TDS2000C Series
Digital Storage Oscilloscopes

Service Manual

077-0446-00

Tektronix

TDS2000C Series
Digital Storage Oscilloscopes

Service Manual

This document applies to firmware version 1.00 and above.

Warning

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

www.tektronix.com

077-0446-00

Tektronix

Copyright © Tektronix. All rights reserved. Licensed software products are owned by Tektronix or its subsidiaries or suppliers, and are protected by national copyright laws and international treaty provisions.

Tektronix products are covered by U.S. and foreign patents, issued and pending. Information in this publication supersedes that in all previously published material. Specifications and price change privileges reserved.

TEKTRONIX and TEK are registered trademarks of Tektronix, Inc.

OpenChoice is a registered trademark of Tektronix, Inc.

Contacting Tektronix

Tektronix, Inc.
14150 SW Karl Braun Drive
P.O. Box 500
Beaverton, OR 97077
USA

For product information, sales, service, and technical support:

- In North America, call 1-800-833-9200.
- Worldwide, visit www.tektronix.com to find contacts in your area.

Table of Contents

General Safety Summary vi
Service Safety Summary viii
Preface ix
Manual Conventions ix
Related Documentation ix

Specifications

Specifications 1-1
Signal Acquisition System Characteristics 1-1
Time Base System 1-5
Triggering System 1-7
Display Specifications 1-11
Interfaces and Output Ports Specifications 1-12
Data Handling Characteristics 1-12
Power Distribution System 1-12
Mechanical Characteristics 1-13
Environmental Performance 1-13
Data Logging System Characteristics 1-14
Limit Testing System Characteristics 1-14

Where to Find Operating Information

Where to Find Operating Information 2-1

Theory of Operation

Theory of Operation 3-1
System Level Block Diagrams 3-2
Main Board 3-4
Acquisition System 3-4
Processing and Display System 3-5
Input Signal Interface 3-5
Probe Compensation 3-5
External Trigger 3-5
Main Board Power 3-5
Power Supply 3-6
Display Module 3-6
Front Panel 3-6
Two-Channel Oscilloscopes 3-6

Four-Channel Oscilloscopes 3-6

Performance Verification

Performance Verification 4-1
Required Equipment 4-1
Test Record 4-2
Performance Verification Procedures 4-3
Self Test 4-3
Self Calibration 4-3
Check DC Gain Accuracy 4-3
Check Bandwidth 4-5
Check Sample Rate Accuracy and Delay Time Accuracy 4-6
Check Edge Trigger Sensitivity 4-7
Check External Edge Trigger Sensitivity 4-9
Check Vertical Position Accuracy 4-10

Adjustment Procedures

Adjustment Procedures 5-1
Required Equipment 5-1
Adjustment Procedure 5-2
Enable the Service Menu 5-2
Adjustment Procedure 5-4
Maintenance 6-1
Preventing ESD 6-1
Inspection and Cleaning 6-1
General Care 6-2
Interior Cleaning 6-2
Exterior Cleaning 6-2
Exterior Inspection 6-3
Interior Inspection 6-3
Cleaning Procedure, Interior 6-4
Removal and Installation Procedures 6-6
Summary of Procedures 6-6
Required Tools 6-8
Rear Feet 6-8
Flip Feet 6-9
Front-Panel Knobs 6-9
Power Button 6-9
Rear Case 6-10
Front Feet 6-11

Power Supply Module 6-12
Internal Assembly 6-13
Display Adapter Module 6-14
Front-Panel Cable 6-17
Main Board Module 6-18
Display Module 6-20
Front-Panel Module 6-21
Keypad 6-22
Troubleshooting 6-23
Adjustment After Repair 6-23
Required Tools and Equipment 6-23
Troubleshooting Tree 6-23
Probe Comp Output 6-28
Troubleshooting the Power Supply 6-29
Troubleshooting the Display 6-30
Troubleshooting the Backlight 6-32
Troubleshooting the Front Panel 6-34
Troubleshooting the Main Board 6-37
Repackaging Instructions 6-40
Diagrams 7-1

Replaceable Parts

Replaceable Parts 8-1
Parts Ordering Information 8-1
Using the Replaceable Parts List 8-2
Parts Lists and Exploded Views 8-3
Appendix A: Example of a Vertical Position Accuracy Test Spreadsheet A-1
Example Filled-In Vertical Position Accuracy Test Spreadsheet A-1

List of Figures

Figure 3-1: Module-level block diagram (2-channel) 3-2
Figure 3-2: Module-level block diagram (4-channel) 3-3
Figure 4-1: Example of a line graph for the Vertical Position Accuracy test 4-13
Figure 5-1: Adjustment setups 5-3
Figure 6-1: Locator for trim and cabinet removal (4-channel model shown)..... 6-7
Figure 6-2: Locator for internal modules (4-channel model shown) 6-7
Figure 6-3: Display Adapter board connections 6-14
Figure 6-4: Connecting the Display cable 6-15
Figure 6-5: Oscilloscope troubleshooting tree (page 1 of 4)..... 6-24
Figure 6-6: Oscilloscope troubleshooting tree (page 2 of 4)..... 6-25
Figure 6-7: Oscilloscope troubleshooting tree (page 3 of 4)..... 6-26
Figure 6-8: Oscilloscope troubleshooting tree (page 4 of 4)..... 6-27
Figure 6-9: Measuring the backlight voltage..... 6-33
Figure 7-1: TDS2000C series block diagram 7-2
Figure 8-1: Exploded diagram, 2-channel models..... 8-4
Figure 8-2: Exploded diagram, 4-channel models..... 8-6
Figure 8-3: Power supply module, cables, and wires (2-ch model shown, with 4-ch model in circle) . 8-8
Figure 8-4: Exploded diagram, back case and trim..... 8-10

List of Tables

Table 1-1: Signal acquisition system characteristics 1-1
Table 1-2: Time base system 1-5
Table 1-3: Triggering system 1-7
Table 1-4: Display specifications 1-11
Table 1-5: Interfaces and output ports specifications 1-12
Table 1-6: Data handling characteristics 1-12
Table 1-7: Power distribution system 1-12
Table 1-8: Mechanical characteristics 1-13
Table 1-9: Environmental performance 1-13
Table 1-10: Data logging system characteristics 1-14
Table 1-11: Limit testing system characteristics 1-14
Table 4-1: Performance verification 4-1
Table 4-2: Test record 4-2
Table 5-1: Required equipment 5-1
Table 5-2: Adjustment steps 5-5
Table 6-1: External inspection checklist 6-3
Table 6-2: Internal inspection checklist 6-4
Table 6-3: Tools and equipment 6-23
Table 6-4: Probe Comp output 6-28
Table 6-5: Troubleshooting the power supply 6-29
Table 6-6: Troubleshooting the display 6-30
Table 6-7: Troubleshooting the front panel – service 6-34
Table 6-8: Troubleshooting the front panel – Service Diag 6-34
Table 6-9: Troubleshooting the front panel – Mfg. test 6-34
Table 6-10: Expected signals at J202 6-35
Table 6-11: Troubleshooting the Main board 6-37
Table 6-12: List of error codes 6-38
Table 8-1: Replaceable parts list 8-2
Table 8-2: Replaceable parts list, 2-channel models 8-3
Table 8-3: Replaceable parts list, 4-channel models 8-5
Table 8-4: Replaceable parts list, power supply module, cables, and wires 8-7
Table 8-5: Replaceable parts list, back case and trim 8-9
Table A-1: Vertical position accuracy test spreadsheet A-1

General Safety Summary

Review the following safety precautions to avoid injury and prevent damage to this product or any products connected to it.

To avoid potential hazards, use this product only as specified.

Only qualified personnel should perform service procedures.

To Avoid Fire or Personal Injury

Use proper power cord. Use only the power cord specified for this product and certified for the country of use.

Connect and disconnect properly. Connect the probe output to the measurement instrument before connecting the probe to the circuit under test. Connect the probe reference lead to the circuit under test before connecting the probe input. Disconnect the probe input and the probe reference lead from the circuit under test before disconnecting the probe from the measurement instrument.

Ground the product. This product is grounded through the grounding conductor of the power cord. To avoid electric shock, the grounding conductor must be connected to earth ground. Before making connections to the input or output terminals of the product, ensure that the product is properly grounded.

Observe all terminal ratings. To avoid fire or shock hazard, observe all ratings and markings on the product. Consult the product manual for further ratings information before making connections to the product.

Connect the probe reference lead to earth ground only.

Do not apply a potential to any terminal, including the common terminal, that exceeds the maximum rating of that terminal.

Power disconnect. The power switch disconnects the product from the power source. See instructions for the location. Do not block the power switch; it must remain accessible to the user at all times.

Do not operate without covers. Do not operate this product with covers or panels removed.

Do not operate with suspected failures. If you suspect that there is damage to this product, have it inspected by qualified service personnel.

Avoid exposed circuitry. Do not touch exposed connections and components when power is present.

Do not operate in wet/damp conditions.

Do not operate in an explosive atmosphere.

Keep product surfaces clean and dry.

Provide proper ventilation. Refer to the manual's installation instructions for details on installing the product so it has proper ventilation.

Terms in This Manual

These terms may appear in this manual:

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

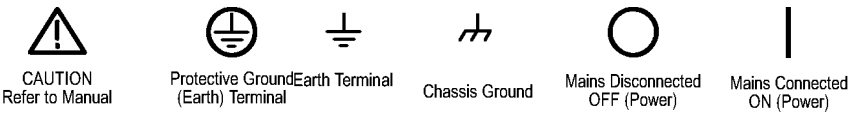
CAUTION. *Caution statements identify conditions or practices that could result in damage to this product or other property.*

Symbols and Terms on the Product

These terms may appear on the product:

- DANGER indicates an injury hazard immediately accessible as you read the marking.
- WARNING indicates an injury hazard not immediately accessible as you read the marking.
- CAUTION indicates a hazard to property including the product.

The following symbol(s) may appear on the product:



Service Safety Summary

Only qualified personnel should perform service procedures. Read this *Service Safety Summary* and the *General Safety Summary* before performing any service procedures.

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

Disconnect Power. To avoid electric shock, switch off the instrument power, then disconnect the power cord from the mains power.

Use Care When Servicing With Power On. Dangerous voltages or currents may exist in this product. Disconnect power, remove battery (if applicable), and disconnect test leads before removing protective panels, soldering, or replacing components.

To avoid electric shock, do not touch exposed connections.

Preface

This service manual provides information to verify performance of, calibrate, troubleshoot, disassemble, and replace parts on the TDS2000C Series Digital Storage Oscilloscopes.

Unless noted otherwise, the term "oscilloscope" refers to all models in the TDS2000C series.

Manual Conventions

This manual uses certain conventions that you should become familiar with before attempting service.

Modules

Throughout this manual, any replaceable component, assembly, or part is referred to by the term *module*.

A module is composed of electrical and mechanical assemblies, circuit cards, interconnecting cables, and user-accessible controls.

Replaceable Parts

This manual refers to any field-replaceable assembly or mechanical part specifically by its name or generically as a replaceable part. In general, a replaceable part is any circuit board or assembly, such as the hard disk drive, or a mechanical part, such as the I/O port connectors, that is listed in the replaceable parts list.

Safety

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

Related Documentation

To read about	Use these documents
Installation and Operation	*TDS2000C Series Digital Storage Oscilloscopes User Manual* (available in 11 languages)
Programmer Commands	*TDS200, TDS1000/2000, TDS1000B/2000B, TDS2000C, and TPS2000 Series Digital Oscilloscopes Programmer Manual*

Specifications

Specifications

These specifications apply to all TDS2000C series oscilloscopes. To verify that an oscilloscope meets specifications, it must first meet the following conditions:

- The oscilloscope must have been operating continuously for twenty minutes within the specified operating temperature.
- You must perform the Do Self Cal operation, accessible through the Utility menu, if the operating temperature has changed by more than 5 °C (9 °F) since the last time the Do Self Cal operation was performed.
- The oscilloscope must be within the factory calibration interval of one year.

Specifications are provided in the following tables. All specifications are guaranteed unless noted "typical." Specifications that are marked with the symbol are checked in the chapter *Performance Verification*. (See page 4-1, *Performance Verification*.)

Signal Acquisition System Characteristics

NOTE. *All amplitude-related or modified specifications require 1X probe attenuation factors unless otherwise specified. This is due to the way the displayed sensitivity works. This does not affect actual methods of attachment. It only alters the relationship between displayed scale factors and the specifications.*

Table 1-1: Signal acquisition system characteristics

Characteristic	Description
Number of Input Channels	Two (for the TDS2001C, TDS2002C, TDS2012C, and TDS2022C) or four (for the TDS2004C, TDS2014C, and TDS2024C) nominally identical channels, sampled simultaneously.
Input Coupling	DC, AC, or GND
Input Impedance, DC Coupled	1 MΩ ±2% in parallel with 20 pF ±3 pF
Maximum Input Voltage	At the front panel connector, 300 V_{RMS}, Installation Category II; derate at 20 dB/decade above 100 kHz to 13 V peak AC at 3 MHz and above.
	Based on sinusoidal or DC input signal. The maximum viewable signal while DC coupled is ±50 V offset ±5 V/div at 4 divisions, or 70 V. AC coupling allows measuring signals on a DC level up to 300 V. For nonsinusoidal waveforms, peak value must be less than 450 V. Excursions above 300 V should be less than 100 ms in duration, and the duty factor is limited to < 44%. The RMS signal level must be limited to 300 V. If these values are exceeded, damage to the instrument may result.
Number of Digitized Bits	8 bits except at 2 mV/div
	Displayed vertically with 25 digitization levels per division, 10 divisions dynamic range.
	2 mV/div setting is generated by digital multiplication and the resolution is reduced. Given 100 levels available, the resolution is >6.5 bits.

Table 1-1: Signal acquisition system characteristics (cont.)

Characteristic	Description
Sensitivity Range	2 mV/div to 5 V/div in 1-2-5 sequence with the probe attenuation set to 1X.
Display Gain Variable	The Display Gain Variable function allows the user to vary the vertical display gain continuously over the full range.
	Resolution is that of the coarse gain from which these data are constructed. Fine gain values (for instance 120 mV/div) are acquired at the next higher coarse gain setting (in this case 200 mV/div).
	The Display Gain Variable is achieved by digital multiplication of the data to obtain the settings between the 1-2-5 gain settings.
	Hard copy outputs to printer will be exactly the same as seen on screen even when the Display Gain Variable is used.
	However, WAVEFORM DATA obtained through the I/O interface is limited to the 1-2-5 gain settings.
Probe Scale Factors	1X, 10X, 20X, 50X, 100X, 500X, 1000X voltage attenuation.
	5, 1, 500 m, 200 m, 20 m, 10 m, 1 m V/A current scale factor.
	This adjusts the display scale factor of the instrument to accommodate various probe types.
	Accuracy of the probe used must be added to the accuracy specifications of instrument.
	No automatic probe interface is provided, so you must verify that the settings match the probe characteristics. The probe check function allows setting of the proper attenuation for voltage probes.
Acquisition Modes	Sample, Peak Detect, Average
	Envelope mode not provided
Retained Front Panel Settings	Front panel settings are retained when the instrument power is turned off and on with the power switch. The settings are retained when the line power is turned off and on.
	The instrument periodically saves front panel settings after settings are changed. There is a delay of three seconds after the last change and before the storage of the settings in memory.
Math Modes	All Units: Channel 1 - Channel 2 Channel 2 - Channel 1 Channel 1 + Channel 2 Channel 1 * Channel 2 FFT
	4 channel units (TDS20X4C): Channel 3 - Channel 4 Channel 4 - Channel 3 Channel 3 + Channel 4 Channel 3 * Channel 4
Voltage Measurement Functions	Mean, Cyc RMS, Peak-to-Peak, Max, Min, RMS, CursorRMS
√ DC Gain Accuracy, Sample or Average Acquisition	*This is the difference between the measured DC gain and the nominal DC gain, divided by the nominal DC gain and expressed as a percent.*
	±3%, 5 V/div through 10 mV/div
	±4%, 5 mV/div and 2 mV/div

Table 1-1: Signal acquisition system characteristics (cont.)

