used in this oscilloscope. Use only deionized water when cleaning the menu buttons or front-panel buttons. Use a 75% isopropyl alcohol solution as a cleaner and rinse with deionized water. Before using any other type of cleaner, consult your Tektronix Service Center or representative.

Avoid the use of high pressure compressed air when cleaning dust from the interior of this instrument. (High pressure air can cause ESD.) Instead, use low pressure compressed air (about 9 psi).

Inspection — Exterior

Inspect the outside of the oscilloscope for damage, wear, and missing parts, using Table 6-2 as a guide. Oscilloscopes that appear to have been dropped or otherwise abused should be checked thoroughly to verify correct operation and performance. Immediately repair defects that could cause personal injury or lead to further damage to the oscilloscope.

Table 6-2: External Inspection Check List

Item	Inspect For	Repair Action
Cabinet, front panel, and cover	Cracks, scratches, deformations, and damaged hardware or gaskets.	Replace defective module.
Front-panel knobs	Missing, damaged, or loose knobs.	Repair or replace missing or defective knobs.
Connectors	Broken shells, cracked insulation, and deformed contacts. Dirt in connectors.	Replace defective modules. Clear or wash out dirt.
Carrying handle and cabinet feet	Correct operation.	Replace defective module.
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 modules.

Cleaning Procedure — Exterior



To prevent getting moisture inside the oscilloscope during external cleaning, use only enough liquid to dampen the cloth or applicator.

1. Remove loose dust on the outside of the oscilloscope with a lint free cloth.
2. Remove remaining dirt with a lint free cloth dampened in a general purpose detergent-and-water solution. Do not use abrasive cleaners.
3. Clean the monitor screen with a lint-free cloth dampened with either isopropyl alcohol or, preferably, a gentle, general purpose detergent-and-water solution.

Inspection — Interior

To access the inside of the oscilloscope for inspection and cleaning, refer to the *Removal and Installation Procedures* in this section.

Inspect the internal portions of the oscilloscope for damage and wear using Table 6-3 as a guide. Defects found should be repaired immediately.

If any electrical module is replaced, check Table 5-1 in Section 5 to see if it is necessary to adjust the oscilloscope.



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

Table 6-3: Internal Inspection Check List

Item	Inspect For	Repair Action
Circuit boards	Loose, broken, or corroded solder connections. Burned circuit boards. Burned, broken, or cracked circuit-run plating.	Remove the failed module, and replace it with a fresh module.
Resistors	Burned, cracked, broken, or blistered condition.	Remove the module with the faulty resistor and replace it with a fresh module.
Solder connections	Cold solder or rosin joints.	Resolder joint and clean with isopropyl alcohol.
Capacitors	Damaged or leaking cases. Corroded solder on leads or terminals.	Remove the module with the faulty capacitor and replace it with a fresh module from the factory.
Semiconductors	Loosely inserted in sockets. Distorted pins.	Firmly seat loose semiconductors. Remove devices that have distorted pins. Carefully straighten pins (as required to fit the socket), using long-nose pliers, and reinsert firmly. Ensure that straightening action does not crack pins causing them to break off.
Wiring and cables	Loose plugs or connectors. Burned, broken, or frayed wiring.	Firmly seat connectors. Repair or replace modules with defective wires or cables.
Chassis	Dents and deformations	Straighten, repair, or replace chassis.

Cleaning Procedure — Interior



If, after doing steps 1 and 2, a module is clean upon inspection, skip the remaining steps.

1. Blow off dust with dry, low-pressure, deionized air (approximately 9 psi).
2. Remove any remaining dust with a lint free cloth dampened in isopropyl alcohol (75% solution) and rinse with a warm deionized water. (A cotton-tipped applicator is useful for cleaning in narrow spaces and on circuit boards.)
3. If steps 1 and 2 do not remove all the dust or dirt, the oscilloscope may be spray washed using a solution of 75% isopropyl alcohol by doing steps 4 through 8.
4. Gain access to the parts to be cleaned by removing easily accessible shields and panels (see *Removal and Installation Procedures*).
5. Spray wash dirty parts with the isopropyl alcohol and wait 60 seconds for the majority of the alcohol to evaporate.
6. Use hot (120° F to 140° F) deionized water to thoroughly rinse the parts.
7. Dry all parts with low-pressure, deionized air.
8. Dry all components and assemblies in an oven or drying compartment using low-temperature (125° F to 150° F) circulating air.

Lubrication

There is no periodic lubrication required for this oscilloscope.

Removal and Installation Procedures

This section contains procedures for removal and installation of all mechanical and electrical modules. Any electrical or mechanical module, assembly, or part listed in Section 10 of this manual is a module.

Preparation — Please Read

WARNING

Before doing this or any other procedure in this manual, read the Safety Summary found at the beginning of this manual. Also, to prevent possible injury to service personnel or damage to oscilloscope components, read Before Servicing and Supplying Operating Power in Section 2 and Preventing ESD in this section.

This section contains the following:

- This preparatory information that you need to properly do the procedures that follow.
- A list of equipment required to remove all modules.
- Procedures for removal and reinstallation of the electrical and mechanical modules.
- A disassembly procedure for removal of all the major modules from the oscilloscope at one time and for reassembly of those modules into the oscilloscope. A complete disassembly is normally only done when completely cleaning the oscilloscope. (Instructions for doing the actual cleaning are found under *Inspection and Cleaning* at the beginning of this section.)
- Three module locator diagrams for finding all the modules in this oscilloscope.

WARNING

Before doing any procedure in this subsection, disconnect the power cord from the line voltage source. Failure to do so could cause serious injury or death.

List of Modules

Section 10 lists all modules.

Cable Removal

Usually cables are partially or completely removed as in the course of removing a module they plug into. However, all field replaceable cables are modules and can be replaced by doing the *Access Procedure*. Figure 6-4 shows the cables and their routing.

General Instructions



READ THESE GENERAL INSTRUCTIONS BEFORE REMOVING A MODULE.

First read over the *Summary of Procedures* that follows to understand how the procedures are grouped. Then read *Equipment Required* for a list of the tools needed to remove and install modules in this oscilloscope.

Reference Figure 6-1. Procedures refer to “front,” “rear,” “top,” etc. of the oscilloscope; note from the figure which sides are referenced.

If you are disassembling this oscilloscope for cleaning, go to the procedure *Disassembly for Cleaning* on page 6-62.

If you are removing a module for service, begin by doing the procedure *Access Procedure* (page 6-13). By following the instructions in that procedure, you remove the module to be serviced while removing the minimum number of additional modules.

Summary of Procedures

The procedures are described in the order in which they appear in this section. In addition, you can look up any procedure for removal and reinstallation of any module in the *Table of Contents* of this manual.

- The *Access Procedure* on page 6-13 first directs you to the procedure(s) that remove any modules that must be removed to access the module to be serviced. It then directs you to the procedure to remove that module.
- *Procedures for Module Removal and Installation* on page 6-21 are the procedures for removing modules. *These procedures assume you have done the access procedure.*

- *Disassembly for Cleaning* on page 6-35 is a procedure, based on the module removal procedures just described, that removes all modules for cleaning. Instructions for cleaning are found in *Inspection and Cleaning*, which begins this section. *The Disassembly for Cleaning procedure does not use the access procedure.*

NOTE

Read the cleaning procedure before disassembling the oscilloscope for cleaning.

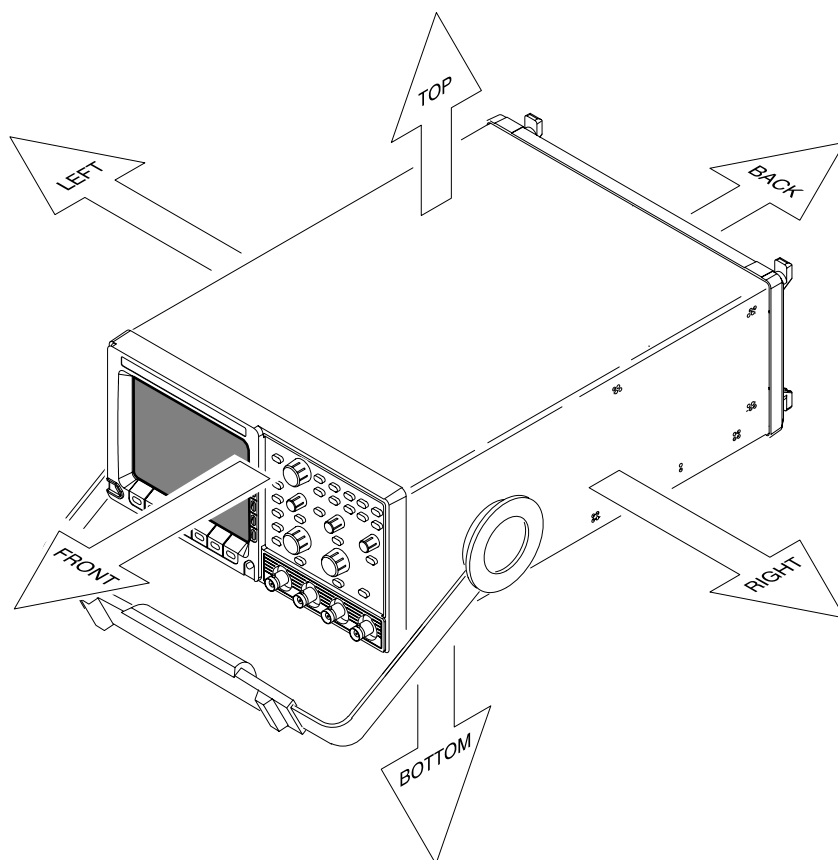


Figure 6-1: Oscilloscope Orientation

Equipment Required — The following tools are required to completely disassemble the oscilloscope into its modules. The tools required to remove an individual module are listed in the first step of its procedure.

All the tools are standard tools readily available from tool suppliers.

Table 6-4: Tools Required for Module Removal

Item No.	Name	Description
1	Screwdriver handle	Accepts Torx®-driver bits.
2	T-15 Torx tip	Torx®-driver bit for T-15 size screw heads.
3	T-20 Torx tip	Torx®-driver bit for T-20 size screw heads. Used only for removal of the cabinet handle.
4	Flat-bladed screwdriver	Screwdriver for removing screws that have standard-heads.
5	Needle-nose pliers	Standard tool. Used for removing EMI gaskets.
6	Duck-bill pliers	4 inch. Used for removing the low voltage power supply.
7	Nut driver, 5/16 inch	Used for removing earth ground cables.
8	Angle-tip tweezers	Used for knob and shaft removal.
9	Flat-bladed spudger	A probe-like tool with a tip like a flat bladed screwdriver. Used to press EMI gaskets into place.
10	Soldering iron	15 watt. Used for removal of some cables and the acquisition assembly.
11	Slip-jaw pliers	Used for removing the front feet from the cabinet.
12	Front cover	This optional accessory protects the front of the oscilloscope when positioned face down in the removal procedures.

Access Procedure

Begin with this procedure when you have identified a module to be removed for service and have read *General Instructions* found earlier in this section.

1. *Locate module to be removed:*
 - a. Find the module to be removed in the module locator diagrams, figures 6-2, 6-3, and 6-4 (pages 6-15, 6-17, and 6-20, respectively).
 - b. Note the number of the figure in which you found the module and the module name.
2. *Access the module:*
 - a. If you have located the module to be replaced in Figure 6-2, do the following subparts:
 - Go to Table 6-5 on page 6-14.
 - Find the procedure that includes the name of the module noted in step 1.
 - Perform the access instructions listed for the procedure found to access and remove the module.
 - Skip to the end of this procedure (step 3) for reinstallation instructions.
 - b. If you have found the module to be removed in either Figure 6-3 or Figure 6-4, cabinet removal is required:
 - First do *Line Fuse and Line Cord* on page 6-23, removing only the line cord.
 - Then do *Front Cover, Rear Cover, Cabinet, Rear EMI Gasket, and Cabinet Handle and Feet* on page 6-24, removing only the rear cover and cabinet.
 - Continue with step 2c.
 - c. If you have located the module to be replaced in Figure 6-3, do the following subparts:
 - Go to Table 6-6 on page 6-16.
 - Find the procedure that includes the name of the module noted in step 1.
 - Perform the access instructions listed for the procedure found to access and remove the module.
 - Skip to the end of this procedure (step 3) for reinstallation instructions.
 - d. If you have located the module to be replaced in Figure 6-4, you are removing one of the field replaceable cables. Do the following subparts:
 - Go to Table 6-7 on page 6-18.

- Find the procedure that includes the name of the cable noted in step 1.
 - Perform the instructions listed in the table for that procedure to access and remove the cable.
 - Follow the instructions listed in the table for the reinstallation of the cable. Then exit this procedure.
3. *Reinstall all modules removed:* Read the instructions found at the end of the procedure that removes the module to be serviced — they guide you in reinstalling all modules removed. All procedures are found under *Procedures for Module Removal and Installation*, which follows this access procedure.

Table 6-5: Access Instructions for Modules in Figure 6-2

Procedure Including Module to be Removed	Page No	Access Instructions
1 <i>Front-Panel Knobs and Shafts</i>	6-21	1 Do only the procedure listed at left.
		2 Remove only the module you want to service.
2 <i>Line Fuse and Line Cord</i>	6-23	1 Do only the procedure listed at left.
		2 Remove only the module you want to service.
3 <i>Front Cover, Rear Cover, Cabinet, Rear EMI Gasket, and Cabinet Handle and Feet</i>	6-24	1 Do <i>Line Fuse and Line Cord</i> removing only the line cord.
		2 Do the procedure listed at left, removing only the module(s) you want to service.
4 <i>Trim Ring, Menu Elastomer, Menu Buttons, and Front EMI Gaskets</i>	6-28	1 Do <i>Line Fuse and Line Cord</i> removing only the line cord.
		2 Do <i>Front Cover, Rear Cover, Cabinet, Rear EMI Gasket, and Cabinet Handle and Feet</i> , removing only the rear cover and cabinet.
		3 Do the procedure listed at left, removing all modules including the module(s) you want to service.
5 <i>A06 Front-Panel Assembly, ESD Shield, and Menu Flex and Probe Code Flex Circuits</i>	6-31	1 Do <i>Line Fuse and Line Cord</i> removing only the line cord.
		2 Do <i>Front Cover, Rear Cover, Cabinet, Rear EMI Gasket, and Cabinet Handle and Feet</i> , removing only the rear cover and cabinet.
		3 Do <i>Trim Ring, Menu Elastomer, Menu Buttons, and Front EMI Gaskets</i> .
		4 Do the procedure listed at left, removing all modules including the module(s) you want to service. When doing the procedure listed at left, do <i>not</i> remove the menu flex circuit unless it is being replaced with a new module.

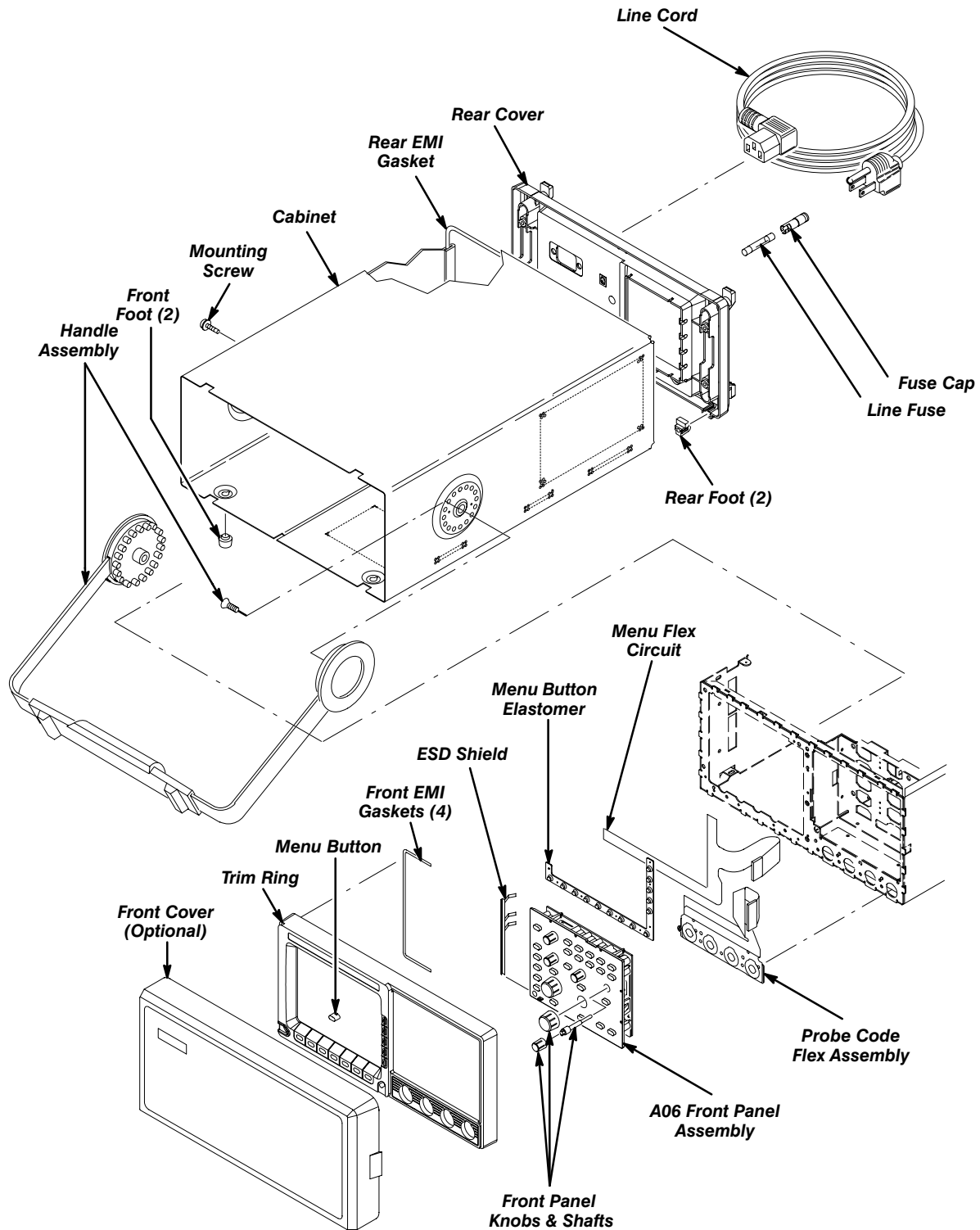


Figure 6-2: Cabinet and Front-Panel Mounted Modules

Table 6-6: Access Instructions for Modules in Figure 6-3

Procedure Listing	Module to be Removed	Page No	Access Instructions
1	A05 Attenuator Assembly and Shield	6-34	1 Do Trim Ring, Menu Elastomer, Menu Buttons, and Front EMI Gaskets (page 6-28). 2 Do A08 Jumper Board Assembly, D1 Bus, and Board Supports, listed as procedure number 3 in this table. Remove only the A08 jumper board assembly. 3 Do A06 Front-Panel Assembly, ESD Shield, and Menu Flex and Probe Code Flex Circuits (page 6-31). Do not remove the menu flex circuit. 4 Do the procedure listed at left to remove the module.
2	A26 Monitor Assembly	6-37	1 Do the procedure listed at left to remove the module.
3	A08 Jumper Board Assembly, D1 Bus, and Board Supports	6-40	1 Do the procedure listed at left to remove the module.
4	A03 CPU Assembly	6-41	1 Do A08 Jumper Board Assembly, D1 Bus, and Board Supports, removing only the board supports. 2 Do the procedure listed at left to remove the module.
5	A02 Display Assembly	6-43	1 Do A08 Jumper Board Assembly, D1 Bus, and Board Supports. Do not remove the A08 jumper board assembly. 2 Do the procedure listed at left to remove the module.
6	A09 DSP Assembly	6-45	1 Do A08 Jumper Board Assembly, D1 Bus, and Board Supports. Do not remove the A08 jumper board assembly. 2 Do the procedure listed at left to remove the module.
7	A01 Backplane Assembly and its Mount	6-46	1 Do A08 Jumper Board Assembly, D1 Bus, and Board Supports. Do not remove the A08 jumper board assembly. 2 Do, in order, the procedures numbered 4-6 (inclusive) in this table. 3 Do the procedure listed at left to remove the module.
8	Fan and Fan Mount	6-54	1 Do the procedure listed at left to remove the module.
9	A25 Low Voltage Power Supply and its Mount	6-51	1 Only if removing the plastic mount that secures the Low Voltage Power Supply, do, in order, the procedures numbered 4–7 (inclusive) in this table. 2 Do procedure <i>Fan and Fan Mount</i>. Do not remove the fan mount. 3 Do the procedure listed at left to remove the module.
10	A07 Auxiliary Power Supply	6-58	1 Do the procedure listed at left to remove the module.
11	Line Filter	6-56	1 Do the procedure listed at left to remove the module.
12	Back-up Batteries	6-49	1 Do the procedure listed at left to remove the module.
13	A04 Acquisition Assembly	6-60	1 Do A08 Jumper Board Assembly, D1 Bus, and Board Supports. Do not remove the board supports. 2 Do the procedure listed at left to remove the module.

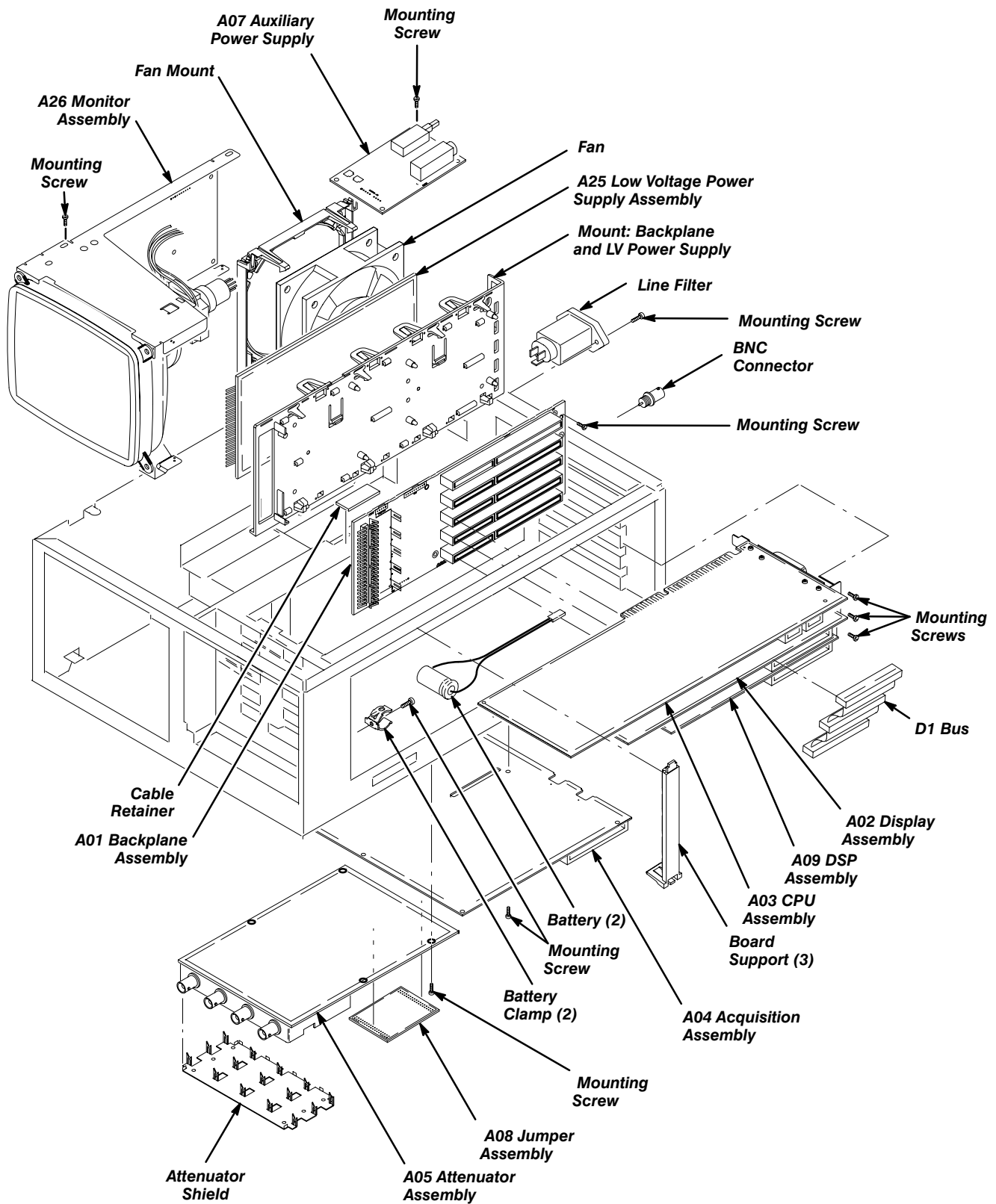


Figure 6-3: Internal Modules

Table 6-7: Access (and Removal) Instructions for Cables in Figure 6-4

Name of Cable	Access and Removal Instructions
1 <i>Backplane to Acquisition</i> <i>Backplane to Attenuator</i>	- Find the procedure <i>A01 Backplane Assembly and its Mount</i> in Table 6-6. - Follow the access instructions found there to access and remove the backplane assembly. - Unsolder the cable(s) to be replaced using a 15 watt soldering iron and remove it. - Reverse these instructions to install the replacement cable.
2 <i>Backplane to Front Panel</i> <i>CPU to Front Panel</i>	- Find the procedure <i>A06 Front-Panel Assembly, ESD Shield, and Menu Flex and Probe Code Flex Circuits</i> in Table 6-6. - Follow the access instructions found there to access and remove the front panel assembly. The cables plugged into that assembly are removed in the process. - Unplug the cable to be replaced from the backplane assembly. See Figure 6-4 for jack location. - Reverse these instructions to install the replacement cable.
3 <i>Backplane to Low Voltage Power Supply</i>	- Reach in from the top of the oscilloscope and unplug the cable at the jacks at the front of the backplane and low voltage power supply modules. - Reverse these instructions to install the replacement cable.
4 <i>Aux Supply to Line Filter</i> <i>Aux Supply to Low Voltage Power Supply</i>	- Find the procedure <i>A07 Auxiliary Power Supply</i> in Table 6-6. - Follow the access instructions found there to access and remove the auxiliary power supply assembly. - Unsolder the cable to be replaced using a 15 watt soldering iron and remove it from the auxiliary power supply. - Reverse these instructions to install the replacement cable.
5 <i>Aux Supply to Low Voltage Power Supply to Ground Lug</i> <i>Line Filter to Ground Lug</i>	- If removing the aux supply to low voltage power supply to ground lug cable, unplug the cable from the low voltage power assembly and from the auxiliary power supply assemblies. - If removing the line filter to ground lug cable, unplug it from the line filter lug. See Figure 6-4. - Using a 5/16 inch nut driver (Item 7) remove the nut(s) that secure the cable to be removed from the lug and remove it. - Reverse these instructions to install the replacement cable.

Table 6-7: Access (and Removal) Instructions for Cables in Figure 6-4 (Cont.)

Name of Cable	Access and Removal Instructions
6 <i>Monitor</i>	1 Find the procedure <i>A02 Display Assembly</i> in Table 6-6. 2 Follow the access instructions found there to access and remove the display assembly. The cable is unplugged from that assembly in the process. 3 Unplug the cable from the monitor. See Figure 6-4 for jack location. 4 Unplug the cable from the auxiliary power supply. See Figure 6-4 for jack location. 5 Reverse these instructions to install the replacement cable.

Removal and Installation Procedures

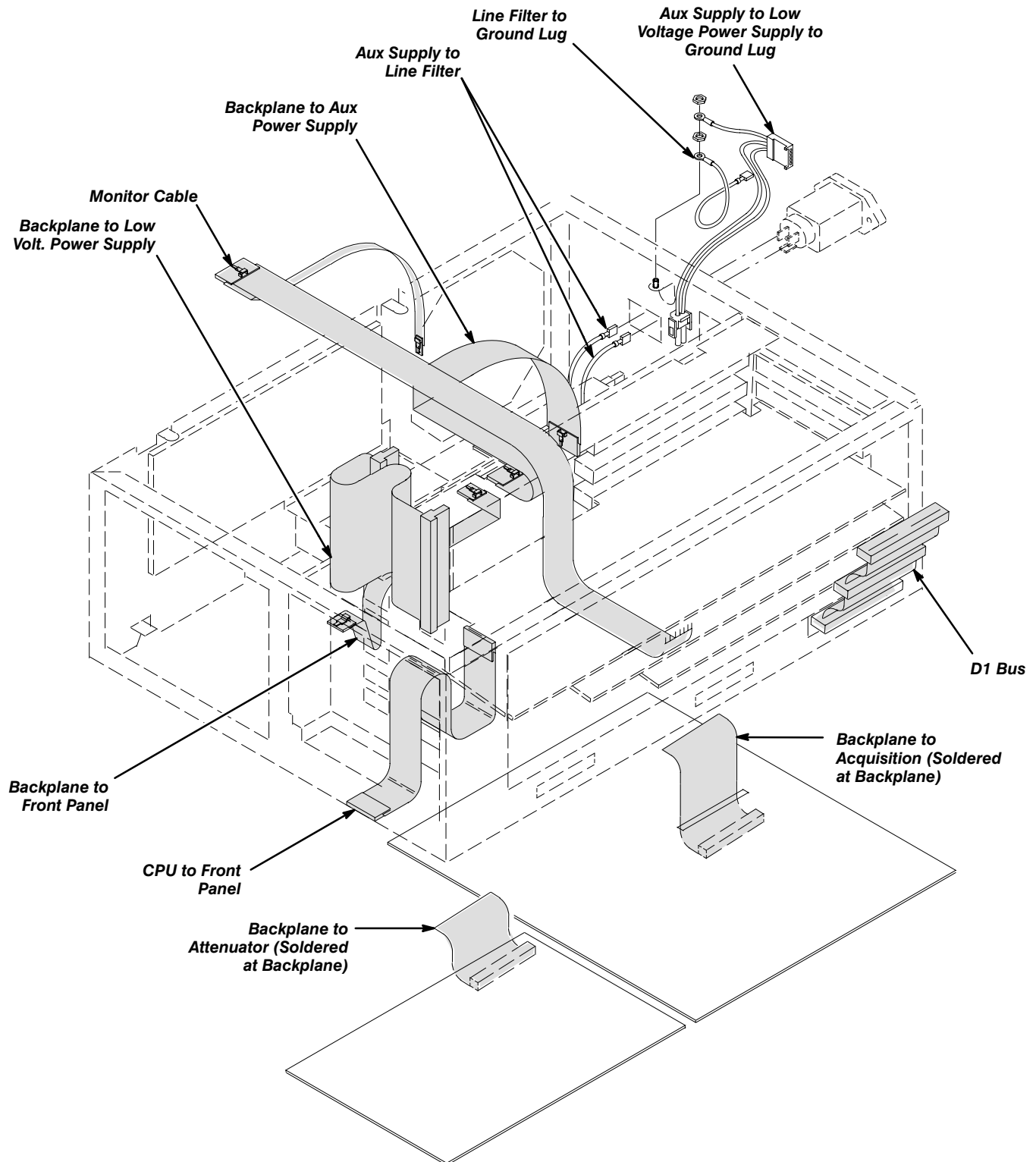


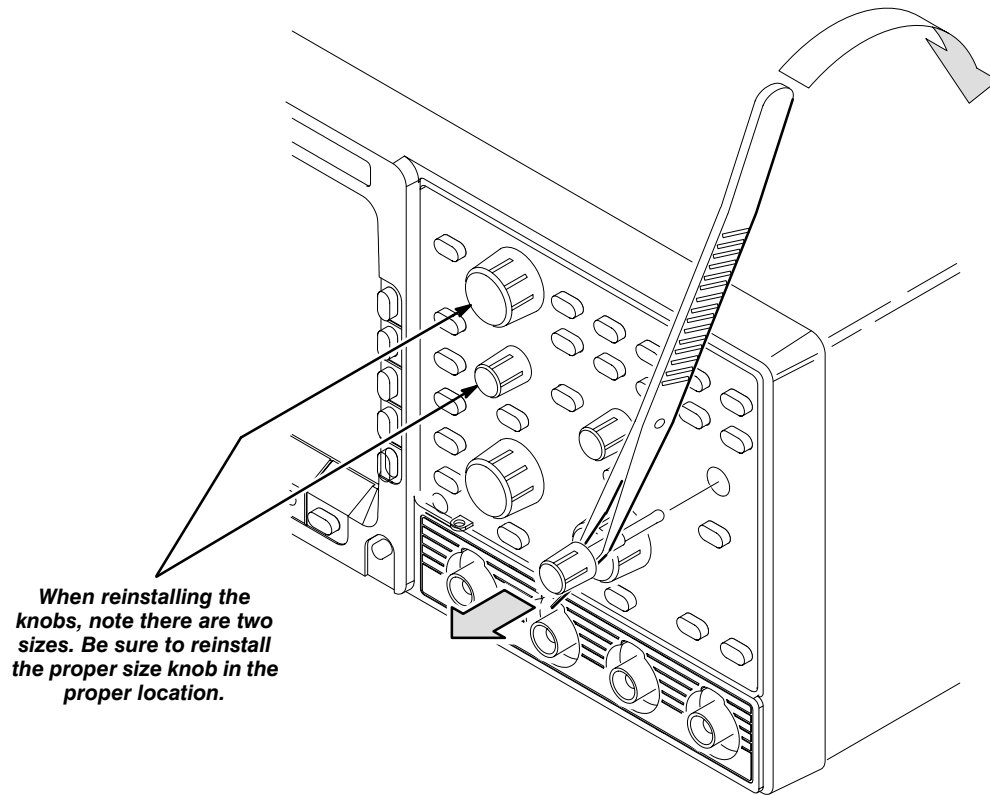
Figure 6-4: Cables and Cable Routing

Procedures for Module Removal and Installation

Do the *Access Procedure* (page 6-13) before doing any procedure in this section.

Front-Panel Knobs and Shafts

1. *Assemble equipment and locate modules to be removed:* Have handy a pair of angled-tip tweezers (Item 8). Find the knob(s) to be removed on the front panel.
2. *Orient the oscilloscope:* Set the oscilloscope so its bottom is down on the work surface and its front is facing you.
3. *Remove the knob(s):* Refer to Figure 6-5 while doing the following substeps.
 - a. Grasp any knob you wish to remove and pull it straight out from the front panel slightly to create some clearance between the base of the knob and the front panel.
 - b. Insert the tweezers between the knob and front panel and use them to remove the knob and its shaft.
4. *Disassemble the knob and shaft:* Pull the shaft out of the knob.
5. *Reinstallation:*
 - a. To reinstall, align the inside of the knob to the end of the shaft and push it in until it snaps.
 - b. Insert the shaft of the assembled knob into its hole in the front panel assembly until it stops.
 - c. Rotate the knob while lightly pushing inwards until the shaft slips into its receptacle. Push the knob all the way in to seat the knob assembly.

**Figure 6-5: Knob and Shaft Removal**

Line Fuse and Line Cord

WARNING

Unplug the line cord from the line voltage power source before continuing. Failure to do so can cause death or injury.