Characteristic	Description
DC Voltage Measurement Accuracy, Average Acquisition Mode	**Vertical position = 0:** ±(3% of |reading| + 0.1 div + 1 mV) **Vertical position ≠ 0 and vertical scale = 2 mV/div to 200 mV/div:** ±[3% of |reading + vertical position| + 1% of |vertical position| + 0. 2 div + 7 mV] **Vertical position ≠ 0 and vertical scale > 200 mV/div:** ±[3% of |reading + vertical position| + 1% of |vertical position| + 0.2 div + 175 mV]
Delta Volts Measurement Accuracy, Average Acquisition Mode	*Delta volts between any two averages of 16 waveforms acquired under the same setup and ambient conditions.*
	(3% of |reading| + 0.05 div)
Analog Bandwidth	*Defined in Section 4.6 of IEEE std 1057. The difference between the upper and lower frequencies, at which the amplitude response, as seen in the data record, is 0.707 (-3 dB) of the response seen in the data record at the specified reference frequency. Specifies only the -3 dB point. It does not include the in-band response.*
√ Analog Bandwidth, DC Coupled, Sample or Average	*This is analog bandwidth when the instrument is DC coupled in sample or average mode. V/div values are accurate for probe attenuation settings of 1X. No probe should be installed for these measurements. System bandwidth is type tested to be equivalent to this specification with the provided probe in 10X mode. Use Section 4.6.1 of IEEE 1057, with the reference frequency of 1 kHz at an amplitude of 5 divisions, driven from a 50 Ω source with external termination at the input BNC (25 Ω effective source).*
	TDS2022C, TDS2024C: to ≥ 200 MHz for 5 mV/div through 5 V/div settings with bandwidth limit at full with temperature between 0°C and 35 °C. DC to > 160 MHz for 5 mV/div through 5 V/div settings with bandwidth limit at full for temperatures between 0 °C and 50 °C. < 5 mV/div settings are limited to 20 MHz bandwidth.
	TDS2012C, TDS2014C: DC to ≥ 100 MHz for 5 mV/div through 5 V/div settings with bandwidth limit at full. < 5 mV/div settings are limited to 20 MHz bandwidth.
	TDS2002C, TDS2004C: DC to ≥ 70 MHz for 5 mV/div through 5 V/div settings with the bandwidth limit at full. < 5 MV/div settings are limited to 20 MHz bandwidth.
	TDS2001C: DC to ≥ 50 MHz for 5 mV/div through 5 V/div settings with the bandwidth limit at full. < 5 mV/div settings are limited to 20 MHz bandwidth.
Analog Bandwidth, DC Coupled, Peak Detect, typical	*This is the analog bandwidth when the instrument is DC coupled. V/div values are accurate for probe attenuation settings of 1X. No probe should be installed for these measurements.*
	TDS2012C, TDS2014C, TDS2022C, TDS2024C: DC to ≥ 75 MHz for 5 mV/div through 5 V/div settings with the bandwidth limit at full. Settings less than 5 mV/div are limited to 20 MHz bandwidth.
	TDS2002C, TDS2004C: DC to ≥ 50 MHz for 5 mV/div through 5 V/div settings with the bandwidth limit at full. Settings less than 5 mV/div are limited to 20 MHz bandwidth.
	TDS2001C: DC to ≥ 30 MHz for 5 mV/div through 5 V/div settings with the bandwidth limit at full. Settings less than 5 mV/div are limited to 20 MHz bandwidth.
Analog Bandwidth Selections	20 MHz bandwidth limit ON/OFF

Table 1-1: Signal acquisition system characteristics (cont.)

Characteristic	Description		
Upper-Frequency Limit, 20 MHz Bandwidth Limited, typical	*This is the upper frequency for Analog Bandwidth when the instrument has 20 MHz bandwidth limiting turned on.*		
	20 MHz		
	Bandwidth of all trigger paths are similarly limited, except the External Trigger, which is not affected by BW Limit function. Each channel is separately limited, allowing different bandwidths on different channels of the same instrument.		
Lower- Frequency Limit, AC Coupled	*This is the lower frequency for Analog Bandwidth when the instrument is AC-coupled*		
	≤ 10 Hz.		
	<1 Hz when 10X, passive probes are used.		
Rise Time, typical	*Model*	*Expected full bandwidth rise time*	
	TDS2022C and TDS2024C	2.1 ns	
	TDS2012C and TDS2014C	3.5 ns	
	TDS2002C and TDS2004C	5.0 ns	
	TDS2001C	7.0 ns	
	Rise time is generally calculated from the following formula: Rise time in ns = 350 / Bandwidth in MHz		
Peak Detect Mode Pulse Response	*This is the capability of the instrument to capture single event pulses using the Peak Detect Acquisition Mode*.		
	The minimum single pulse widths for guaranteed 50% or greater amplitude capture are as follows:		
	Model	*Sec/Div Setting*	*Minimum Pulse Width*
	TDS2002C TDS2004C TDS2012C TDS2014C TDS2022C TDS2024C	50 sec/div to 5 µS/div	12 ns
	TDS2001C	50 sec/div to 5 µS/div	13 ms
Vertical Position Ranges	*These are the ranges of the user-settable input offset voltage.*		
	Volts/Div Setting	*Position Range*	
	2 mV/div to 200 mV/div	± 1.8 V	
	> 200 mV/div to 5 V/div	± 45 V	
√ Vertical Position Accuracy	*This is the accuracy of the nominal voltage level represented by the code at the vendor of the A-D converter's dynamic range.*		
	Volts/Div Setting	*Position Accuracy*	
	2 mV/div to 200 mV/div	±(1% of |selected value| + 0.1 div + 5 mV) within the range ±1.8 V	
	> 200 mV/div to 5 V/div	±(1% of |selected value| + 0.1 div + 125 mV) within the range ±45 V	

Table 1-1: Signal acquisition system characteristics (cont.)

Common Mode Rejection Ratio (CMRR), typical	*With the same signal applied to each channel, CMRR is the ratio of the acquired signal amplitude to the amplitude of the MATH difference waveform, either (Channel 1 - Channel 2), (Channel 2 - Channel 1), (Channel 3 - Channel 4) or (Channel 4 - Channel 3)*	
	Model	*Common Mode Rejection Ratio*
	TDS2012C TDS2014C TDS2022C TDS2024C	100:1 at 60 Hz, reducing to 10:1 with 50 MHz sine wave, with equal Volts/Div and Coupling settings on each channel.
	TDS2001C TDS2002C TDS2004C	100:1 at 60 Hz, reducing to 20:1 with a sine wave with frequency equal to ½ the -3 dB bandwidth and with equal Volts//Div and Coupling settings on each channel.
Crosstalk (Channel Isolation)	*Section 4.11.1 of IEEE std. 1057. It is the ratio of the level of a signal input into one channel to that of the same signal present in another channel due to stray coupling.*	
	Model	*Crosstalk*
	TDS2022C TDS2024C	≥ 100:1 with a 100 MHz sine wave and with equal V/div settings on each channel
	TDS2012C TDS2014C	≥ 100:1 with a 50 MHz sine wave and with equal V/div settings on each channel
	TDS2002C TDS2004C	≥ 100:1 with a 30 MHz sine wave and with equal V/div settings on each channel
	TDS2001C	≥ 100:1 with a 20 MHz sine wave and with equal V/div settings on each channel

Time Base System

Table 1-2: Time base system

Characteristic	Description	
Sample-Rate Range	*This is the 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. (IEEE 1057, 2.2.1)*	
	Model	*Sample-rate range*
	TDS2012C TDS2014C TDS2022C TDS2024C	5 S/s to 2000 MS/s
	TDS2002C TDS2004C	5 S/s to 1000 MS/s
	TDS2001C	5 S/s to 500 MS/s
Waveform Interpolation	(Sin x)/x interpolation	
	Waveform interpolation is activated for sweep speeds of 100ns/div and faster.	

Table 1-2: Time base system (cont.)

Characteristic	Description	
Record Length	*This is the total number of samples contained in a single acquired waveform record (Memory Length in IEEE 1057.2.2.1).*	
	2,500 samples per record.	
Seconds/Division Range	5 ns/div to 50 s/div in 1–2.5–5 sequence	
	Sec/Div Variable function is not available for this product.	
√ Long-Term Sample Rate and Horizontal Position Time Accuracy	*This is the maximum, total, long-term error in sample-rate or horizontal position time accuracy, expressed in parts per million.*	
	±50 ppm over any ≥1 ms interval.	
Horizontal Position Time Range	*Horizontal scale setting*	*Horizontal position time range*
	5 ns/div to 10 ns/div	-4 div * s/div to 20 ms
	25 ns/div to 100 µs/div	-4 div * s/div to 50 ms
	250 µs/div to 10 s/div	-4 div * s/div to 50 s
	25 s/div to 50 s/div	-4 div * s/div to 250 s
	The user controls the time from the trigger to the center graticule on the display with the Horizontal Position knob.	
	The resolution of the Horizontal Position time is 1/25 of a horizontal division.	
Horizontal Window Display	The Window Zone enables a user to select a part of the display to be magnified. The user controls the location with the Horizontal Position knob and the width with the Sec/Div knob. Vertical cursors show the selected zone. To magnify the zone, the user selects the window from the menu.	
Delta Time Measurement Accuracy	*This is the accuracy of delta time measurements made on any single waveform.* *The limits are given in the following table for signals having an amplitude ≥ 5 divisions, a slew rate at the measurement points of ≥ 2.0 divisions/ns, and acquired ≥ 10 mV/div.*	
	Condition	*Time Measurement Accuracy*
	Single shot, sample mode, full bandwidth selected	±(1 Sample Internal + 100 ppm * |reading| + 0.6 ns)
	> 16 averages, full bandwidth selected	±(1 Sample Internal + 100 ppm * |reading| + 0.4 ns)
	The Sample Interval is the time between the samples in the waveform record.	
Time Measurement Functions	Frequency, Period, Rise Time, Fall Time, Positive Width, negative Width, Positive Duty Cycle, Phase, Delay	

Triggering System

Table 1-3: Triggering system

Characteristic	Description	
Trigger Types	Edge, Video, Pulse Width	
Trigger Source Selection	*Models*	Trigger source selections
	TDS2001C TDS2002C TDS2012C TDS2022C	Channel 1 Channel 2 External External/5 AC Line
	TDS2004C TDS2014C TDS2024C	Channel 1 Channel 2 Channel 3 Channel 4 External External/5 AC Line
	External/5 selection attenuates the external signal by 5.	
	When Bandwidth Limit is selected for a channel, the bandwidth of that channel's trigger path will also be limited. The bandwidth of the External Trigger path is not affected by the bandwidth limit.	
Horizontal Trigger Position	The trigger position is set by the Horizontal Position knob.	
Trigger Holdoff Range	500 ns minimum to 10 s maximum	
	The ability to set large values of Holdoff is limited by the difficulty in adjusting the Holdoff at Sec/Div settings less than 100 ms/Div. This is because Holdoff cannot be set in Scan Mode, which begins at 100 ms/div when Trigger Mode is AUTO. By adjusting Trigger Mode to NORMAL, the Scan Mode operation is turned off, and Holdoff can be adjusted at larger seconds/Div settings.	
External Trigger Input Impedance	1 M ±2% in parallel with 20 pF ±3 pF	
External Trigger Maximum Input Voltage	300 V_{RMS}, Installation Category II; derate at 20 dB/decade above 100 kHz to 13 V peak AC at 3 MHz and above	
	Based on sinusoidal or DC input signal. The maximum viewable signal while DC coupled is ±50 V offset ±5 V/div at 4 divisions, or 70 V. AC coupling allows measuring signals on a DC level up to 300 V. For nonsinusoidal waveforms, peak value must be less than 450 V. Excursions above 300 V should be less than 100 ms duration and the duty factor is limited to < 44%. RMS signal level must be limited to 300 V. If these values are exceeded, damage to the instrument may result.	
Line Trigger Characteristics	Line Trigger mode provides a source to synchronize the trigger with the AC line input.	
	Input Amplitude requirements: 85 V_{AC} - 265 V_{AC}.	
	Input Frequency requirements: 45 Hz - 440 Hz.	
Edge Trigger		
Trigger Modes	Auto, Normal	

Table 1-3: Triggering system (cont.)

Characteristic	Description			
Trigger Coupling	AC, DC, Noise Reject, High Frequency Reject, Low Frequency Reject			
	The External Trigger path does not have a DC blocking capacitor ahead of the trigger input circuit. The rolloff associated with AC coupling happens after the input circuit. When attempting to trigger on an AC signal that has a DC offset, care must be used to avoid overloading the input of the External Trigger circuit. For signals that have a large DC offset, using Channel 1 or Channel 2 (and Channel 3 or Channel 4 for the TDS20X4B) with AC coupling is preferred.			
Trigger Slope	Rising Edge, Falling Edge			
√ Sensitivity, Edge-Type Trigger, DC Coupled	*Measurement Style A) The minimum signal levels for achieving stable frequency indication on the Trigger Frequency Counter within 1% of correct indication.* *Measurement Style B) Section 4 10.2 in IEEE Std. #1057. The minimum signal levels required for stable edge triggering of an acquisition when the trigger Source is DC coupled.*			
	Trigger Source		*Sensitivity (Measurement style A), typical*	*Sensitivity (Measurement style B)*
	Channel Inputs	All products	1.5 div from DC to 10 MHz (> 2 mV/div) 4 div from DC to 10 MHz (2 mV/Div)	1 div from DC to 10 MHz > 2 mV/div) 2.5 div from DC to 10 MHz (2 mV/Div)
		TDS2001C	3 div between 10 MHz and 50 MHz	1.5 div between 10 MHz and 50 MHz
		TDS2002C TDS2004C	3 div between 10 MHz and 70 MHz	1.5 div between 10 MHz and 70 MHz
		TDS2012C TDS2014C	3 div between 10 MHz and 100 MHz	1.5 div between 10 MHz and 100 MHz
		TDS2022C TDS2024C	3 div between 10 MHz and 200 MHz	1.5 div from 10 MHz to 100 MHz 2.0 div above 100 MHz to 200 MHz
	Ext	All products	300 mV from DC to 100 MHz	200 mV from DC to 100 MHz
		TDS2022C TDS2024C	500 mV from 100 MHz to 200 MHz	350 mV from 100 MHz to 200 MHz
	Ext/5	All products	1.5 V from DC to 100 MHz	1 V from DC to 100 MHz
		TDS2022C TDS2024C	2.5 V from 100 MHz to 200 MHz	1.75 V from 100 MHz to 200 MHz
	Trigger Frequency Readout typically stabilizes at 50% more signal than generates a stable visual display.			

Table 1-3: Triggering system (cont.)

Characteristic	Description	
Sensitivity, Edge-Type Trigger, non-DC Coupled, typical	Trigger Source	Sensitivity
	AC	Same as DC Coupled limits for frequencies 50 Hz and above
	Noise Rej	Effective in Sample or Average Mode, > 10 mV/div to 5 V/div. Reduces DC Coupled trigger sensitivity by 2X.
	HF Rej	Same as DC Coupled limits from DC to 7 kHz.
	LF Ref	Same as DC Coupled limits for frequencies above 300 kHz.
	Since AC coupling is not done in the front end, use of a 10M probe does not affect the low frequency corner.	
Lowest Frequency for Successful Operation of "Set Level to 50%" Function, typical	50 Hz.	
	Using a 10M probe will not affect the operation of this function.	
Trigger Level Ranges, typical	*Input Channel*	*±8 divisions from center screen*
	Ext	±1.6 V
	Ext/5:	±8 V
	The settable resolution for Trigger Level is 0.02 division for an input channel source, 4 mV for Ext source, and 20 mV for Ext/5 source.	
Trigger Level Accuracy, DC Coupled, typical	*This is the amount of deviation allowed between the level on the waveform at which triggering occurs and the level selected for DC-coupled triggering signals*	
	±(0.2 div + 5 mV) for signals within ±4 divisions from the center screen, having rise and fall times of ≥ 20 ns.	
	Ext: ±(6% of setting + 40 mV) for signals less than ±800 mV	
	Ext/5: ±(6% of setting + 200 mV) for signals less than ±4 V	
Video Trigger		
Default Settings for Video Trigger	Trigger Mode: Auto	
	Trigger Coupling: AC	
Video Trigger Source Selection	Same as Trigger Source Selections listed above except Line Trigger. Line Trigger source is meaningless in this mode.	
Video Trigger Polarity Selection	Normal (Negative going Sync Signal), Invert (Positive going Sync Signal)	
Video Sync Selection	Line, Line #, Odd Field, Even Field, Field: PAL/SECAM, NTSC formats	
Video Trigger Formats and Field Rates	Field rates: 50 Hz to 60 Hz.	
	Line rates: 15 kHz to 20 kHz (NTSC, PAL, SECAM)	

Table 1-3: Triggering system (cont.)

Characteristic	Description	
Video Trigger Sensitivity, typical	*This is the minimum peak–to–peak video signal required for stable Video-Type triggering.*	
	Source	*Typical sensitivity*
	Input Channels	2 divisions of composite video
	Ext	400 mV of composite video
	Ext/5	2 V of composite video
Pulse-Width Trigger		
Pulse-Width Trigger Modes	< (Less than), > (Greater than), = (Equal), ≠ (Not equal)	
Pulse Width Trigger Edge	Falling edge for positive polarity pulse. Rising edge for negative polarity pulse.	
Pulse Width Range	33 ns ≤ width ≤ 10 seconds	
Pulse Width Resolution	16.5 ns or 1 part per thousand, whichever is larger	
Equal Guardband	t > 330 ns: ±5% < guardband < ±(5.1% + 16.5 ns) t ≤ 330 ns: guardband = ±16.5 ns.	
	All pulses, even from the most stable sources, have some amount of jitter. To avoid disqualifying pulses that are intended to qualify but are not absolutely correct values, we provide an arbitrary guardband. Any measured pulse width within the guardband will qualify. If you are looking for pulse width differences that are smaller than the guardband width, offsetting the center should allow discriminating differences down to the guardband accuracy.	
Not Equal Guardband	330 ns < 1: ±5% ≤ guardband < ±(5.1% + 16.5 ns) 165 ns < 1 < 330 ns: guardband = -16.5 ns/+33 ns t ≤ 165 ns: guardband = ±16.5 ns	
	All pulses, even from the most stable sources, have some amount of jitter. To avoid disqualifying pulses that are intended to qualify but are not absolutely correct values, we provide an arbitrary guardband. Any measured pulse width outside the guardband will qualify. If you are looking for pulse width differences that are smaller than the guardband width, offsetting the center should allow discriminating differences down to the guardband accuracy. Not equal has slightly better ability to deal with small pulse widths than equal. The accuracy is not better.	
Pulse-Width Trigger Point	Equal: The oscilloscope triggers when the trailing edge of the pulse crosses the trigger level.	
	Not Equal: If the pulse is narrower than the specified width, the trigger point is the trailing edge. Otherwise, the oscilloscope triggers when a pulse continues longer than the time specified as the Pulse Width.	
	Less than: The trigger point is the trailing edge.	
	Greater than (also called the time out trigger): The oscilloscope triggers when a pulse continues longer than the time specified as the Pulse Width.	
Trigger Frequency Counter		
Trigger Frequency Counter	This provides the user with a higher accuracy means of identifying the frequency of trigger signals. Since averaging takes place over a longer time span, the number of stable digits is improved over the automatic measurement of the same type.	

Table 1-3: Triggering system (cont.)

Frequency Counter Resolution	6 digits
Frequency Counter Accuracy, typical	±51 ppm including all reference errors and ±1 count errors.
Frequency Counter Frequency Range, typical	AC coupled. 10 Hz minimum to rated bandwidth.
Frequency Counter Signal Source	Pulse width or edge selected trigger source. Frequency counter measures selected trigger source at all times in pulse width and edge mode, including when oscilloscope acquisition is halted due to changes in run status, or acquisition of a single shot event has completed. Frequency counter does NOT measure pulses that do not qualify as legitimate trigger events. Pulse Width mode: Counts pulses of sufficient magnitude inside the 250 ms measurement window that qualify as triggerable events (for example, all narrow pulses in a PWM pulse train if set to < mode and the limit is set to a relatively small number). Edge Trigger mode: Counts all pulses of sufficient magnitude.

Display Specifications

Table 1-4: Display specifications

Characteristic	Description
Display Type	11.5 cm (width) * 8.64 cm (height), 14.3 cm diagonal (5.7”), QVGA, active TFT color liquid crystal display (LCD) with color characters/waveforms on a black background. Surface antiglare (3H) treatment.
Display Resolution	*The number of individually addressable pixels* 320 horizontal by 240 vertical pixels The video display contains both the character and waveform displays.
Brightness, typical	*The light output of the backlight.* 400 cd/m^2, typical. 320 cd/m^2 min.
Contrast Ratio and Control, typical	Available black room contrast ratio, full black to full white. 400 minimum, 500 typical.

Interfaces and Output Ports Specifications

Table 1-5: Interfaces and output ports specifications

Characteristic	Description
USB Device	USB 2.0 Full Speed device. 12 Mb/second maximum. Supports PICTBRIDGE compatibility and provides USB-TMC communications with Tektronix extensions. Standard
USB Host	USB 2.0 Full Speed host. 12 Mb/sec maximum. Supports USB Mass Storage Class. Bulk Only Subclass only. Provides full 0.5 A of 5 V. Standard
USB Host Current	Provides full 0.5 A of 5 V. Standard
GPIB Interface	GPIB access via TEK-USB-488 accessory.
Probe Compensator, Output Voltage and Frequency, typical	Output voltage: 5.0 V ±10% into 1 MΩ load.
	Frequency: 1 kHz

Data Handling Characteristics

Table 1-6: Data handling characteristics

Characteristic	Description
Retention of Front Panel Settings	Front panel settings are stored periodically in memory. The settings are not lost when the instrument is turned off or if there is a power failure.
Stored Waveforms and Multiple Front Panel Settings	Two Channel 1, Channel 2, or Math waveforms can be stored in nonvolatile waveform memory A or B. One, both, or neither of A or B waveform memories can be displayed. For the TDS20X4C, four waveforms, A, B, C, D, or Math can be stored. Ten user setups of the current instrument settings can be saved and restored from nonvolatile memory. Additional storage is available when an appropriate mass storage device is connected via USB.

Power Distribution System

Table 1-7: Power distribution system

Characteristic	Description
Power Consumption	Less than 30 W at 85 to 275 V_{AC} input.
Source Voltage	Full Range: 100 to 240 V_{ACRMS} ± 10%, Installation Category II (Covers range of 90 to 264 V_{AC}
Source Frequency	360 Hz to 440 Hz from 100 V_{AC} to 120 V_{AC}. 45 Hz to 66 Hz from 100 V_{AC} to 240 V_{AC}.
Fuse Rating	1 Amps, T rating, 250 V; IEC and UL approved.

Mechanical Characteristics

Table 1-8: Mechanical characteristics

Characteristic	Description	
Weight	Requirements that follow are nominal: 2.0 kg (4.4 lbs), stand alone instrument 2.2 kg (4.9 lbs), with accessories 3.6 kg (8 lbs), when packaged for domestic shipment	
Size	Height	158 mm (6.22 in)
	Width	326.3 mm (12.85 in)
	Depth	124.1 mm (4.88 in)
Cooling Method	Convection cooled	

Environmental Performance

Table 1-9: Environmental performance

Characteristic	Description	
Temperature	Operating	0° C to +50° C (32 °F to 122 °F), with 5° C/minute maximum gradient, noncondensing, up to 3000 m altitude
	Nonoperating	-40° C to +71° C (-40 °F to 159.8 °F), with 5° C/minute maximum gradient
Humidity	Operating	5% to 85% relative humidity (% RH) at up to +40° C 5% to 45% RH above +40° C up to +50° C, noncondensing, and as limited by a Maximum Wet-Bulb Temperature of +37° C (derates relative humidity to 45 % RH at +50° C)
	Nonoperating	5% to 85% relative humidity (% RH) at up to +40° C 5% to 45% RH above +40° C up to +50° C, noncondensing. Above +50° C limited by a Maximum Wet-Bulb Temperature of +37° C (derates relative humidity to 12% RH at +71° C)
Altitude	Operating	Up to 3000 meters (10,000 feet)
	Nonoperating	Up to 3000 meters (10,000 feet). Altitude is limited by possible damage to the LCD at higher altitudes. This damage is independent of operation

Data Logging System Characteristics

NOTE. *This software feature directs the oscilloscope to automatically collect data over a period of time. After you configure the trigger conditions to use, you can use the data logging menu to set up the oscilloscope so that it will save all of the triggered waveform to a USB memory device, within a time duration that you have set.*

Table 1-10: Data logging system characteristics

Characteristic	Description
Duration	The time period. 30 min, 1 hour, 1.5 hour, 2 hour, 2.5 hour, 3 hour, 3.5 hour, 4 hour, 4.5 hour, 5 hour, 5.5 hour, 6 hour, 6.5 hour, 7 hour, 7.5 hour, 8 hour.
Source	The signal source which you want to save the waveform. Channel 1, Channel 2, Channel 3, Channel 4, Math
Select Folder	The file folder where you save the waveform data. You can create the new folder or change the existing folder as the folder where you want to save the waveform data.

Limit Testing System Characteristics

NOTE. *This software feature directs the oscilloscope to monitor an active input signal against a template and to output pass or fail results by judging whether the input signal is within the bounds of the template.*

Table 1-11: Limit testing system characteristics

Characteristic	Description
Source	*The signal source which you want to do the limit testing.* Channel 1, Channel 2, Channel 3, Channel 4, Math
Compare Ref Channel	*The reference channel # where the template is saved.* RefA, RefB, RefC, RefD. The limit testing system will compare the source signal with this template.
Run/Stop	*To enable or disable the limit testing function.* Run, Stop.
Template Setup	You can use this menu item to set up a limit test waveform template. The template is the mask signal that you define as the boundary to compare with the input source signal. You can create the template from internal or external waveforms with specific horizontal and vertical tolerances.
Source	*The location of the signal source that is used to create the limit test template.* Channel 1, Channel 2, Channel 3, Channel 4, Math

Table 1-11: Limit testing system characteristics (cont.)

Characteristic	Description
Vertical Limit	*The vertical limit in vertical divisions.* 0~1000 mdiv
Horizontal Limit	*The horizontal limit in horizontal divisions.* 0~500 mdiv.
Destination Ref Channel	*The location of the reference memory location that is used to store the limit test template.* RefA, RefB, RefC, RefD.
Display Template	*Displays or does not display a stored test template.* On, Off.
Action on Violation	*Defines the actions the oscilloscope will take after a violation is detected.* Save Image: The oscilloscope will automatically save a screen image when a violation is detected. Save Waveform: The oscilloscope will automatically save a digital copy of the source waveform when a violation is detected.
Stop After	*Defines the conditions that will cause the oscilloscope to end limit testing.* Manual: Lets you stop the test by toggling the “Run/stop” choice. Waveforms: Lets you set the numbers of waveforms to test before stopping limit testing. Violations: Lets you set the numbers of violations to detect before stopping limit testing. Elapsed time: Lets you set the elapsed test time in seconds to pass before stopping limit testing.

Where to Find Operating Information

Where to Find Operating Information

For information on installing and operating your TDS2000C Series Digital Storage Oscilloscope, refer to the *TDS2000C Series Digital Storage Oscilloscope User Manual*. The user manuals are available in eleven languages and are on the Web at www.tektronix.com.

Theory of Operation

Theory of Operation

This section covers the electrical operation of the TDS2000C series oscilloscopes to the module level by describing the basic operation of each functional circuit block.

NOTE. *The descriptions for the 2-channel and 4-channel models are slightly different.*

System Level Block Diagrams

Two high-level block diagrams are provided, one for 2-channel models and one for 4-channel models. (See Figure 3-1 on page 3-2.) (See Figure 3-2 on page 3-3.)

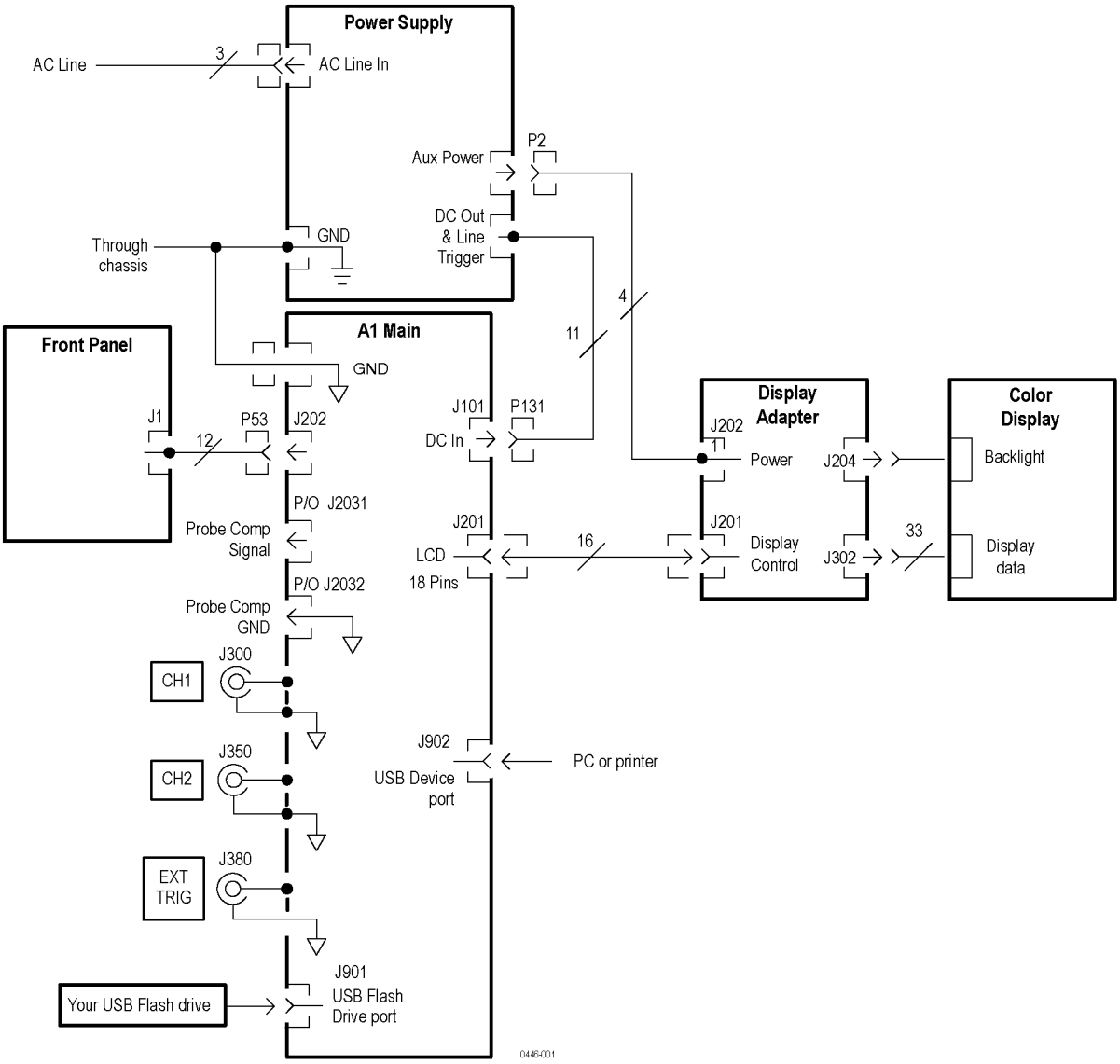


Figure 3-1: Module-level block diagram (2-channel)