1. *Assemble equipment and locate modules to be removed:* Have handy a flat-bladed screwdriver (Item 4). Locate the line fuse and line cord in the locator diagram *Cabinet and Front-Panel Mounted Modules*, Figure 6-2.
2. *Orient the oscilloscope:* Set the oscilloscope so its bottom is down on the work surface and its rear is facing you. If you are servicing the line cord, do the next step; if you are servicing the line fuse, skip to step 4.

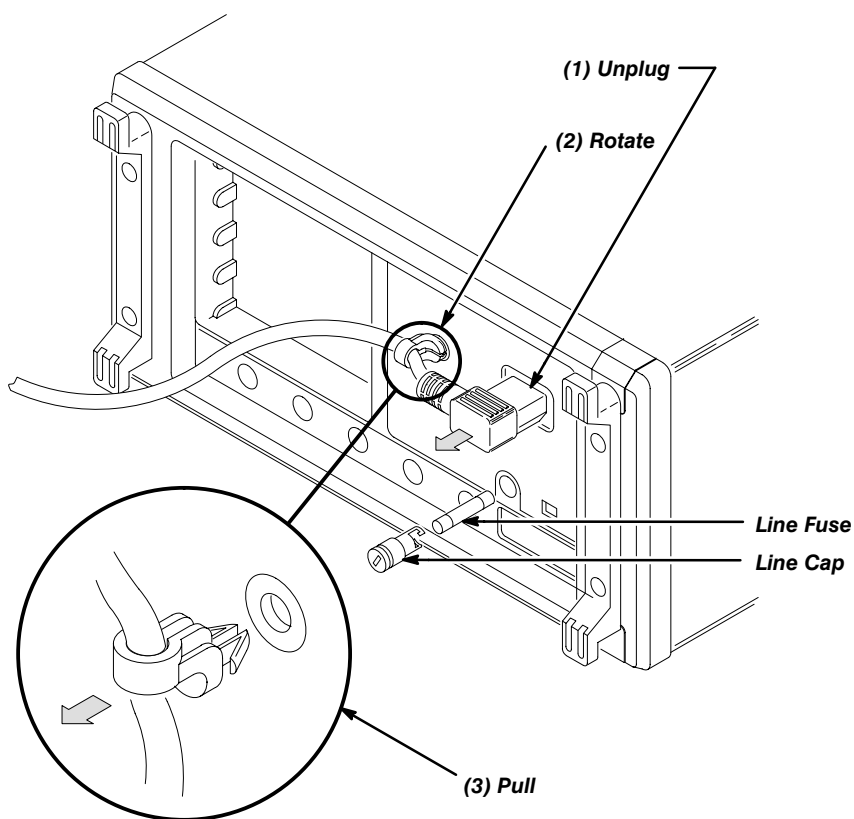


Figure 6-6: Line Fuse and Line Cord Removal

3. *Remove line cord:*
 - a. Find the line cord on the rear cover. (See Figure 6-6.)
 - b. Now, remove the line-cord retaining clamp by first unplugging the line cord from its receptacle.

- c. Next, grasp both the line cord and the retaining clamp and rotate them 90 degrees counter-clockwise.
 - d. Pull the line cord and clamp away to complete the removal.
4. *Remove line fuse:* Find the fuse cap on the rear panel. (See Figure 6-6.) Now, remove the fuse cap by turning it counter clockwise using a flat-bladed screwdriver, and remove the line fuse.
5. *Reinstallation:* Do in reverse steps 3 and 4 to reinstall the line fuse and then the line cord.

Front Cover, Rear Cover, Cabinet, Rear EMI Gasket, and Cabinet Handle and Feet

1. *Assemble equipment and locate modules to be removed:*
 - a. Have handy a screwdriver with a size T-15 Torx® tip (Items 1 and 2). If removing the EMI gasket at the inside rear of the cabinet, also have handy a pair of needle-nose pliers (Item 5).
 - b. Make sure the oscilloscope front cover is installed; if it is not, install it by snapping its edges over the trim ring.
 - c. Locate the rear cover and cabinet in the locator diagram *Cabinet and Front-Panel Mounted Modules*, Figure 6-2.
2. *Orient the oscilloscope:*
 - a. Pull out on both of the hubs on the cabinet handle to unlock it for positioning. While holding the hubs unlocked, rotate the handle towards the bottom of the oscilloscope.
 - b. Set the oscilloscope so its face is down with its front cover on the work surface and its bottom facing you. Reference Figure 6-7 on page 6-25 as you do the following steps.
3. *Remove the front feet:* If removing a front foot for replacement, use a pair of slip-jaw pliers to firmly grip the foot, then pull with a turning motion to remove. Reverse the process to install the replacement foot. If no other modules are being serviced, skip to the end (step 9) of this procedure.
4. *Remove rear cover:* Remove the four T-15 Torx® screws securing the rear cover to the oscilloscope. Lift off the rear cover. If no other modules are being serviced, skip to the end (step 9) of this procedure.
5. *Remove the rear feet:* If removing a rear foot for replacement, use your fingers to press the foot out from inside the rear cover. Reverse process to install the replacement foot. If no other modules are being serviced, skip to the end (step 9) of this procedure.
6. *Remove the cabinet:*
 - a. Remove the T-15 Torx® screw at the left side of the oscilloscope.
 - b. Grasp the two handle hubs and pull them outward as if to rotate the handle.

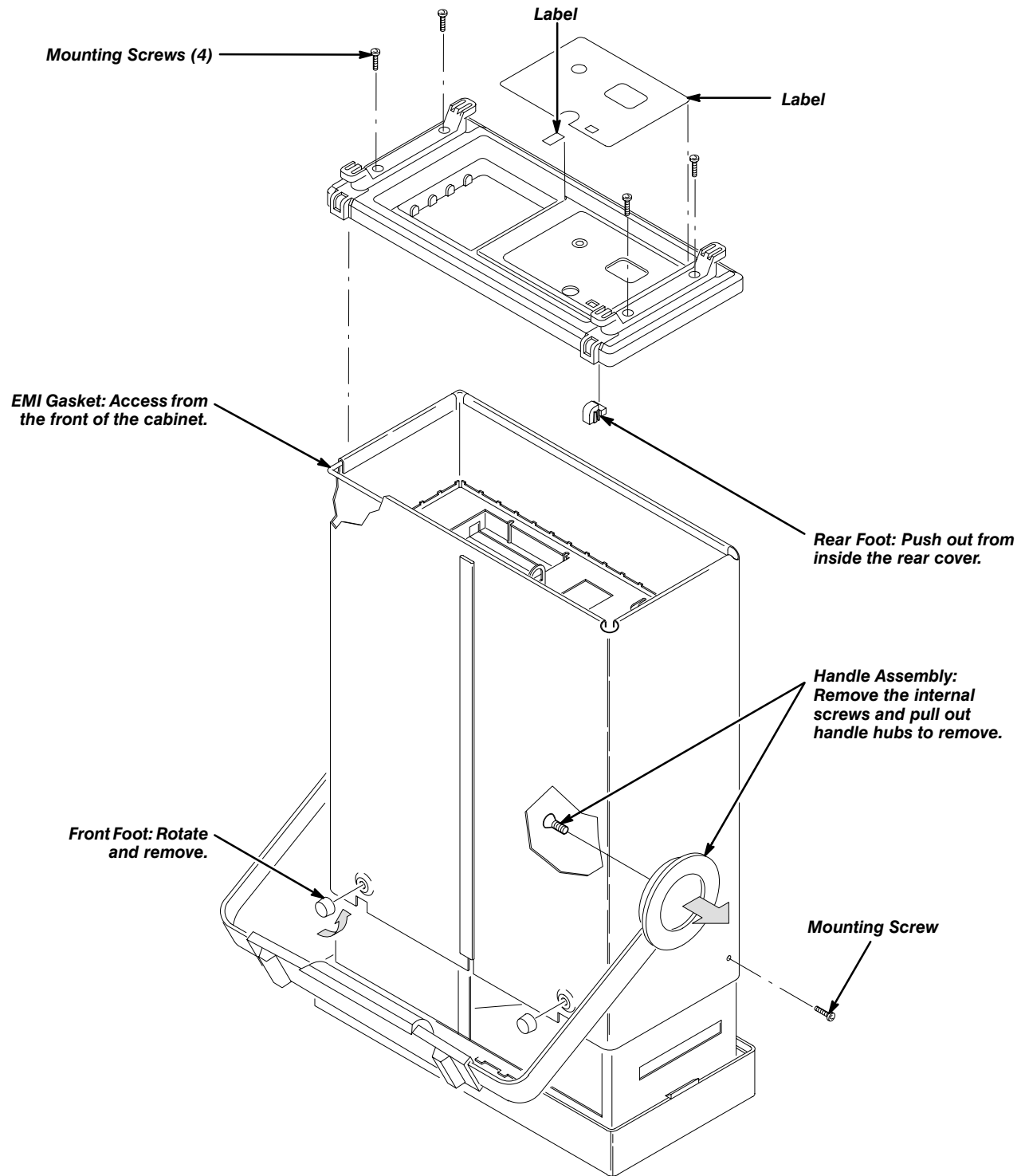


Figure 6-7: Front Cover, Rear Cover, Cabinet, EMI Gasket, and Cabinet Handle and Feet Removal

- c. While holding the handle hubs pulled out, lift the cabinet upwards to slide it off the oscilloscope.

- d. At the rear of the cabinet, grasp its left and right edges. Take care not to bind or snag the cabinet on the internal cabling as you remove the cabinet.
 - e. If no other cabinet modules are being serviced, skip the rest of this procedure.
7. *Remove the handle assembly:* If removing the handle assembly for cleaning or replacement, do the following substeps:
- a. Working from the inside of the cabinet, remove the T-15 Torx® screw securing each handle hub to the cabinet.
 - b. Working from the outside of the cabinet, grasp the two handle hubs and pull them outward from the cabinet until they are out of the cabinet.
 - c. While holding the handle hubs pulled out, lift the handle away to remove.



DO NOT do step 8 to remove the EMI gasket from the rear of the cabinet unless it must be replaced due to damage. If you are not replacing that gasket, skip to step 9.

When reinstalling the EMI gasket and the oscilloscope cabinet, carefully follow the instructions given. Unless the instructions are performed properly, the oscilloscope may not meet its emissions requirements (EMI).

8. *Remove the EMI gasket:* If removing the EMI gasket for replacement, do the following substeps.
- a. Locate the EMI gasket to be removed in the diagram *Front Cover, Rear Cover, Cabinet, EMI Gasket, and Cabinet Handle and Feet Removal*, Figure 6-7.
 - b. Look for the point where the ends of the gasket touch in the channel at the rear edge of the cabinet.
 - c. Use a pair of needle-nose pliers to pry up one of the ends of the gasket.
 - d. Grasp the EMI gasket, and gently pull it out of its channel.
9. *Reinstallation of cabinet and rear cover:*
- a. If the EMI gasket was removed, press the EMI gasket back into its groove at the rear edge of the cabinet. When installing, make sure the ends of the gasket touch, but do not overlap. (Cut off excess length if required to prevent overlap.)
 - b. See step 7 to reinstall the handle assembly if it was removed. If installing a new handle assembly, also do the following:
 - Find the label that matches your model of oscilloscope (TDS 410, TDS 420, or TDS 460).

- Remove the covering from the back of the sticky-back label, align it to the handle, and press firmly to install.
- c. Do, in reverse order, steps 3 and 4 to reinstall the cabinet while observing the following precautions and requirements:
 - Take care not to bind or snag the cabinet on internal cabling; redress cables as necessary.
 - When sliding the cabinet onto the oscilloscope, be sure that the ridge around the rear of the main chassis slides into the groove containing the EMI gasket on the rear of the cabinet.
 - Install the four screws at the rear panel and tighten to 8 inch-lbs torque before installing the single screw at the left side of the cabinet. Tighten this screw to 8 inch-lbs.
- d. If installing a new rear panel, also do the following:
 - Find the appropriate labels for your rear panel.
 - Remove the covering from the back of the sticky-back label, align it to the handle, and press firmly to install.
- e. See the procedure *Line Fuse and Line Cord* to reinstall the line cord, which completes the oscilloscope reassembly.

Trim Ring, Menu Elastomer, Menu Buttons, and Front EMI Gaskets

1. *Assemble equipment and locate modules to be removed:*
 - a. Have handy a wooden spudger (Item 9).
 - b. Locate the modules to be removed in the locator diagram *Cabinet and Front-Panel Mounted Modules*, Figure 6-2.
2. *Orient the oscilloscope:* Set the oscilloscope so its rear is down on the work surface and its bottom is facing you.
3. *Remove the front cover:* If it is installed, grasp the front cover by its left and right edges and snap it off of the front of the oscilloscope. (When reinstalling, align and snap the cover back on.)

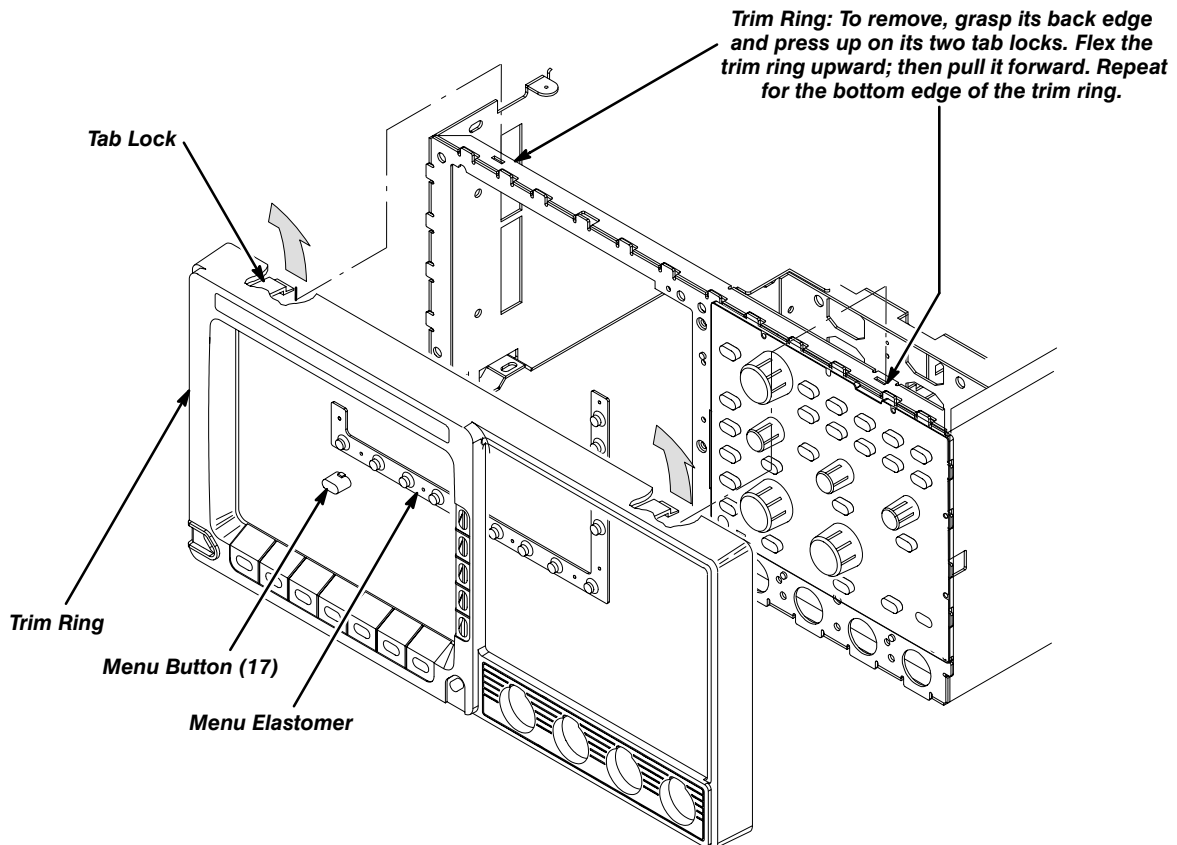


Figure 6-8: Trim Ring, Menu Elastomer, and Menu Buttons Removal



DO NOT touch the carbon contact points on the menu elastomer installed in the trim ring. Also, do not touch the contacts on the menu button flex circuit exposed when you remove the trim ring. You should wear clean cloth gloves that are free of lint when handling the menu elastomer or when touching the menu button flex circuit mounted on the front chassis.

4. *Remove the trim ring:*
 - a. Grasp the trim ring by its top edge and pry it up and lift it forward to snap it off of the top front of the main chassis.
 - b. Repeat the process, prying on the bottom edge of the trim ring to complete its removal.
 - c. Lay the trim ring on its face on the work surface.
5. *Remove the EMI gaskets:* If servicing the front EMI gaskets, lift them out of the trim ring.
6. *Remove the menu elastomer:* If servicing the menu elastomer, lift it out of the trim ring.
7. *Remove the menu buttons:* If servicing the menu buttons, lift them out of the trim ring.
8. *Reinstallation:*
 - a. If the menu buttons were removed, insert each button into its hole in the trim ring.
 - b. If the menu elastomer was removed, align it over the menu button holes in the trim ring and press it in to install. Avoid touching the carbon contact points on the elastomer.
 - c. Without installing the EMI gaskets, align the trim ring to the front of the chassis and push it on to seat. Be sure that both pairs of flex locks, one pair each at the inside top and bottom of the trim ring, snap over the edge of the chassis.
 - d. Do the following subparts to install the EMI gaskets (see Figure 6-9):
 - Install the front cover on the oscilloscope.
 - Lay the scope so its front cover is on the work surface.
 - Align a EMI gasket so it lays between any pair of adjacent flex locks along the groove between the cabinet.
 - Using a wood spudger, push the EMI gasket until it is firmly seated at the bottom of the groove. It should not overlap either flex lock.
 - Repeat the process just described to install the remaining three gaskets.
 - e. If the trim ring installed in substep c is a new trim ring, also do the following:
 - Find the label that matches your oscilloscope model (TDS 410, TDS 420, or TDS 460).
 - Remove the covering from the back of the sticky-back label, align it to the handle (see Figure 6-7 on page 6-25), and press firmly to install.

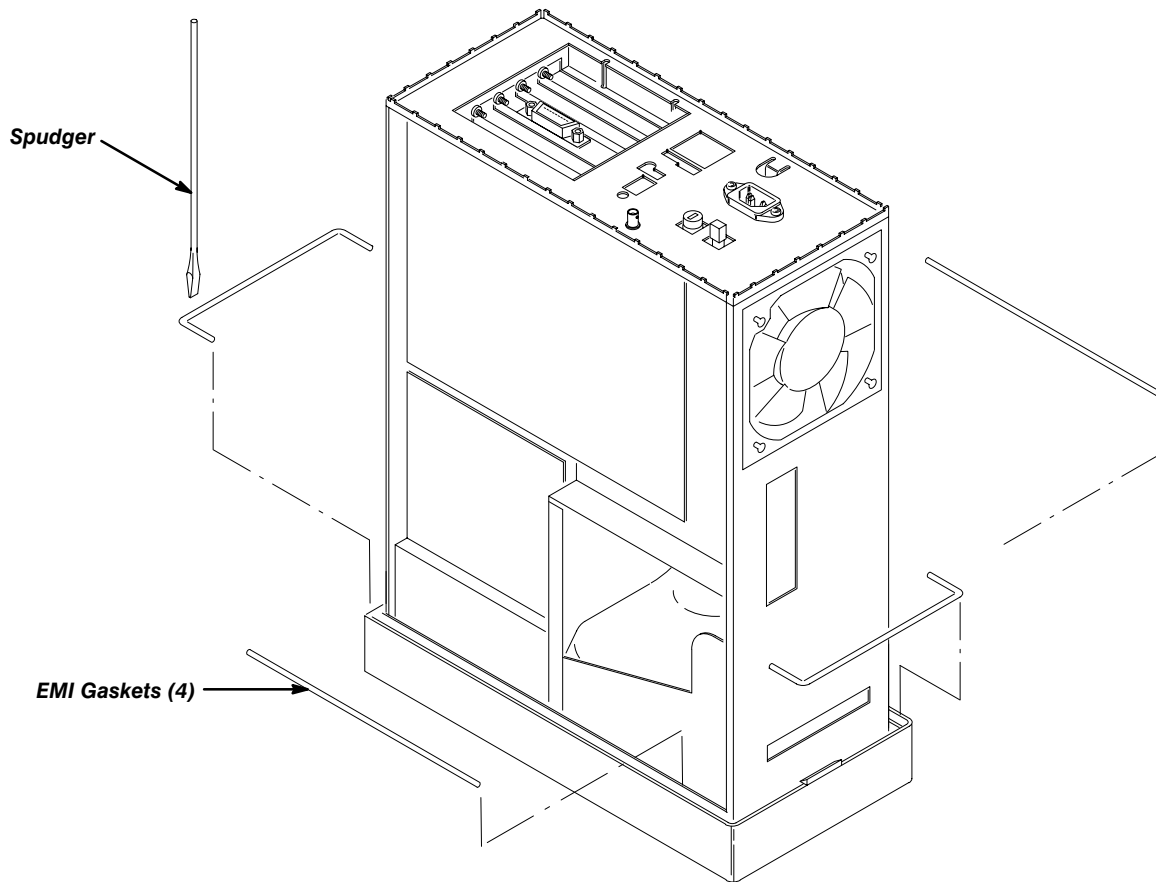


Figure 6-9: EMI Gasket Removal and Installation

- f. See the following procedures to install those modules removed by the access procedure:
- *Front Cover, Rear Cover, Cabinet, Rear EMI Gasket, and Cabinet Handle and Feet* (page 6-24) to reinstall the cabinet and rear cover
 - *Line Fuse and Line Cord* (page 6-23) to reinstall the line cord, which completes the oscilloscope reassembly

A06 Front-Panel Assembly, ESD Shield, and Menu Flex and Probe Code Flex Circuits

1. *Access the module:* Be sure you have performed the *Access Procedure* on page 6-13 and removed the modules as instructed.
2. *Assemble equipment and locate modules to be removed:*
 - a. Have handy a flat bladed screwdriver (Item 4).
 - b. Locate the modules to be removed in the locator diagram *Cabinet and Front-Panel Mounted Modules*, Figure 6-2.
3. *Orient the oscilloscope:* Set the oscilloscope so its bottom is down on the work surface and its front is facing you.
4. *Remove the front-panel assembly:*
 - a. Insert a flat-bladed screwdriver (Item) into the slot at the front-right of the chassis. Push inwards to release the snap lock at the right side.
 - b. Lift the front-panel assembly out of the front of the main chassis until you can reach the interconnect cables connecting it to various other modules.
 - c. Unplug the following cables from their jacks on the front-panel assembly:
 - The CPU-to-front panel cable at J101
 - The menu flex circuit at J103
 - The probe code flex circuit at J104
 - The backplane-to-front panel cable at J106
 - d. Finally, lift the front-panel assembly out of the front of the main chassis to complete the removal.
5. *Remove the ESD shield:* If replacing this shield, note how the small cutout on the shield is aligned to the snap lock at the lower-left corner of the assembly and reference for later replacement. Then pull the ESD shield off the left edge of the front panel to remove. (The shield snaps on and off.)

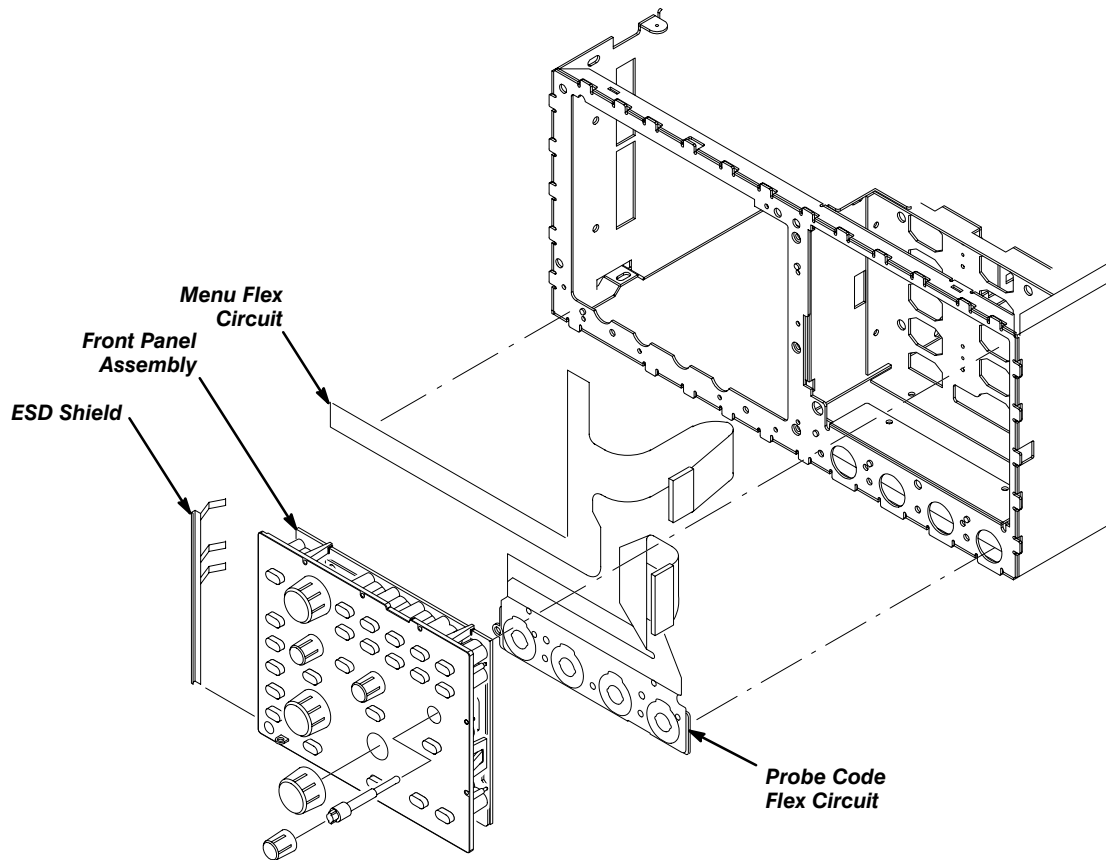


Figure 6-10: A06 Front-Panel Assembly, ESD Shield, and Menu Flex and Probe Code Flex Circuits Removal

6. *Remove the Probe Code Flex Circuit:* If replacing or cleaning the probe code flex circuit, remove the four T-15 Torx® screws and lift it away from the front of the main chassis.



Perform step 7 only if disassembling for cleaning and lubrication. (Components removed in step 7 are not field replaceable.) Otherwise, skip to step 9 to continue this procedure.

7. *Further disassembly of front-panel assembly:* If the front panel or the front-panel buttons are to be serviced, do the following substeps.
 - a. Remove the front-panel control knobs from the front-panel assembly using the method described in *Front-Panel Knobs and Shafts* on page 6-21.
 - b. Release the three snap locks at the edge of the circuit board, and then tilt the board away from the assembly until it unplugs from J405. See Figure 6-11.
 - c. Slide the circuit board out from the retainers found at the edge opposite the snap locks, and lift it away from the rest of the assembly.

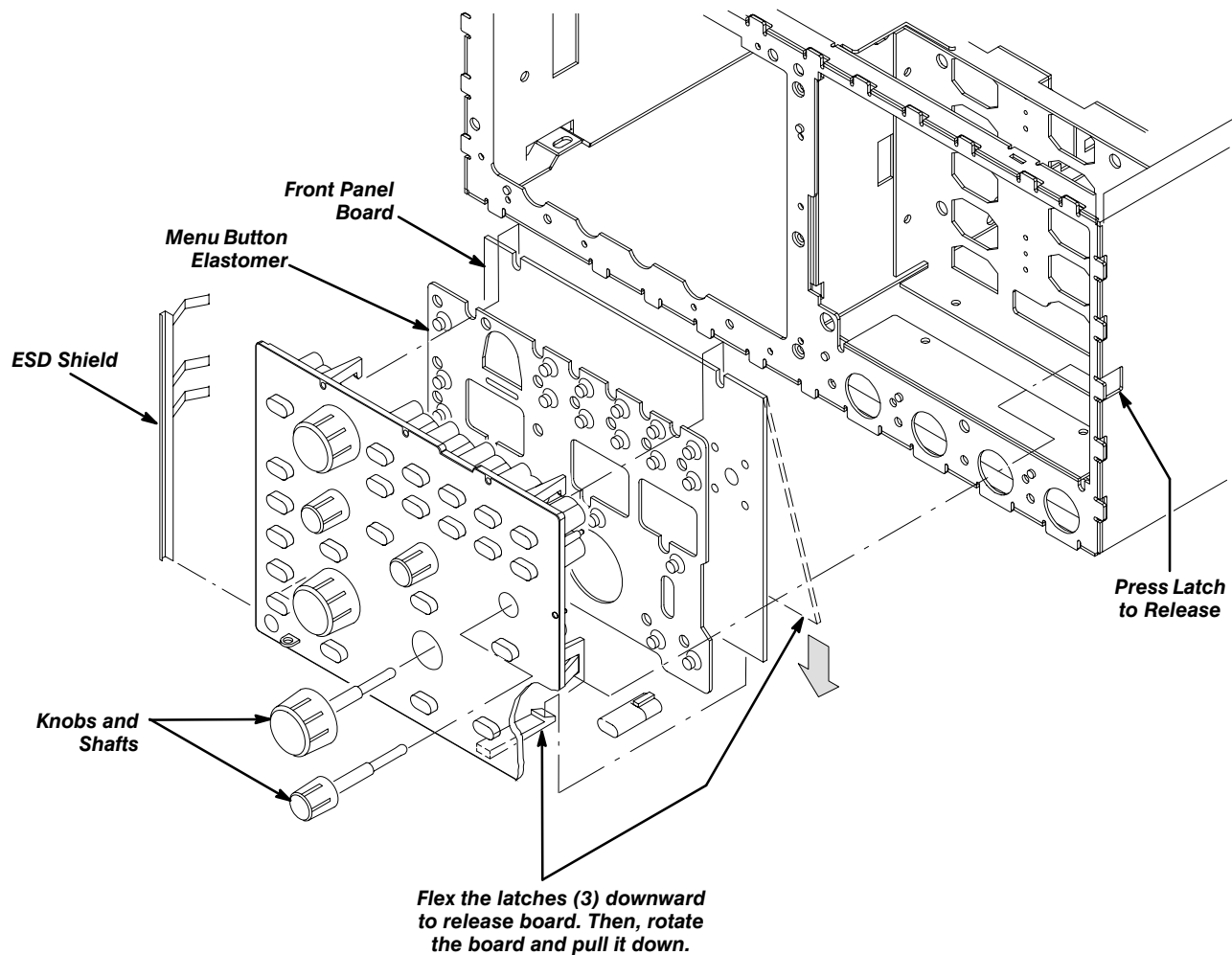


Figure 6-11: Disassembly of the Front-Panel Assembly

- d. Hand disassemble the front-panel-assembly components using Figure 6-11 as a guide. Reverse the procedure to reassemble, using the same Figure 6-11 as a guide.
8. *Remove the control potentiometer(s):* If removing them for cleaning (they are not field replaceable), unplug the four control potentiometers from the back of the front-panel assembly.
- STOP

Perform step 9 only if replacing a failed or damaged menu flex circuit with a fresh unit from the factory. (Removal of the circuit is likely to destroy it.) If such is not the case, skip to step 10 to continue this procedure.
9. *Remove the menu flex circuit:* Pull the flex circuit away from the front of the main chassis. (The flex circuit is held on by its sticky backing.)

10. *Reinstallation:*

- a. If the menu flex circuit was removed in step 9, do the following subparts to install a new circuit (reference Figure 6-10 on page 6-32):
 - DO NOT touch the contacts on the menu flex circuit with your bare fingers. You should wear clean cloth gloves that are free of lint when installing the menu flex circuit on the front chassis.
 - Wipe the front of the chassis using isopropyl alcohol and a clean, lint-free cloth. Let the chassis dry. (Some adhesive from the flex circuit you removed will be left on the front of the chassis. This is normal.)
 - Find the score line in the adhesive backing and peel the backing off of the menu flex circuit.
 - Carefully align the three holes on the menu flex circuit to the locator studs on the front of the main chassis. When the alignment is correct, press the flex circuit against the chassis so it adheres to the chassis.
 - Clean the surface of the menu flex circuit just installed using isopropyl alcohol and a clean, lint-free cloth.
- b. See step 6 to install the probe code flex circuit if it was removed.
- c. See step 5 to install the ESD shield if it was removed.
- d. If the front-panel assembly was disassembled for cleaning in step 7, apply a thin coating of bearing grease (Dow Corning #1292) to the two switch patterns (circular patterns for the vertical scale rotary switches) on the circuit board. Then reverse substeps 7a–7d to reassemble, using Figure 6-11 as a guide.
- e. Do in reverse order substeps 4a through 4d, reversing the procedure outlined in each step. Be sure to dress the CPU-to-front-panel cable so that the loop of extra cable length is in the front-panel cavity of the chassis, as shown in Figure 6-4.
- f. See the following procedures to install those modules removed by the access procedure:
 - *Front Cover, Rear Cover, Cabinet, Rear EMI Gasket, and Cabinet Handle and Feet* (page 6-24) to reinstall the cabinet and rear cover
 - *Line Fuse and Line Cord* (page 6-28) to reinstall the line cord, which completes the oscilloscope reassembly

A05 Attenuator Assembly and Shield

1. *Access the module:* Be sure you have performed the *Access Procedure* on page 6-13 and removed the modules as instructed.

2. *Assemble equipment and locate modules to be removed:* Have handy a screwdriver with a size T-15 Torx® tip (Items 1 and 2).
3. *Orient the oscilloscope:* Set the oscilloscope so its top is down on the work surface and its front is facing you.
4. *Remove the Attenuator Assembly:*
 - a. Unplug the backplane to attenuator cable at J101.
 - b. Using Figure 6-12 as a guide, remove the four T-15 Torx® screws securing the attenuator assembly to the front of the chassis.
 - c. Lift the attenuator assembly away from the oscilloscope to complete its removal.