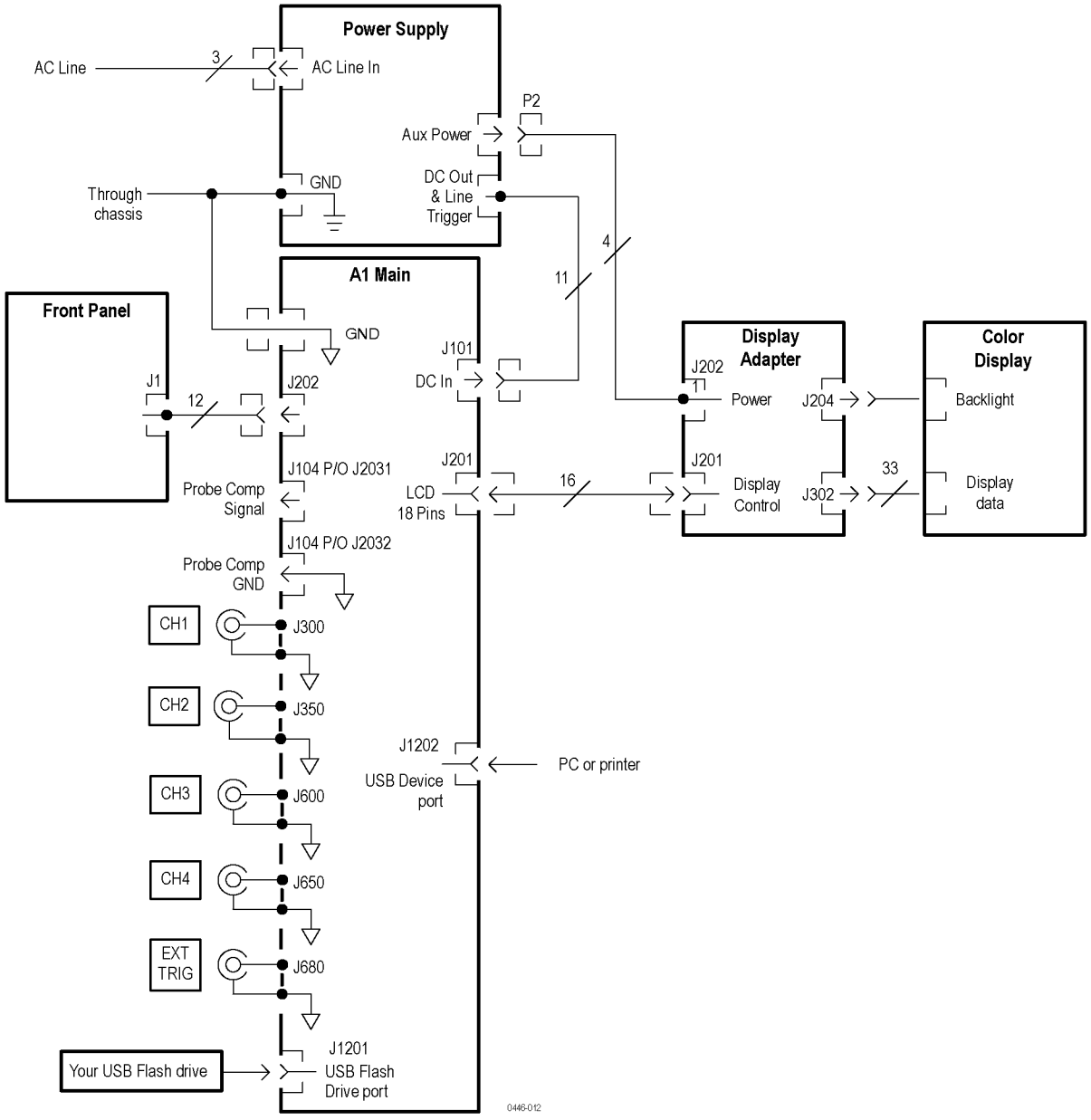


Figure 3-2: Module-level block diagram (4-channel)

Main Board

The Main board is also called the acquisition board. The Main board of the 4-channel oscilloscopes is essentially two 2-channel oscilloscopes tied together through a common microprocessor, and some special interconnects to support combining the display and trigger systems. The focus of the Main board discussion is the 2-channel system, with differences for the 4-channel models noted as necessary.

At a minimum, the Main board contains attenuators, an amplifier ASIC, a digitizer/trigger system ASIC, a signal processing/display/system services ASIC, RAM, flash PROM, a system microprocessor, USB controller, USB RAM, system communication RAM, and special power supplies. For a 4-channel oscilloscope, the attenuators are duplicated. Most of the other aspects of the circuitry remain unchanged.

Acquisition System

Signals from the channel **1** and channel **2** and other input connectors pass through attenuators and an AC-coupling switch to the amplifier ASIC. The Ext Trig input has an abbreviated version of this path, lacking some of the attenuator settings and the AC coupling switch.

The amplifier ASIC contains buffers and variable gain amplifiers, as well as filters that provide 20 MHz bandwidth limiting. The task of the amplifier ASIC is to convert from a 1 MΩ single-ended environment in the front end to a much lower impedance differential (and thus less noise-sensitive) environment for the acquisition process. The amplifier ASIC assures that the input signal is amplified to a level that will allow the fullest possible use of the digitizer.

The acquisition ASIC contains samplers and peak detectors for each input channel, a common amplifier, an A/D converter, and the trigger logic. The digitized waveform samples are transferred to the processing and display ASIC. In 4-channel systems, the two acquisition ASICs are interconnected so that a trigger on one ASIC can cause a trigger on the other.

The processor system adds the microprocessor and flash PROM to the processing and display system. The processor system interprets the front-panel control changes detected by the display ASIC, provides control parameters based on user setting requests, computes waveform measurements, and manages the USB interfaces via the dedicated USB controller. Saved setups, waveforms, and calibration constants are stored in nonvolatile memory sections within the flash PROM. The processor system shares DRAM with the display system.

Processing and Display System

The processing and display system consists of the display ASIC, DRAM, and system oscillator. Digitized acquisition samples are received by the display ASIC and stored in DRAM. Once data are received by the display ASIC, various corrections are applied, display rasterization is performed, and the waveform is placed in a display buffer. At the same time, the waveform is read from the display buffers and written to the LCD. Additional circuitry in the display ASIC supports scanning the front panel, handling DRAM refresh, providing the processor clock, and performing various memory mapping tasks required by all elementary microprocessor based systems. In a 4-channel system, the two display ASICs are interconnected so that one ASIC can provide display information for the second.

The processing and display system handles some of the computational tasks. Other tasks are performed by the processor system. Since all array processing is performed in the processing and display system, no computations can be performed that involve data from two different channel sets. Thus, subtracting channel 3 data from channel 2 is prohibited. Channel 1 and Channel 2 data may be combined in all of the supported ways.

Input Signal Interface

BNC connectors are mounted on the Main board for all signal inputs. The signal inputs are compatible with the supplied TPP0101 and TPP0201 probes.

Probe Compensation

The Probe Comp and ground terminals are provided for probe adjustment.

External Trigger

The Ext Trig channel is processed on the chain containing the highest numbered normal input channel.

Main Board Power

To support various functions on the Main board, several secondary power supplies are generated. For the amplifier and acquisition ASICs, the Main board creates a +2.5 V and -2.5 V supply. The +2.5 V supply is derived from the +3.3 V logic supply. The -2.5 V supply is derived from the -4 V supply. One three-terminal regulator provides +5 V for internal uses. A second three-terminal regulator provides USB power to preclude USB faults from seriously disrupting operation of the oscilloscope.

An additional power supply provides the LCD bias voltage, which ranges from +19 to +28 V, depending on contrast setting and display type. This +28 V supply has a temperature sensor on the Front-Panel board that varies the output voltage of the supply to maintain contrast over a wide temperature range.

Power Supply

The main power supply module for the TDS2000C series oscilloscopes is a wide input range universal supply. It can provide about 25 W of power for the oscilloscope, while allowing the input to run from about 90 V to 264 V. Input frequency ranges from 47 Hz to 440 Hz, which allows operation in virtually all countries in the world and in several off-grid environments, such as power on military aircraft.

The secondary supplies from the power supply and the approximate current draws are listed in a table with the associated connector pins on J101. (See Table 6-5.)

The P2 connector uses 4 positions and 3 wires, which are +6 V, +3.3 V, and GND.

For information on voltages used in the oscilloscope, refer to the *Troubleshooting* section of this manual.

Display Module

The color display module is a standard passive liquid crystal display (LCD). The unit is patterned with 320 columns x 3 sub-columns by 240 rows and has the associated drivers and backlight. The LED backlight output is about 75 mA at 15.5 V.

Front Panel

Two-Channel Oscilloscopes

You can manipulate all of the switches, and position encoders on the Front-Panel board of 2-channel oscilloscopes. Several LEDs are used to indicate when the Multipurpose knob is active, when Autorange is active, and when a Save action is in progress. For more information on the LEDs, refer to the User Manual for your oscilloscope.

An IC on the Front-Panel board provides buffering and multiplexing of switch signals to the Main board. Two signals and a sense line are provided by the Main board to support the front panel. One of these lines resets the scan; a second line clocks the scan to the next position; and the sense line receives the current state of the selected switch or encoder position.

For the encoders, some amount of debouncing occurs inside the front-panel IC. All key debouncing is handled in the display ASIC on the Main board.

The LEDs are controlled by latching the value of the Channel 1 - 2 front-panel scan counter when the appropriate scan value is set.

Four-Channel Oscilloscopes

The Front-Panel board of the 4-channel units is effectively two panels in parallel. The left side of the board is largely handled by the display ASIC for channels 1 and 2. The right side of the board is handled by the channel 3 and 4 ASIC. Separate front-panel ICs support these data paths.

Performance Verification

Performance Verification

This chapter contains performance verification procedures for the specifications marked with the check mark. The following equipment, or a suitable equivalent, is required to complete these procedures.

Required Equipment

Table 4-1: Performance verification

Description	Minimum requirements	Examples
DC Voltage Source	17.5 mV to 7 V, ±0.5% accuracy	Wavetek 9100 Universal Calibration System with Oscilloscope Calibration Module (Option 250) Fluke 5500A Multi-product Calibrator with Oscilloscope Calibration Option (Option 5500A-SC)
Leveled Sine Wave Generator	50 kHz and 200 MHz, ±3% amplitude accuracy	
Time Mark Generator	10 ms period, ±10 ppm accuracy	
50Ω BNC Cable	BNC male to BNC male, ≈ 1 m (36 in) long	Tektronix part number 012-0482-XX
50Ω BNC Cable	BNC male to BNC male, ≈ 25 cm (10 in) long	Tektronix part number 012-0208-XX
50Ω Feedthrough Termination	BNC male and female connectors	Tektronix part number 011-0049-XX
Dual Banana to BNC Adapter	Banana plugs to BNC female	Tektronix part number 103-0090-XX
BNC T Adapter	BNC male to dual BNC female connectors	Tektronix part number 103-0030-XX
Splitter, Power	Frequency range: DC to 4 GHz. Tracking: >2.0%	Tektronix part number 015-0565-XX
Adapter (four required)	Male N-to-female BNC	Tektronix part number 103-045-XX
Adapter	Female N-to-male BNC	Tektronix part number 103-0058-XX
Leads, 3 Black	Stacking Banana Plug Patch Cord, ≈ 45 cm (18 in) long	Pomona #B-18-0
Leads, 2 Red	Stacking Banana Plug Patch Cord, ≈ 45 cm (18 in) long	Pomona #B-18-2

Test Record

Table 4-2: Test record

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

Instrument performance test	Minimum	Incoming	Outgoing	Maximum
Channel 1 DC Gain Accuracy	5 mV/div	33.6 mV		36.4 mV
	200 mV/div	1.358 V		1.442 V
	2 V/div	13.58 V		14.42 V
Channel 2 DC Gain Accuracy	5 mV/div	33.6 mV		36.4 mV
	200 mV/div	1.358 V		1.442 V
	2 V/div	13.58 V		14.42 V
Channel 3 DC Gain Accuracy [1]	5 mV/div	33.6 mV		36.4 mV
	200 mV/div	1.358 V		1.442 V
	2 V/div	13.58 V		14.42 V
Channel 4 DC Gain Accuracy [1]	5 mV/div	33.6 mV		36.4 mV
	200 mV/div	1.358 V		1.442 V
	2 V/div	13.58 V		14.42 V
Channel 1 Bandwidth		2.12 V		— [2]
Channel 2 Bandwidth		2.12 V		— [2]
Channel 3 Bandwidth [1]		2.12 V		— [2]
Channel 4 Bandwidth [1]		2.12 V		— [2]
Sample Rate and Delay Time Accuracy		-2 divs		+2 divs
Channel 1 Edge Trigger Sensitivity		Stable trigger		— [3]
Channel 2 Edge Trigger Sensitivity		Stable trigger		— [3]
Channel 3 Edge Trigger Sensitivity [1]		Stable trigger		— [3]
Channel 4 Edge Trigger Sensitivity [1]		Stable trigger		— [3]
External Edge Trigger Sensitivity		Stable trigger		— [3]
Channel 1 Vertical Position Accuracy, Minimum margin		0		—
Channel 2 Vertical Position Accuracy, Minimum margin		0		—
Channel 3 Vertical Position Accuracy [1], Minimum margin		0		—
Channel 4 Vertical Position Accuracy [1], Minimum margin		0		—

[1] Channels 3 and 4 are only available on four channel oscilloscopes.

[2] The bandwidth test does not have a high limit.

[3] The limits vary by model. Check the procedure for the correct limits.

Performance Verification Procedures

Before beginning these procedures, two conditions must be met:

- The oscilloscope must have been operating continuously for twenty minutes within the operating temperature range specified in the Environmental Performance table. (See Table 1-9.)
- You must perform the Self Calibration operation described below. If the ambient temperature changes by more than 5 °C, you must perform the Self Calibration operation again.

The time required to complete the entire procedure is approximately one hour.

WARNING. *Some procedures use hazardous voltages. To prevent electrical shock, always set voltage source outputs to 0 V before making or changing any interconnections.*

Self Test

This internal procedure is automatically performed every time the oscilloscope is powered on. No test equipment or hookups are required. Verify that no error messages are displayed before continuing with this procedure.

Self Calibration

The self calibration routine lets you quickly optimize the oscilloscope signal path for maximum measurement accuracy. You can run the routine at any time, but you should always run the routine if the ambient temperature changes by 5 °C or more.

1. Disconnect all probes and cables from the channel input connectors (channels **1**, **2**, **3**, **4**).
2. Push the **Utility** button and select the **Do Self Cal** option to start the routine. The routine takes approximately one minute to complete.
3. Verify that self calibration passed.

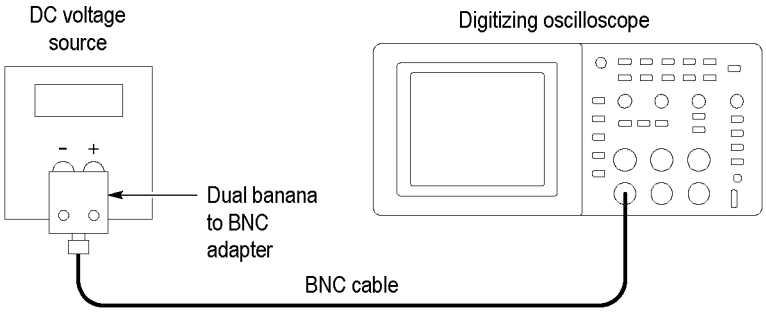
Check DC Gain Accuracy

This test checks the DC gain accuracy of all input channels.

1. Set the DC voltage source output level to **0 V**.
2. Set up the oscilloscope using the following table:

Push menu button	Select menu option	Select setting
Default Setup	—	—
Channel **1**	Probe	1X
Acquire	Average	16
Measure	Source	Channel under test
	Type	Mean

3. Connect the oscilloscope channel under test to the DC voltage source as shown in the following figure:



4. For each vertical scale (volts/division) setting in the following table, perform the following steps:

   a. Set the DC voltage source output level to the positive voltage listed and then record the mean measurement as V_{pos}.

   b. Reverse the polarity of the DC voltage source and record the mean measurement as V_{neg}.

   c. Calculate $V_{diff} = V_{pos} - V_{neg}$ and compare V_{diff} to the accuracy limits in the following table:

Vertical Scale (volts/div) setting	DC voltage source output levels	Accuracy limits for V_{diff}
5 mV/div	+17.5 mV, -17.5 mV	33.6 mV to 36.4 mV
200 mV/div	+700 mV, -700 mV	1.358 V to 1.442 V
2 V/div	+7.00 V, -7.00 V	13.58 V to 14.42 V

5. Set DC voltage source output level to **0 V**.

6. Disconnect the test setup.

7. Repeat steps 1 through 6 for all input channels.

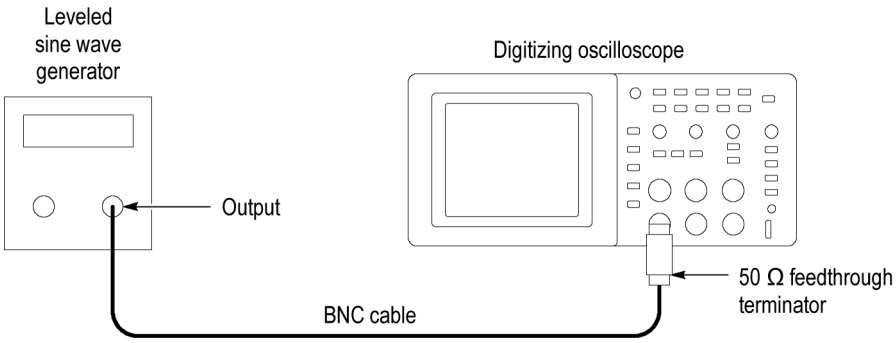
Check Bandwidth

This test checks the bandwidth of all input channels.

1. Set up the oscilloscope using the following table:

Push menu button	Select menu option	Select setting
Default Setup	—	—
Channel **1**	Probe	1X
Acquire	Average	16
Trig Menu	Coupling	Noise Reject
Measure	Source	Channel under test
	Type	Pk-Pk

2. Connect the oscilloscope channel under test to the leveled sine wave generator as shown in the following figure:



3. Set the oscilloscope **Vertical Scale** (volts/division) to **500 mV/div**.
4. Set the oscilloscope **Horizontal Scale** (seconds/division) to **10 ms/div**.
5. Set the leveled sine wave generator frequency to **50 kHz**.
6. Set the leveled sine wave generator output level so the peak-to-peak measurement is between **2.98 V** and **3.02 V**.
7. Set the leveled sine wave generator frequency to:
   - **50 MHz** if you are checking a TDS2001C
   - **70 MHz** if you are checking a TDS2002C or TDS2004B
   - **100 MHz** if you are checking a TDS2012C or TDS2014C
   - **200 MHz** if you are checking a TDS2022C or TDS2024C
8. Set the oscilloscope **Horizontal Scale** (seconds/division) to **10 ns/div**.
9. Check that the peak-to-peak measurement is ≥ **2.12 V**.
10. Disconnect the test setup.
11. Repeat steps 1 through 10 for all input channels.

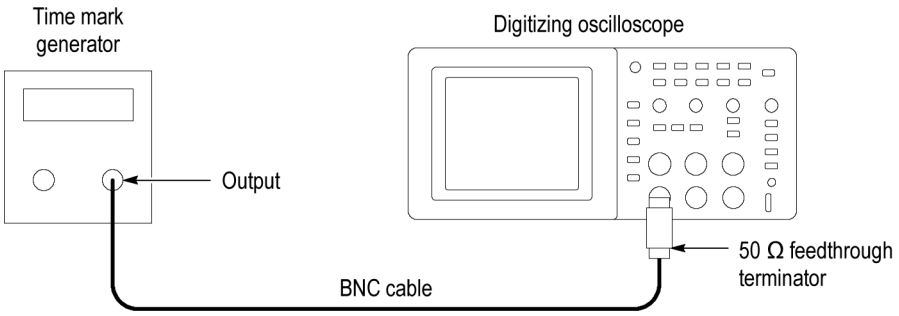
Check Sample Rate Accuracy and Delay Time Accuracy

This test checks the time base accuracy.

1. Set up the oscilloscope using the following table:

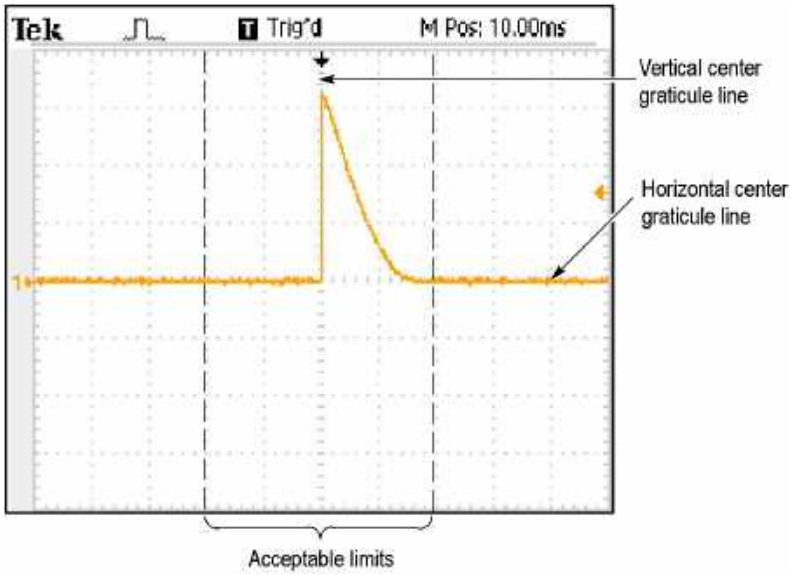
Push menu button	Select menu option	Select setting
Default Setup	—	—
Channel **1**	Probe	1X

2. Connect the oscilloscope to the time mark generator as shown in the following figure:



3. Set the time mark generator period to **10 ms**.
4. Set the oscilloscope **Vertical Scale** (volts/division) to **500 mV/div**.
5. Set the oscilloscope Main **Horizontal Scale** (seconds/division) to **1 ms/div**.
6. Push **Set To 50%**.
7. Use the **Vertical Position** control to center the test signal on screen.
8. Use the **Horizontal Position** control to set the position to **10.00 ms**.
9. Set the oscilloscope **Horizontal Scale** (seconds/division) to **250 ns/div**.

10. Check that the rising edge of the marker crosses the center horizontal graticule line within ±2 divisions of the vertical center graticule line, as shown in the following figure:



NOTE. *One division of displacement from graticule center corresponds to a 25 ppm time base error.*

11. Disconnect the test setup.

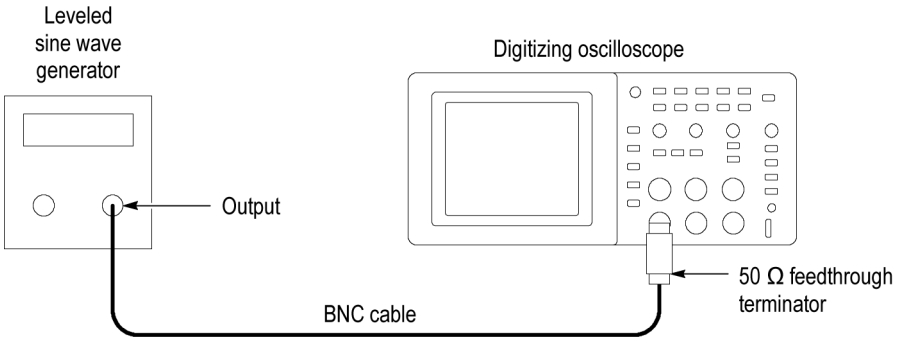
Check Edge Trigger Sensitivity

This test checks the edge trigger sensitivity for all input channels.

1. Set up the oscilloscope using the following table:

Push menu button	Select menu option	Select setting
Default Setup	—	—
Channel **1**	Probe	1X
Trig Menu	Mode	Normal
Acquire	Sample	—
Measure	Source	Channel under test
	Type	Pk-Pk

2. Connect the oscilloscope channel under test to the leveled sine wave generator as shown in the following figure:



3. Set the oscilloscope **Vertical Scale** (volts/division) to **500 mV/div**.
4. Set the oscilloscope **Horizontal Scale** (seconds/division) to **25 ns/div**.
5. Set the leveled sine wave generator frequency to **10 MHz**.
6. Set the leveled sine wave generator output level to approximately **500 mV_{p-p}** so that the measured amplitude is approximately **500 mV**. (The measured amplitude can fluctuate around 500 mV.)
7. Push **Set To 50%**. Adjust **Trigger Level** as necessary and then check that triggering is stable.
8. Set the leveled sine wave generator frequency to:
   - **50 MHz** if you are checking a TDS2001C
   - **70 MHz** if you are checking a TDS2002C, or TDS2004C
   - **100 MHz** if you are checking a TDS2012C, TDS2014C, TDS2022C, or TDS2024C
9. Set the oscilloscope **Horizontal Scale** (seconds/division) to **5 ns/div**.
10. Set the leveled sine wave generator output level to approximately **750 mV_{p-p}** so that the measured amplitude is approximately **750 mV**. (The measured amplitude can fluctuate around 750 mV.)
11. Push **Set To 50%**. Adjust **Trigger Level** as necessary and then check that triggering is stable.
12. For the TDS2022C and TDS2024C models, set the frequency to 200 MHz, and increase the amplitude to 1 V_{p-p}. Verify stable triggering.
13. Set the oscilloscope **Horizontal Scale** (seconds/division) to **2.5 ns/div**.
14. Change the oscilloscope setup using the following table:

Push menu button	Select menu option	Select setting
Trig Menu	Slope	Falling

15. Push **Set To 50%**. Adjust **Trigger Level** as necessary and then check that triggering is stable.
16. Disconnect the test setup.
17. Repeat steps 1 through 16 for all input channels.

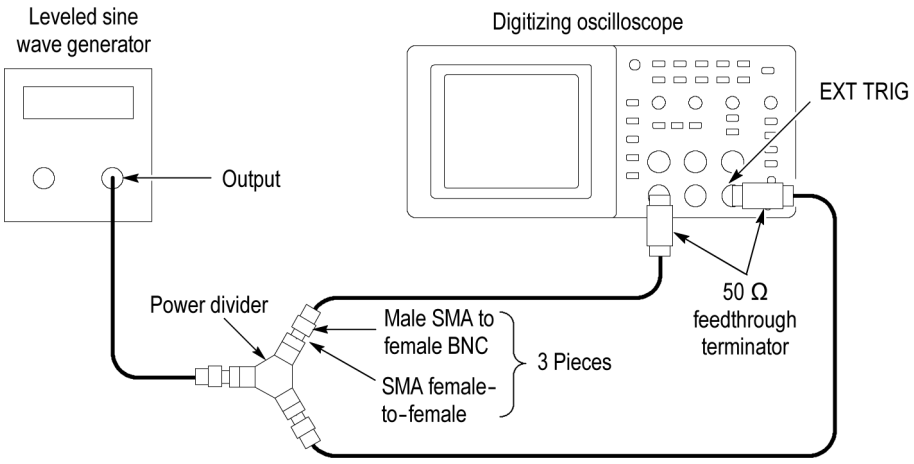
Check External Edge Trigger Sensitivity

This test checks the edge trigger sensitivity for the external trigger.

1. Set up the oscilloscope using the following table:

Push menu button	Select menu option	Select setting
Default Setup	—	—
Channel **1**	Probe	1X
Trig Menu	Source	Ext
	Mode	Normal
Acquire	Sample	—
Measure	Source	CH1
	Type	Pk-Pk

2. Connect the oscilloscope to the leveled sine wave generator as shown in the following figure, using channel **1** and **Ext Trig**.



3. Set the oscilloscope **Vertical Scale** (volts/division) to **100 mV/div**.
4. Set the oscilloscope **Horizontal Scale** (seconds/division) to **25 ns/div**.
5. Set the leveled sine wave generator frequency to **10 MHz**.
6. Set the sine wave generator output level to approximately **300 mV_{p-p}** into the power splitter. This is about **200 mV_{p-p}** on channel **1** of the oscilloscope.

   The **Ext Trig** input will also be receiving approximately 200 mV_{p-p}. Small deviations from the nominal 200 mV_{p-p} oscilloscope display are acceptable.

7. Set the leveled sine wave generator frequency to:
   - **50 MHz** if you are checking a TDS2001C
   - **70 MHz** if you are checking a TDS2002C, or TDS2004C
   - **100 MHz** if you are checking a TDS2012C, TDS2014C, TDS2022C, or TDS2024C
8. Set the oscilloscope **Horizontal Scale** (seconds/division) to **5 ns/div**.
9. Push **Set To 50%**. Adjust **Trigger Level** as necessary and then check that triggering is stable.
10. For TDS2022C and TDS2024C models, set the sine wave generator output level for a channel **1** display to approximately **350 mV_{p-p}**.
11. For TDS2022C and TDS2024C models, set the sine wave generator frequency to **200 MHz**.
12. Set the oscilloscope **Horizontal Scale** (seconds/division) to **2.5 ns/div**.
13. Push **Set To 50%**. Adjust **Trigger Level** as necessary and then check that triggering is stable.
14. Change the oscilloscope setup using the following table:

Push menu button	Select menu option	Select setting
Trig Menu	Slope	Falling

15. Push **Set To 50%**. Adjust **Trigger Level** as necessary and then check that triggering is stable.
16. Disconnect the test setup.

Check Vertical Position Accuracy

The results of this test and the DC Gain Accuracy test together define the DC Measurement Accuracy of the oscilloscope. The DC Measurement Accuracy specification encompasses two different ranges of operation over two different attenuator settings.

- DC Gain Accuracy: Identifies errors, mostly from the A/D converter, when the vertical position (known as offset in these oscilloscopes) is set to 0 divisions (or a grounded input will show screen center)
- Vertical Position Accuracy: Identifies errors, mostly from the position control, made when the vertical position is set to a non-zero value

The two attenuator settings operate identically, so verification of the attenuation range from -1.8 V to 1.8 V also verifies the attenuation range of -45 V to 45 V.

1. Set up the oscilloscope as shown in the following table:

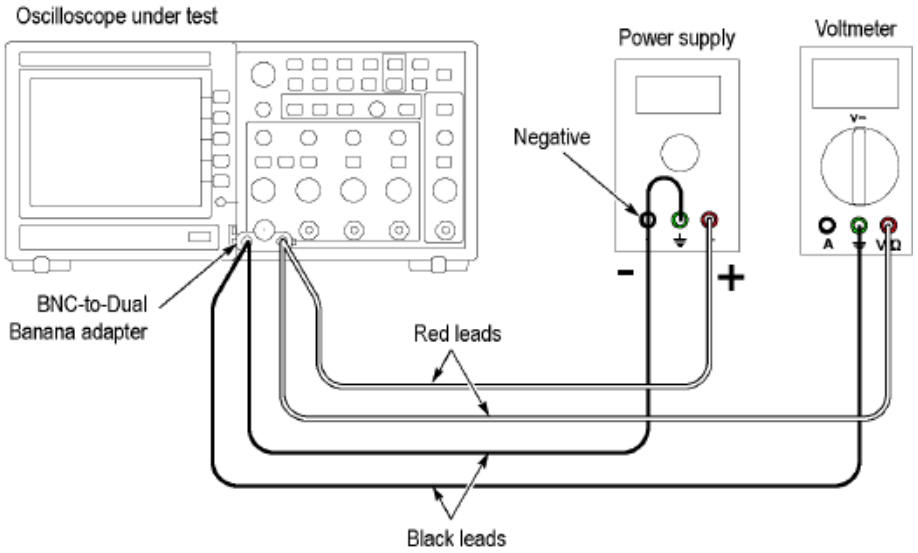
Push menu button	Select menu option	Select setting
Default Setup	—	—
Channels **1**, **2**, **3**, **4**	Probe	1X
Channels **1**, **2**, **3**, **4**	Volts/Div	50 mV/div
Trig Menu	Source	Ext [1]
	Mode	Auto
Acquire	Sample	—
Measure	Source	Channel under test
	Type	Mean

[1] The test operates without a trigger. To maintain uniformity and to avoid false triggering on noise, the Ext trigger is the recommended source.

2. Make a spreadsheet approximately as shown in the example in Appendix A. You only need to enter the values for column A and the equations. The values in columns B, C, D, E, F, and G are examples of the measured or calculated values.