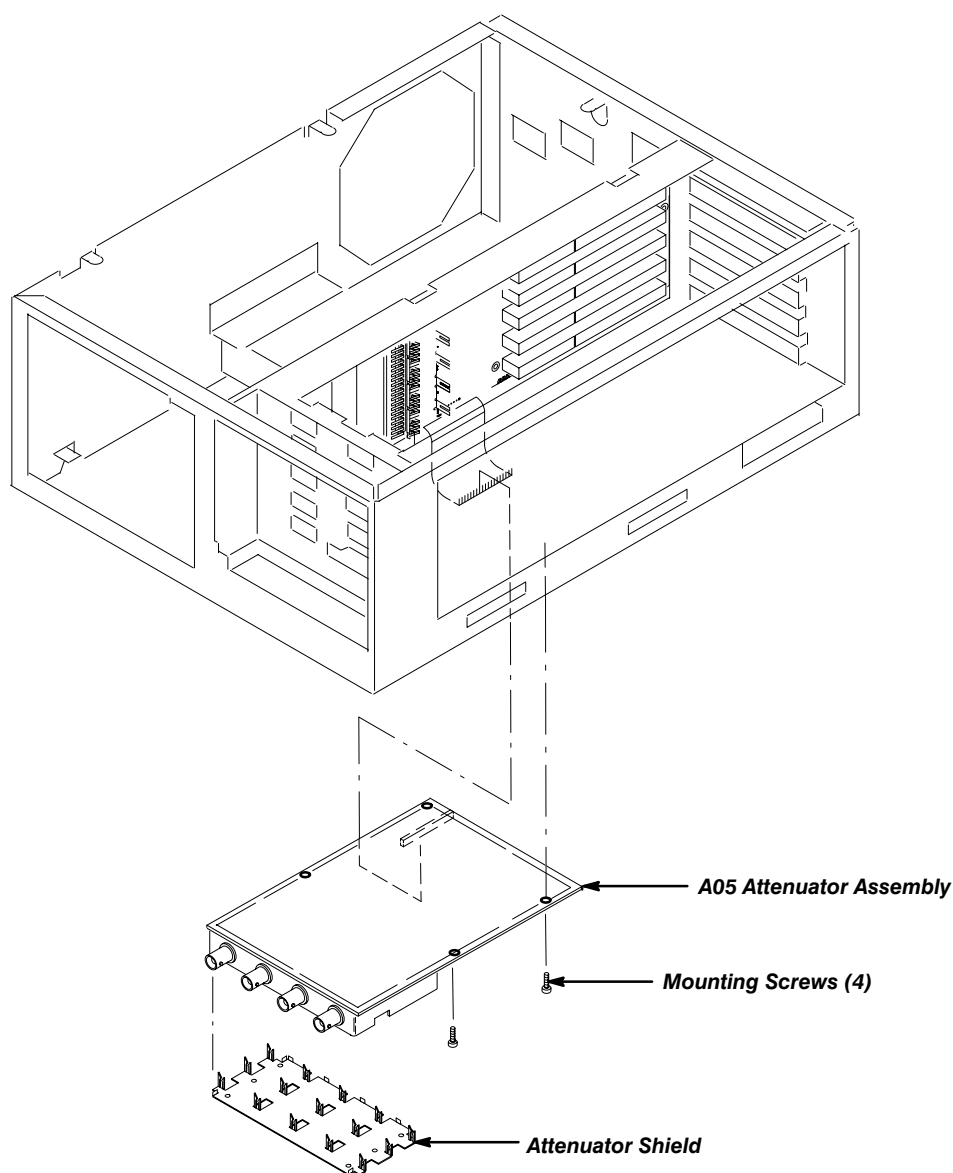


Figure 6-12: A05 Attenuator Removal

5. *Reinstallation:*

- a. Perform in reverse order substeps 4a and 4c, reversing the removal instructions in each substep to reinstall the assembly.
- b. See the following procedures in the order listed to replace modules removed by the access procedure:
 - *A06 Front-Panel Assembly, ESD Shield, and Menu Flex and Probe Code Flex Circuits* on page 6-31
 - *Trim Ring, Menu Elastomer, Menu Buttons, and Front EMI Gaskets* on page 6-28
 - *Front Cover, Rear Cover, Cabinet, Rear EMI Gasket, and Cabinet Handle and Feet* (page 6-24) to reinstall the cabinet and rear cover
 - *Line Fuse and Line Cord* (page 6-23) to reinstall the line cord, which completes the oscilloscope reassembly

A26 Monitor Assembly

NOTE

The display tube and the display-driver board are a single module and must be removed and replaced as such. They are listed as a single module in the Replaceable Parts List.

1. *Access the module:* Be sure you have performed the *Access Procedure* on page 6-13 and removed the modules as instructed.
2. *Assemble equipment and locate modules to be removed:* Have handy a screwdriver with a size T-15 Torx® tip (Items 1 and 2). Locate the module to be removed in the locator diagram *Internal Modules*, Figure 6-2, page 6-15.
3. *Orient the digitizing oscilloscope:* Set the digitizing oscilloscope so its bottom is down on the work surface, with its front facing you.

WARNING

Monitor assembly handling: Use care when handling a monitor. If you break its display tube it may implode, scattering glass fragments with high velocity and possibly injuring you. Wear protective clothing, including safety glasses (preferably a full-face shield). Avoid striking the display tube with or against any object.

Monitor storage: Store the monitor with its display tube face down in a protected location, placing it on a soft, nonabrasive surface to prevent scratching the face plate.

4. *Remove the monitor:*
 - a. Take the precautions outlined in the **WARNING** above. Refer to Figure 6-13 while doing the following substeps.
 - b. Unplug the main cable at (J901), then rotate the digitizing oscilloscope so its top is down on the work surface, with its bottom facing upwards.
 - c. Remove the three T-15 Torx® screws securing the monitor assembly to the bottom of the main chassis. Return the digitizing oscilloscope to the orientation established in step 2.

WARNING

High-voltage is present on the anode lead. It is NOT necessary to unplug the anode from the monitor when removing or replacing the monitor module; therefore, do not do so.

- d. Remove the three T-15 Torx® screws securing the monitor assembly to the top of the chassis. (See Figure 6-13 to locate the screws.)
- e. Push up on the left top tab lock on the trim ring and pull the left corner of the trim ring forward slightly. (The left top tab lock is shown in Figure 6-8 on page 6-28.)
- f. Tilt the rear of the monitor assembly upward slightly. Slide the monitor assembly back in the main chassis until it stops (about 3/4 inch). Now lift it straight up out of the the top of the main chassis to complete the removal.
- g. While heeding the **WARNING** on monitor handling that immediately precedes step 4 of this monitor removal procedure, store the monitor assembly in a protected location. Place it face down on a soft, nonabrasive surface to prevent scratching the face plate.

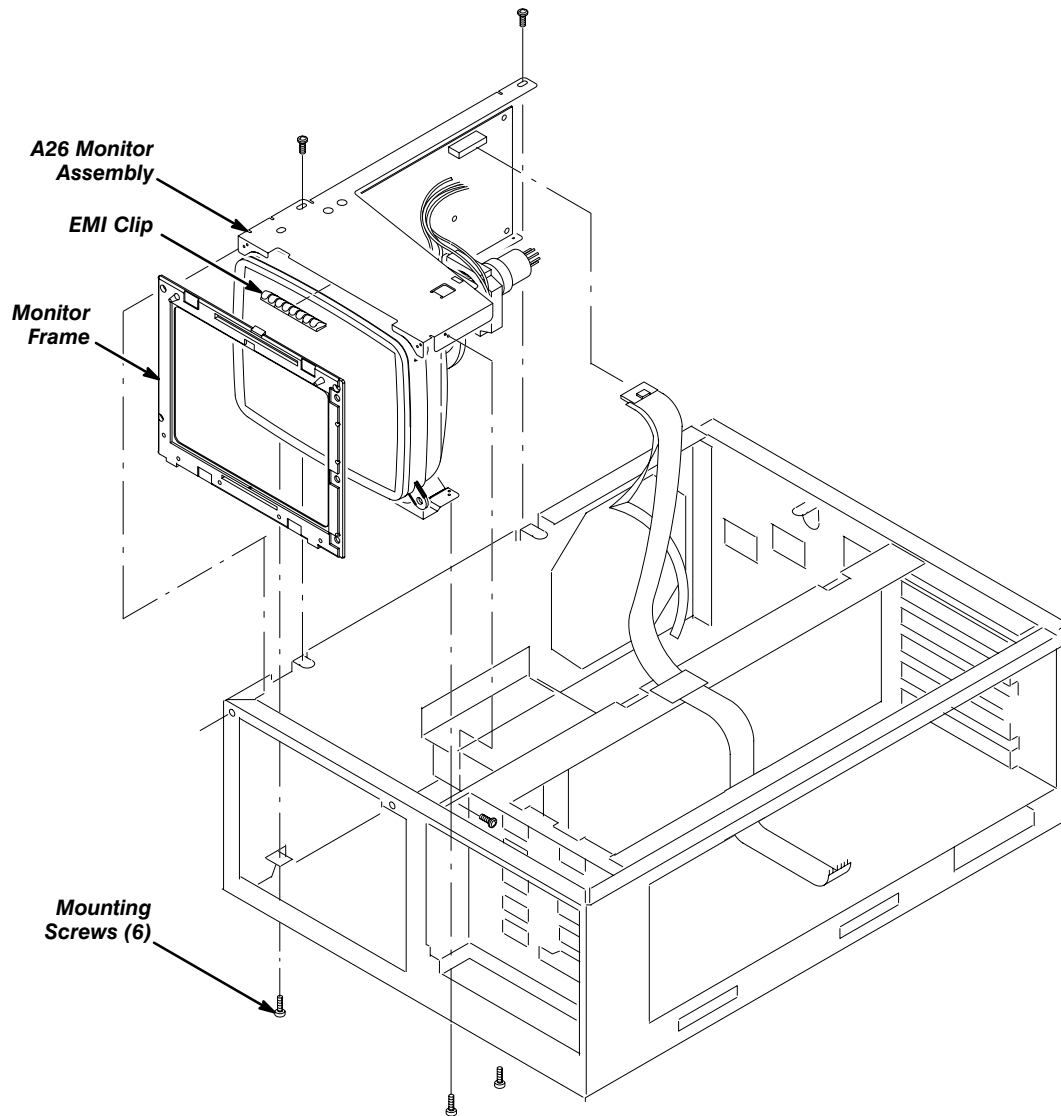


Figure 6-13: A26 Monitor Assembly Removal

5. *Reinstallation:*

- a. Perform in reverse order 4a-4f, reversing the removal instructions in each step and substep to reinstall the assembly. If the EMI clips on the monitor are replaced, be sure to center them in the notched area of the top and bottom of the chassis.
- b. See the following procedures in the order listed to replace modules removed by the access procedure:
 - *A06 Front-Panel Assembly, ESD Shield, and Menu Flex and Probe Code Flex Circuits* on page 6-31
 - *Trim Ring, Menu Elastomer, Menu Buttons, and Front EMI Gaskets* on page 6-28
 - *Front Cover, Rear Cover, Cabinet, Rear EMI Gasket, and Cabinet Handle and Feet* (page 6-24) to reinstall the cabinet and rear cover
 - *Line Fuse and Line Cord* (page 6-23) to reinstall the line cord, which completes the oscilloscope reassembly

A08 Jumper Board Assembly, D1 Bus, and Board Supports

1. *Locate the modules to be removed:* Find the modules to be removed in the locator diagram *Internal Modules*, (Figure 6-2 on page 6-15) or in Figure 6-4 on page 6-20.
2. *Orient the digitizing oscilloscope:* Set the digitizing oscilloscope so its left side is down, with its front facing to the left of you.
3. *Remove the board supports:* Depress the snap lock at the bottom end of the board support and tilt the support outwards to remove from the chassis. Repeat for the second and third board supports. See Figure 6-14.
4. *Remove the D1 Bus:* Grasp the D1 bus by its cable pull tab and pull to unplug it from J1 of the Display assembly. Then grasp the cable and pull to unplug it from J3 of the acquisition assembly and J2 of the DSP assembly. See Figure 6-14.
5. *Remove the jumper board assembly:* Grasp the jumper board assembly by opposite edges and pull out to unplug it from J102 of the attenuator assembly and J9 of the acquisition assembly. Take care to pull the jumper board straight out with a minimum of rocking motion. See Figure 6-14.
6. *Reinstallation:* Do steps 3 through 5, reversing instructions in each step to reinstall any module removed.

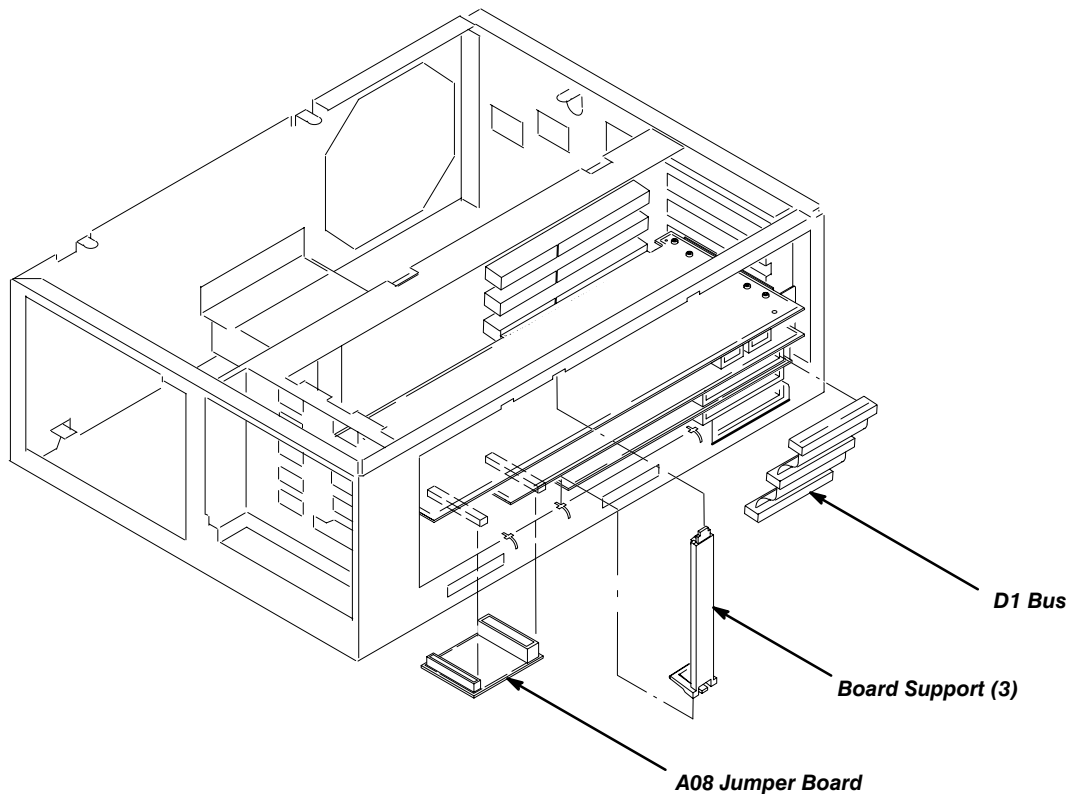


Figure 6-14: A08 Jumper Board Assembly, D1 Bus, and Board Supports Removal

A03 CPU Assembly

1. *Access the module:* Be sure you have performed the *Access Procedure* on page 6-13 and removed the modules as instructed.
2. *Assemble equipment and locate modules to be removed:* Have handy a screwdriver with a size T-15 Torx® tip (Items 1 and 2). Locate the modules to be removed in the locator diagram *Internal Modules*, Figure 6-2, page 6-15.
3. *Orient the digitizing oscilloscope:* Set the digitizing oscilloscope so its left side is down, with its front facing to the left of you.
4. *Remove the CPU board:* Using Figure 6-15 as a guide, perform the following substeps:
 - a. Unplug the CPU to front panel cable from the front-panel assembly at J101.
 - b. Remove the single T-15 Torx® screw from the bracket covering the *unused rear-panel slot* at the inside rear corner of the main chassis.

- c. Remove the single T-15 Torx® screw from the bracket that secures the *CPU assembly* at the inside rear corner of the main chassis.
- d. Working from the rear of the oscilloscope, remove the single T-15 Torx® screw from the bracket that secures the CPU assembly to the rear of the main chassis.

CAUTION

Note that the screw removed in step d is shorter (0.250 inch/ 6.35 mm) than the screws (0.625 inch/15.875 mm) removed in substeps b and c. Be sure to install the short screw in its proper location when reinstalling the board. See Figure 6-15.

- e. Grasp the board by its edge and pull outward to unplug it from J3 of the backplane assembly.
- f. Slide the board part way out until you can reach the battery cable at J5. Unplug the battery cable.
- g. Slide the board the rest of the way out of the main chassis to complete its removal.

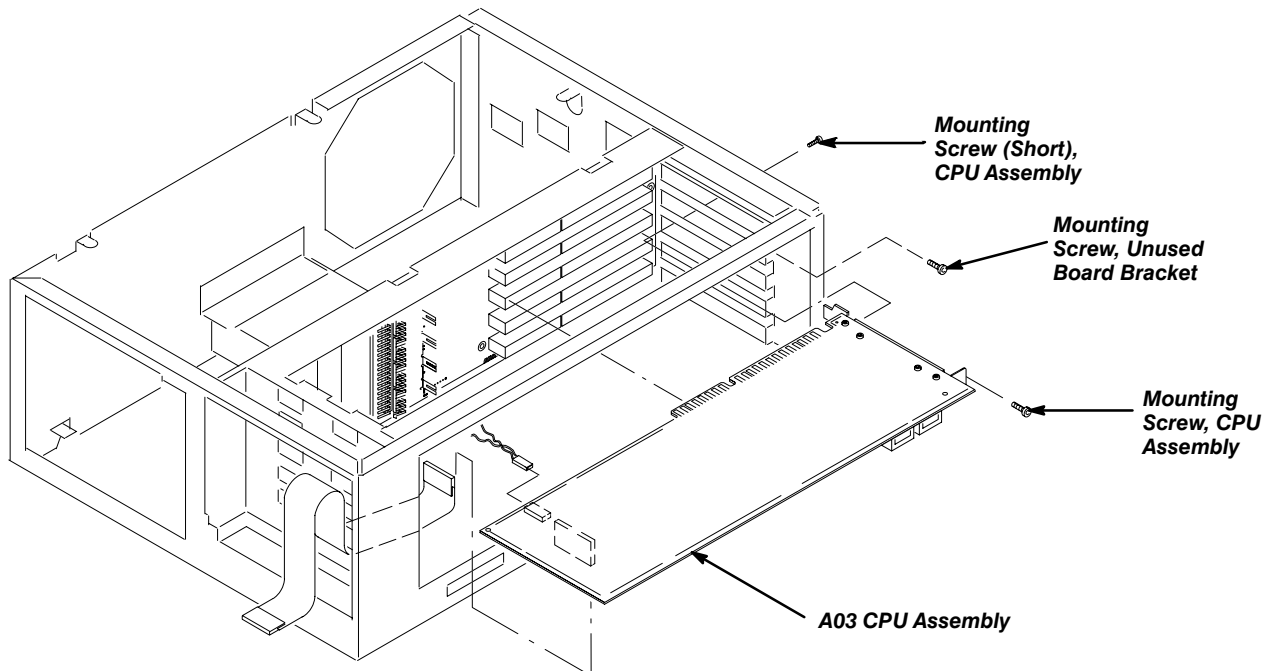


Figure 6-15: A03 CPU Removal

5. *Reinstallation:*

- a. Perform in reverse order substeps 4a–4g, reversing the removal instructions in each step and substep to reinstall the assembly. After plugging in the CPU to front panel cable at J101, be sure to dress the cable so that the loop of extra cable is tucked behind the front-panel assembly, as shown in Figure 6-15. The cable should come from J101 on the CPU assembly and route directly through the chassis opening to the front-panel cavity.
- b. See the following procedures in the order listed to replace modules removed by the access procedure:
 - *A08 Jumper Board Assembly, D1 Bus, and Board Supports* on page 6-40 (board supports)
 - *Front Cover, Rear Cover, Cabinet, Rear EMI Gasket, and Cabinet Handle and Feet* (page 6-24) to reinstall the cabinet and rear cover
 - *Line Fuse and Line Cord* (page 6-28) to reinstall the line cord, which completes the oscilloscope reassembly

A02 Display Assembly

1. *Access the module:* Be sure you have performed the *Access Procedure* on page 6-13 and removed the modules as instructed.
2. *Assemble equipment and locate modules to be removed:* Have handy a screwdriver with a size T-15 Torx® tip (Items 1 and 2). Locate the modules to be removed in the locator diagram *Internal Modules*, Figure 6-3 on page 6-17.
3. *Orient the digitizing oscilloscope:* Set the digitizing oscilloscope so its left side is down, with its front facing to the left of you.
4. *Remove the display board:* Using Figure 6-16 as a guide, perform the following substeps:
 - a. Unplug the monitor to display cable at J2.
 - b. Remove the single T-15 Torx® screw from the bracket that secures the *CPU assembly* at the inside rear corner of the main chassis.
 - c. Remove the single T-15 Torx® screw from the bracket that secures the *display assembly* at the inside rear corner of the main chassis.
 - d. Working from the rear of the oscilloscope, remove the single T-15 Torx® screw from the bracket that secures the display assembly to the rear of the main chassis.

CAUTION

Note that the screw removed in step d is shorter (0.250 inch/ 6.35 mm) than the screws removed in substeps b and c (0.625 inch/15.875 mm). Be sure to install the short screw in its proper location when reinstalling the board. Installation of the long screw will damage the display assembly circuit board.

- e. Grasp the board by its edge and pull outward to unplug it from J4 of the backplane assembly to complete the removal.

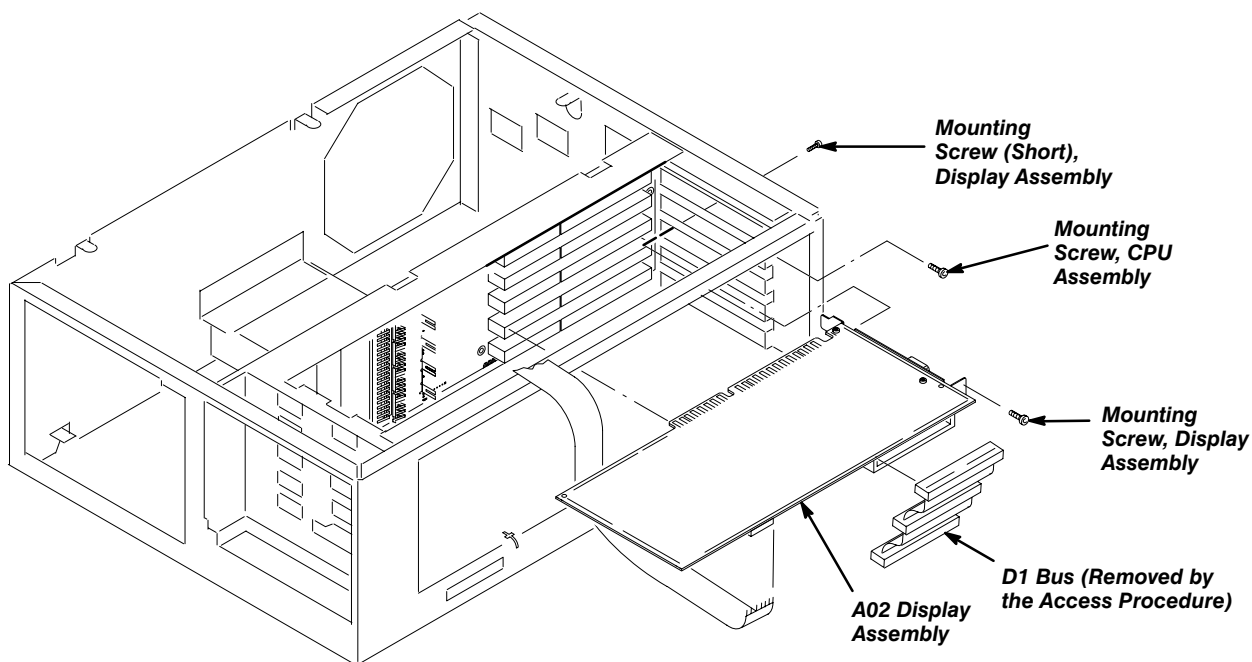


Figure 6-16: A02 Display Assembly Removal

5. *Reinstallation:*

- a. Perform in reverse order substeps 4a-4e, reversing the removal instructions in each substep to reinstall the assembly.
- b. See the following procedures in the order listed to replace modules removed by the access procedure:
 - *A08 Jumper Board Assembly, D1 Bus, and Board Supports* on page 6-40 (board supports and D1 bus only)

- *Front Cover, Rear Cover, Cabinet, Rear EMI Gasket, and Cabinet Handle and Feet* (page 6-24) to reinstall the cabinet and rear cover
- *Line Fuse and Line Cord* (page 6-28) to reinstall the line cord, which completes the oscilloscope reassembly

A09 DSP Assembly

1. *Access the module:* Be sure you have performed the *Access Procedure* on page 6-13 and removed the modules as instructed.
2. *Assemble equipment and locate modules to be removed:*
 - a. Have handy a screwdriver with a size T-15 Torx® tip (Items 1 and 2).
 - b. Locate the modules to be removed in the locator diagram *Internal Modules*, Figure 6-3 on page 6-17.
3. *Orient the digitizing oscilloscope:* Set the digitizing oscilloscope so its left side is down, with its front facing to the left of you.
4. *Remove the DSP Assembly:* Use Figure 6-17 as a guide perform the following substeps:
 - a. Unplug the battery-backup cable at J5.
 - b. Remove the single T-15 Torx® screw from the bracket that secures *the display assembly* at the inside rear corner of the main chassis.
 - c. Remove the single T-15 Torx® screw from the bracket that secures *the DSP assembly* at the inside rear corner of the main chassis.
 - d. Working from the rear of the oscilloscope, remove the single T-15 Torx® screw from the bracket that secures the DSP assembly to the rear of the main chassis.



Note that the screw removed in step d is shorter (0.250 inch/6.35 mm) than the screws removed in substeps b and c (0.625 inch/15.875 mm). Be sure to install the short screw in its proper location when reinstalling the board. Installation of the long screw will damage the DSP assembly circuit board.

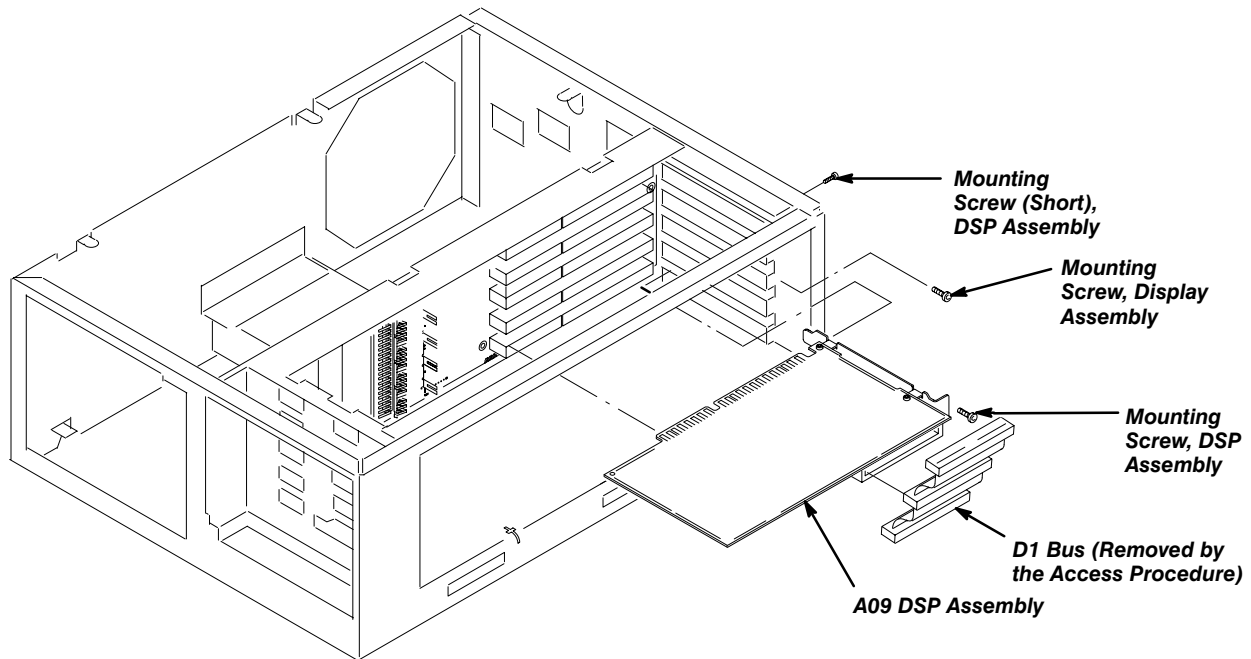


Figure 6-17: A09 DSP Assembly Removal

- e. Grasp the board by its edge and pull outward to unplug it from J5 of the backplane assembly to complete the removal.
5. *Reinstallation:*
- a. Perform in reverse order substeps 4a-4e, reversing the removal instructions in each substep to reinstall the assembly.
 - b. See the following procedures in the order listed to replace modules removed by the access procedure:
 - *A08 Jumper Board Assembly, D1 Bus, and Board Supports* on page 6-40 (board supports and D1 bus only)
 - *Front Cover, Rear Cover, Cabinet, Rear EMI Gasket, and Cabinet Handle and Feet* (page 6-24) to reinstall the cabinet and rear cover
 - *Line Fuse and Line Cord* (page 6-28) to reinstall the line cord, which completes the oscilloscope reassembly

A01 Backplane Assembly and its Mount

1. *Access the module:* Be sure you have performed the *Access Procedure* on page 6-13 and removed the modules as instructed.
2. *Assemble equipment and locate modules to be removed:*

- a. Have handy a screwdriver with a size T-15 Torx® tip (Items 1 and 2) and a flat-bladed screwdriver (Item 4).
 - b. Locate the modules to be removed in the locator diagram *Internal Modules*, Figure 6-3 on page 6-17.
3. *Orient the digitizing oscilloscope*: Set the digitizing oscilloscope so its left side is down, with its front facing to the left.
4. *Remove the backplane assembly*: Using Figure 6-18 as a guide, perform the following substeps:
 - a. There may be unused board brackets, mounted on the rear panel, that correspond to unused board slots in the *backplane assembly*. For any unused bracket, do the following subparts to remove it:
 - Remove the single T-15 Torx® screw that secures the used bracket at the inside rear corner of the main chassis.
 - Working from the rear of the oscilloscope, remove the single T-15 Torx® screw from the bracket that secures the DSP assembly to the rear of the main chassis.
 - b. Unplug the backplane to acquisition cable at J7 of the acquisition assembly.
 - c. Unplug the backplane to attenuator cable at J101 of the attenuator assembly.
 - d. Unplug the backplane to AUX power cable at J6 of the AUX power supply.
 - e. Unplug the backplane to front panel cable at J8 of the backplane assembly.
 - f. Unplug the backplane to low voltage power cable at J7 of the backplane assembly.

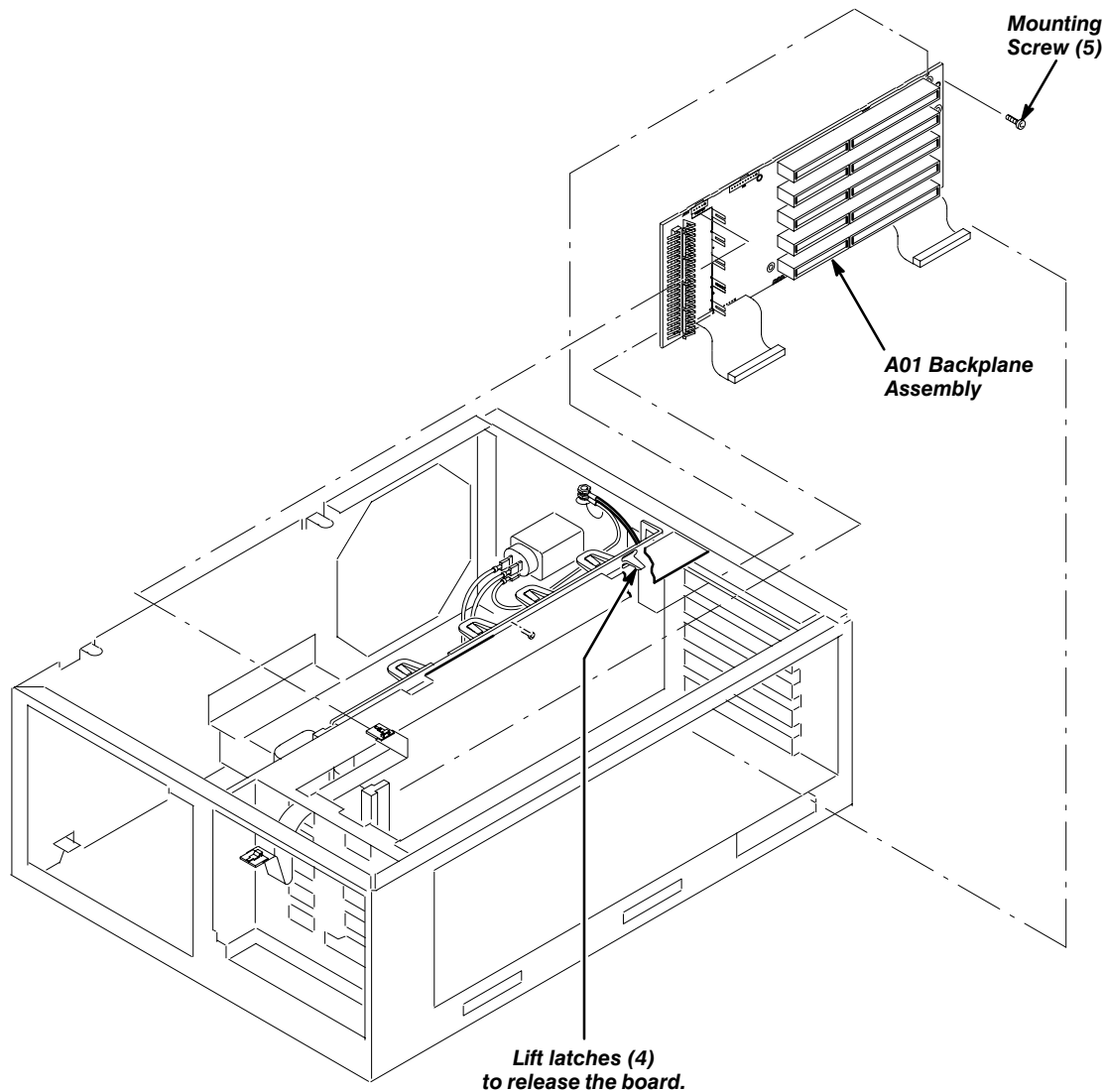


Figure 6-18: A01 Backplane Assembly and its Mount Removal

- g. Remove the five T15 Torx® screws mounting the board to the chassis.
- h. Turn the digitizing oscilloscope so its bottom is facing down on the work surface. Leave its front facing to the left.
- i. Find the flex lock nearest the front of the digitizing oscilloscope. Using a flat-bladed screwdriver, push the flex lock so it flexes enough to clear the board.
- j. While holding the flex lock, slightly pull up on the front corner of the board nearest that retainer until the board clears that flex lock. Repeat for the remaining three flex locks.

- k. Once the board is clear of all four flex locks, grasp the board by the edge near those flex locks and rotate that edge upwards slightly and pull the board out of its retainer slot at its opposite edge.
- l. As you lift the backplane assembly out of the chassis, guide the backplane to attenuator and backplane to acquisition cables up through their slots in the bottom of the chassis.
- m. Lift the assembly all of the way out of the chassis to complete the removal.

5. *Reinstallation:*

- a. Perform in reverse order substeps 4a-4m reversing the removal instructions in each substep to reinstall the assembly. Observe the following precautions as you do the substeps:
 - Be sure to guide the backplane to attenuator and backplane to acquisition cables up through their slots in the bottom of the chassis when doing step 4l
 - Be sure to align the board to the retainer slot when doing step 4k
 - Seat the board until the four retainers snap over the edge of the backplane assembly when doing substep 4j
- b. See the following procedures in the order listed to replace modules removed by the access procedure:
 - *A08 Jumper Board Assembly, D1 Bus, and Board Supports* on page 6-40 (board supports and D1 bus only)
 - *Front Cover, Rear Cover, Cabinet, Rear EMI Gasket, and Cabinet Handle and Feet* (page 6-24) to reinstall the cabinet and rear cover
 - *Line Fuse and Line Cord* (page 6-28) to reinstall the line cord, which completes the oscilloscope reassembly

Back-up Batteries



The batteries used in this oscilloscope can present a fire or chemical burn hazard if mistreated. Do not recharge, rapidly discharge, disassemble, heat above 100°C, or incinerate.