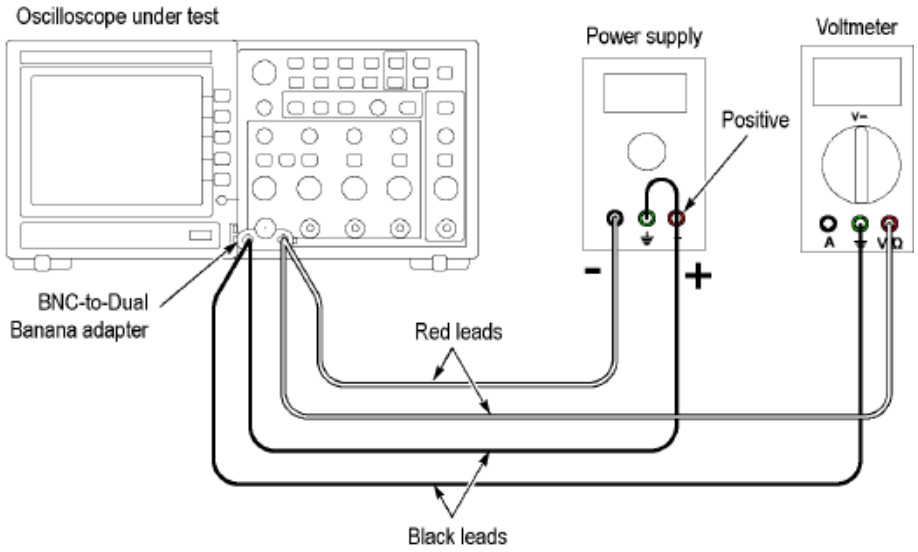
   The PDF version of the TDS2000C service manual (which you can download from the www.tektronix.com Web site), includes an empty spreadsheet for your convenience. To access and save the test spreadsheet, see the instructions in *Appendix A: Example of a Vertical Position Accuracy Test Spreadsheet* on page A-1.

3. Connect the oscilloscope, power supply, and voltmeter as shown in the following figure:



4. Set the power supply to the 1.8 V value shown in column A, the Approximate Test Voltage.

5. Adjust the vertical position knob for the DC line to position the line in the center of the screen.
6. Enter the voltage on the voltmeter and on the oscilloscope into the spreadsheet in the appropriate columns, B and C.
7. Repeat steps 4 through 6 for the values of 1.76 V through 0 V.
8. Swap the connections to the positive terminal of the power supply with those at the negative terminal as shown in the following figure:



9. Repeat steps 4 through 6 for the values of -0.04 V through -1.8 V.
10. Enter the Minimum Margin number (cell I16) for the channel tested in the test record.
11. Repeat steps 1 through 10 for all input channels.

Data verification. To verify data, set the spreadsheet to present a line graph of columns D, E, and F. Verify that no error values (the blue line in the center) go above the yellow line (upper line), or below the purple line (lower line). For calculations involved in this example, refer to the data in the previous table (see step 1).

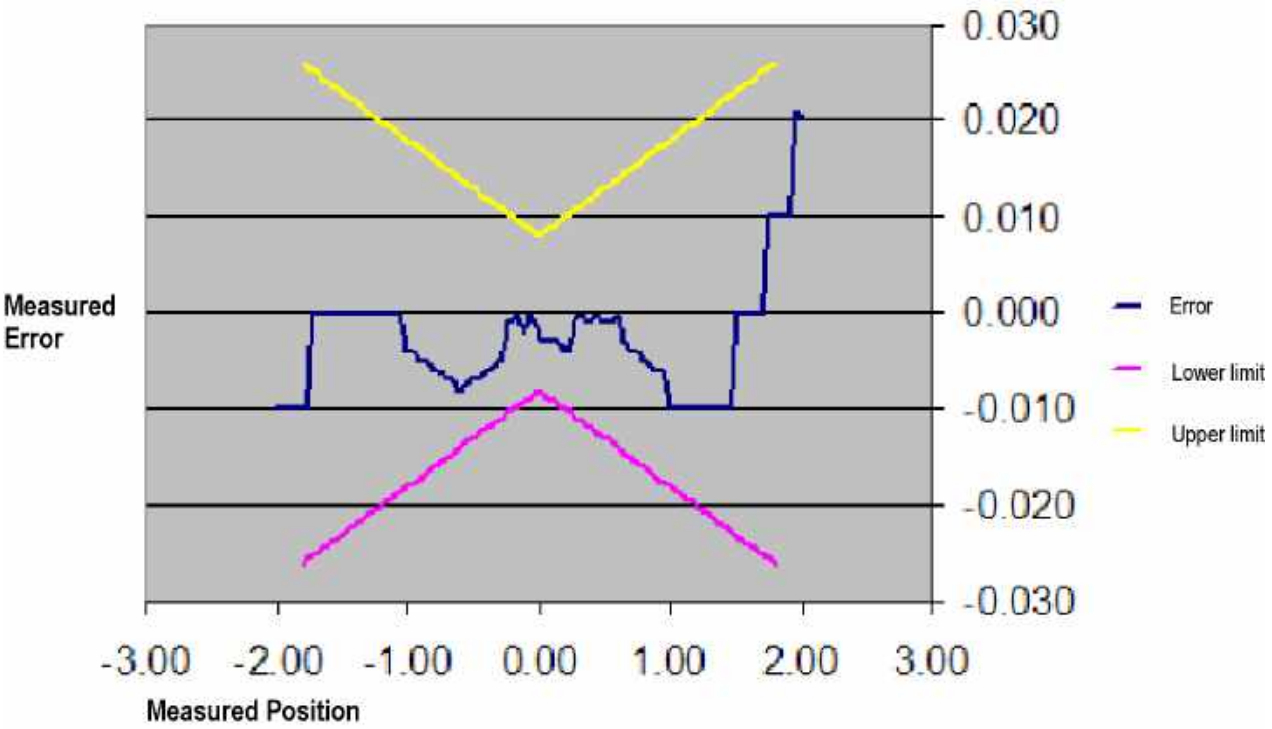


Figure 4-1: Example of a line graph for the Vertical Position Accuracy test

Adjustment Procedures

Adjustment Procedures

This chapter contains adjustment procedures for the TDS2000C series oscilloscopes.

Only qualified personnel should perform service procedures. Read the *Service Safety Summary* and the *General Safety Summary* at the beginning of this manual before performing any service procedures. Refer to the user manual for information about using the TDS2000C oscilloscopes.

NOTE. *The voltage references inside the TDS2000C oscilloscopes are very stable over time and do not require routine updates. Do not perform any procedure in this section unless the oscilloscope does not meet specifications. Refer to the Performance Verification section to check the oscilloscope performance to specifications.*

Required Equipment

The equipment described in the following table, or a suitable equivalent, is required to complete these procedures. (See Table 5-1.)

Table 5-1: Required equipment

Description	Minimum requirements s	Example
DC Voltage Source	-20 V to 20 V, ± 0.1% accuracy	Wavetek 9100 Universal Calibration System with Oscilloscope Calibration Module (Option 250) Fluke 5500A Multi-product Calibrator with Oscilloscope Calibration Option (Option 5500A-SC)
Leveled Sinewave Generator	5 kHz and 200 MHz, ±0.6% amplitude accuracy	
50 Ω BNC Cable	BNC male to BNC male, ≈ 1 m (36 in) long	Tektronix part number 012-0482-XX
50 Ω BNC Cable (seven)	BNC male to BNC male, ≈ 25 cm (10 in) long	Tektronix part number 012-0208-XX
50 Ω Feedthrough Termination	BNC male and female connectors	Tektronix part number 011-0049-XX
Dual Banana to BNC Adapter	Banana plugs to BNC female	Tektronix part number 103-0090-XX
BNC T (three)	One male and two female BNC connectors	Tektronix part number 103-0030-XX

Adjustment Procedure

The adjustment procedure consists of 70 steps for the 2-channel oscilloscope, and 106 steps for the 4-channel model. Each step requires an external voltage source for new calibration constants.

Before performing the adjustment procedure, warm up the oscilloscope for at least ten minutes in an ambient temperature between 20 °C and 30 °C. Adjustments performed before warm up or outside this temperature range may result in poor performance.

If all steps in the procedure are completed successfully, a "Pass" message is displayed and the new calibration constants take effect. If any step fails, the procedure is aborted and the current calibration is not affected. You can choose to abort the procedure at any step, without affecting the current calibration, by selecting FCAL ABORT.

NOTE. *While performing the adjustment procedure, keep in mind that some of the steps take a significant amount of time (up to 5 minutes) to complete.*

Equipment setups are shown in the following figure. (See Figure 5-1 on page 5-3.) Signal requirements for each step are shown in the following table. (See Table 5-2 on page 5-5.)

Enable the Service Menu

Before performing the adjustment procedure, enable the Service menu as follows:

1. Power on the oscilloscope.
2. Push the front-panel **Measure** button to access the Measure menu.
3. Push the top option button to access the Measure 1 menu.
4. Push and hold the front-panel **Single** button.
5. Push and hold the front-panel **AutoSet** button.
6. Wait at least two seconds.
7. Release the **Single** button.
8. Release the **AutoSet** button. A message appears in the lower left corner of the screen stating "Service mode ON."
9. Push the front-panel **Utility** button. The last item in the Utility menu is now "Service."

At completion of the Adjustment procedure, disable the "Service" menu through the **Utility** front panel button, the "Service" option button, and the "Service" Mode Off" option button.

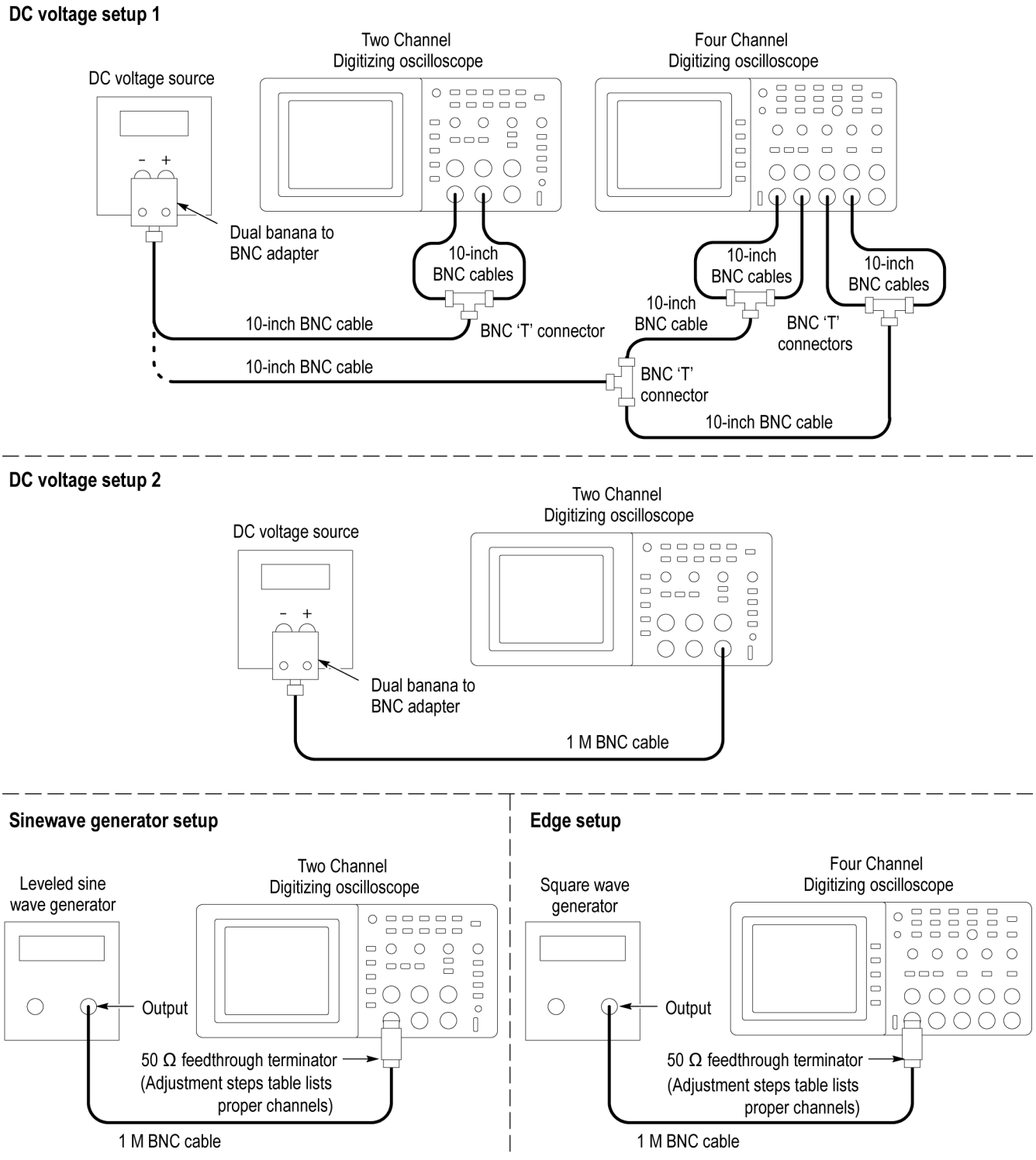


Figure 5-1: Adjustment setups

Adjustment Procedure

Use this procedure to load new calibration constants.

1. Enable the Service menu. (See page 5-2, *Enable the Service Menu.*)
2. Push the **Service** option button.
3. Push the **Factory Cal** option button.
4. Push the **Warmup Timer** option button.
5. Push the **Start Timer** option button to allow a 10-minute warm up. After 10 minutes, the oscilloscope displays a large black or green cross.
6. Press the front-panel **Utility** button and push the **Service** option button.
7. Push the **Factory Cal** option button.
8. Push the **FCAL INIT** option button to initiate the factory calibration routine. You are now in step 1 of the procedure.
9. As indicated by step 1, connect a 0.0 V_{DC} source to the channel inputs. (See Table 5-2.)
10. Press **FCAL STEP** to load the calibration constant for step 1.
11. Follow the screen prompts along with the Adjustment setup table for the remainder of the routine, applying the proper signal for each step. (See Table 5-2.)

NOTE. *During some steps, the oscilloscope may appear to be idle for several minutes while it is processing information internally. You must wait for the screen prompt to continue.*

If any step in the procedure fails, the procedure terminates. Failure will result if an incorrect signal source is connected. If this happens, you must start the procedure over from the beginning.

If the procedure completes successfully, a "Pass" message is displayed and the new adjustment takes effect.

12. Compensate the signal path by performing the self-calibration routine.
13. Disconnect all probes and cables from the channel input connectors.
14. Press the **Utility** button and select **Do Self Cal** to confirm that you are ready to proceed.
15. Disable the Service menu option by pushing the **Utility** front-panel button and the **Service** and **Service Mode Off** option buttons.

Table 5-2: Adjustment steps

Input	Setup diagram	2-ch model step number	4-ch model step number	Signal	Signal source setting
Ch 1 through Ch x	DC voltage 1	1	1	DC Voltage 1	0.0 V
		2	2	DC Voltage 1	-20.0 V
		3	3	DC Voltage 1	-2.0 V
		4	4	DC Voltage 1	-1.6 V
		5	5	DC Voltage 1	-1.2 V
		6	6	DC Voltage 1	-0.8 V
		7	7	DC Voltage 1	-0.4 V
		8	8	DC Voltage 1	-0.32 V
		9	9	DC Voltage 1	-0.2 V
		10	10	DC Voltage 1	-0.16 V
		11	11	DC Voltage 1	-0.08 V
		12	12	DC Voltage 1	-0.04 V
		13	13	DC Voltage 1	-0.03 V
		14	14	DC Voltage 1	-0.02 V
		15	15	DC Voltage 1	-0.015 V
		16	16	DC Voltage 1	0.015 V
		17	17	DC Voltage 1	0.02 V
		18	18	DC Voltage 1	0.03 V
		19	19	DC Voltage 1	0.04 V
		20	20	DC Voltage 1	0.08 V
		21	21	DC Voltage 1	0.16 V
		22	22	DC Voltage 1	0.2 V
		23	23	DC Voltage 1	0.32 V
		24	24	DC Voltage 1	0.4 V
		25	25	DC Voltage 1	0.8 V
		26	26	DC Voltage 1	1.2 V
		27	27	DC Voltage 1	1.6 V
		28	28	DC Voltage 1	2.0 V
		29	29	DC Voltage 1	20.0 V
		30	30	DC Voltage 1	0.0 V
Ext Trig	DC voltage 2	31	31	DC Voltage 2	-5.0 V
		32	32	DC Voltage 2	-1.0 V
		33	33	DC Voltage 2	1.0 V
		34	34	DC Voltage 2	5.0 V

Table 5-2: Adjustment steps (cont.)

Input	Setup diagram	2-ch model step number	4-ch model step number	Signal	Signal source setting
Ch 1	Sinewave generator	35	35	Sinewave Generator, 50 Ω	5 kHz, 1 V_{p-p}
		36	36	Sinewave Generator, 50 Ω	1 MHz, 100 mV_{p-p}
		37	37	Sinewave Generator, 50 Ω	1 MHz, 1 V_{p-p}
		38	38	Sinewave Generator, 50 Ω	50 kHz, 1 V_{p-p}
		39	39	Sinewave Generator, 50 Ω	20 MHz, 1 V_{p-p}
		40	40	Sinewave Generator, 50 Ω	BWL, 25 mV_{p-p}
		41	41	Sinewave Generator, 50 Ω	BWL, 50 mV_{p-p}
		42	42	Sinewave Generator, 50 Ω	BWL, 100 mV_{p-p}
		43	43	Sinewave Generator, 50 Ω	BWL, 250 mV_{p-p}
		44	44	Sinewave Generator, 50 Ω	BWL, 500 mV_{p-p}
		45	40	Sinewave Generator, 50 Ω	BWL, 1 V_{p-p}
		46	46	Sinewave Generator, 50 Ω	5 kHz, 2.5 V_{p-p}
		47	47	Sinewave Generator, 50 Ω	1 MHz, 2.5 V_{p-p}
		48	48	Sinewave Generator, 50 Ω	50 kHz, 2.5 V_{p-p}
		49	49	Sinewave Generator, 50 Ω	20 MHz, 2.5 V_{p-p}
		50	50	Sinewave Generator, 50 Ω	BWL, 2.5 V_{p-p}
		51	51	Sinewave Generator, 50 Ω	BWL, 5 V_{p-p}
		52	52	Sinewave Generator, 50 Ω	BWL, 1.6 V_{p-p}
	Edge	53	53	Edge, 50 Ω.	1 kHz, 0 to -800 mV

Table 5-2: Adjustment steps (cont.)

Input	Setup diagram	2-ch model step number	4-ch model step number	Signal	Signal source setting
Ch 2	Sinewave generator	54	54	Sinewave Generator, 50 Ω	5 kHz, 1 V_{p-p}
		55	55	Sinewave Generator, 50 Ω	1 MHz, 100 mV_{p-p}
		56	56	Sinewave Generator, 50 Ω	1 MHz, 1 V_{p-p}
		57	57	Sinewave Generator, 50 Ω	50 kHz, 1 V_{p-p}
		58	58	Sinewave Generator, 50 Ω	20 MHz, 1 V_{p-p}
		59	59	Sinewave Generator, 50 Ω	BWL, 25 mV_{p-p}
		60	60	Sinewave Generator, 50 Ω	BWL, 50 mV_{p-p}
		61	61	Sinewave Generator, 50 Ω	BWL, 100 mV_{p-p}
		62	62	Sinewave Generator, 50 Ω	BWL, 250 mV_{p-p}
		63	63	Sinewave Generator, 50 Ω	BWL, 500 mV_{p-p}
		64	64	Sinewave Generator, 50 Ω	BWL, 1 V_{p-p}
		65	65	Sinewave Generator, 50 Ω	5 kHz, 2.5 V_{p-p}
		66	66	Sinewave Generator, 50 Ω	1 MHz, 2.5 V_{p-p}
		67	67	Sinewave Generator, 50 Ω	50 kHz, 2.5 V_{p-p}
		68	68	Sinewave Generator, 50 Ω	20 MHz, 2.5 V_{p-p}
		69	69	Sinewave Generator, 50 Ω	BWL, 2.5 V_{p-p}
		70	70	Sinewave Generator, 50 Ω	BWL, 5 V_{p-p}

Table 5-2: Adjustment steps (cont.)

Input	Setup diagram	2-ch model step number	4-ch model step number	Signal	Signal source setting
Ch 3	Sinewave generator	NA	71	Sinewave Generator, 50 Ω	5 kHz, 1 V_{p-p}
			72	Sinewave Generator, 50 Ω	1 MHz, 100 mV_{p-p}
			73	Sinewave Generator, 50 Ω	1 MHz, 1 V_{p-p}
			74	Sinewave Generator, 50 Ω	50 kHz, 1 V_{p-p}
			75	Sinewave Generator, 50 Ω	20 MHz, 1 V_{p-p}
			76	Sinewave Generator, 50 Ω	BWL, 25 mV_{p-p}
			77	Sinewave Generator, 50 Ω	BWL, 50 mV_{p-p}
			78	Sinewave Generator, 50 Ω	BWL, 100 mV_{p-p}
			79	Sinewave Generator, 50 Ω	BWL, 250 mV_{p-p}
			80	Sinewave Generator, 50 Ω	BWL, 500 mV_{p-p}
			81	Sinewave Generator, 50 Ω	BWL, 1 V_{p-p}
			82	Sinewave Generator, 50 Ω	5 kHz, 2.5 V_{p-p}
			83	Sinewave Generator, 50 Ω	1 MHz, 2.5 V_{p-p}
			84	Sinewave Generator, 50 Ω	50 kHz, 2.5 V_{p-p}
			85	Sinewave Generator, 50 Ω	20 MHz, 2.5 V_{p-p}
			86	Sinewave Generator, 50 Ω	BWL, 2.5 V_{p-p}
			87	Sinewave Generator, 50 Ω	BWL, 5 V_{p-p}
			88	Sinewave Generator, 50 Ω	BWL, 1.6 V_{p-p}
	Edge	N/A	89	Edge, 50 Ω.	1 kHz, 0 to -800 mV

Table 5-2: Adjustment steps (cont.)

Input	Setup diagram	2-ch model step number	4-ch model step number	Signal	Signal source setting
Ch 4	Sinewave generator	NA	90	Sinewave Generator, 50 Ω	5 kHz, 1 V_{p-p}
			91	Sinewave Generator, 50 Ω	1 MHz, 100 mV_{p-p}
			92	Sinewave Generator, 50 Ω	1 MHz, 1 V_{p-p}
			93	Sinewave Generator, 50 Ω	50 kHz, 1 V_{p-p}
			94	Sinewave Generator, 50 Ω	20 MHz, 1 V_{p-p}
			95	Sinewave Generator, 50 Ω	BWL, 25 mV_{p-p}
			96	Sinewave Generator, 50 Ω	BWL, 50 mV_{p-p}
			97	Sinewave Generator, 50 Ω	BWL, 100 mV_{p-p}
			98	Sinewave Generator, 50 Ω	BWL, 250 mV_{p-p}
			99	Sinewave Generator, 50 Ω	BWL, 500 mV_{p-p}
			100	Sinewave Generator, 50 Ω	BWL, 1 V_{p-p}
			101	Sinewave Generator, 50 Ω	5 kHz, 2.5 V_{p-p}
			102	Sinewave Generator, 50 Ω	1 MHz, 2.5 V_{p-p}
			103	Sinewave Generator, 50 Ω	50 kHz, 2.5 V_{p-p}
			104	Sinewave Generator, 50 Ω	20 MHz, 2.5 V_{p-p}
			105	Sinewave Generator, 50 Ω	BWL, 2.5 V_{p-p}
			106	Sinewave Generator, 50 Ω	BWL, 5 V_{p-p}

Maintenance

This chapter contains the information needed to do periodic and corrective maintenance on the oscilloscope, as well as repackaging instructions to use if you need to return the oscilloscope to Tektronix for service.

Preventing ESD

Before servicing this product, read the *Safety Summary* and *Introduction* at the front of the manual and the electrostatic discharge (ESD) information below.

CAUTION. *Static discharge can damage any semiconductor component in this oscilloscope.*

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

- Minimize handling of static-sensitive modules.
- Transport and store static-sensitive modules in their static protected containers or on a metal rail. Label any package that contains static-sensitive modules.
- Discharge the static voltage from your body by wearing a grounded antistatic wrist strap while handling these modules.
- Service static-sensitive modules only at static-free workstations. Do not allow anything capable of generating or holding a static charge on the workstation surface.
- Handle circuit boards by the edges when possible.
- Do not slide the modules over any surface.
- Avoid handling modules in areas that have a floor or work-surface covering capable of generating a static charge.

Inspection and Cleaning

Inspection and cleaning are done as preventive maintenance. Preventive maintenance, when done regularly, can 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 you do maintenance depends on the severity of the environment in which you use the oscilloscope. A good time to perform preventive maintenance is just before adjustment of the oscilloscope.

General Care

For best performance, follow these recommendations:

- Protect the oscilloscope from adverse weather conditions. The oscilloscope is not waterproof.
- Do not store or leave the oscilloscope where the liquid crystal display (LCD) is exposed to direct sunlight or high humidity for long periods of time.
- The front and rear cases help keep dust out of the oscilloscope and must be in place during normal operation.
- To avoid damage to the oscilloscope or probes, do not expose them to any sprays, liquids, or solvents.

Interior Cleaning

Use a dry, low-velocity stream of air to clean the interior of the chassis. Use a soft-bristle, non-static-producing brush for cleaning around components. If you must use a liquid for minor interior cleaning, use a 75% isopropyl alcohol solution and rinse with deionized water.

WARNING. *To avoid injury, power off the instrument and disconnect it from line voltage before performing any procedure that follows.*

Exterior Cleaning

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.*

Clean the exterior surfaces of the chassis with a dry lint-free cloth or a soft-bristle brush. If any dirt remains, use a cloth or swab dipped in a 75% isopropyl alcohol solution. Use a swab to clean narrow spaces around controls and connectors. Do not use abrasive compounds on any part of the chassis that may damage the chassis.

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

Clean the On/Standby switch using a dampened cleaning towel. Do not spray or wet the switch directly.

If the display is very dirty, moisten the wipe with distilled water or a 75% isopropyl alcohol solution and gently rub the display surface. Avoid using excess force or you may damage the plastic display surface.

Exterior Inspection

Inspect the outside of the oscilloscope for damage, wear, and missing part. (See Table 6-1.) Immediately repair defects that could cause personal injury or lead to further damage to the oscilloscope.

Table 6-1: External inspection checklist

Item	Inspect for	Repair action
Front and rear case	Cracks, scratches, deformations, damaged hardware	Repair or 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	Repair or replace defective modules. Clear or wash out dirt.
Carrying handle, and cabinet feet	Correct operation	Repair or replace defective module
Accessories	Missing items or parts of items, bent pins, broken or frayed cables, and damaged connectors	Repair or replace damaged or missing items, frayed cables, and defective modules

Interior Inspection

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

Inspect the internal portions of the oscilloscope for damage and wear. (See Table 6-2.) Repair any defects immediately.

If any circuit board is repaired or replaced, check the table to see if it is necessary to adjust the oscilloscope. (See Table 6-2.)

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

Table 6-2: Internal inspection checklist

Item	Inspect for	Repair action
Circuit boards	Loose, broken, or corroded solder connections. Burned circuit boards. Burned, broken, or cracked circuit-run plating.	Remove and replace damaged circuit board.
Resistors	Burned, cracked, broken, blistered condition.	Remove and replace damaged circuit board.
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 and replace damaged circuit board.
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, deformations, and damaged hardware.	Straighten, repair, or replace defective hardware.

Cleaning Procedure, Interior

To clean the oscilloscope interior, perform the following 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 then wipe with a lint-free cloth dampened with warm deionized water. A cotton-tipped applicator is useful for cleaning in narrow spaces and on circuit boards.

   STOP. If, after performing steps 1 and 2, a module is clean on inspection, skip steps 3, 4, and 5. Proceed with step 6.

3. If steps 1 and 2 do not remove all the dust or dirt, all modules in the oscilloscope except the Display Module and Front Panel Module may be spray washed using a solution of 75% isopropyl alcohol.

   - During cleaning of the Acquisition board (Main board), make sure that no residue is left in the attenuators. Debris or residue can cause several problems with signal fidelity that cannot be corrected by calibration. When handling the board, avoid handling the attenuators since skin oils may cause problems.
   - Extensive cleaning of the Display Module is difficult because water must not be trapped between the display shield and the display. The polarizers integrated into the display degrade with long-term exposure to water. The display shield and display must be replaced as an assembly if significant moisture or debris become trapped inside. Cotton tipped applicators and lint-free rags moistened in isopropyl alcohol and/or deionized water offer the best cleaning with the least opportunity for damage to the assembly.
   - The Front-Panel module can be damaged by deposition of film or debris inside the knob encoders. To avoid this, be careful not to drip liquid or blow debris into the encoders.

4. Spray wash dirty parts with the 75% isopropyl alcohol solution and wait 60 seconds for the majority of the alcohol to evaporate.

5. Use hot (49 °C to 60 °C / 120 °F to 140 °F) deionized water to thoroughly rinse the parts.

6. Dry all parts with low-pressure, deionized air.

7. Dry all components and assemblies in an oven or drying compartment using low-temperature (52 °C to 66 °C / 125 °F to 150 °F) circulating air.

Lubrication. Periodic lubrication is not required for the oscilloscope.

Removal and Installation Procedures

WARNING. *Only qualified personnel should perform service procedures. Before doing this or any other procedure in this manual, read the General Safety Summary and Service Safety Summary found at the beginning of this manual. To prevent damage to electrical components, refer Preventing ESD. (See page 6-1, Preventing ESD.)*

Always disconnect the power cord before disassembling any part of the oscilloscope.

Refer to the module locator drawings to find the modules that you want to remove or install. (See Figure 6-1 on page 6-7.) (See Figure 6-2 on page 6-7.)

Refer to the *Inspection and Cleaning* procedure if you are disassembling the instrument for cleaning. (See page 6-1, *Inspection and Cleaning*.)

Refer to the *Replaceable Parts List* for a list of all replaceable modules and their part numbers.

Refer to the *Exploded View Diagrams* for each procedure, as indicated in the table.

Summary of Procedures

Complete disassembly is best achieved by following the procedures in the order given in the following table:

Procedure	Begins on page
Rear Feet	(See page 6-8, *Rear Feet*.)
Flip Feet	(See page 6-9, *Flip Feet*.)
Front-Panel Knobs	(See page 6-9, *Front-Panel Knobs*.)
Rear Case	(See page 6-10, *Rear Case*.)
Front Feet	(See page 6-11, *Front Feet*.)
Power Supply Module	(See page 6-12, *Power Supply Module*.)
Internal Assembly	(See page 6-13, *Internal Assembly*.)
Display Adapter Module	(See page 6-14, *Display Adapter Module*.)
Front-Panel Cable	(See page 6-17, *Front-Panel Cable*.)
Main Board Module	(See page 6-18, *Main Board Module*.)
Display Module	(See page 6-20, *Display Module*.)
Front-Panel Module	(See page 6-21, *Front-Panel Module*.)
Keypad	(See page 6-22, *Keypad*.)