Replace batteries with the part number listed in the Replaceable Parts List, Section 10, only. Use of another battery presents a risk of fire or explosion.

Dispose of used batteries promptly. Small quantities of used batteries may be disposed of in normal refuse. Keep away from children. Do not disassemble, and do not dispose of in fire.



Disconnection of the batteries from their plugs results in the loss of all saved front panel setups and saved waveforms. Adjustment constants, stored internally when the oscilloscope is adjusted, are not lost.

1. *Assemble equipment and locate modules to be removed:* Locate the *back-up battery* to be removed in the locator diagram *Internal Modules*, Figure 6-3, page 6-17.
2. *Orient the digitizing oscilloscope:* Set the digitizing oscilloscope so its top is down on the work surface, with its right side facing you.
3. *Remove back-up battery 1:* Unplug the back-up battery cable at J5 of the CPU assembly. Then pull the battery out of its clamp near the front of the chassis to remove.

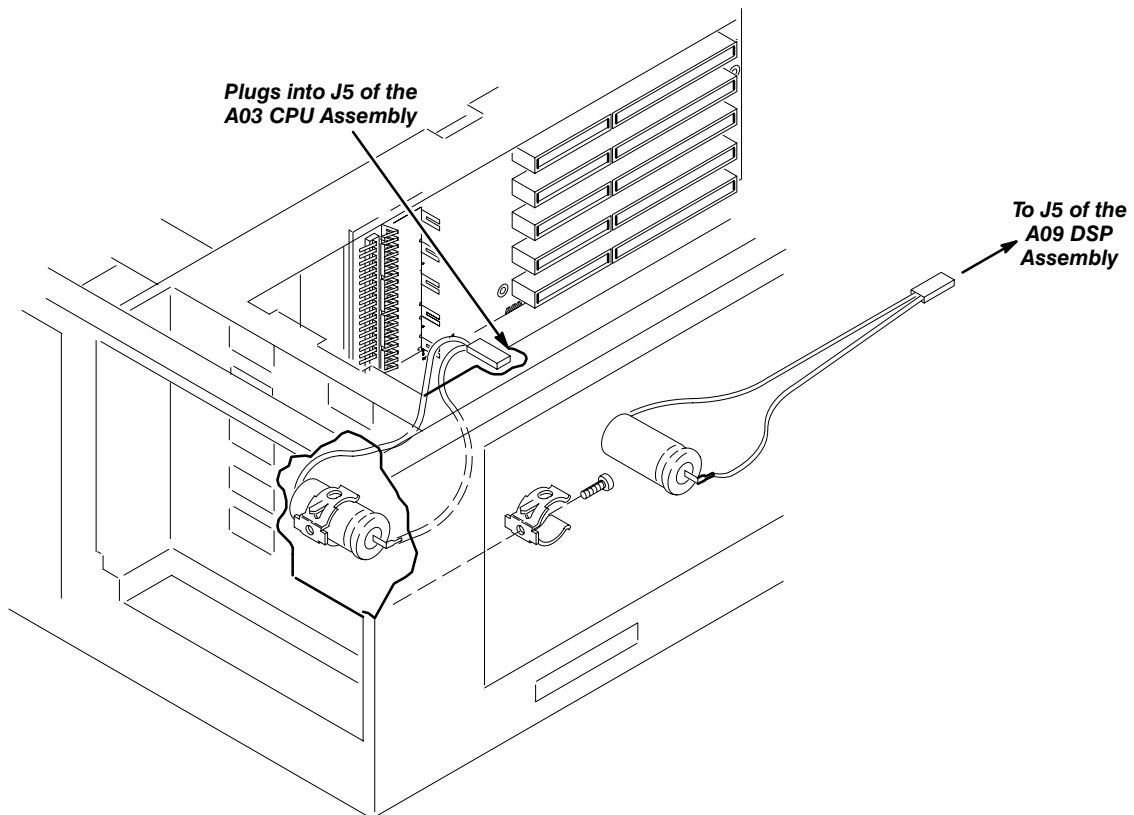


Figure 6-19: Battery Removal

4. *Remove back-up battery 2:* Unplug the back-up battery cable at J5 of the DSP assembly. Then pull the battery out of its clamp near the front of the chassis to remove.
5. *Remove the battery retaining clip:* If replacement of the battery clip is necessary, unscrew the clip from the chassis by rotating it counter-clockwise.
6. *Reinstallation:*
 - a. If the battery retaining clip(s) was removed, install it by screwing its threaded stud into the chassis.
 - b. Do steps 3 and 4, reversing the removal instructions to reinstall the each battery.
 - c. See the following procedures in the order listed to replace modules removed by the access procedure:
 - *Front Cover, Rear Cover, Cabinet, Rear EMI Gasket, and Cabinet Handle and Feet* (page 6-24) to reinstall the cabinet and rear cover
 - *Line Fuse and Line Cord* (page 6-28) to reinstall the line cord, which completes the oscilloscope reassembly

A25 Low Voltage Power Supply and its Mount

1. *Access the module:* Be sure you have performed the *Access Procedure* on page 6-13 and removed the modules as instructed.
2. *Locate modules to be removed:*
 - a. Have handy a screwdriver with a size T-15 Torx® tip (Items 1 and 2) and a pair of duck bill pliers (Item 6).
 - b. Find the low voltage power supply and, if it is to be removed, the power-supply mount in the locator diagram *Internal Modules*, Figure 6-3 on page 6-17.
3. *Orient the digitizing oscilloscope:* Set the digitizing oscilloscope so its bottom is down on the work surface and its front is facing to the right.



When releasing the low voltage power supply from its mount, take care not to push on the board components. Rather, push on the board edge when performing the following step and its substeps.

4. *Remove the low voltage power supply:*
 - a. Unplug the cable coming from the backplane assembly at J2.
 - b. Unplug the cable coming from the AUX power supply at J1.
 - c. Working through the opening created when the fan was removed (*Access Procedure*), remove the T-15 Torx® screw at the center of the power supply board.
 - d. Using a pair of duck-bill pliers, squeeze to release each of the four flex locks at the top edge of the low voltage power supply assembly.
 - e. Once released, tilt the board out away from the flex locks, and unplug the AC power cable where it connects to the cable from the low voltage power supply.
 - f. Lift the low voltage power supply assembly out of the chassis to complete its removal.

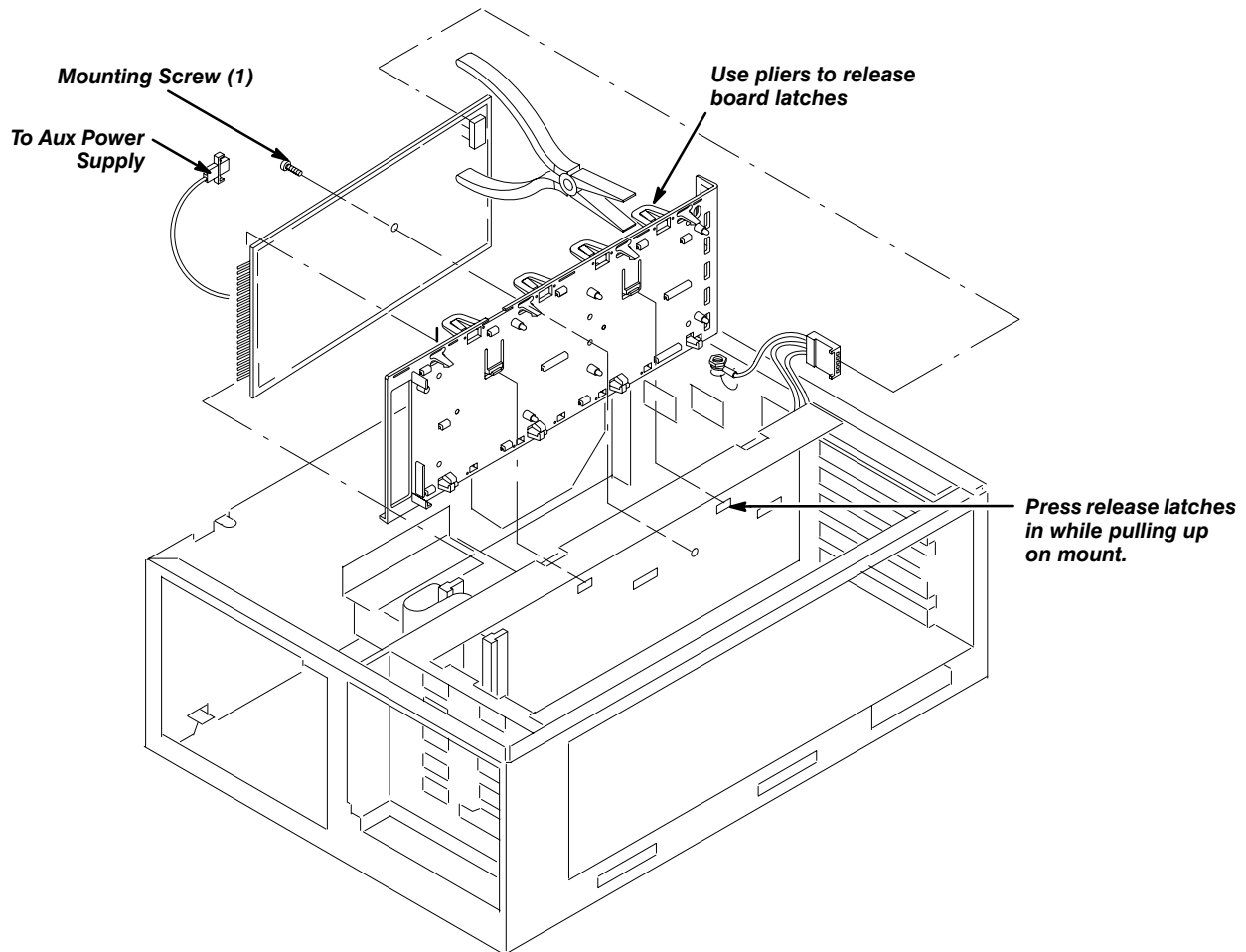


Figure 6-20: A25 Low Voltage Power Supply Removal



DO NOT do step 5 unless servicing a broken power supply mount or removing that mount for cleaning.

5. *Remove the power-supply mount:*

- a. Place the digitizing oscilloscope so its left side is down with its top facing you.
- b. Depress the two retainer locks and slide the power-supply mount towards the top of the digitizing oscilloscope to unlock from the chassis.
- c. Lift the power-supply mount out of the chassis to complete the removal. When reinstalling the power-supply mount, be sure to press it flush against the chassis before sliding it towards the bottom of the chassis to lock.

6. *Reinstallation:*

- a. If the power supply mount was removed, do the following subparts:
 - Do in reverse order substeps 5a–5c, reversing the removal instructions in each substep to reinstall the assembly
 - See *A02 Display Assembly*, on page 6-43, to reinstall that assembly
 - See *A09 DSP Assembly*, on page 6-45, to reinstall that assembly
 - See *A08 Jumper Board Assembly, D1 Bus, and Board Supports* on page 6-40 to reinstall the board supports and D1 bus only
- b. Perform in reverse order substeps 4a-4f, reversing the removal instructions in each substep to reinstall the assembly. *Be sure to seat the board until all of the four flex locks are locked.*
- c. See the following procedures to replace the modules removed by the access procedure.
 - *Front Cover, Rear Cover, Cabinet, Rear EMI Gasket, and Cabinet Handle and Feet* (page 6-24) to reinstall the cabinet and rear cover
 - *Line Fuse and Line Cord* (page 6-28) to reinstall the line cord, which completes the oscilloscope reassembly

Fan and Fan Mount

1. *Access the module:* Be sure you have performed the *Access Procedure* on page 6-13 and removed the modules as instructed.
2. *Assemble equipment and locate modules to be removed:* Locate the modules to be removed in the locator diagram *Internal Modules*, Figure 6-3, page 6-17.
3. *Orient the digitizing oscilloscope:* Set the digitizing oscilloscope so that its bottom is down and its rear is facing you.
4. *Remove the fan:*
 - a. Unplug the power cable for the *fan* from J3 on the *Auxiliary Power Supply*.
 - b. Release the two flex locks securing the top of the fan to the fan mount, then lift the fan out from the top of the chassis.
 - c. When reinstalling the fan, be sure the two locks snap into place to secure the fan.



DO NOT do step 5 unless servicing a broken fan mount or removing that mount for cleaning.

5. *Remove the fan mount:*
 - a. Rotate the digitizing oscilloscope so the side that houses the fan *mount* is facing upwards.
 - b. Depress the two flex locks to release them (see Figure 6-21).
 - c. While holding the flex locks released, slide the fan mount so its four retainer lugs slide from their small retainer holes in the chassis into their large release holes.
 - d. Move the fan mount inward so its retainer lugs are out of the large retainer holes and lift it out of the chassis to remove.

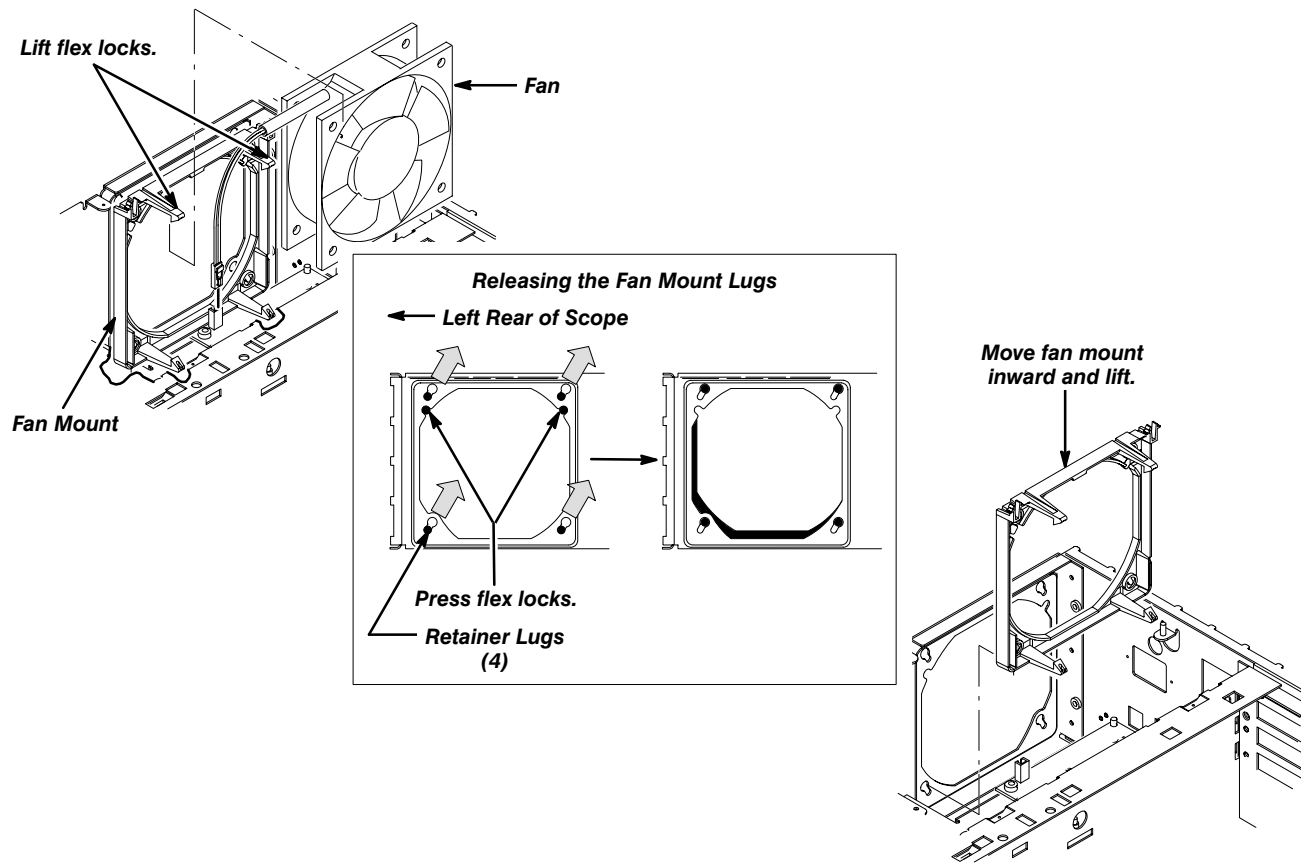


Figure 6-21: Fan and Fan Mount Removal

6. Reinstallation:

- a. If the fan mount was removed, perform in reverse order substeps 5a–5d reversing the removal instructions in each substep to reinstall the fan mount. Be sure to seat the fan mount so its two flex locks snap to secure it on the chassis.
- b. Do in reverse order substeps 4a–4c, to reinstall the fan.
- c. See the following procedures to replace the modules removed by the access procedure:
 - *Front Cover, Rear Cover, Cabinet, Rear EMI Gasket, and Cabinet Handle and Feet* (page 6-24) to reinstall the cabinet and rear cover
 - *Line Fuse and Line Cord* (page 6-28) to reinstall the line cord, which completes the oscilloscope reassembly

Line Filter

1. *Access the module:* Be sure you have performed the *Access Procedure* on page 6-13 and removed the modules as instructed.
1. *Assemble equipment and locate modules to be removed:* Have handy a screwdriver with a size T-15 Torx® tip (Items 1 and 2). Locate the line filter in the locator diagram *Internal Modules*, Figure 6-3, page 6-17.
2. *Orient the digitizing oscilloscope:* Set the digitizing oscilloscope so its bottom is down on the work surface and its rear is facing you.
3. *Remove the line filter:* Refer to Figure 6-22 when doing the following substeps.
 - a. Unplug the three connectors at the line filter.
 - b. Remove the two screws mounting the line filter to the chassis. Pull the filter out through the rear of the chassis to complete the removal.

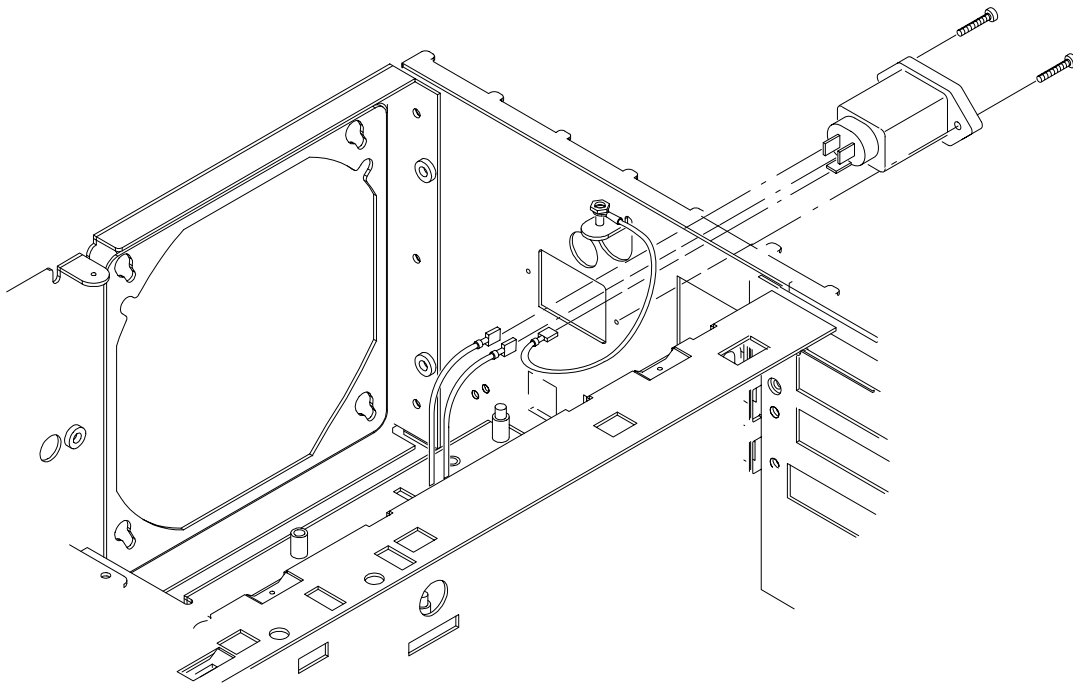


Figure 6-22: Line Filter Removal

4. *Reinstallation:*

WARNING

When reconnecting the auxiliary power supply to the line filter, be sure to connect the neutral side of the line filter to the black-striped lead and the load side to the white-striped lead.

It is not necessary to disconnect the earth ground from the chassis lug that it is bolted to. If, however, you have done so, be sure to install the earth lead (and its nut) from the line filter before installing the earth lead (and its nut) from the low voltage power supply.

- a. Do in reverse order substeps 3a–3b, reversing the removal instructions in each substep to reinstall the assembly.
- b. See the following procedures to replace the modules removed by the access procedure:
 - *Front Cover, Rear Cover, Cabinet, Rear EMI Gasket, and Cabinet Handle and Feet* (page 6-24) to reinstall the cabinet and rear cover
 - *Line Fuse and Line Cord* (page 6-28) to reinstall the line cord, which completes the oscilloscope reassembly

A07 Auxiliary Power Supply

1. *Access the module:* Be sure you have performed the *Access Procedure* on page 6-13 and removed the modules as instructed.
2. *Assemble equipment and locate modules to be removed:*
 - a. Have handy a screwdriver with a size T-15 Torx® tip (Items 1 and 2) and a 5/16 inch nut-driver (Item 7).
 - b. Locate the *auxiliary power supply* in the locator diagram *Internal Modules*, Figure 6-3 on page 6-17.
3. *Orient the digitizing oscilloscope:* Set the digitizing oscilloscope so its bottom is down on the work surface and its rear is facing you.
4. *Remove the auxiliary power supply:* Reference Figure 6-23 while doing the following substeps.
 - a. Unplug the monitor-power cable at J4, the fan-power cable at J3, the cable from the backplane assembly at J7, and the cable from the low voltage power supply assembly at J1.
 - b. Now, release and disconnect the remote-power cable where it joins the cable from the low voltage power supply assembly.
 - c. Unplug the two connectors at the line filter.

WARNING

When reconnecting the auxiliary power supply assembly to the line filter, be sure to connect the neutral side of the line filter to the black-striped lead and the load side to the white-striped lead.

- d. Remove the two T-15 Torx® screws mounting the auxiliary power supply assembly to the chassis. Then, pull up on the board to release it from the two retainers. Lift the board out of the chassis to complete the removal.

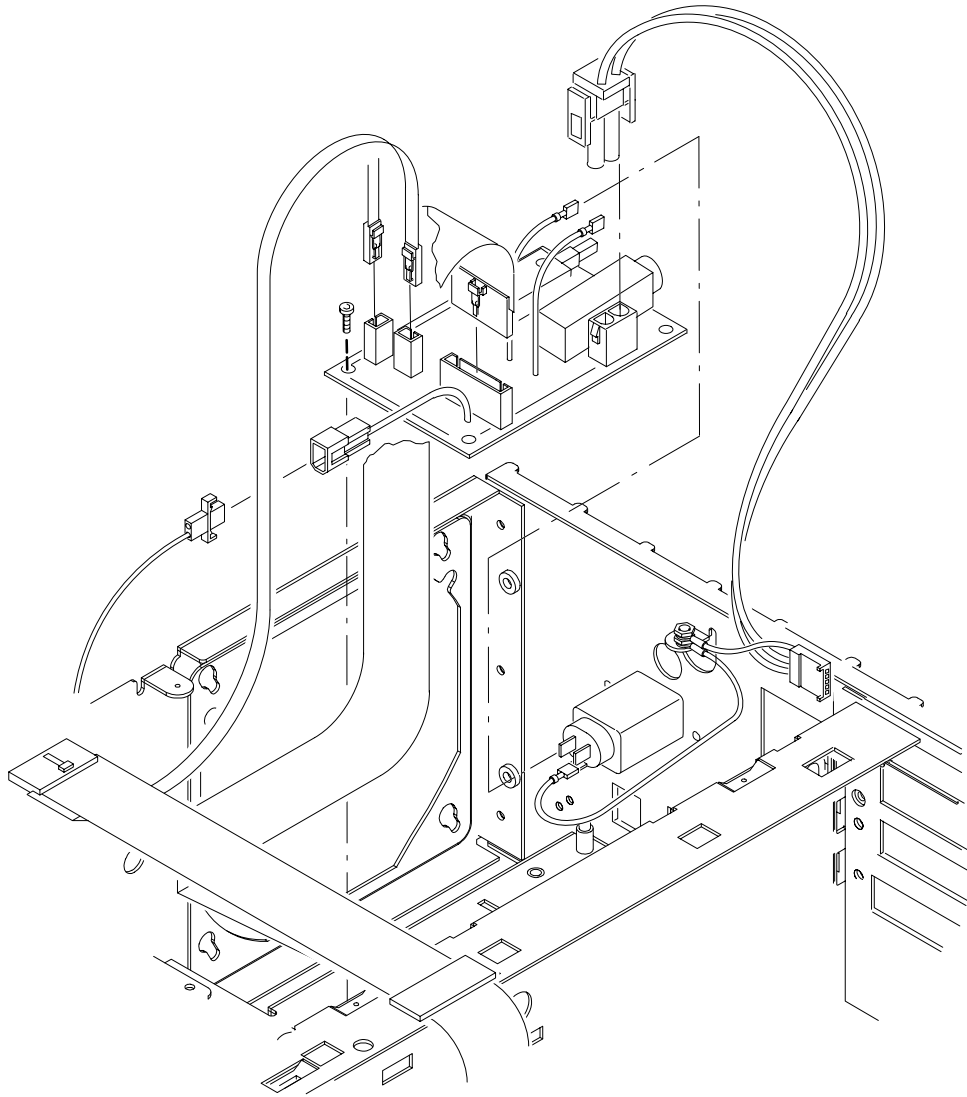


Figure 6-23: Auxiliary Power Supply Removal

5. Reinstallation:

- a. Perform in reverse order substeps 4a–4d reversing the removal instructions in each substep to reinstall the assembly. Be sure to seat the board until the two mounting posts snap locked on the assembly when reinstalling.
- b. See the following procedures in the order listed to replace modules removed by the access procedure:
 - *A08 Jumper Board Assembly, D1 Bus, and Board Supports* on page 6-40 (board supports and D1 bus only)

- *A06 Front-Panel Assembly, ESD Shield, and Menu Flex and Probe Code Flex Circuits* on page 6-31
- *Trim Ring, Menu Elastomer, Menu Buttons, and Front EMI Gaskets* on page 6-28
- *Front Cover, Rear Cover, Cabinet, Rear EMI Gasket, and Cabinet Handle and Feet* (page 6-24) to reinstall the cabinet and rear cover
- *Line Fuse and Line Cord* (page 6-28) to reinstall the line cord, which completes the oscilloscope reassembly

A04 Acquisition Assembly

1. *Access the module:* Be sure you have performed the *Access Procedure* on page 6-13 and removed the modules as instructed.
2. *Assemble equipment and locate modules to be removed:* Have handy a screwdriver with a size T-15 Torx® tip (Items 1 and 2). Locate the *acquisition assembly* in the locator diagram *Internal Modules*, Figure 6-3 on page 6-17.
3. *Orient the digitizing oscilloscope:* Set the digitizing oscilloscope so its bottom is up, with its front facing you.
4. *Remove the acquisition assembly:* Use Figure 6-24 as a guide.
 - a. Unplug the cable from the backplane assembly from J7 and the cable from the acquisition assembly at J5.
 - b. Remove the six screws securing the acquisition assembly to the bottom of the chassis, and lift out the acquisition assembly to complete its removal.

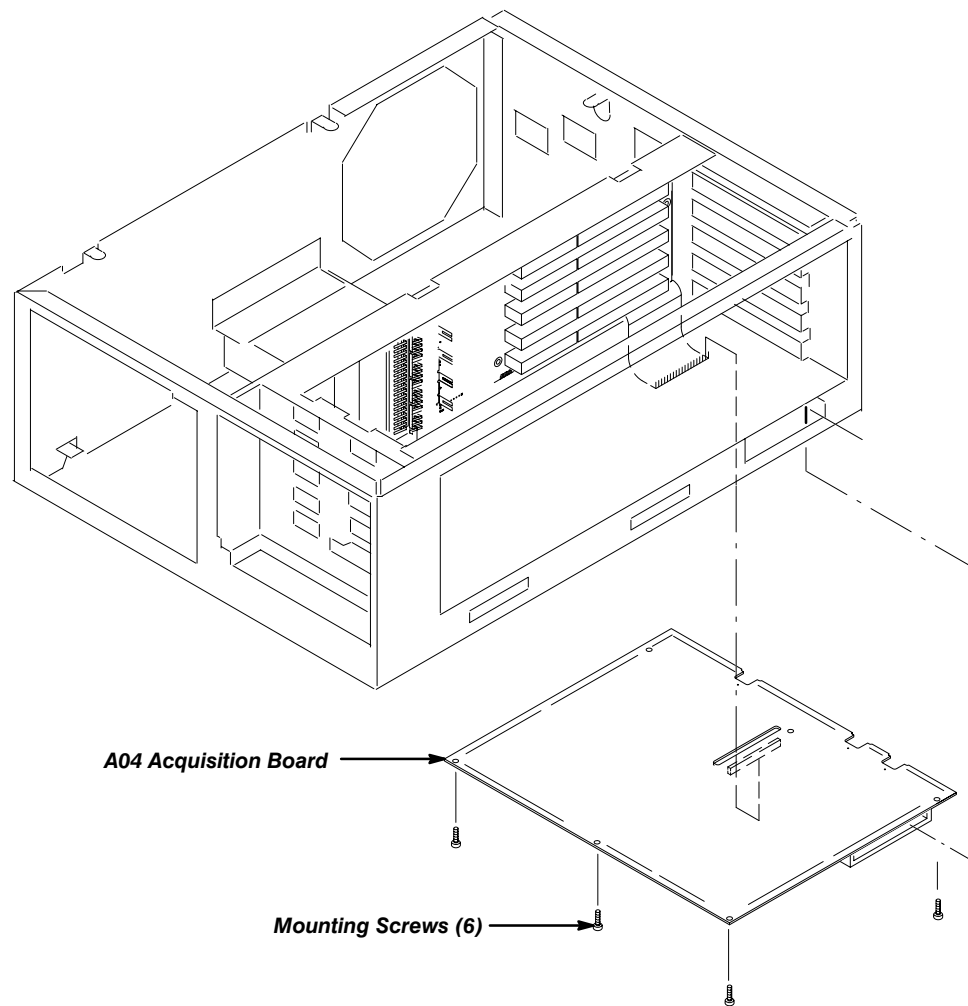


Figure 6-24: A04 Acquisition Board Removal

5. *Reinstallation:*

- a. Perform in reverse order substeps 4a-4b reversing the removal instructions in each substep to reinstall the assembly.
- b. See the following procedures in the order listed to replace modules removed by the access procedure:
 - *A08 Jumper Board Assembly, D1 Bus, and Board Supports* on page 6-40 to install the jumper board and D1 bus only
 - *Front Cover, Rear Cover, Cabinet, Rear EMI Gasket, and Cabinet Handle and Feet* (page 6-24) to reinstall the cabinet and rear cover
 - *Line Fuse and Line Cord* (page 6-28) to reinstall the line cord, which completes the oscilloscope reassembly

Main Chassis

1. *Remove the main chassis:* Since the removal of the *main chassis* requires the removal of virtually all modules, perform the procedure *Disassembly for Cleaning* that follows.
2. *Reinstallation:* See reinstallation instructions in *Disassembly for Cleaning*.

Disassembly for Cleaning

This procedure is for disassembly of the digitizing oscilloscope into its individual modules so they can be cleaned. Read the cleaning instructions in *Inspection and Cleaning* on page 6-5 of this section before disassembling this oscilloscope.

1. *Assemble equipment and locate modules to be removed:*
 - a. Have handy a screwdriver with a size T-15 Torx® tip (Items 1 and 2), a T-20 Torx® tip (Item 3), a flat-bladed screwdriver (Item 4), a pair of angle-tip tweezers (Item 8), duck bill pliers (Item 6), flat bladed spudger (Item 9), and a soldering iron (Item 10).
 - b. Familiarize yourself with the modules illustrated in Figures 6-2, 6-3, and 6-4.
2. *Remove all modules:* Do, in the order listed the following procedures. They are found under *Procedures for Module Removal and Installation* which starts on page 6-21.
 - a. *Line Fuse and Line Cord* (page 6-23)
 - b. *Front Cover, Rear Cover, Cabinet, Rear EMI Gasket, and Cabinet Handle and Feet* (page 6-24)
 - c. *Trim Ring, Menu Elastomer, Menu Buttons, and Front EMI Gaskets* (page 6-28)
 - d. *A06 Front-Panel Assembly, ESD Shield, and Menu Flex and Probe Code Flex Circuits* (page 6-31)
 - e. *Fan and Fan Mount* (page 6-54)
 - f. *A25 Low Voltage Power Supply and its Mount* (page 6-51)
 - g. *A26 Monitor Assembly* (page 6-43)
 - h. *A07 Auxiliary Power Supply* (page 6-58)

- i. *Line Filter* (page 6-56)
 - j. *A08 Jumper Board Assembly, D1 Bus, and Board Supports* (page 6-40)
 - k. *A03 CPU Assembly* (page 6-41)
 - l. *A02 Display Assembly* (page 6-43)
 - m. *A09 DSP Assembly* (page 6-45)
 - n. *A01 Backplane Assembly and its Mount* (page 6-46)
 - o. *Back-up Batteries* (page 6-49)
 - p. *A05 Attenuator Assembly and Shield* (page 6-34)
 - q. *A04 Acquisition Assembly* (page 6-60)
3. *Reassembly*: Do substeps a–q in the order listed. Observe the following instructions as you do them:
- The procedures called out in the substeps that follow reinstall all the modules. When doing these procedures, do their steps in reverse order.
 - When reinstalling the modules, ignore any instructions that require connecting a cable or bus to a module that you have not yet installed. You will make the necessary connections when you install the missing module later.
 - Ignore any instructions to do the *Access Procedure*. The access procedure is only used when removing individual modules for servicing, not when doing a disassembly/reassembly for cleaning.
 - Ignore any instructions directing you to see other procedures to reinstall modules removed by the access procedure. The substeps that follow direct you to the procedures needed to reinstall all of the modules.
- a. *A04 Acquisition Assembly* (page 6-60)
 - b. *A05 Attenuator Assembly and Shield* (page 6-34)
 - c. *Back-up Batteries* (page 6-49)
 - d. *A01 Backplane Assembly and its Mount* (page 6-46)
 - e. *A09 DSP Assembly* (page 6-45)
 - f. *A02 Display Assembly* (page 6-43)
 - g. *A03 CPU Assembly* (page 6-41)
 - h. *Line Fuse and Line Cord* (page 6-23)
 - i. *A08 Jumper Board Assembly, D1 Bus, and Board Supports* (page 6-40)

- j. *Line Filter* (page 6-56)
- k. *A07 Auxiliary Power Supply* (page 6-58)
- l. *A26 Monitor Assembly* (page 6-43)
- m. *A25 Low Voltage Power Supply and its Mount* (page 6-51)
- n. *Fan and Fan Mount* (page 6-54)
- o. *Trim Ring, Menu Elastomer, Menu Buttons, and Front EMI Gaskets* (page 6-28)
- p. *A06 Front-Panel Assembly, ESD Shield, and Menu Flex and Probe Code Flex Circuits* (page 6-31)
- q. *Front Cover, Rear Cover, Cabinet, Rear EMI Gasket, and Cabinet Handle and Feet* (page 6-24)

Troubleshooting

This subsection contains information and procedures designed to help you isolate faulty modules in the oscilloscope. If a module needs to be replaced, follow the *Removal and Installation Procedures* located in this section. If servicing a TDS 410, follow the procedures for the TDS 420, but ignore all references to CH 3 and CH 4.



This oscilloscope operates over several ranges of line voltage (see Source Voltage and Frequency on page 1-16 of Section 1, Specification). Before stepping the line voltage from one range to a higher range, set the principal power switch (rear panel) to its OFF position. Failure to do so can damage the oscilloscope.

Diagnostics

The oscilloscope has two levels of internal diagnostics that focus on verifying, adjusting, and, if need be, isolating faulty modules.

Both levels of internal diagnostics report any bad modules and/or interfaces. If they do find a bad module and/or interface, use the troubleshooting procedures in this section to determine which module needs to be replaced.

The two levels of diagnostics are the short confidence set and an extended set that tests the oscilloscope circuitry in-depth and takes more time. At power-up, the oscilloscope automatically executes the short set. The extended set is optional and is executed by using the following procedure:

Prerequisites: Power up the oscilloscope and allow a 20 minute warm-up before doing this procedure.

1. *Display the System diagnostics menu:*
 - a. Press **SHIFT**; then press **UTILITY**.
 - b. Repeatedly press the main-menu button **System** until **Diag/Err** is highlighted in the menu that pops up.
 - c. Repeatedly press the main-menu button **Area** until **All** is highlighted in the menu that pops up.
2. *Run the System Diagnostics:* Press the main-menu button **Execute**; then press the side-menu button **OK Confirm Run Test**.
3. *Wait:* The internal diagnostics do an exhaustive verification of proper oscilloscope function. This verification will take about two minutes. When finished, the oscilloscope displays a report of any bad modules and/or interfaces.



Firmware Updates

Firmware updates are easy to do. Simply install the firmware disks on your PC and follow the instructions in the README file located on the first disk. The firmware update kit is listed as an optional accessory in Section 10.

NOTE

You must set both switches of the Protection switch to the unprotected position before updating the firmware. Figure 6-25 shows how to set the switch. After loading the firmware, be sure you set both switches back to the protected position and cycle power.

If you want to order a firmware update, see *Optional Accessories* in Section 10 *Mechanical Parts List* for the part number.

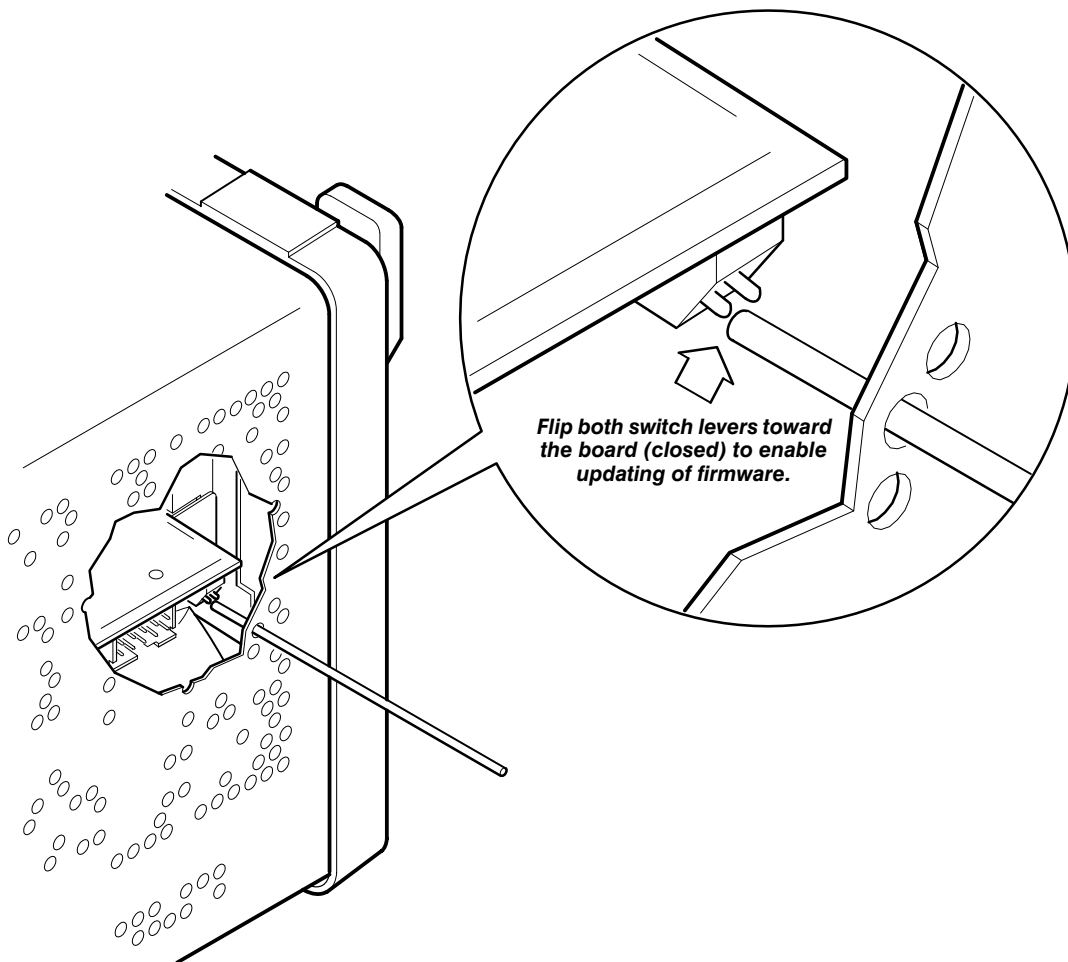


Figure 6-25: Accessing the Protection Switch

Troubleshooting Equipment

Equipment listed in Tables 4-1, 5-3, 6-4, and 6-8 of this manual, or equivalent equipment, may be useful while troubleshooting this oscilloscope. Construction of and set-up of other troubleshooting equipment are also listed in this part of the manual.

Table 6-8: Troubleshooting Test Equipment, Fixtures, and Supplies

Item Number and Description	Minimum Requirements	Example	Purpose
1 Console Port	Tektronix part number 174-2613-00	Tektronix part number 174-2613-00 (see Figure 6-26)	Troubleshooting using the Console Port
2 Computer	IBM® PC compatible		Troubleshooting using the Console Port
3 Extension cable	Console port to computer connection		Troubleshooting using the Console Port
4 Telecommunication software		Cross Talk®	Troubleshooting using the Console Port
5 Oscilloscope	150 MHz (for the TDS 410 and TDS 420) or 350 MHz (for the TDS 460)	TEKTRONIX TDS 410, TDS 420, or TDS 460	General troubleshooting

Console Port Set Up

The console port allows you to see detailed diagnostic messages when faults in the oscilloscope prevent display of the normal diagnostics. Use this procedure to set up the console port:

NOTE

You may need a DB-9 to DB-25 adaptor, null modem adaptor, gender changer adaptor, and an extension cable to connect the console port to your personal computer (see Figure 6-26). Using Table 6-9 you can wire a cable to take the place of a DB9 to DB25 adaptor, null modem adaptor, gender changer, and an extension cable.

1. *Equipment required:* Console port (Item 1), a personal computer or terminal (Item 2), and telecommunication (terminal) software (Item 4) for the personal computer. Your personal computer will also require a DB-9 to DB-25 adaptor, null modem adaptor, gender changer adaptor, and an extension cable to connect the console port to your personal computer (see Figure 6-26).
2. *Prerequisites:* Power off the oscilloscope.

3. *Accessing J3: Using the Front Cover, Rear Cover, Cabinet, Rear EMI Gasket, and Cabinet Handle and Feet* disassembly procedure, remove the cabinet.

Table 6-9: Connections for a 9 to 25 Pin Null Modem Cable

DB-9 Signals	DB-9 Pin	DB-25 Pin	DB-25 Signals
DCD	1	20	DTR
RD	2	2	TD
TD	3	3	RD
DTR	4	6 and 8	DSR and DCD
SG	5	7	SG
DSR	6	20	DTR
RTS	7	5	CTS
CTS	8	4	RTS
Unused (RI)	9	—	All Others Unused

4. *Connecting the equipment:* Attach the console-port cable to J3 on the A03 CPU module (see Figure 6-26) and, using an extender cable or adaptors, to the RS-232 serial port of your personal computer (or RS-232 terminal).
5. *Configure the personal computer:*
 - a. *Load the software:* Load telecommunication (terminal) software into your personal computer.
 - b. *Select the software port:* Configure the telecommunication software so that it accesses the serial port that you connected to the console port (Com1 or Com2).
 - c. *Configure port parameters:* Set the telecommunication software (or terminal) parameters:
 - Baud Rate 9600
 - Parity None
 - Data Bits 8
 - Stop Bits 1
 - Duplex Full
 - Protocol None
 - Terminal ANSI
 - d. *Select terminal mode:* After configuring the software parameters, switch the software to terminal mode.

6. *Use the console port:* Power up the oscilloscope. Diagnostic messages are echoed to the personal computer display.

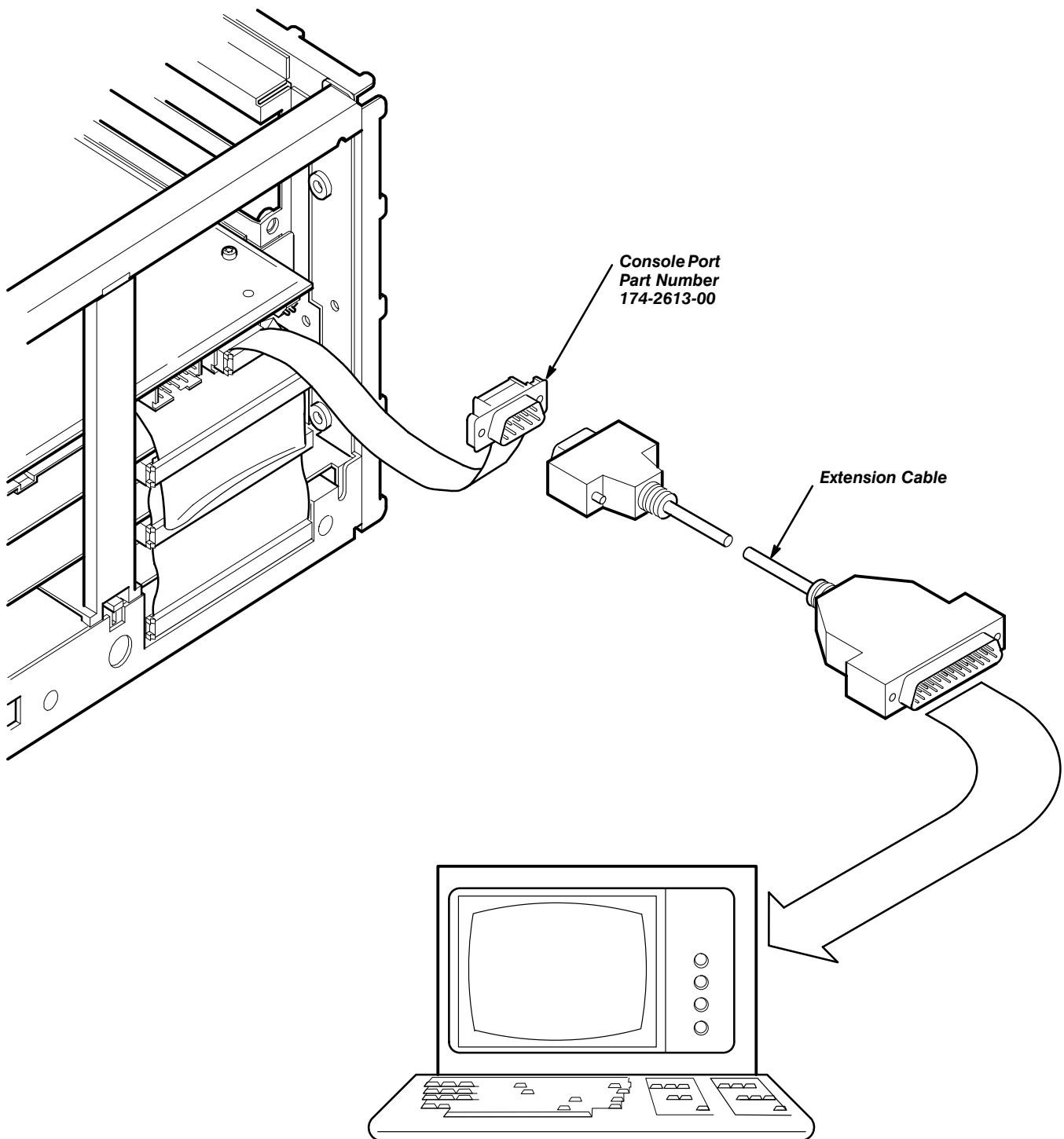


Figure 6-26: Console Port Connections

Troubleshooting

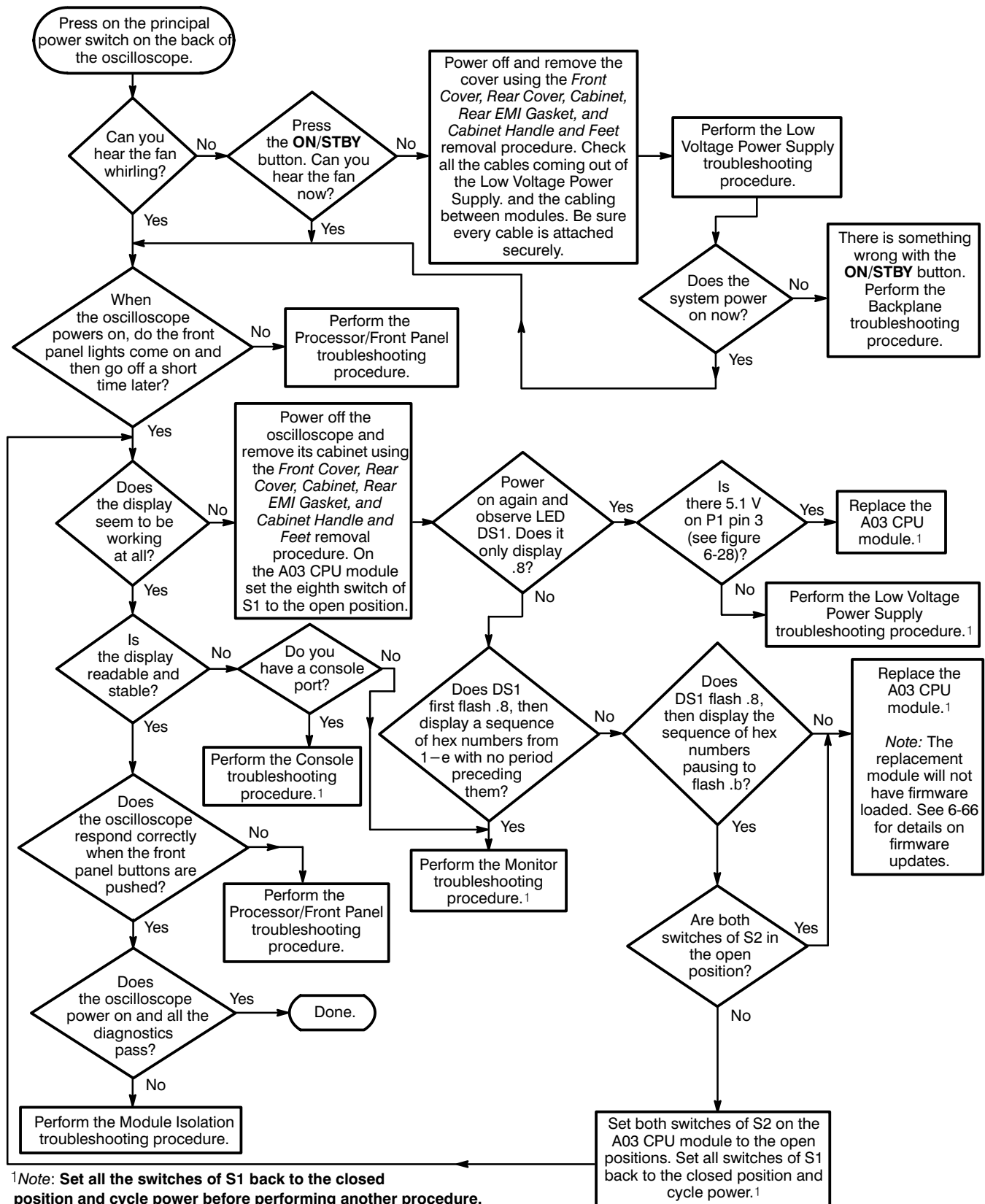


Figure 6-27: Primary Troubleshooting Procedure



Pin 3

Pin 1

Pin 32

Troubleshooting

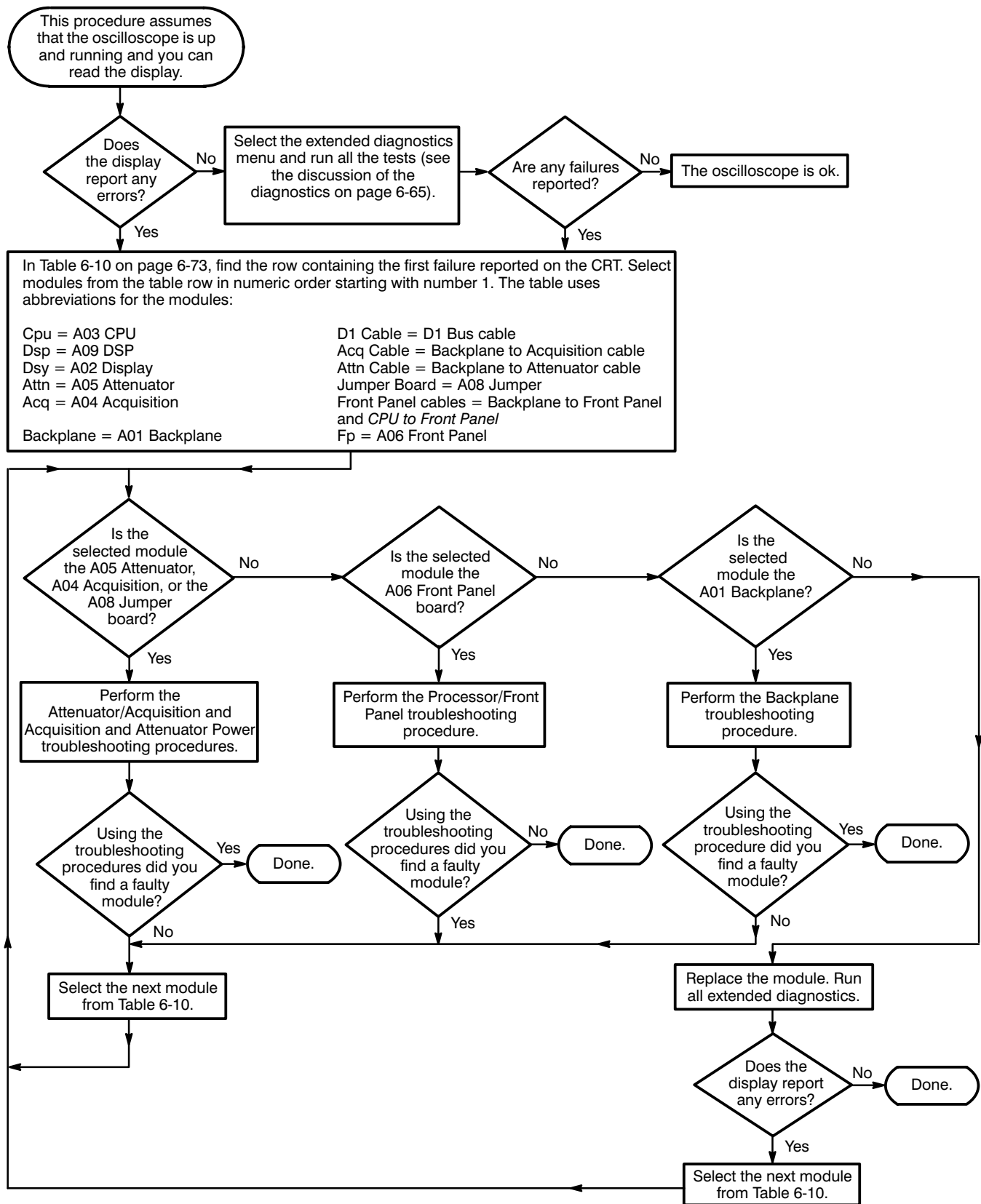


Figure 6-29: Module Isolation Troubleshooting Procedure

Table 6-10: Diagnostic Failure Priority List

Module	Cpu	Dsp	Dsy	Attn	Acq	Back-plane	D1 Cable	Acq Cable	Attn Cable	Attn/Acq Jumper Board	Front Panel Cables	Fp
Cpu	1	2	3			4	5					
Cal Initialization	1											
Cpu/Dsp or AT bus	2	1	3			4						
Dsp		1	2		4		3					
Cpu/Dsp/Dsy or D1 bus		3	1		4		2					
Cpu/Dsp/Dsy or AT bus	1	2	3			4						
Dsy		3	1		4		2					
Cpu/Attn or I2C bus	2			1	5	4			3			
Attn				1	3	2						
Cpu/Acq, D1/I2C bus	5	4			1		2	3				
Acq				3	1	4	5			2		
Acq/Attn				2	3		4			1		
Fp/Cpu	3										2	1

Troubleshooting

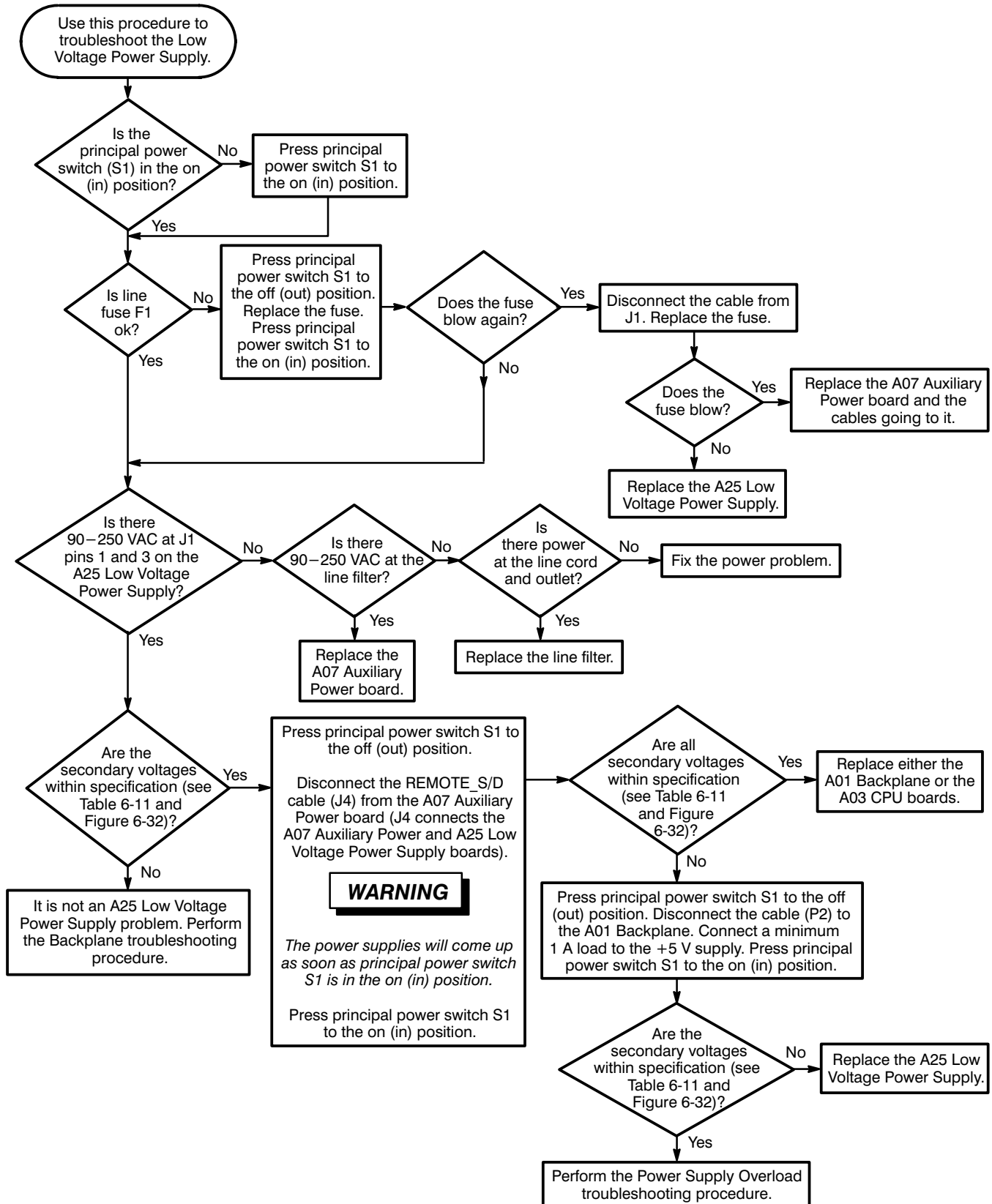


Figure 6-30: Low Voltage Power Supply Troubleshooting Procedure

Table 6-11: Normal Output Voltage

Supply	J2 Pin	Minimum Output	Maximum Output
+5.1 V	20	+5.05 V	+5.15 V
+15 V	8	+14.85 V	+15.15 V
−6.4 V	6	−6.35 V	−6.45 V
−15 V	2	−14.85 V	−15.15 V

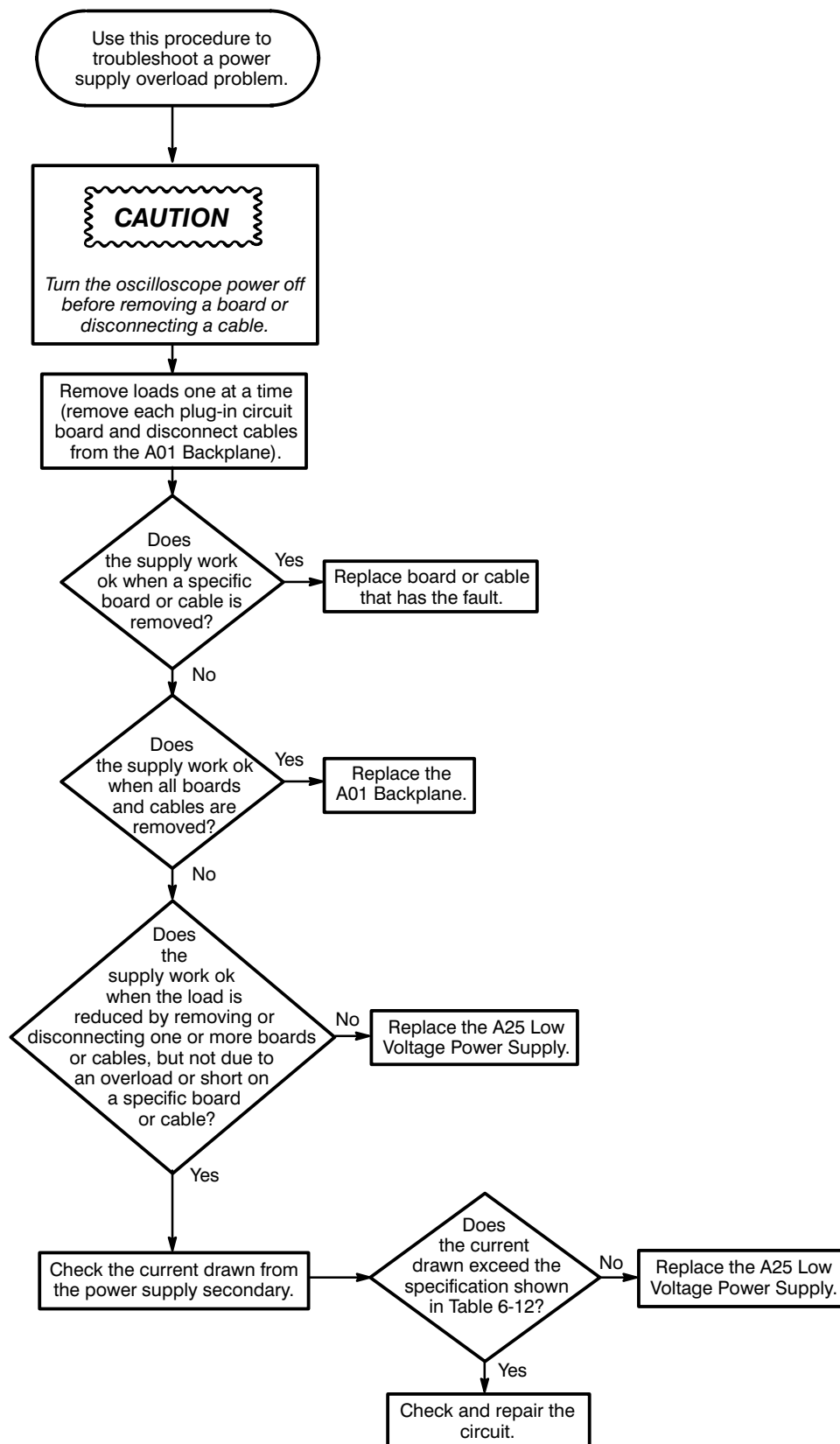


Figure 6-31: Power Supply Overload Troubleshooting Procedure

Table 6-12: Power Supply Maximum Current

Supply	J2 Pins	Maximum Current
+5.1 V	16–20	15 A
+15 V	8 and 9	3.5 A
–6.4 V	6 and 7	5.5 A
–15 V	1 and 2	0.75 A

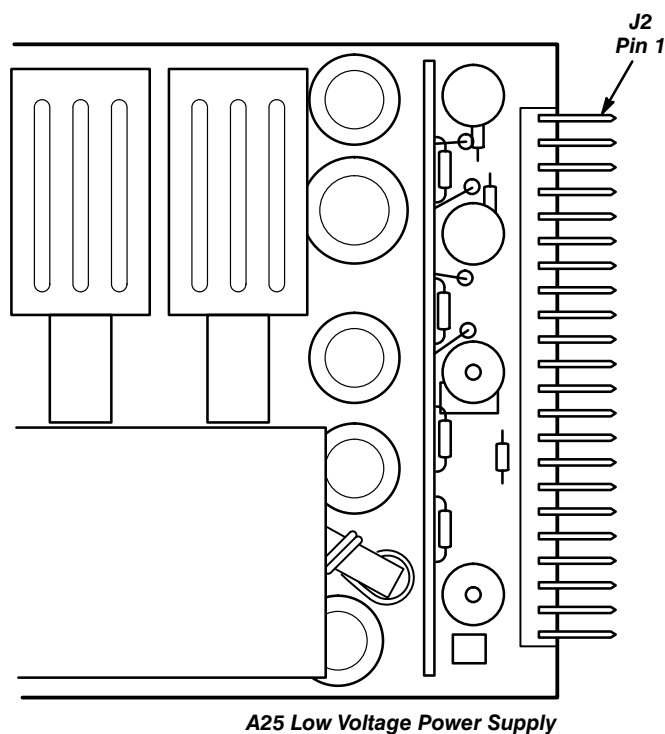


Figure 6-32: A25 Low Voltage Power Supply Module (Right Side)

Troubleshooting

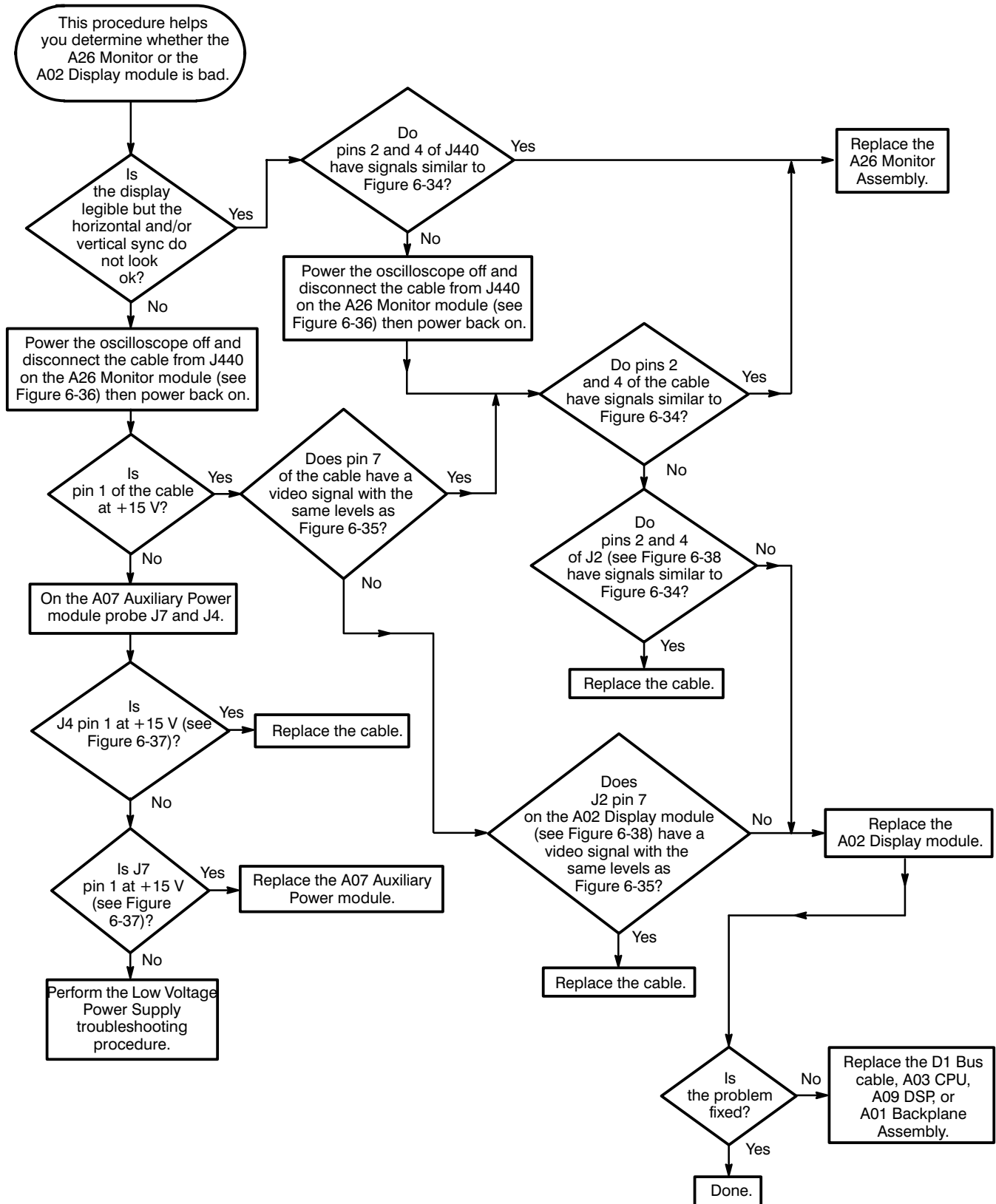


Figure 6-33: Monitor Troubleshooting Procedure

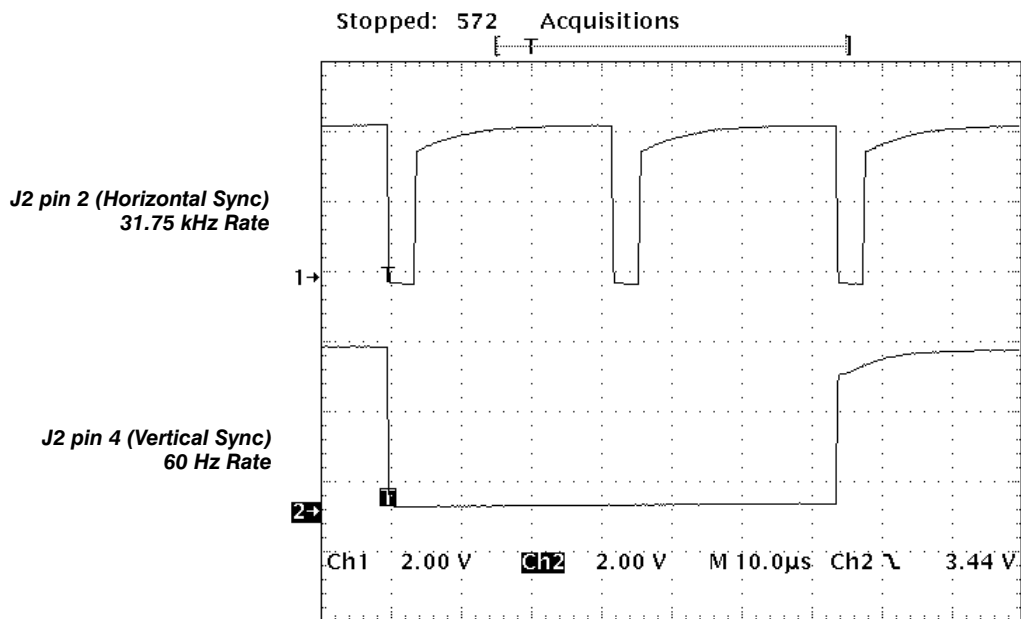


Figure 6-34: Horizontal and Vertical Sync Signals

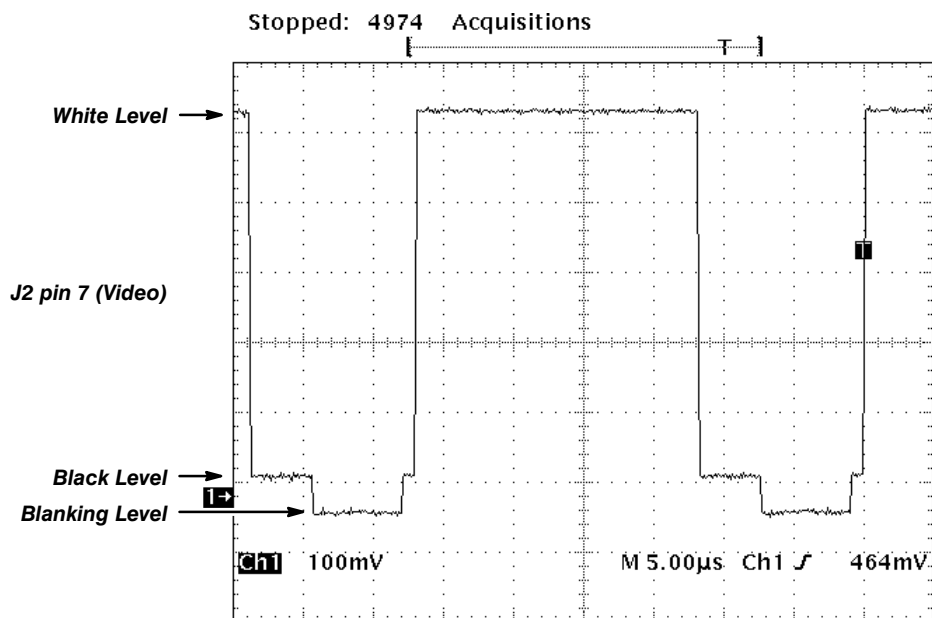


Figure 6-35: A Video Signal with White, Black, and Blanking Levels

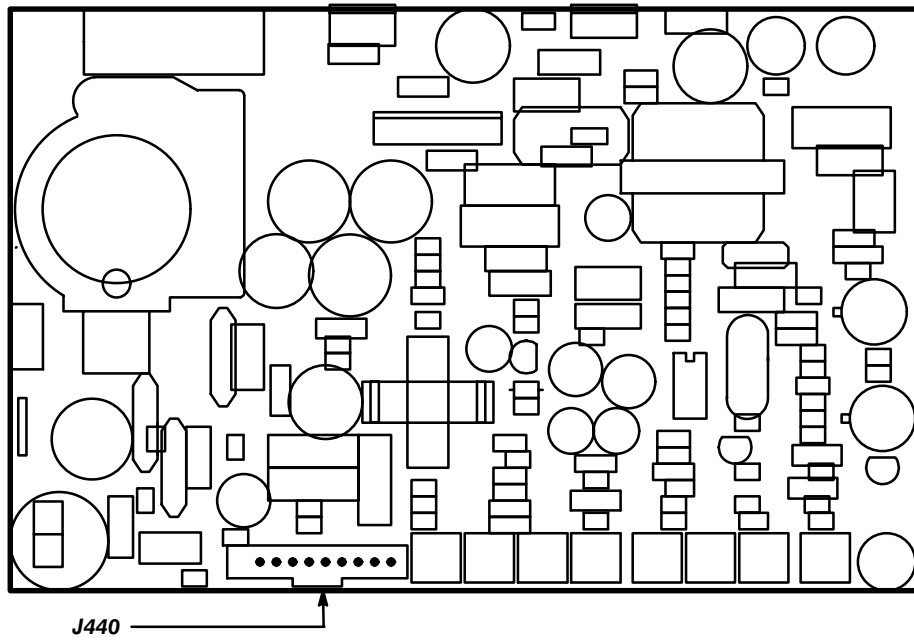


Figure 6-36: A26 Monitor Connector J440

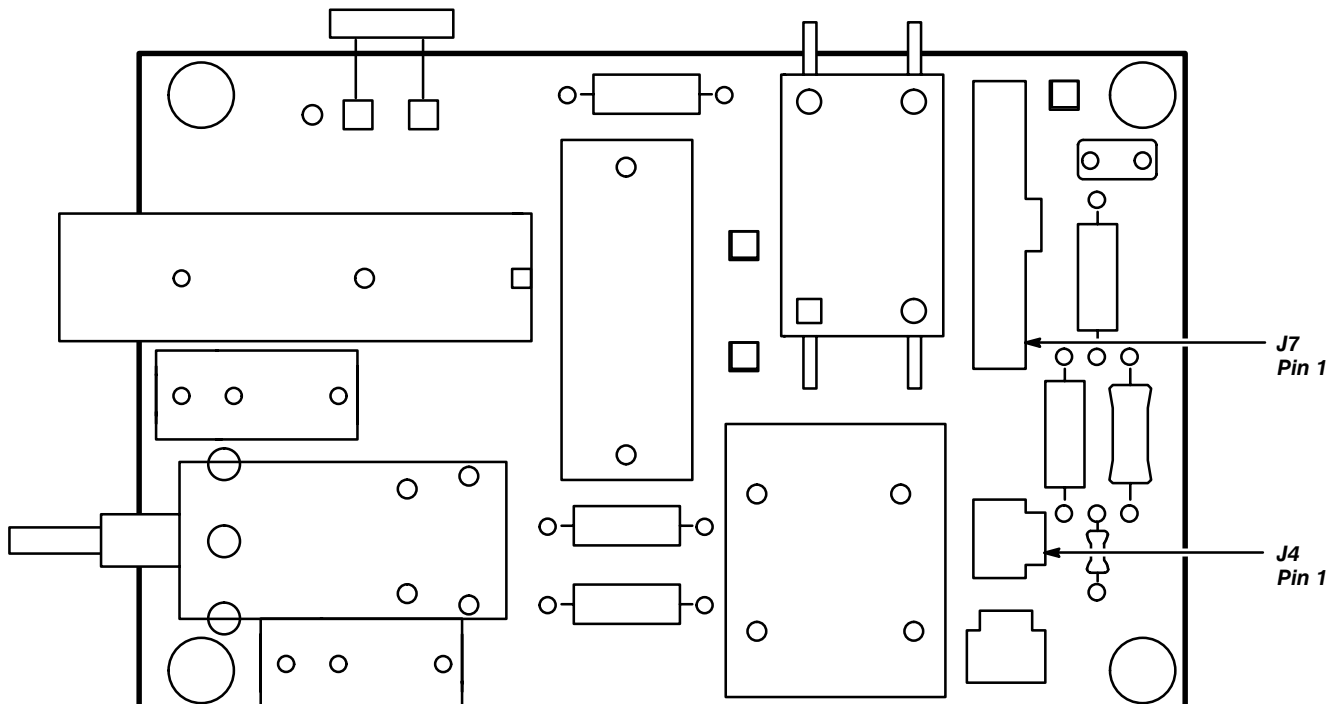


Figure 6-37: A07 Auxiliary Power Connectors J4 and J7

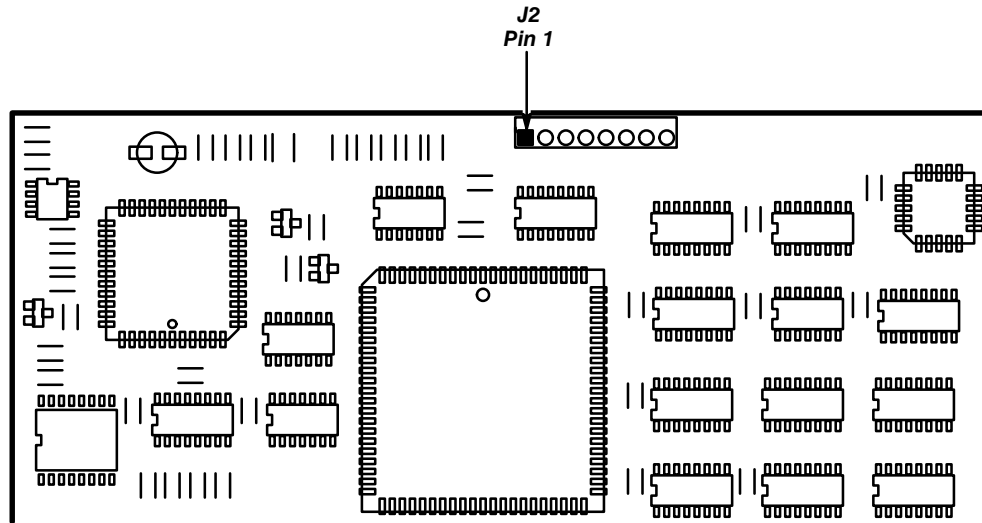


Figure 6-38: A02 Display Connector J2

Troubleshooting

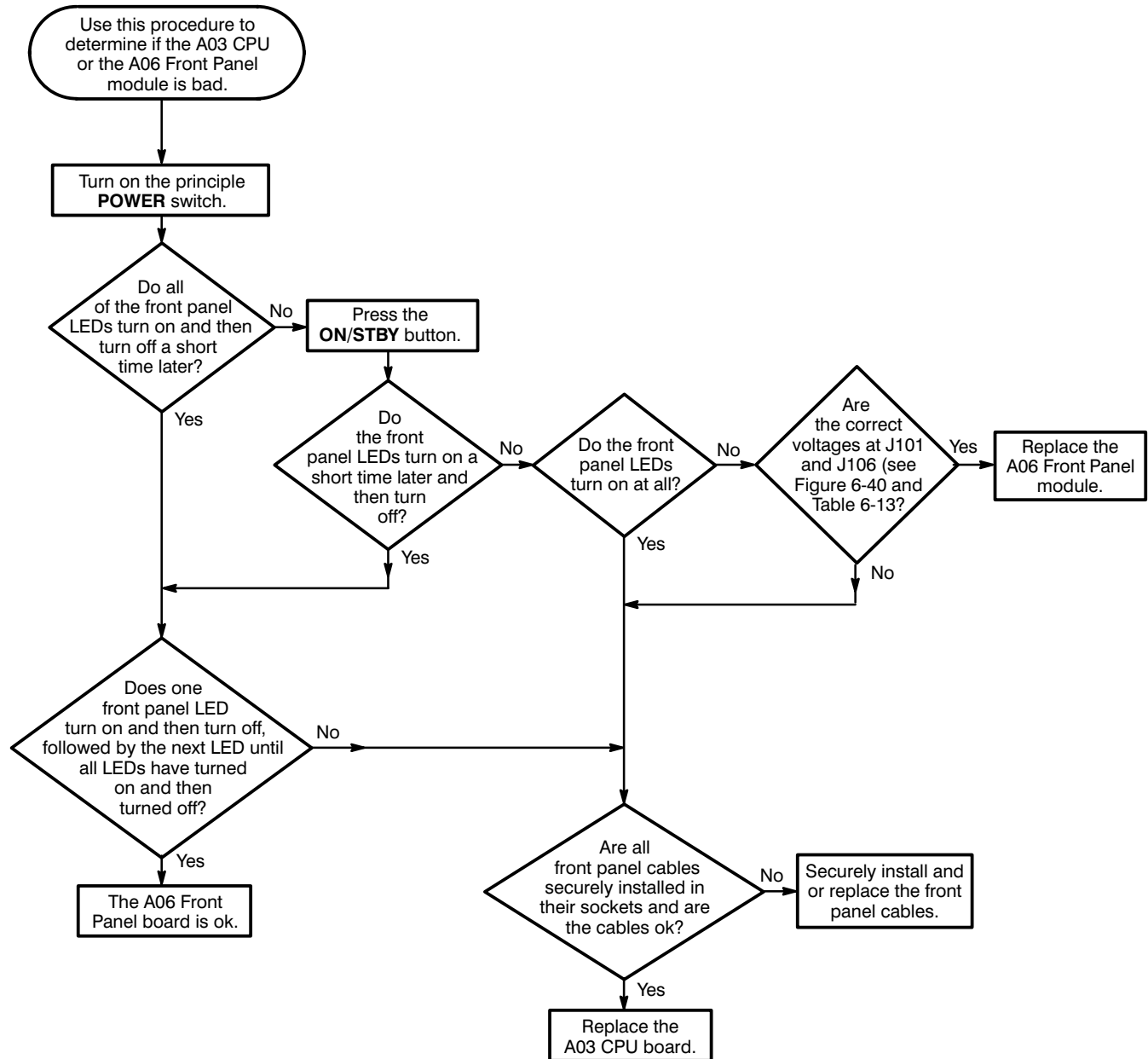


Figure 6-39: Processor/Front Panel Troubleshooting Procedure

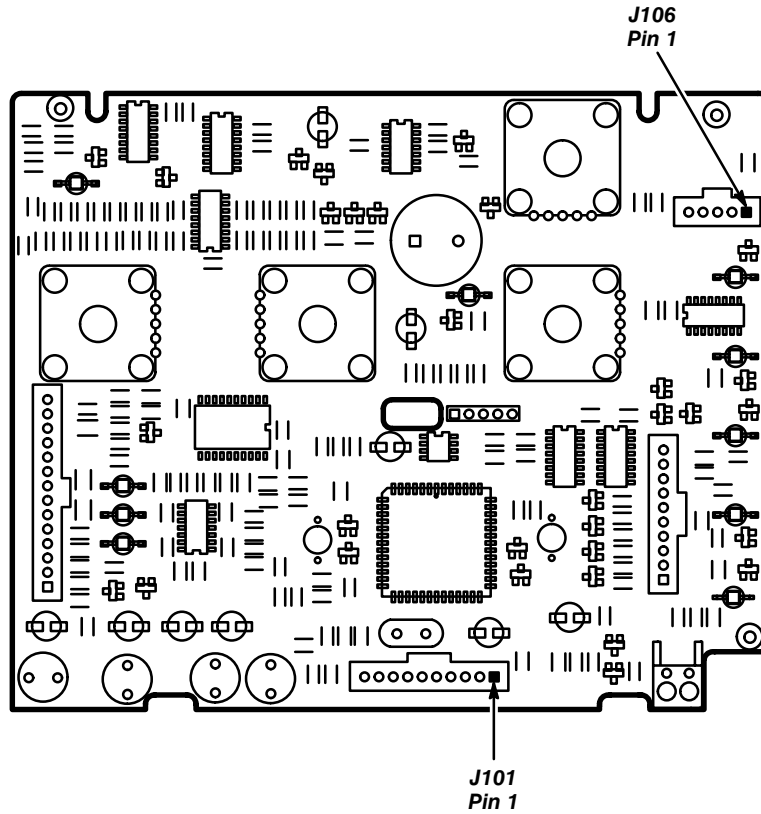


Figure 6-40: A06 Front Panel Board Power Connectors J101 and J106

Table 6-13: Front Panel Connector Voltages

Connector	Pin	Nominal Voltage
J101	Pins 2 and 4	5.1 V
J106	Pin 1	15 V
J106	Pin 2	5.1 V
J106	Pin 4	−5 V
J106	Pin 5	−15 V

Troubleshooting

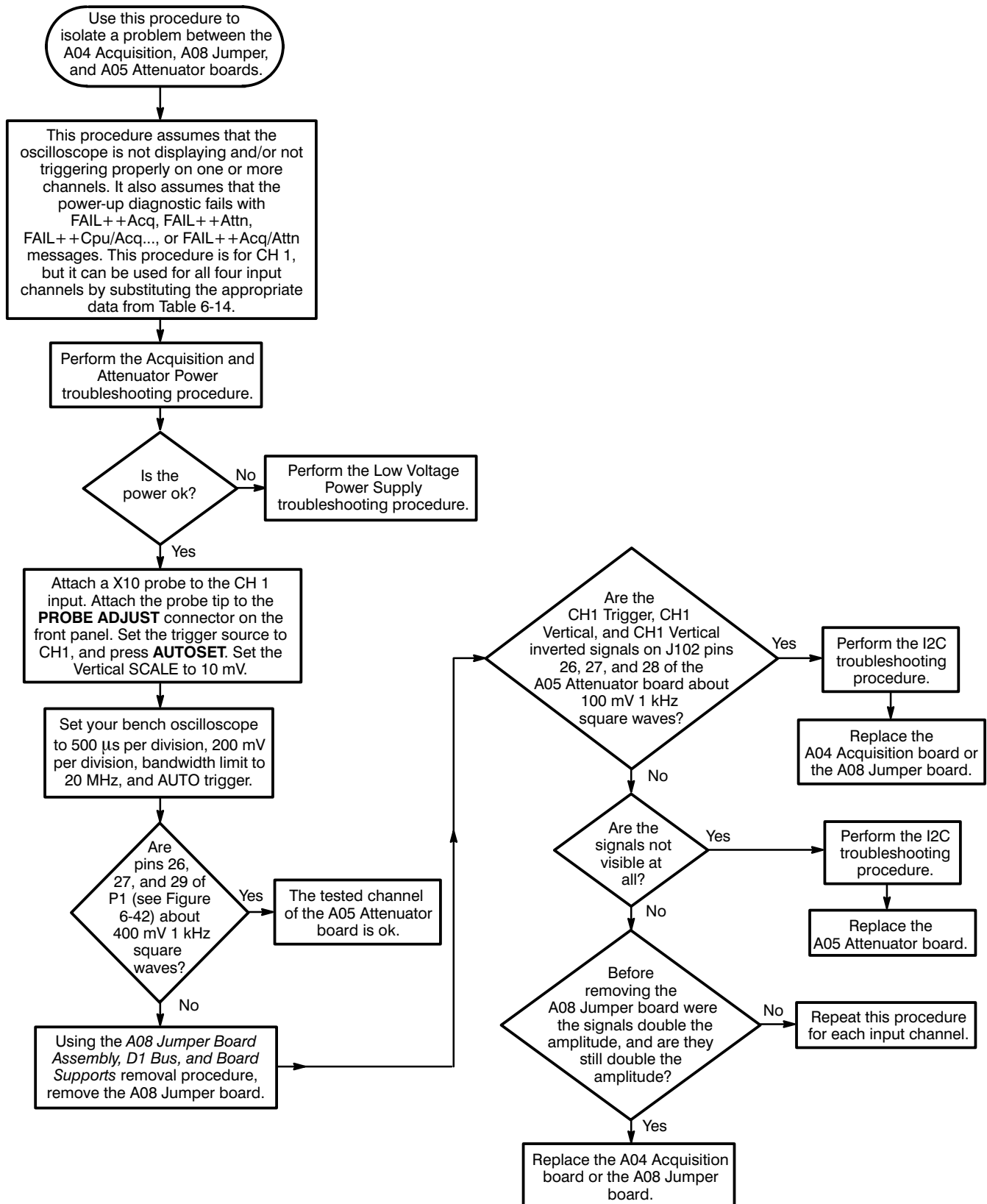


Figure 6-41: Attenuator/Acquisition Troubleshooting Procedure

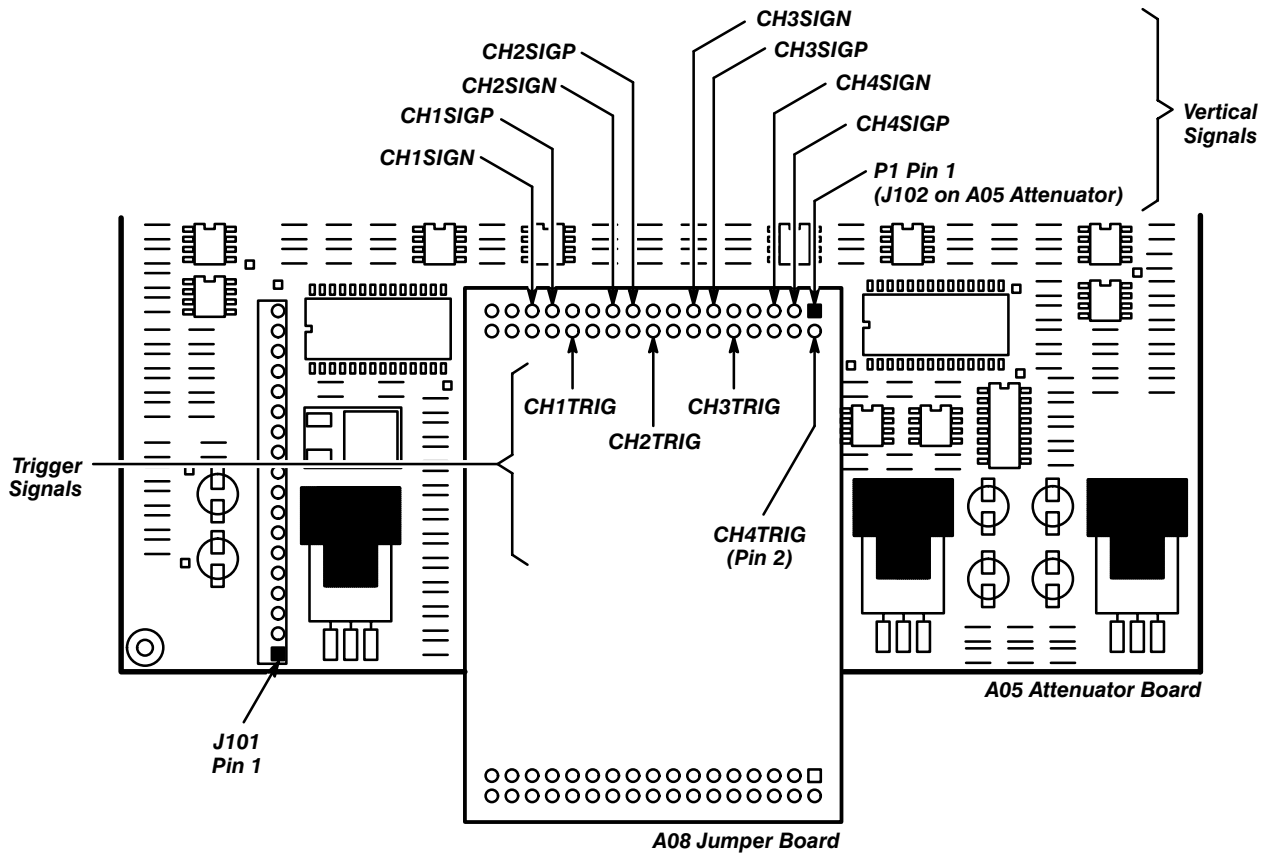


Figure 6-42: A08 Jumper and A05 Attenuator Boards Signal Locations

Table 6-14: Channel and P1 Signal Locations

Channel Number	Trigger P1 Pin Number	Vertical P1 Pin Number	Vertical Inverted P1 Pin Number
1	26	27	29
2	18	19	21
3	10	11	13
4	2	3	5

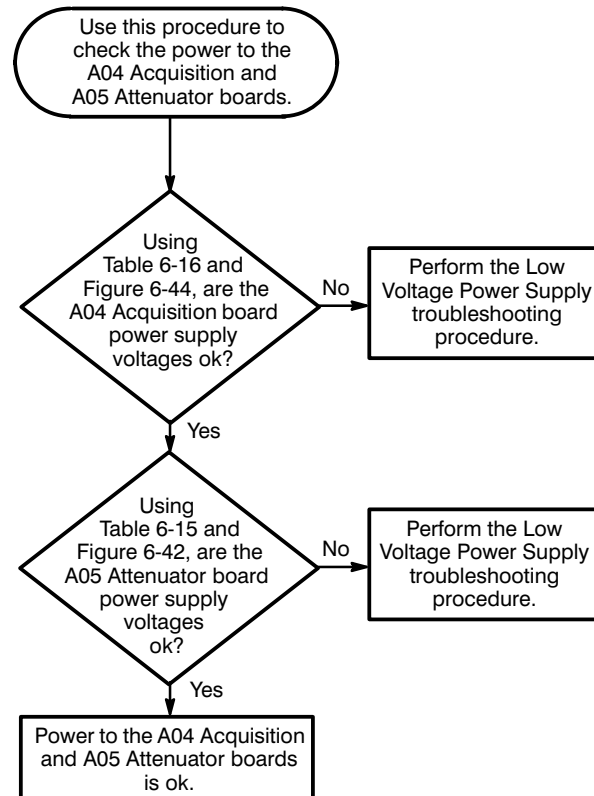


Figure 6-43: Acquisition and Attenuator Power Troubleshooting Procedure

Table 6-15: A05 Attenuator Board Power

J101 Pin	Voltage	High	Low
7	+5.1 V	+5.15 V	+4.9 V
10	+6 V	+6.6 V	+6.0 V
14	−6.4 V	−6.0 V	−6.5 V
16	+15 V	+15.3 V	+14.7 V
17	−15 V	−14.7 V	−15.3 V

Table 6-16: A04 Acquisition Board Power

J7	Voltage	High	Low
9	−15 V	−14.7 V	−15.3 V
12	−6.4 V	−6.0 V	−6.6 V
16	+5 V	+5.15 V	+4.9 V
19	+15 V	+15.3 V	+14.7 V

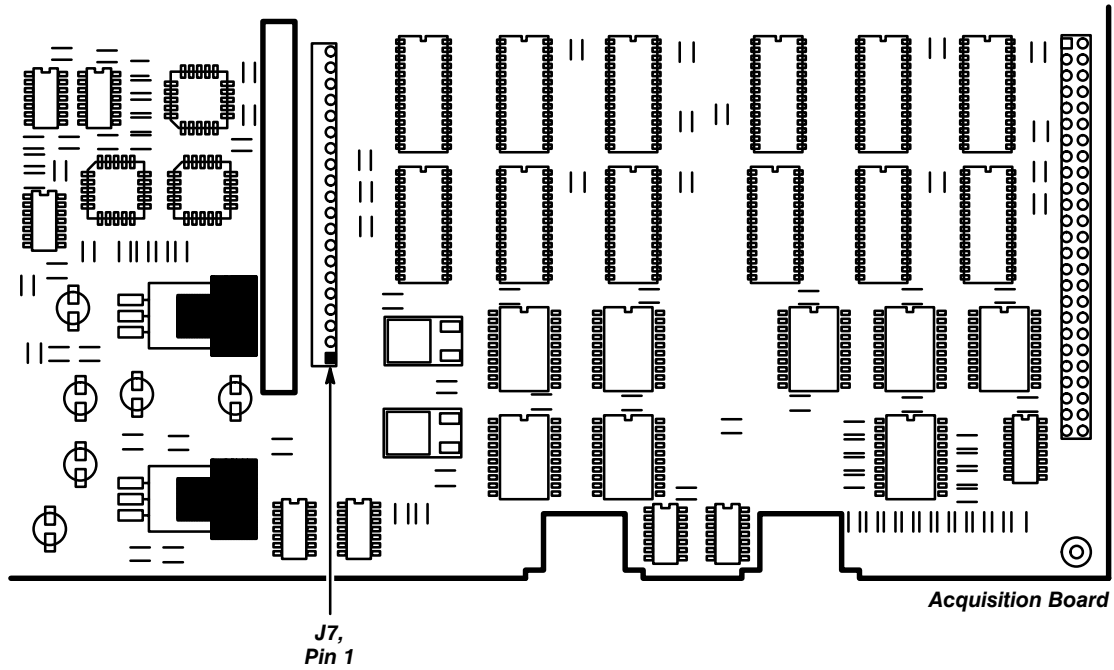


Figure 6-44: A04 Acquisition Board Power Connector

Troubleshooting

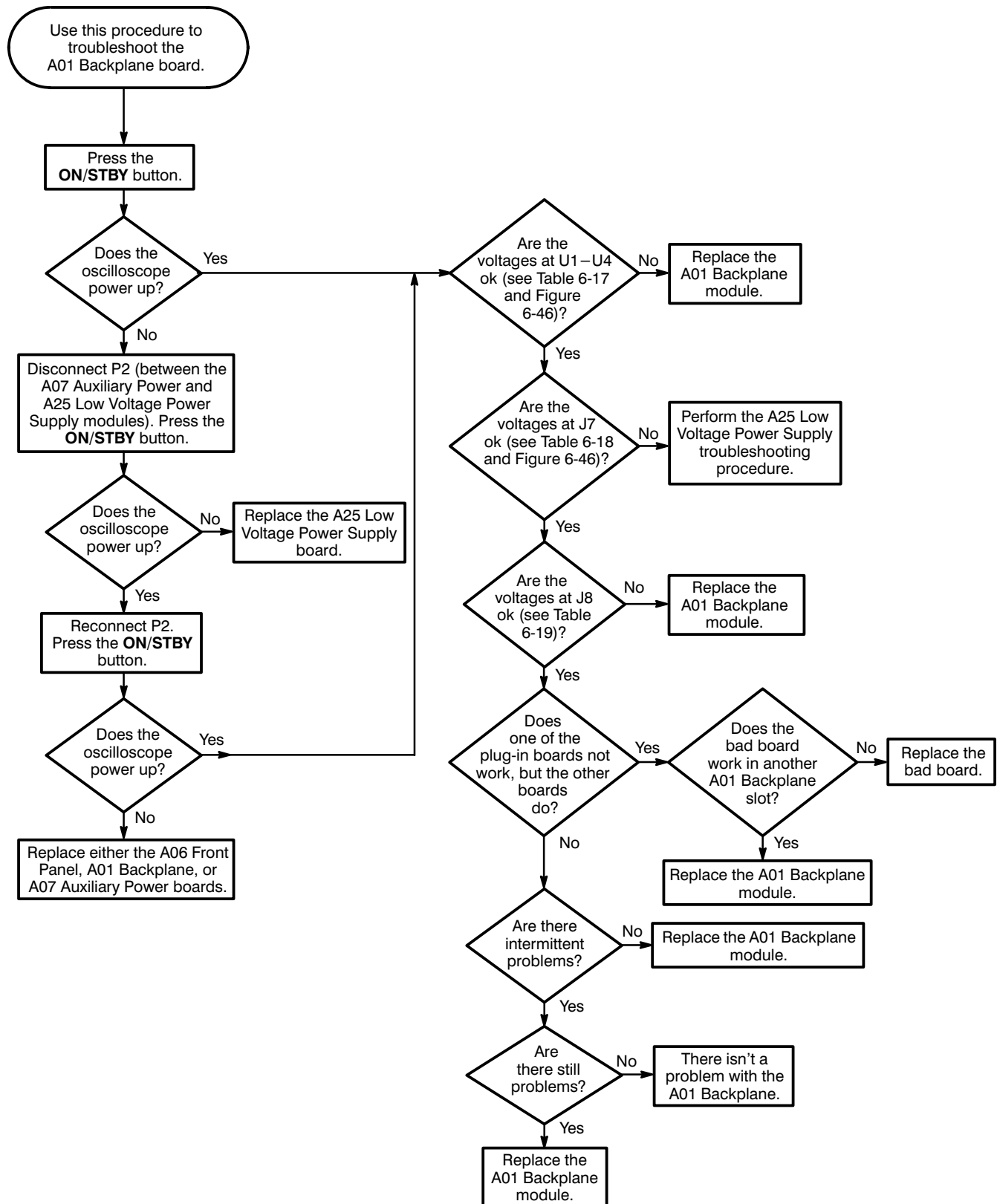


Figure 6-45: Backplane Troubleshooting Procedure

Table 6-17: Regulator Voltages

Regulator	Nominal Voltage	Minimum Voltage	Maximum Voltage
U1 pin 3	−12 V	−11.5 V	−12.5 V
U2 pin 3	+12 V	+11.5 V	+12.5 V
U3 pin 2	+6.3 V	+6.07 V	+6.57 V
U4 pin 3	−5 V	−4.8 V	−5.2 V

Table 6-18: J7 Voltages

Pin	Nominal Voltage	Minimum Voltage	Maximum Voltage
1	−15 V	−14.85 V	−15.15 V
2	−15 V	−14.85 V	−15.15 V
7	−6.4 V	−6.336 V	−6.464 V
8	+15 V	+14.85 V	+15.15 V
9	+15 V	+14.85 V	+15.15 V
18	+5.1 V	+5.151 V	+5.05 V
19	+5.1 V	+5.151 V	+5.05 V

Table 6-19: J8 Front Panel Voltages

Pin	Nominal Voltage	Minimum Voltage	Maximum Voltage
1	+15 V	+14.25 V	+15.75 V
2	+5 V	+5.05 V	+5.15 V
4	−5 V	−5.05 V	−5.2 V
5	−15 V	−14.85 V	−15.15 V

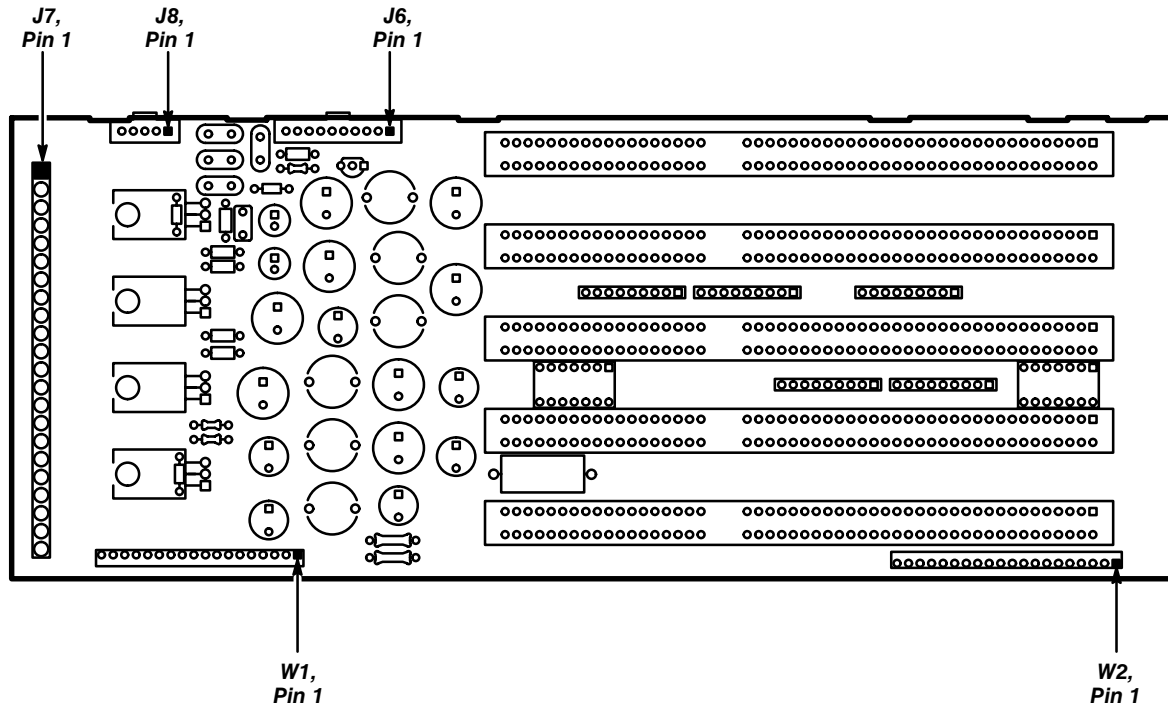


Figure 6-46: A01 Backplane Module

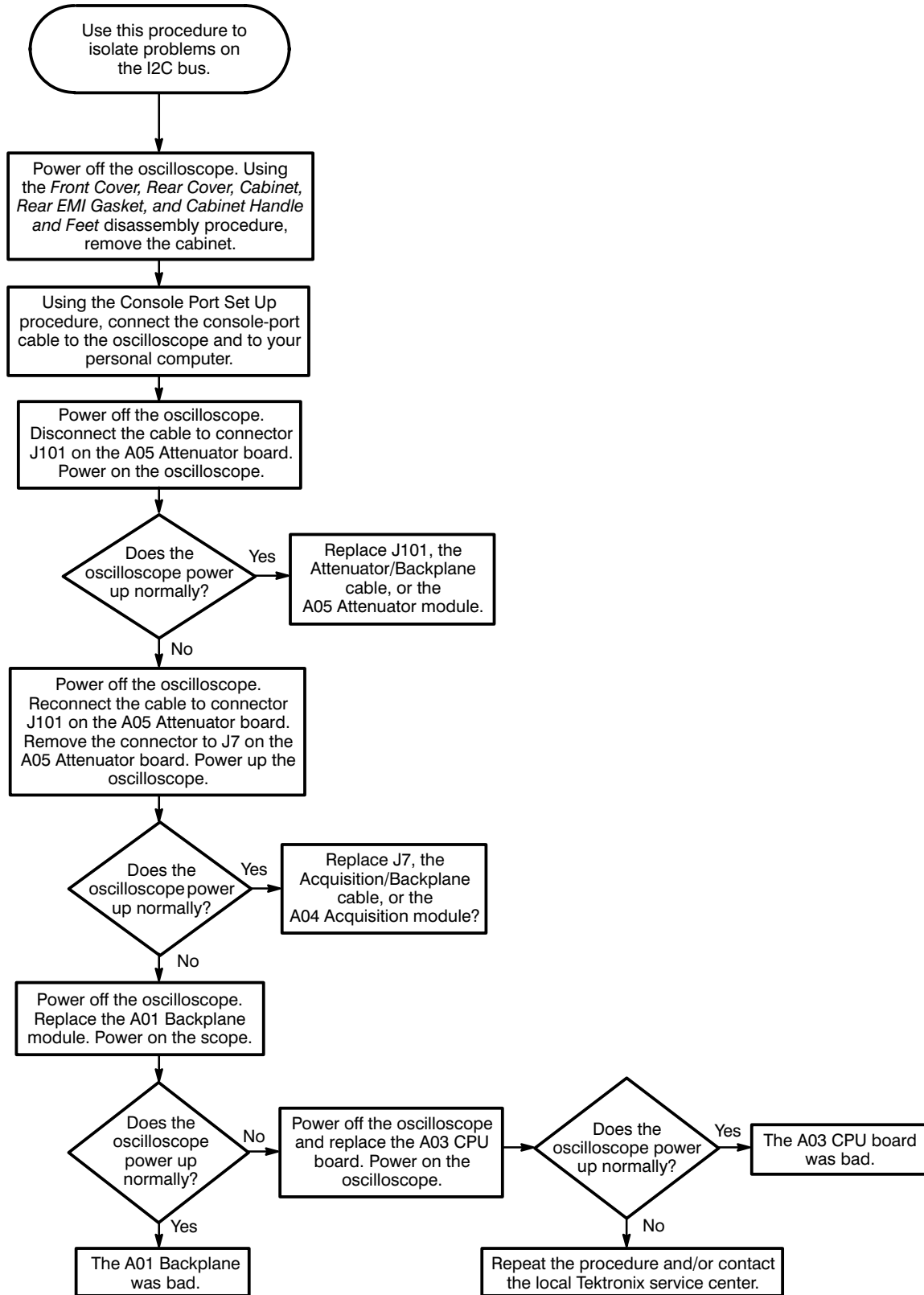


Figure 6-47: I2C Isolation Troubleshooting Procedure

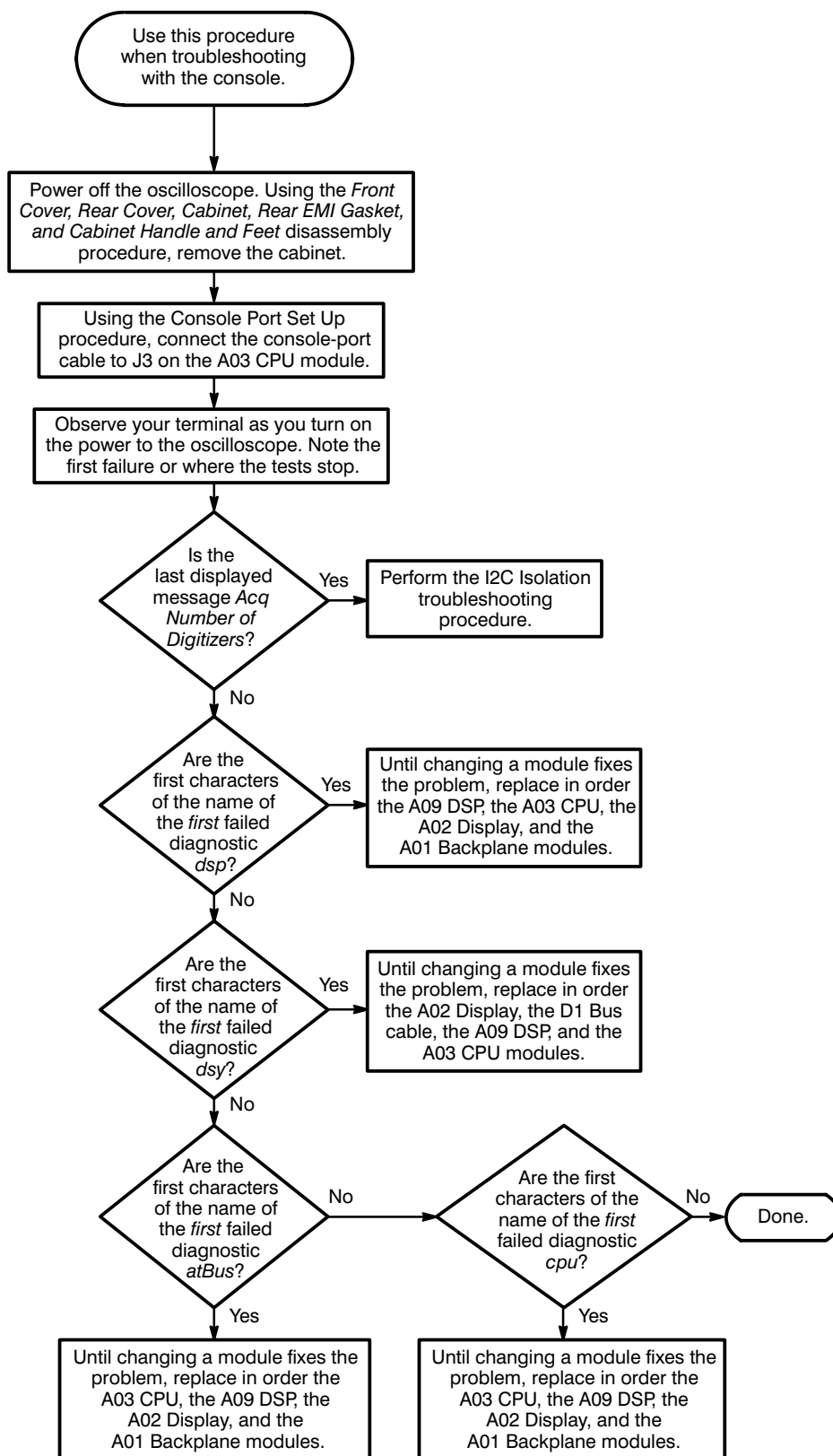


Figure 6-48: Console Troubleshooting Procedure

Options and Accessories

This section describes the various options as well as the standard and optional accessories that are available for the TDS 410, TDS 420, and TDS 460 Digitizing Oscilloscopes.

Options

Options include:

Option 02: Front Cover and Pouch

With this option, Tektronix ships a front cover and pouch with the instrument.

Option 05: Video Trigger

This option provides a video trigger. It lets you trigger on positive or negative sync pulses. It also lets you select interlaced field one, interlaced field two, or both fields noninterlaced. You can define the signal class to be NTSC, PAL, SECAM, or you can customize the class.

Option 13: RS-232/Centronics Hardcopy Interface

With this option, Tektronix ships the oscilloscope equipped with a RS-232 and a Centronics interface that can be used to obtain hardcopies of the oscilloscope screen.

Option 2F: Advanced DSP Math

With this option, the oscilloscope can compute and display three advanced math waveforms: integral of a waveform, differential of a waveform, and an FFT (Fast Fourier Transform) of a waveform.

Option 3P: Printer Pack

With this option, Tektronix ships a Seiko DPU-411 thermal printer, cables, manual, and an accessory pouch mounted to the top of the oscilloscope. Hardcopies of the screen are produced on four inch thermal paper. The pouch holds the printer and has additional room for accessories.

Option 2A: 60,000 Point Record Length and Video Trigger

This option combines Option 1M (60,000 point records) and Option 05 (Video Trigger).

Option 2B: 60,000 Point Record Length, Video Trigger, and Advanced DSP Math

This option combines Option 1M (60,000 point records), Option 05 (Video Trigger), and Option 2F (Advanced DSP Math).

Options A1 – A5: International Power Cords

Besides the standard North American, 110 V, 60 Hz power cord, Tektronix ships any of five alternate power cord configurations with the oscilloscope when ordered by the customer.

Table 7-1: International Power Cords

Option	Power Cord
A1	Universal European—220 V, 50 Hz
A2	UK—240 V, 50 Hz
A3	Australian—240 V, 50 Hz
A4	North American—240 V, 60 Hz
A5	Switzerland—220 V, 50 Hz

Option B1: Module Level Service Manual

When Option B1 is ordered, Tektronix ships a module level service manual with the oscilloscope.

Option 1M: 60,000 Point Record Length

This option provides a maximum record length of 60,000 points per acquisition (60,000/channel).

Warranty-Plus Service Options

The following options add to the services available with the standard warranty. (The standard warranty appears on the back side of the title page in this manual.)

- **Option M2:** When Option M2 is ordered, Tektronix provides five years of warranty/remedial service.
- **Option M3:** When Option M3 is ordered, Tektronix provides five years of warranty/remedial service and four oscilloscope calibrations.
- **Option M8:** When Option M8 is ordered, Tektronix provides four calibrations and four performance verifications, one of each in the second through the fifth years of service.

Option 1K: K212 Instrument Cart

With this option, Tektronix ships a three tray instrument cart (the K212).

Option 1P: HC100 4 Pen Plotter

With this option, Tektronix ships a four-color plotter designed to make waveform plots directly from the digitizing oscilloscope without requiring an external controller. It handles A4 and US letter size media.

Option 1R: Rackmounted Digitizing Oscilloscope

Tektronix ships the digitizing oscilloscope, when ordered with Option 1R, configured for installation in a 19 inch wide instrument rack. Customers with instruments not configured for rackmounting can order a rackmount kit (016-1166-00) for field conversions.

Instructions for rackmounting the digitizing oscilloscope are shipped with the option 1R.

Option 22: Additional Probes

With this option, Tektronix ships two additional probes identical to the two standard-accessory P6138 probes normally shipped with the instrument. This provides one probe for each front-panel input.

Option 23: Active Probes

With this option, Tektronix ships two active high speed voltage probes (the P6205 10X FET).

Option 25: P6562 AS Probes

With this option, Tektronix ships four P6562A SMD probes.

Option 29: TD100 Data Manager

With this option, Tektronix ships a TD100 Data Manager, which provides a 40 MByte hard drive, 3.5 inch floppy drive, and TDS Data Manager software.

Option 9C: Certificate of Calibration and Test Data Report

Tektronix ships a Certificate of Calibration which states this instrument meets or exceeds all warranted specifications and was calibrated using standards and instruments whose accuracies are traceable to the National Institute of Standards and Technology, an accepted value of a natural physical constant or a ratio calibration technique. The calibration is in compliance with US MIL-STD-45662A. This option also includes a test data report for the instrument.

Standard Accessories

The following standard accessories are included with the digitizing oscilloscope:

Table 7-2: Standard Accessories

Accessory	Part Number
User Manual	070-8034-XX
Programmer Manual	070-8709-XX
Reference	070-8035-XX
Performance Verification	070-8721-XX
U.S. Power Cord	161-0230-01
Probes (qty. two) P6138 10X Passive	P6138 (single unit)

Probe Accessories

These are accessories to the standard probe listed previously (P6138). Except for the probe-tip-to-circuit board adapter, they can also be ordered separately.

Table 7-3: Probe Accessories

Accessory	Part Number
Retractable Hook Tip	013-0107-06
Body Shell, tip cover	204-1049-00
Probe-Tip-to-Circuit Board Adapter (qty. two standard, optionally available in package of 25 as 131-5031-00)	No customer orderable part number for double unit
6-Inch Slip-On Ground Lead	196-3113-02
Low Inductance Ground Lead	195-4240-00
Marker Rings Set (qty. eighteen rings which includes two each of nine colors)	016-0633-00
Ground Collar	343-1003-01
6-Inch Alligator Clip Ground Lead	196-3305-00
Screwdriver: adjustment tool, metal tip	003-1433-00
SMT KlipChip™	206-0364-00
Accessory Pouch	016-0708-00

Optional Accessories

You can also order the following optional accessories:

Table 7-4: Optional Accessories

Accessory	Part Number
TDS 410, TDS 420, & TDS 460 Service Manual	070-8036-XX
Plotter (GPIB and Centronics Standard)	HC100
Plotter (Centronics Standard)	HC200
Oscilloscope Cart	K212
Rackmount Kit (for field conversion)	016-1166-00
Oscilloscope Camera	C9
Oscilloscope Camera Adapter	016-1154-00
Soft-Sided Carrying Case	016-1158-00
Transit Case	016-1157-00
GPIB Cable (1 meter)	012-0991-01
GPIB Cable (2 meter)	012-0991-00
Security Cable	012-1388-00
Front Cover	200-3232-00
Pouch	016-1159-00
VGA Cable (SN B030099 and below)	73893013 (NEC)
(SN B030100 and above)	CTL3VGAMM-5 (LCOM)

Accessory Probes

The following optional accessory probes are recommended for use with your digitizing oscilloscope:

- P6101A 1X, 15 MHz, Passive probe.
- P6156 10X, 3.5 GHz, Passive, low capacitance, (low impedance Zo) probe. Option 25 provides 100X.
- P6009 Passive, high voltage probe, 100X, 1500 VDC + Peak AC.
- P6015A Passive high voltage probe, 1000X, 20 kVDC + Peak AC (40 kV peak for less than 100 ms).
- P6205 750 MHz probe bandwidth. Active (FET) voltage probe.
- P6204 Active, high speed digital voltage probe. FET. DC to 1 GHz. DC offset. 50 Ω input. Use with 1103 TekProbe Power Supply for offset control.

- P6046 Active, differential probe, 1X/10X, DC to 100 MHz, 50 Ω input.
- A6501 Buffer Amplifier (active fixtured), 1 GHz, 1 M Ω , 10X.
- P6501 Option 02: Microprobe with TekProbe power cable (active fixtured), 750 MHz, 1 M Ω , 10X.
- AM 503S—DC/AC Current probe system, AC/DC. Uses A6302 Current Probe.
- AM 503S Option 03: DC/AC Current probe system, AC/DC. Uses A6303 Current Probe.
- P6021 AC Current probe. 120 Hz to 60 MHz.
- P6022 AC Current probe. 935 kHz to 120 MHz.
- CT-1 Current probe—designed for permanent or semi-permanent in-circuit installation. 25 kHz to 1 GHz, 50 Ω input.
- CT-2 Current probe—designed for permanent or semi-permanent in-circuit installation. 1.2 kHz to 200 MHz, 50 Ω input.
- CT-4 Current Transformer—for use with the AM 503S (A6302) and P6021. Peak pulse 1 kA. 0.5 Hz to 20 MHz with AM 503S (A6302).
- P6701A Opto-Electronic Converter, 500 to 950 nm, DC to 850 MHz 1 V/mW.
- P6703A Opto-Electronic Converter, 1100 to 1700 nm, DC to 1 GHz 1 V/mW.
- P6711 Opto-Electronic Converter, 500 to 950 nm, DC to 250 MHz 5 V/mW.
- P6713 Opto-Electronic Converter, 1100 to 1700 nm, DC to 300 MHz. 5 V/mW.
- TVC 501 Time-to-voltage converter. Time delay, pulse width and period measurements.
- P6562 SMT Probe, 350 MHz.
- P6048 TTL Logic Probe.

Probe Accessories

The following optional accessories are recommended for use with the standard probe listed under *Standard Accessories*.

Table 7-5: Probe Accessories

Accessory	Part Number
Connector, BNC: BNC to Probe Tip Adapter	013-0226-00
Connector, BNC: 50 Ω , BNC to Probe Tip Adapter	013-0227-00
Connector, Probe: Package of 100, compact	131-4244-00

Table 7-5: Probe Accessories (Cont.)

Accessory	Part Number
Connector, Probe: Package of 25, compact	131-5031-00
Screwdriver Adjustment Tool, Package of five	003-1433-01
Compact-to-Miniature Probe Tip Adapter	013-0202-02
Probe Tip Holder: (holds three tips)	352-0670-00
3 Inch Slip-On Ground Lead	196-3113-03
Probe Holder: Black ABS	352-0351-00
IC Protector Tip, Package of 10	015-0201-07
IC Protector Tip, Package of 100	015-0201-08
Marker Ring Set: Two each of nine colors	016-0633-00
SMT KlipChip™: 20 Adapters	SMG50
Low-Inductance Spring-Tips: Two each of five different springs and insulator	016-1077-00
Probe Tip-to-Chassis Adapter	131-4210-00

NOTE

The next four items below can only be used with the Compact-to-Miniature Probe Tip Adapter.

Dual-Lead Adapter	015-0325-00
BNC-to-Probe Tip Adapter	013-0084-01
G.R.-to-Probe Tip Adapter, 50 Ω	017-0088-00
Bayonet Ground Assembly	013-0085-00

Accessory Software

The following optional accessories are Tektronix software products recommended for use with your digitizing oscilloscope:

Table 7-6: Accessory Software

Software	Part Number
EZ-Test Program Generator	S45F030
Wavewriter: AWG and waveform creation	S3FT400
LabWindows	S3FG910

Warranty Information

Check for the full warranty statements for this product, the probes, and the products listed above on the back of each product manual's title page.

Replaceable Electrical Parts List

The modules that make up this instrument are often a combination of mechanical and electrical subparts. Therefore, all replaceable modules are listed in Section 10, *Mechanical Parts List*. Refer to that section for part numbers when using this manual.

Replaceable Electrical Parts List

Diagrams

This section contains the block diagram and the interconnection diagram for this oscilloscope. If servicing a TDS 410, ignore all references to CH 3 and CH 4.

Symbols

Graphic symbols and class designation letters are based on ANSI Standard Y32.2–1975. Abbreviations are based on ANSI Y1.1–1972.

Logic symbology is based on ANSI/IEEE Std 91–1984 in terms of positive logic. Logic symbols depict the logic function performed and can differ from the manufacturer's data.

The tilde (~) preceding a signal name indicates that the signal performs its intended function when in the low state.

Other standards used in the preparation of diagrams by Tektronix, Inc are:

- Tektronix Standard 062–2476 Symbols and Practices for Schematic Drafting
- ANSI Y14.159–1971 Interconnection Diagrams
- ANSI Y32.16–1975 Reference Designations for Electronic Equipment
- MIL–HDBK–63038–1A Military Standard Technical Manual Writing Handbook

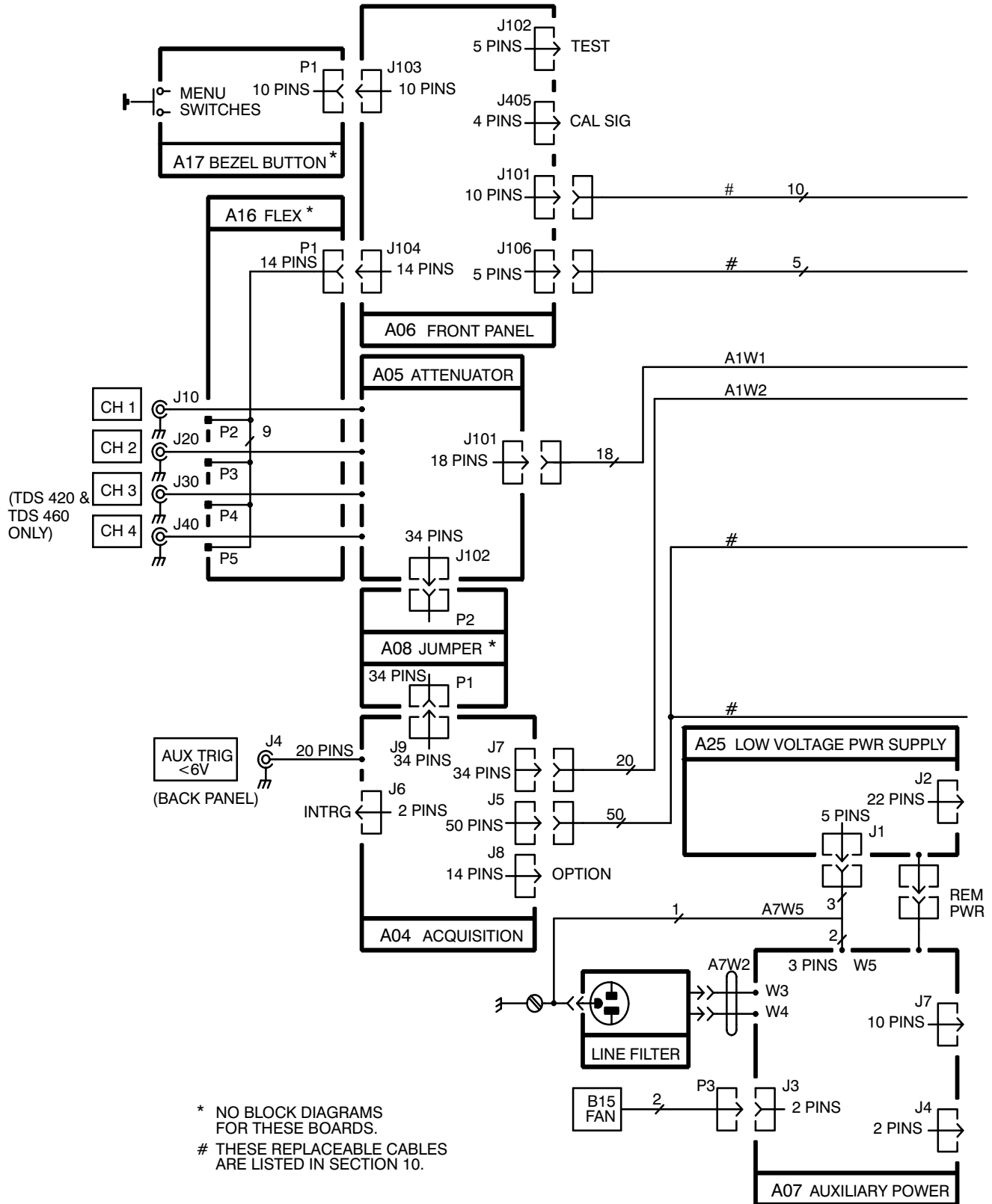


Figure 9-1: TDS 400 Interconnections

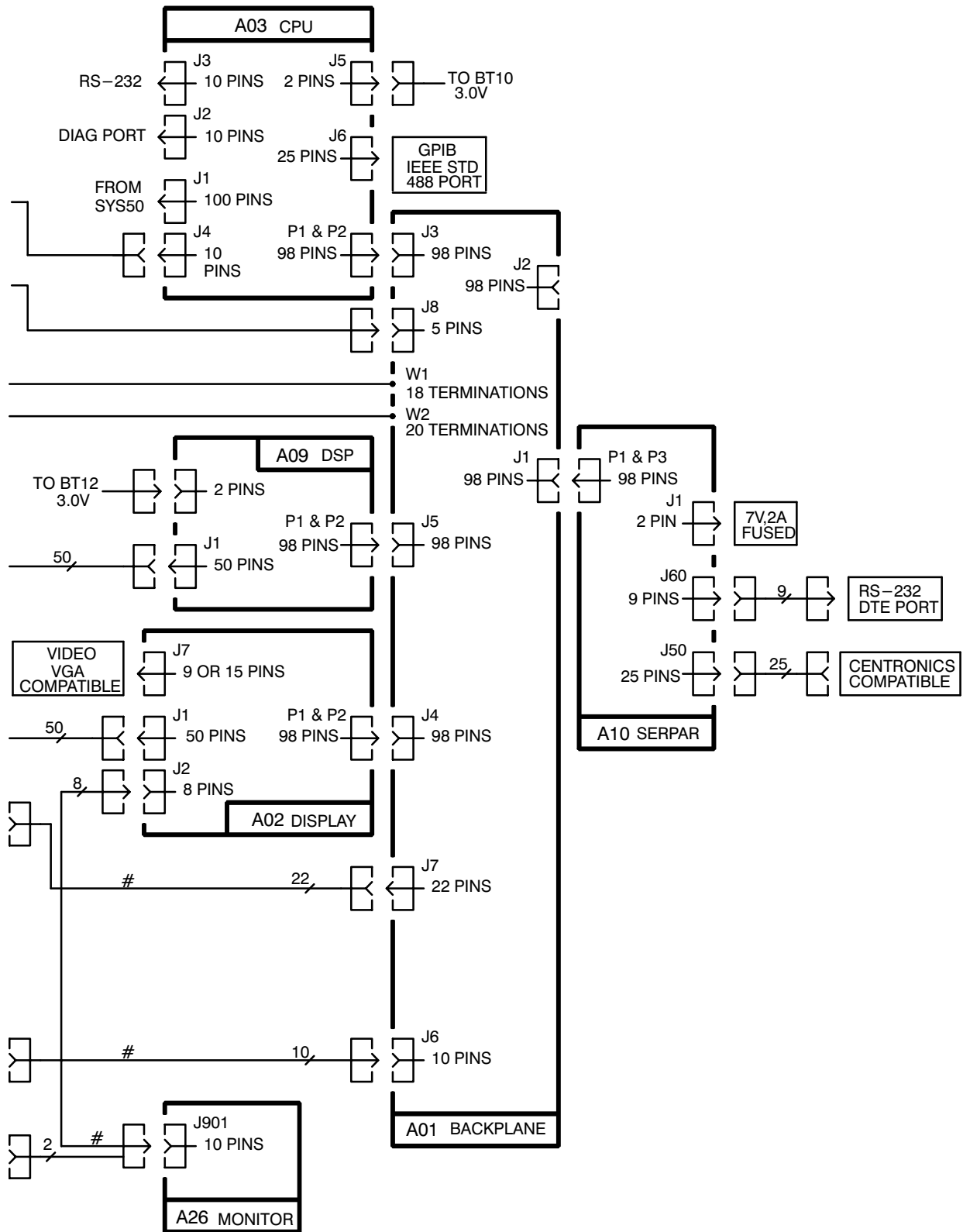


Figure 9-1: TDS 400 Interconnections (Cont.)

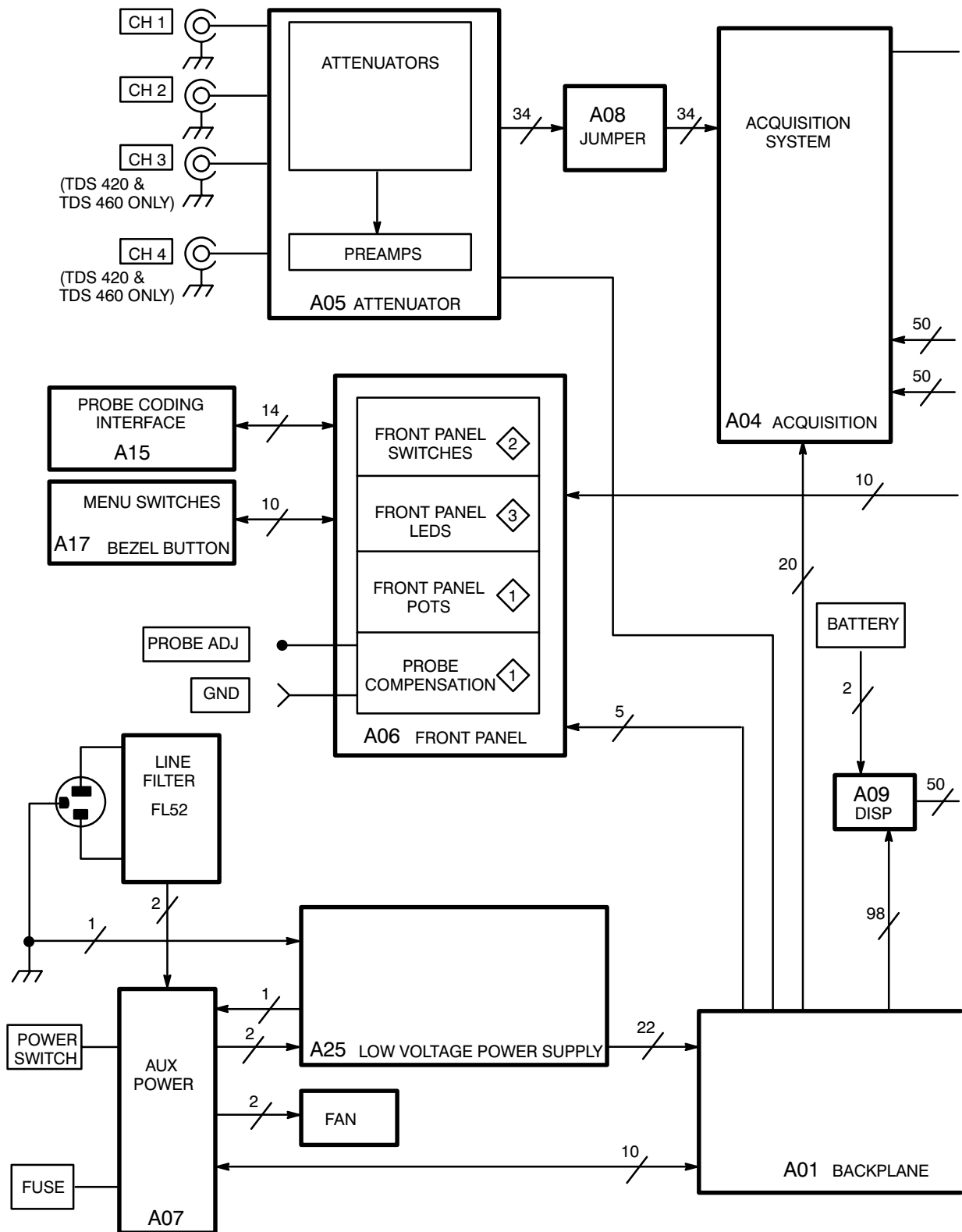


Figure 9-2: TDS 400 Block Diagram

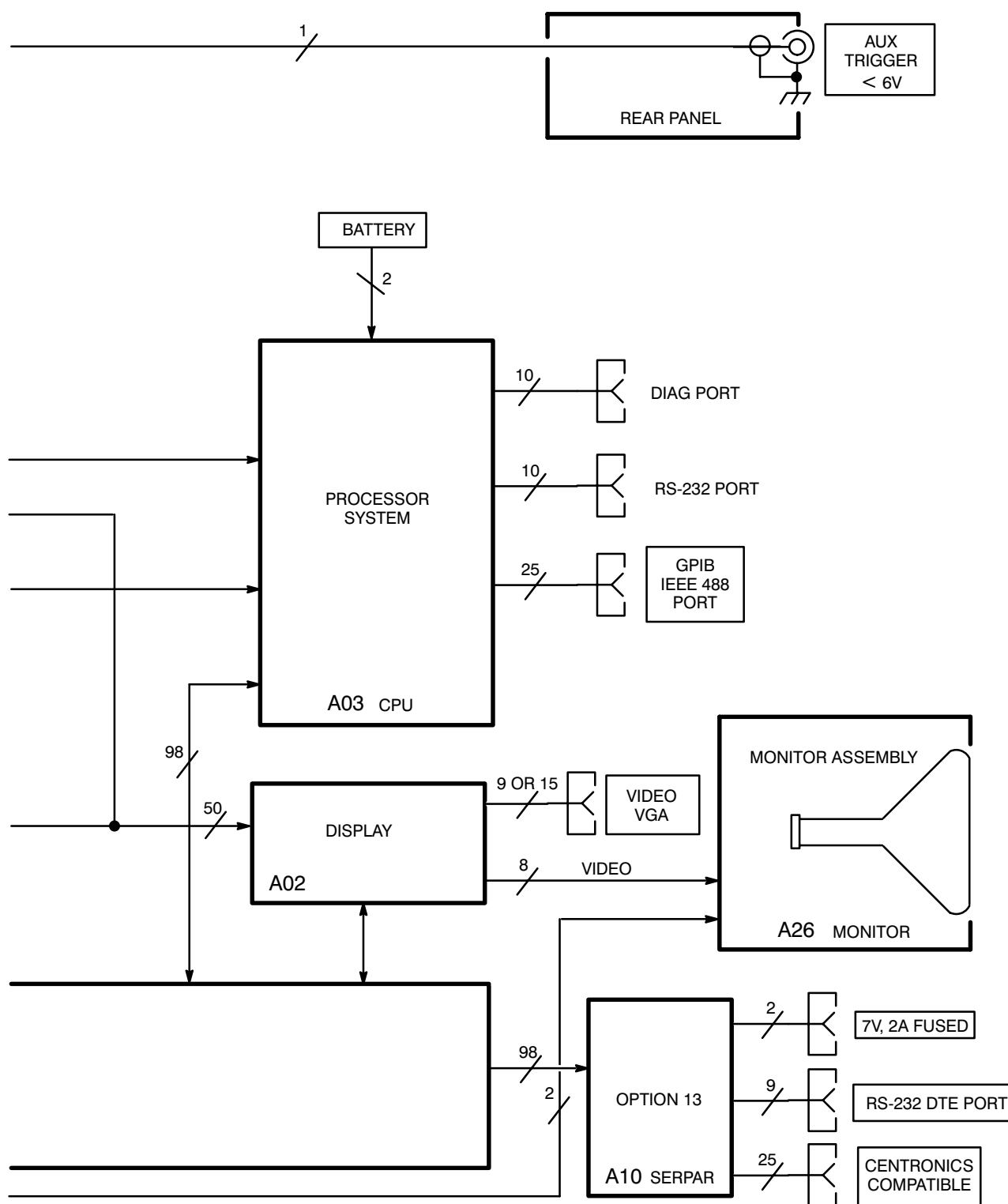


Figure 9-2: TDS 400 Block Diagram (Cont.)

Replaceable Parts List

This section contains a list of the modules that are replaceable for the TDS 400. Use this list to identify and order replacement parts.

Parts Ordering Information

Replacement parts are available from or through your local Tektronix, Inc. service center or representative.

Changes to Tektronix instruments are sometimes made to accommodate improved components as they become available and to give you the benefit of the latest circuit improvements. Therefore, when ordering parts, it is important to include the following information in your order.

- Part number
- Instrument type or model number
- Instrument serial number
- Instrument modification number, if applicable

If a part you order has been replaced with a different or improved part, your local Tektronix service center or representative will contact you concerning any change in the part number.

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

Module Replacement

The TDS 400 is serviced by module replacement so there are three options you should consider:

- **Module Exchange.** In some cases you may exchange your module for a remanufactured module. These modules cost significantly less than new modules and meet the same factory specifications. For more information about the module exchange program, call 1–800–TEKWIDE, ext. 6630.
- **Module Repair.** You may ship your module to us for repair, after which we will return it to you.
- **New Modules.** You may purchase new replacement modules in the same way as other replacement parts.

Using the Replaceable Parts List

The tabular information in the Replaceable Parts List is arranged for quick retrieval. Understanding the structure and features of the list will help you find the all the information you need for ordering replacement parts.

Item Names

In the Replaceable 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, U.S. Federal Cataloging Handbook H6–1 can be used where possible.

Indentation System

This parts list is indented to show the relationship between items. The following example is of the indentation system used in the Description column:

1	2	3	4	5	Name & Description
					<i>Assembly and/or Component</i>
					<i>Attaching parts for Assembly and/or Component</i>
					<i>(END ATTACHING PARTS)</i>
					<i>Detail Part of Assembly and/or Component</i>
					<i>Attaching parts for Detail Part</i>
					<i>(END ATTACHING PARTS)</i>
					<i>Parts of Detail Part</i>
					<i>Attaching parts for Parts of Detail Part</i>
					<i>(END ATTACHING PARTS)</i>

Attaching parts always appear at 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 Standards Institute (ANSI) standard Y1.1

CROSS INDEX – MFR. CODE NUMBER TO MANUFACTURER

Mfr. Code	Manufacturer	Address	City, State, Zip Code
S3109	FELLER	72 VERONICA AVE UNIT 4	SUMMERSET NJ 08873
S3629	SCHURTER AG H C/O PANEL COMPONENTS CORP	2015 SECOND STREET	BERKELEY CA 94170
S4246	JAPAN SERVO CO LTD	7 KANDA MITOSHIRO-CHO CHIYODA-KU	TOKYO JAPAN
TK0435	LEWIS SCREW CO	4300 S RACINE AVE	CHICAGO IL 60609-3320
TK0860	LABEL GRAPHICS	6700 SW BRADBURY CT	PORTLAND OR 97224
TK1163	POLYCAST INC	9898 SW TIGARD ST	TIGARD OR 97223
TK1891	PRESTOLE CORP	34589 GLENDALE ST	LIVONIA MI 48150-1303
TK1908	PLASTIC MOLDED PRODUCTS	4336 SO ADAMS	TACOMA WA 98409
TK1918	SHIN-ETSU POLYMER AMERICA INC	1181 NORTH 4TH ST	SAN JOSE CA 95112
TK1935	ACCRA-FAB INC	11007 NE 37TH CIRCLE	VANCOUVER WA 98682
TK2058	TDK CORPORATION OF AMERICA	2055 GATEWAY PLACE SUITE 200	SAN JOSE CA 95110
TK2432	UNION ELECTRIC	15/F #1, FU-SHING N. ROAD	TAIPEI, TAIWAN ROC
TK2469	UNITREK CORPORATION	3000 LEWIS & CLARK WAY SUITE #2	VANCOUVER WA 98601
TK2478	GRIMES COMPANY	115 S AROVISTA CIRCLE	BREA CA 92631
0DWW6	MICRO POWER ELECTRONICS	7973 SW CIRRRUS DRIVE BLDG. #22	BEAVERTON OR 97005
0JR05	TRIQUEST CORP	3000 LEWIS AND CLARK HWY	VANCOUVER WA 98661-2999
0KB01	STAUFFER SUPPLY	810 SE SHERMAN	PORTLAND OR 97214
00779	AMP INC	2800 FULLING MILL PO BOX 3608	HARRISBURG PA 17105
07416	NELSON NAME PLATE CO	3191 CASITAS	LOS ANGELES CA 90039-2410
18565	CHOMERICS INC	77 DRAGON COURT	WOBBURN MA 01801-1039
22670	G M NAMEPLATE INC	2040 15TH AVE WEST	SEATTLE WA 98119-2728
24931	SPECIALTY CONNECTOR CO INC	2100 EARLYWOOD DR PO BOX 547	FRANKLIN IN 46131
30817	INSTRUMENT SPECIALTIES CO INC	EXIT 53 RT 80 BOX A	DELAWARE WATER GAP PA 18327
34416	PARSONS MFG CORP	1055 OBRIAN DR	MENLO PARK CA 94025-1408

CROSS INDEX – MFR. CODE NUMBER TO MANUFACTURER

Mfr. Code	Manufacturer	Address	City, State, Zip Code
50463	POWER SYSTEMS INC.	45 GRIFIN ROAD	SOUTH LINFIELD, CT 06002
61857	SAN-0 INDUSTRIAL CORP	85 ORVILLE DR PO BOX 511	BOHEMIA LONG ISLAND NY 11716-2501
70903	COOPER BELDEN ELECTRONICS WIRE AND CABLE SUB OF COOPER INDUSTRIES INC		
80009	TEKTRONIX INC	14150 SW KARL BRAUN DR PO BOX 500	BEAVERTON OR 97077-0001

Fig. & Index No.	Tektronix Part No.	Serial No.		Qty	12345 Name & Description	Mfr. Code	Mfr. Part No.
		Effective	Dscont				
10-1-1	334-8202-XX			1	MARKER, IDENT:HANDLE	80009	3348202XX
-2	390-1109-XX			1	CABINET,SCOPE:ALUMINUM,TEK BLUE	TK1935	ORDER BY DESC
-3	367-0289-XX			1	HANDLE,CARRYING:13.855,SST	0JR05	ORDER BY DESC
-4	212-0144-XX			2	SCREW,TPG,TF:8-16 X 0.562 L,PLASTITE	0KB01	ORDER BY DESC
-5	348-0659-XX			2	FOOT,CABINET:BLACK POLYURETHANE	0JR05	ORDER BY DESC
-6	348-0764-XX			1	SHLD GSKT,ELEK:0.125 X 0.188,WIRE MESH,37 L	18565	ORDER BY DESC
-7	334-8176-XX			1	MARKER,IDENT:MKD REAR	07416	ORDER BY DESC
-8	334-8561-XX			1	MARKER,IDENT:OPTIONS	80009	3348561XX
-9	161-0230-01			1	CABLE ASSY,PWR,:3,18 AWG,92 L,SVT,TAN (STANDARD ACCESSORY)	TK2432	ORDER BY DESC
-10	343-1213-XX			1	CLAMP,PWR CORD:POLYIMIDE (STANDARD ACCESSORY)	TK1163	ORDER BY DESC
-11	200-2264-XX			1	CAP,FUSEHOLDER:3AG FUSES (AMERICAN)	S3629	FEK 031 1666
	200-2265-XX			1	CAP,FUSEHOLDER:5 X 20MM FUSES (EUROPEAN)	S3629	FEK 031.1663
-12	159-0014-XX			1	FUSE,CARTRIDGE:3AG,5A,250V,0.8SEC, (AMERICAN)	61857	SS2-5A
	159-0255-XX			1	FUSE,CARTRIDGE:FAST BLOW,4A,125V (EUROPEAN)	61857	EQ4A
-13	211-0691-XX			4	SCREW,MACHINE:6-32 X 0.625,PNH,STL	0KB01	ORDER BY DESC
-14	200-3991-XX			1	COVER,REAR:HARD,POLYCARBONATE,LEXAN	80009	2003991XX
-15	348-1219-XX			2	FOOT,REAR:SANTOPRENE	80009	3481219XX
-16	211-0730-XX			1	SCR,ASSEM WSHR:6-32 X 0.375,PNH,STL CD PL	0KB01	ORDER BY DESC
-17	259-0085-XX			1	FLEX CIRCUIT:PROBE CODE	80009	2590085XX
-18	348-1258-XX			4	SHLD,GASKET,ELE:2 LAYER,0.094 X 0.188 X 8.750	80009	3481258XX
-19	672-1365-XX			1	CIRCUIT BD ASSY:FRONT PANEL ASSY (TDS420/460 ONLY)	80009	6721365XX
	672-1430-XX			1	CIRCUIT BD ASSY:FRONT PANEL ASSY (TDS410 ONLY)	80009	6721430XX
-20	614-0895-XX			1	FRONT PNL ASSY:	80009	6140895XX
-21	333-3905-XX			1	FRONT PANEL: (TDS420/460 ONLY)	80009	3333905XX
	333-4133-XX			1	FRONT PANEL: (TDS410 ONLY)	80009	3334133XX
-22	384-1689-XX			6	SHAFT EXTENDER:ACETAL	80009	3841689XX
-23	366-2113-XX			3	KNOB:MEDIUM,DETENTED	TK1163	ORDER BY DESC
-24	366-2111-XX			3	KNOB:SMALL,FLUTED	TK1163	ORDER BY DESC
-25	200-3232-XX			1	COVER,FRONT:ASB (OPTIONAL ACCESSORY)	TK1908	ORDER BY DESC
-26	354-0709-XX			1	RING,TRIM:LEXAN 940 (TDS420/460 ONLY)	80009	3540709XX
	354-0736-XX			1	TRIM,DECORATIVE:FRONT (TDS410 ONLY)	80009	3540736XX
-27	366-2164-XX			14	PUSH BUTTON:SMOKE TAN	80009	3662164XX

Fig. & Index No.	Tektronix Part No.	Serial No.		Qty	12345 Name & Description	Mfr. Code	Mfr. Part No.
		Effective	Dscont				
10-1-28	334-8214-XX			1	MARKER,IDENT:BEZEL (TDS420 ONLY)	80009	3348214XX
	334-8215-XX			1	MARKER,IDENT:BEZEL (TDS460 ONLY)	80009	3348215XX
	334-8733-XX			1	MARKER,IDENT:BEZEL (TDS410 ONLY)	80009	3348733XX
-29	131-5421-XX			2	CONTACT,ELEC:ESD PROTECTION,0.005 ST STL	80009	1315421XX
-30	260-2539-XX			1	SWITCH SET:BEZEL	TK1918	2602539XX
-31	259-0086-XX			1	FLEX CIRCUIT:BEZEL BUTTON	07416	ORDER BY DESC

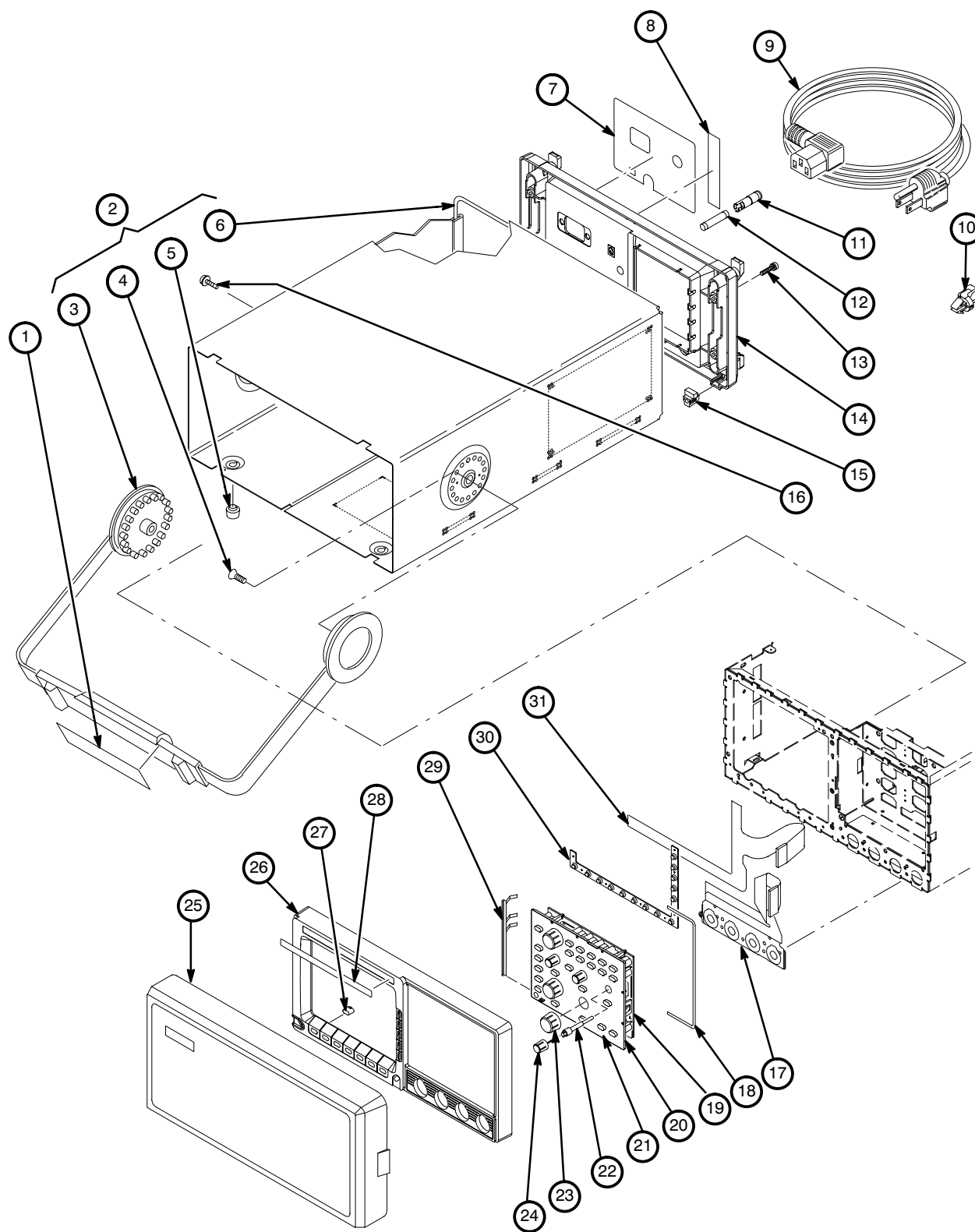


Figure 10-1: External and Front Panel Modules

Fig. & Index No.	Tektronix Part No.	Serial No. Effective	Dscont	Qty	12345 Name & Description	Mfr. Code	Mfr. Part No.
10-2-1	426-2436-XX			1	FRAME,CRT FLTR:POLYCARBONATE	TK1163	ORDER BY DESC
-2	348-1291-XX			2	SHLD,GSKT ELEK:CLIP-ON EM GASKET	30817	9760-5090-20
-3	213-0882-XX			35	SCREW,TPG,TR:6-32 X 0.437 TAPTITE,PNH,STL	0KB01	ORDER BY DESC
-4	119-3917-XX	B010100	B012480	1	DISPLAY MODULE: (TDS420 ONLY)	80009	1193917XX
	640-0079-XX	B012481		1	DISPLAY MODULE:7 INCH, MONOCHROME P31 (TDS420 ONLY)	80009	6400079XX
	119-3917-XX	B010100	B011418	1	DISPLAY MODULE: (TDS460 ONLY)	80009	1193917XX
	640-0079-XX	B011419		1	DISPLAY MODULE:7 INCH, MONOCHROME P31 (TDS460 ONLY)	80009	6400079XX
	640-0079-XX			1	DISPLAY MODULE:7 INCH, MONOCHROME P31 (TDS410 ONLY)	80009	6400079XX
-5	426-2426-XX			1	FRAME,FAN MTG:POLYCARBONATE	80009	4262426XX
-6	671-1682-XX			1	CIRCUIT BD ASSY:AUXILIARY POWER	80009	6711682XX
-7	119-1770-XX			1	FAN ASSEMBLY:12VDC,1.72W,35CFM W/CONN	S4246	CUDC12D4
-8	119-3939-XX			1	POWER SUPPLY:100VAC AT 440 HZ	50463	PSI-135X-38 69
-9	386-6159-XX			1	SUPPORT,CKT BD:BACK PLANE & PWR SPLY	80009	3866159XX
-10	334-3003-XX			1	MARKER,IDENT:DANGER POWER LINE	TK0860	ORDER BY DESC
-11	119-5028-XX			1	FILTER,RFI:4A,250V,48 TO 440HZ	80009	1195028XX
-12	131-5105-XX			1	CONN,RF JACK:BNC,;50 OHM,FEMALE,STR	24931	28JR200-2
-13	407-4032-XX			2	BRACKET,CKT BD:	80009	4074032XX
-14	211-0722-XX			4	SCREW,MACHINE:6-32 X 0.25,PNH,STL	0KB01	ORDER BY DESC
-15	671-1783-XX	B010100	B030099	1	CIRCUIT BD ASSY:CPU (TDS420 ONLY)	80009	6711783XX
	671-3268-XX	B030100		1	CIRCUIT BD ASSY:CPU (TDS420 ONLY)	80009	6713268XX
	671-1783-XX	B010100	B030099	1	CIRCUIT BD ASSY:CPU (TDS460 ONLY)	80009	6711783XX
	671-3268-XX	B030100		1	CIRCUIT BD ASSY:CPU (TDS460 ONLY)	80009	6713268XX
	671-1783-XX			1	CIRCUIT BD ASSY:CPU (TDS410 ONLY)	80009	6711783XX
-16	671-1784-XX	B010100	B030099	1	CIRCUIT BD ASSY:DISPLAY (TDS420 ONLY)	80009	6711784XX
	671-3269-XX	B030100		1	CIRCUIT BD ASSY:DISPLAY (TDS420 ONLY)	80009	6713269XX
	671-1784-XX	B010100	B030099	1	CIRCUIT BD ASSY:DISPLAY (TDS460 ONLY)	80009	6711784XX
	671-3269-XX	B030100		1	CIRCUIT BD ASSY:DISPLAY (TDS460 ONLY)	80009	6713269XX
	671-1784-XX			1	CIRCUIT BD ASSY:DISPLAY (TDS410 ONLY)	80009	6711784XX
-17	671-1684-XX			1	CIRCUIT BD ASSY:DSP	80009	6711684XX
-18	386-6158-XX			3	SUPPORT,CKT BD:MAT MATERIAL	80009	3866158XX
-19	146-0056-XX			2	BATTERY:3V,1200MAH,2/3A LITHIUM BATTERY	0DW6	ORDER BY DESC
-20	671-1679-XX			1	CIRCUIT BD ASSY:ACQUISITION (TDS420 ONLY)	80009	6711679XX
	671-1685-XX			1	CIRCUIT BD ASSY:ACQUISITION (TDS460 ONLY)	80009	6711685XX
	671-3087-XX			1	CIRCUIT BD ASSY:ACQUISITION (TDS410 ONLY)	80009	6713087XX
-21	344-0116-XX			2	RTNR,CAPACITOR:0.625 DIA,STEEL	TK1891	E50003-007

Fig. & Index No.	Tektronix Part No.	Serial No. Effective Dscont	Qty	12345 Name & Description	Mfr. Code	Mfr. Part No.
10-2-22	671-1683-XX		1	CIRCUIT BD ASSY:JUMPER	80009	6711683XX
-23	671-1680-XX		1	CIRCUIT BD ASSY:ATTENUATOR (TDS420 ONLY)	80009	6711680XX
	671-1686-XX		1	CIRCUIT BD ASSY:ATTENUATOR (TDS460 ONLY)	80009	6711686XX
	671-3086-XX		1	CIRCUIT BD ASSY:ATTENUATOR (TDS410 ONLY)	80009	6713086XX
-24	337-3713-XX		1	SHIELD,ELEC:ATTENUATOR	TK1935	337-3713-XX
-25	671-1676-XX		1	CIRCUIT BD ASSY:BACKPLANE	80009	6711676XX
-26	200-3660-XX		1	COVER,AUTO CAL:POLYCARBONATE	TK1163	ORDER BY DESC
-27	441-1982-XX		1	CHASSIS ASSY:ALUMINUM	80009	4411982XX

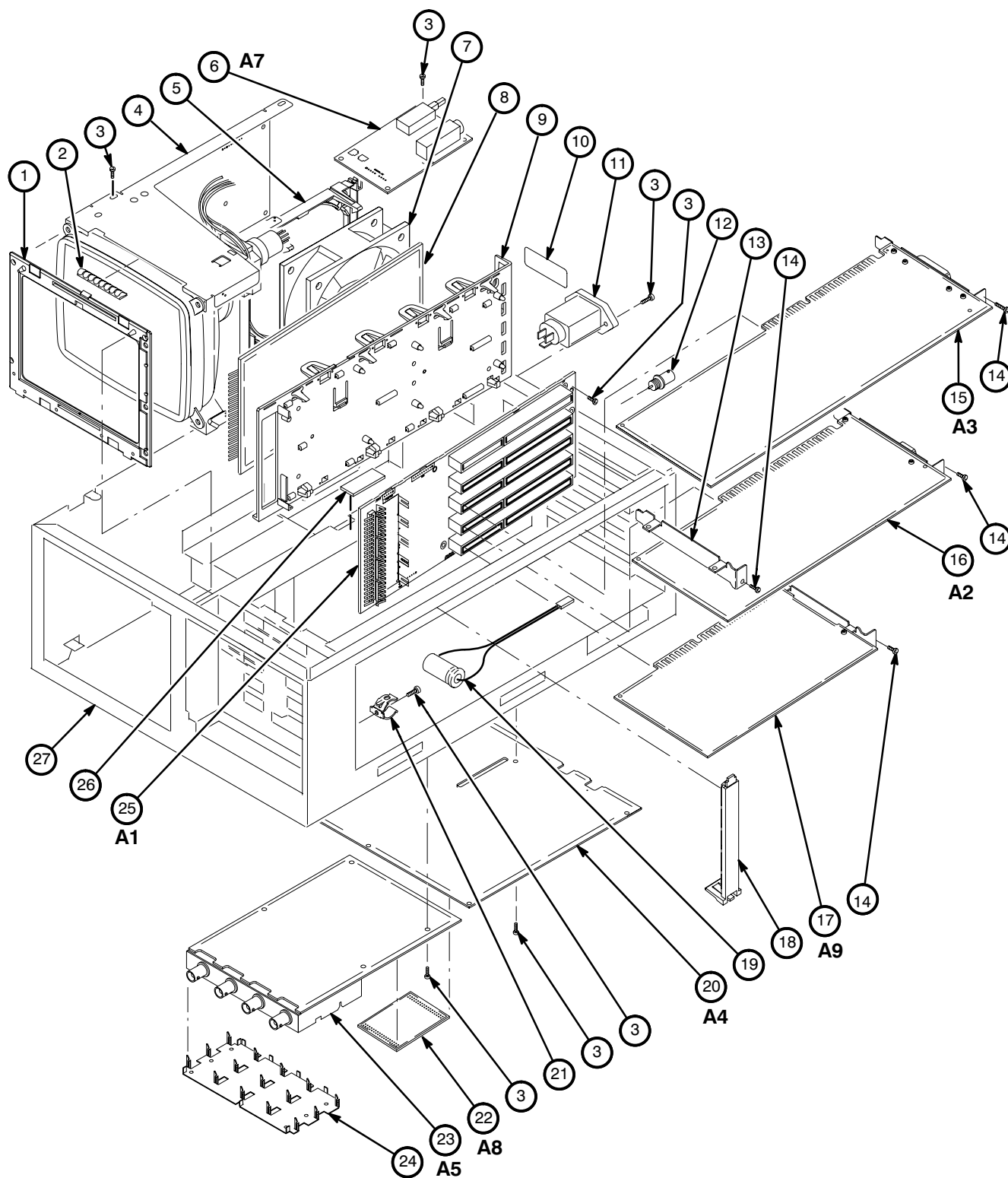


Figure 10-2: Internal Modules

Fig. & Index No.	Tektronix Part No.	Serial No. Effective	Dscont	Qty	12345 Name & Description	Mfr. Code	Mfr. Part No.
10-3-1	174-2661-XX			1	CABLE,SPELEC:18 AWG,AMP	TK2469	1742661XX
-2	174-2282-XX			1	CA ASSY,SPELEC:	TK2469	1742282XX
-3	174-2283-XX			2	CA ASSY,SPELEC:	TK2469	1742283XX
-4	174-2373-XX			1	CA ASSY,SPELEC:2,18 AWG,2.0 L	TK2469	1742373XX
-5	174-2288-XX			1	CA ASSY,SPELEC:	TK2469	1742288XX
-6	210-0457-XX			2	NUT,PL,ASSEM WA:6-32 X 0.312,STL CD PL	TK0435	ORDER BY DESC
-7	174-2631-XX			1	CABLE ASSY,PWR:1460 PVC,18 AWG	TK2469	1742631XX
-8	174-2281-XX			1	CA ASSY,SPELEC:50,28 AWG,2.3 L,FLAT CABLE	TK2469	ORDER BY DESC
-9	174-2280-XX			1	CA ASSY,SPELEC:	TK2469	1742280XX
-10	174-2278-XX			1	CA ASSY,SPELEC:	TK2469	1742278XX
-11	174-2284-XX			1	CA ASSY,SPELEC:	80009	1742284XX

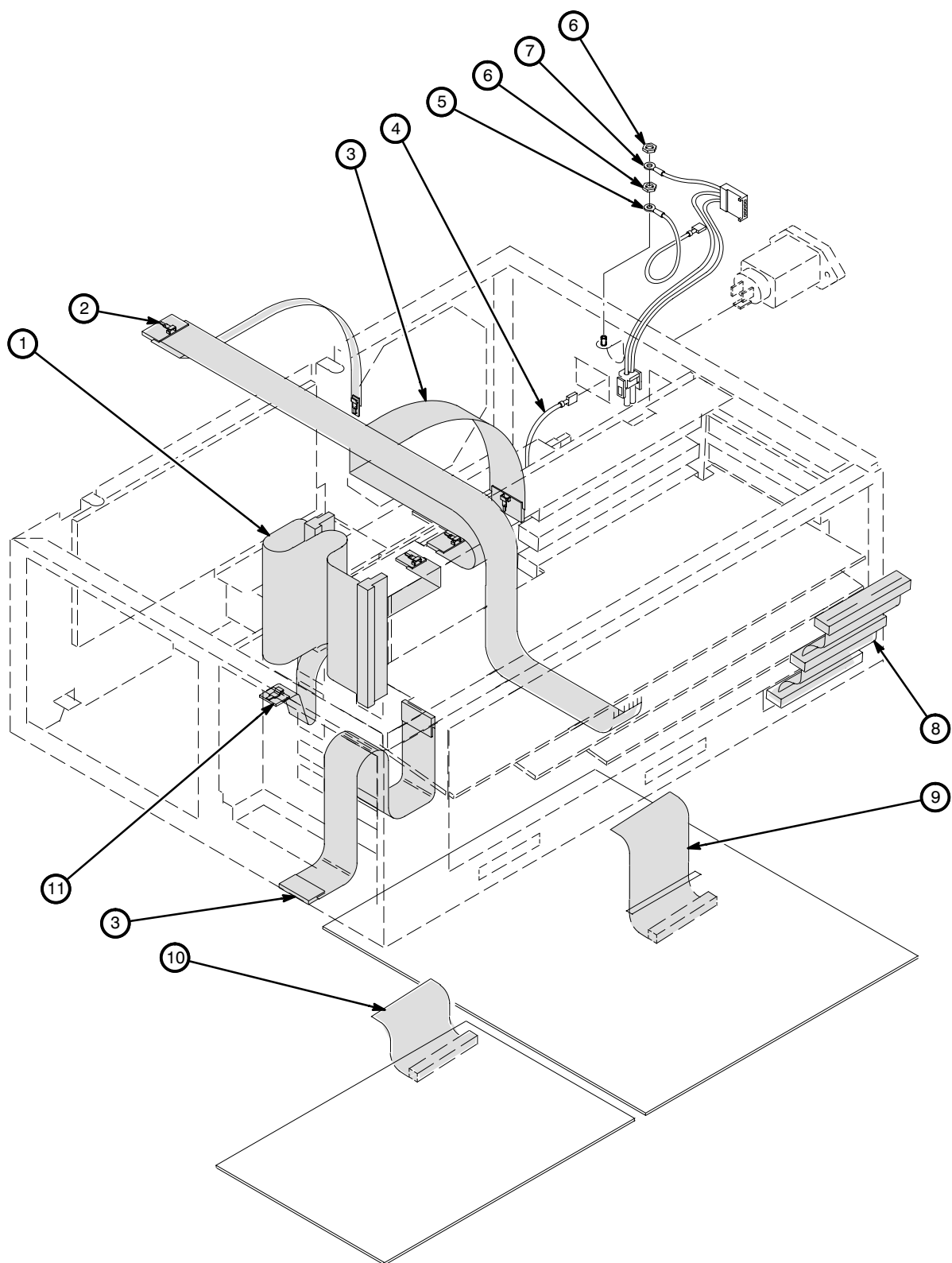


Figure 10-3: Cables and Routing

Fig. & Index No.	Tektronix Part No.	Serial No. Effective Dscont	Qty	12345 Name & Description	Mfr. Code	Mfr. Part No.
STANDARD ACCESSORIES						
	-----		1	ACCESSORY PKG:(2) P6138 1.3M PROBES		
	070-8034-XX		1	MANUAL,TECH:TUTORIAL/USER	80009	0708034XX
	070-8035-XX		1	MANUAL,TECH:QUICK REF	80009	0708035XX
	070-8036-XX		1	MANUAL,TECH:SERVICE	80009	0708036XX
	070-8709-XX		1	MANUAL,TECH:PROGRAMMER	80009	0708709XX
	070-8721-XX		1	MANUAL,TECH:PERFORMANCE VERIFICATION	80009	0708721XX
	-----		1	CABLE ASSY,PWR,,:3,18 AWG,92 L,SVT,TAN (STANDARD-SEE FIGURE 10-1-9)	TK2432	ORDER BY DESC
	161-0104-05		1	CABLE ASSY,PWR,,:3,18 AWG,240V,98.0 L (OPTION A3-AUSTRALIAN)	S3109	SAA/3-OD3CCFC3X
	161-0104-06		1	CABLE ASSY,PWR,,:3 X 0.75MM SQ,220V,98.0 L (OPTION A1-EUROPEAN)	S3109	VIIGSOPO-HO5VVF
	161-0104-07		1	CABLE ASSY,PWR,,:3,1.0MM SQ,240 VOLT,2.5 M (OPTION A2-UNITED KINGDOM)	S3109	ORDER BY DESC
	161-0104-08		1	CABLE ASSY,PWR,,:3,18 AWG,98 L,SVT,GREY/BLK (OPTION A4-NORTH AMERICAN)	70903	ORDER BY DESC
	161-0167-00		1	CABLE ASSY,PWR,,:3.0 X 0.75,6A,240V,2.5M L (OPTION A5-SWITZERLAND)	S3109	ORDER BY DESC
	-----		1	CLAMP,PWR CORD:POLYIMIDE (SEE FIGURE 10-1-10)	TK1163	ORDER BY DESC

Fig. & Index No.	Tektronix Part No.	Serial No. Effective Dscont	Qty	12345 Name & Description	Mfr. Code	Mfr. Part No.
OPTIONAL ACCESSORIES						
	003-1463-XX		1	WRENCH,BNC:WRENCH FOR BNC FIXTURE	80009	0031463XX
	003-1464-XX		1	FIXTURE,BNC:BNC FIXTURE FOR TDS400	80009	0031464XX
	003-1472-XX		1	HAND TOOL:CLAMP, DETENT SPRING	80009	0031472XX
	012-0991-XX		1	CABLE,COMPOSITE:IDC,GPIB:2 METER,24 COND	00779	553577-3
	012-0991-XX		1	CABLE,GPIB:LOW EMI,1 METER	00779	553577-2
	012-1388-XX		1	CABLE ASSEMBLY:OSCILLOSCOPE SECURITY	TK2478	TSC-20
	016-1230-XX		1	POUCH:POUCH AND PLATE	80009	0161230XX
	016-1154-XX		1	HOOD ASSEMBLY:2KDSO	80009	0161154XX
	016-1157-XX		1	CASE,CARRYING:26 X 22 X 12,HARD TRANSFER	34416	ORDER BY DESC
	016-1158-XX		1	CASE,CARRYING:SOFT PADDED,OPTIONS	80009	0161158XX
	016-1166-XX		1	RACK MOUNT KIT:RACK MOUNT TDS400	80009	0161166XX
	063-1130-XX		1	SOFTWARE PKG:DISK,FIRMWARE,V1.3,UTIL V1.8 (TDS420/460 ONLY)	80009	0631130XX
	063-1352-XX		1	SOFTWARE PKG:DISK MAINTENANCE TOOLS	80009	0631352XX
	063-2037-XX		1	SOFTWARE PKG:OPERATING S/W (TDS410 ONLY)	80009	0632037XX
	063-2039-XX		1	SOFTWARE PKG:FIELD ADJUST,V2.1	80009	0632039XX
	067-0206-XX		1	FIXTURE,CAL:CRT SCALE,CLEAR	80009	0670206XX
	067-0208-XX		1	FIXTURE,CAL:RECOVERING TIME	80009	0670208XX
	067-0213-XX		1	FIXTURE,CAL:CRT ALIGNMENT	80009	0670213XX
	-----		1	COVER,FRONT:ASB (SEE FIGURE 10-1-25)		
	070-8521-XX		1	MANUAL,TECH:RACKMOUNT	80009	0708521XX
	070-8567-XX		1	MANUAL,TECH:RS-232/CENTRONICS (OPTION 13 ONLY)	80009	0708567XX
	070-8722-XX		1	MANUAL,TECH:INSTRUCTION (OPTION 3P ONLY)	80009	0708722XX
	070-8762-XX		1	MANUAL,TECH:USER,VIDEO DISPLAY (OPTION 05 ONLY)	80009	0708762XX