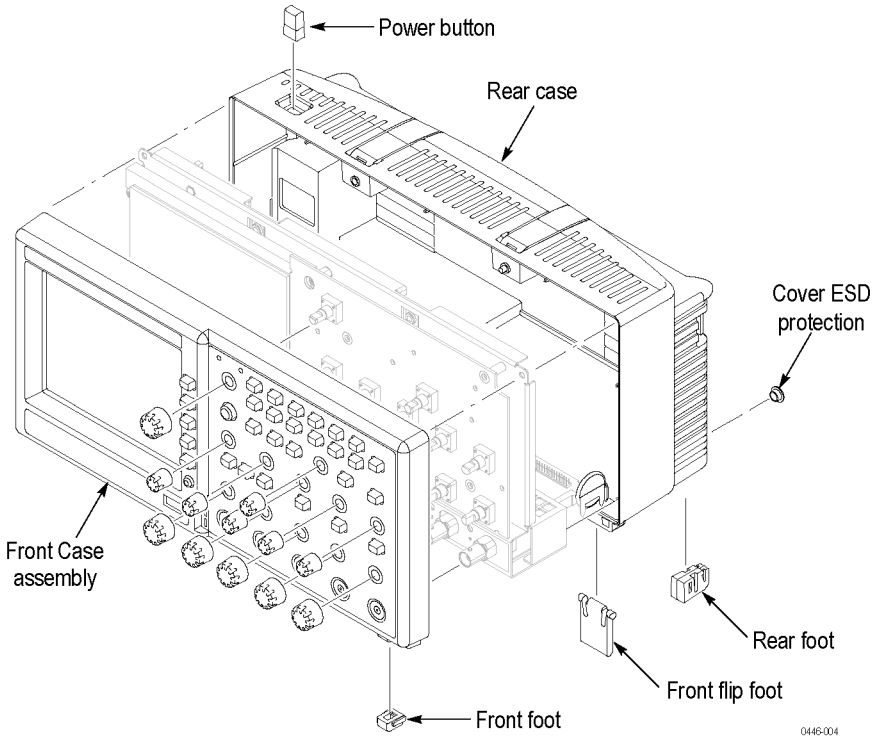


Figure 6-1: Locator for trim and cabinet removal (4-channel model shown)

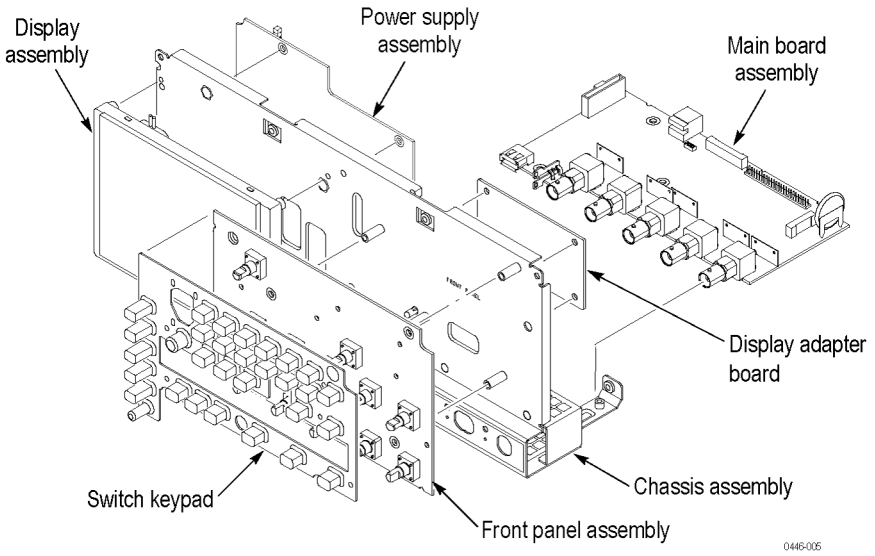


Figure 6-2: Locator for internal modules (4-channel model shown)

Required Tools

Use the following tools to remove and replace all modules in the oscilloscope:

- Torque-limiting screwdriver, long shank, 12 in-lb (1.3 N·m) range with Torx® T-15 tip; if you use a magnetic screwdriver with interchangeable bits, the T-15 bit must be a long bit, at least 5 cm (2 in) overall length
- Torque-limiting screwdriver with Torx T-8 bit
- 5/8 inch deep socket with wide center hole (S·K Hand Tool Corp., S-K #40820, or equivalent)
- Torque wrench to 40 in-lb (4.5 N·m)
- Screwdriver with 1/4 inch flat blade
- Pliers (all-purpose and needle-nose)
- Sharp knife (X-ACTO®knife or equivalent)
- 3M Electrical Tape 92 with 1-mil polyimide Kapton backing, temperature rated 180 °C, UL510 Flame Retarded

Rear Feet

You will need a flat-blade screwdriver to remove the rear feet.

Refer to the exploded view diagram. (See page 8-10.)

Removal.

1. Place the oscilloscope face down on a soft surface such as an anti-static mat.
2. Use a flat-blade screwdriver to pry out the foot, or twist the foot as you are removing it so that it disengages from the guides. Use care not to mar the surface of the rear case.

Installation.

1. Place the oscilloscope face down on a soft surface such as an anti-static mat.
2. Align the slots of the rear foot with the guides in the rear case and press the foot in.

Flip Feet

You will need a pair of needle-nose pliers to remove the flip feet.

Refer to the exploded view diagram. (See page 8-10.)

Removal.

1. Place the oscilloscope face down on a soft surface such as an anti-static mat.
2. Grip the flip foot with the pliers as close to the notches as possible and squeeze gently on the foot.
3. Twist slightly to swing one hinge free of the slot.
4. Remove the flip foot from the case.

Installation.

1. Place the oscilloscope face down on a soft surface such as an anti-static mat.
2. Hold the flip foot with the smooth side facing down.
3. Gently squeeze the foot so that the hinge on one side fits into the slot, and twist slightly to snap into the slot on the other side.

Front-Panel Knobs

Refer to the exploded view diagram for the 2-channel models or the 4-channel models. (See page 8-4.) (See page 8-6.)

NOTE. *Wrap the plier jaws with tape (such as electrical tape) to avoid scratching the knob.*

Removal. Firmly grasp the knob (with pliers if necessary) and pull it away from the front panel.

Installation. Align the keyed knob with the shaft and press the knob onto the shaft.

Power Button

Refer to the exploded view diagram for either the 2-channel or the 4-channel models. (See page 8-4.) (See page 8-8.)

NOTE. *Wrap the plier jaws with tape (such as electrical tape) to avoid scratching the button.*

Removal. Firmly grasp the button with pliers and pull it straight out of the cabinet.

Installation. Press the button onto the power button shaft until it snaps into place.

Rear Case

You will need a torque-limiting Torx T-15 screwdriver and pliers for this procedure.

Refer to the exploded view diagram. (See page 8-10.)

Removal.

1. Remove the power button. (See page 6-9, *Power Button*.)
2. Place the oscilloscope face down on a soft surface such as an anti-static mat.
3. Remove the two ESD protection covers from the rear case to expose two screws.
4. Remove the five screws located on the rear case. Tilt the handle to gain access to the top two screws.
5. Lift the rear case off of the oscilloscope.

Installation.

1. Place the oscilloscope face down on a soft surface (such as an anti-static mat).

CAUTION. *Be careful not to pinch any wires or other parts between the front and rear cases.*

2. Place the rear case onto the assembled oscilloscope and verify that:
   - All of the edges align with the front case.
   - The Li-ION battery is vertical in the battery location.
   - The slots align near the USB connector and near the battery.

CAUTION. *Avoid cross-threading the screws that attach the rear case to the front case. An easy way to avoid this is to slip the screw into the hole and, using slight pressure, slowly rotate the screw counterclockwise until you feel the screw slip into the screw threads. Then tighten the screw clockwise. A properly started screw will exhibit very little resistance going in.*

3. Install the five screws in the rear case. Tilt the handle to access the top two holes.
4. Install the two ESD protection covers.
5. Install the power button. (See page 6-9, *Power Button*.)

Front Feet

You will need a torque-limiting Torx T-15 screwdriver and pliers for this procedure.

Refer to the exploded view diagram for the 2-channel models or the 4-channel models. (See page 8-4.) (See page 8-6.)

Removal.

1. Remove the power button and rear case. (See page 6-10, *Rear Case*.)
2. Slide the front feet out of the front case.

Installation. Slide the feet into the slots provided in the front case.

NOTE. *If the front feet are not installed, but are available, they can be inserted by carefully pinching them and pushing them into their slots. For example, you may need to do this if the rear case has been removed, and a foot has been rubbed off and unnoticed until the case is being assembled.*

Power Supply Module

Use a torque-limiting Torx T-15 screwdriver and pliers for this procedure.

Refer to the exploded view diagram. (See page 8-8.)

Removal.

1. Remove the power button and rear case. (See page 6-10, *Rear Case*.)
2. Disconnect the following wires:
   - The ground wire on the power supply module from the chassis ground lug.
   - The display adapter power supply cable from P2.
   - The power supply cable on the Main board at J101. Press down on the latch while pulling up on the cable.
3. Remove the five screws that connect the power supply module to the chassis and lift the module from the internal assembly.

Installation.

1. Align and place the power supply module into the internal assembly.
2. Install the two longer screws with thread lock into the IEC connector mounting holes.
3. Install the three shorter screws through the power supply and into the chassis.
4. Connect the following wire and cables: (See Figure 6-3.)
   - The ground wire on the power supply module to the chassis ground lug. You may need to use pliers to secure the wire in place.
   - The display adapter power supply cable at P2.
   - The power supply cable to the Main board at J101. Twist the cable to keep it from contacting the boards and chassis.

NOTE. *Wind up the power supply cable until it is tight; loops are okay. This keeps the cable bundle together.*

5. Assemble the oscilloscope by performing the installation procedure for each module that was removed.

Internal Assembly

You will need a torque-limiting Torx T-15 screwdriver and a pair of pliers for this procedure.

Refer to the exploded view diagram. (See page 8-10.)

Removal.

1. Remove the front-panel knobs. (See page 6-9, *Front-Panel Knobs*.)
2. Remove the power button and rear case. (See page 6-10, *Rear Case*.)
3. Remove the five screws attaching the internal assembly to the front case.
4. Lift the entire internal assembly (consisting of the chassis, all of the boards, and the display screen) out of the front case.

NOTE. *The switch keypad will most likely remain inside the front case. You do not need to remove it with the internal assembly.*

Installation.

1. Install the switch keypad mat in the front case if it was removed.
2. Place the internal assembly in the front case.
3. Install the five screws to attach the internal assembly to the front case.
4. Assemble the oscilloscope by performing the installation procedure for each module that was removed.

Display Adapter Module

You will need a torque-limiting Torx T-15 screwdriver and pliers for this procedure.

Refer to the exploded view diagram. (See page 8-8.)

Removal.

1. Remove the power button and rear case. (See page 6-10, *Rear Case*.)
2. Disconnect the Display cable from J201 on the Main board by pulling straight up from the connector. Remove the cable tie to release the cable. (See Figure 6-3.)

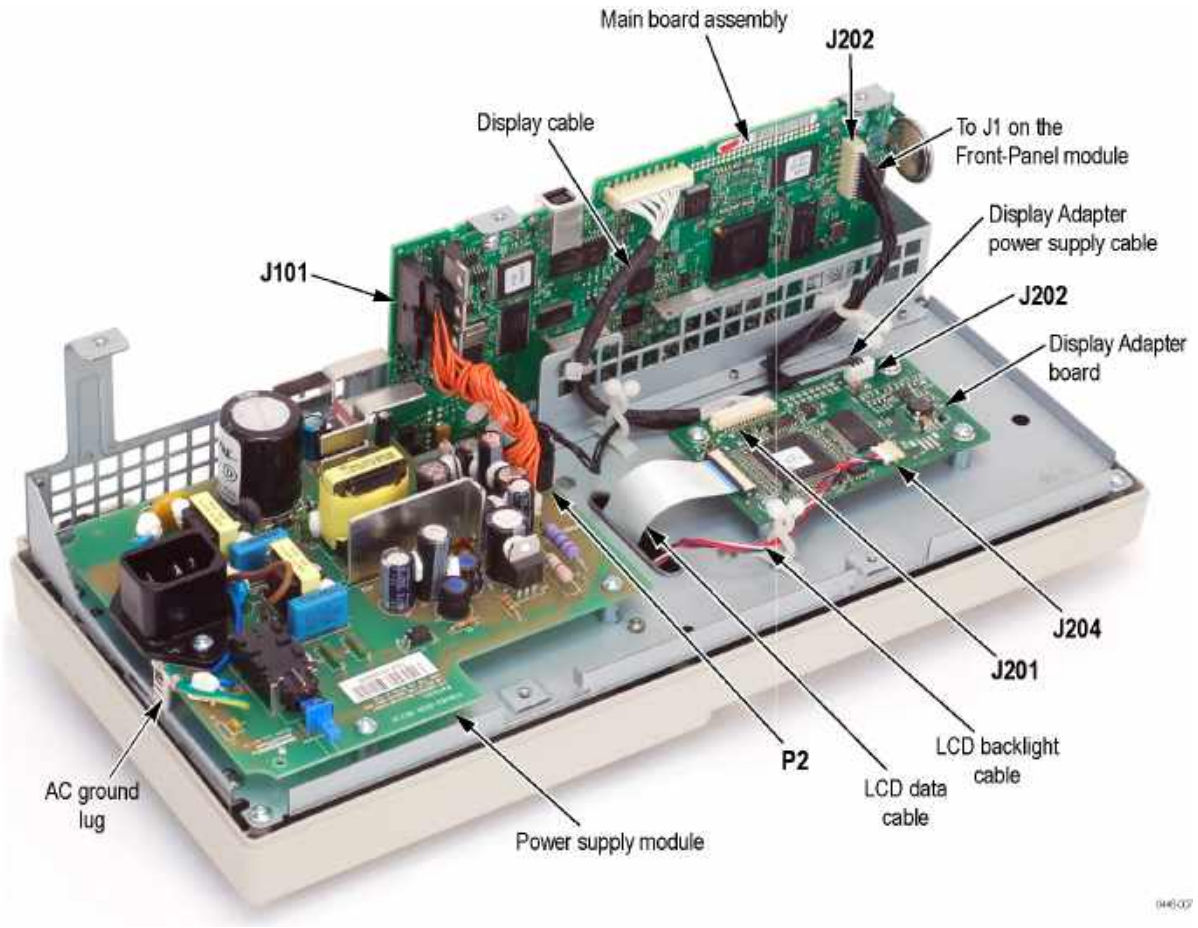


Figure 6-3: Display Adapter board connections

3. Disconnect the LCD data cable from the Display Adapter board.
4. Disconnect the LCD backlight cable from the Display Adapter board at J204.
5. Disconnect the Display Adapter board power cable from the Display Adapter board at J202.

6. Remove the four screws that hold the Display Adapter board to the chassis and save the screws for installation of the replacement board.
7. Loosen the Display Adapter board and disconnect the display cable at J201.
8. Remove the Display Adapter board from the chassis.

Installation.

1. Connect the display cable to the Display Adapter board at J201. (See Figure 6-3.)
2. Position the Display Adapter board on the instrument chassis and align the board with the holes in the chassis.
3. Use the four screws that were removed to attach the Display Adapter board to the chassis.
4. Connect the Display cable to J201 on the Main board as shown in the figure. For the 4 channel models, make sure that the two ferrite EMI suppressors are attached as shown. (See Figure 6-4.)

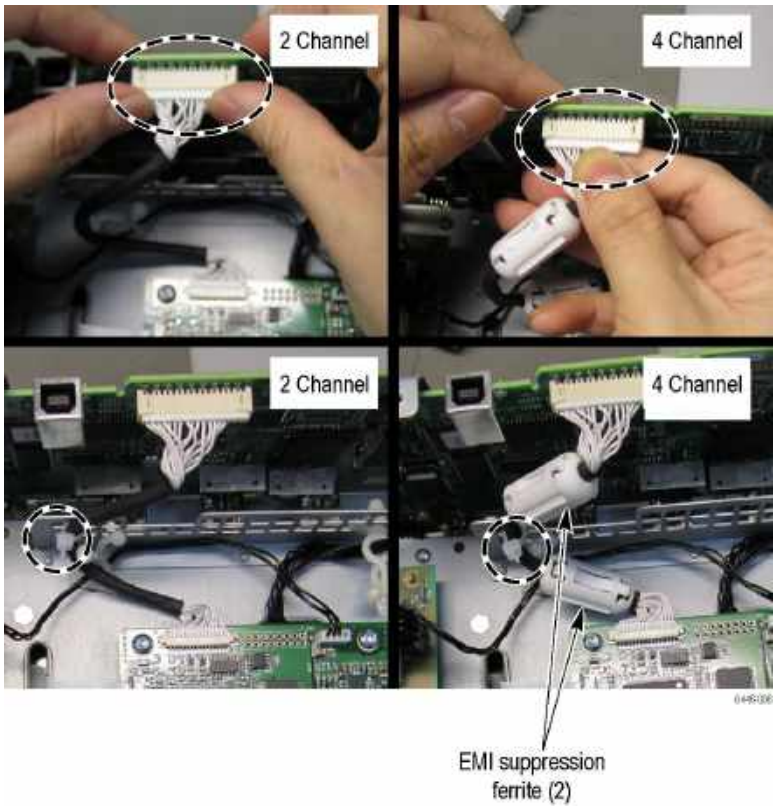


Figure 6-4: Connecting the Display cable

5. Attach the Display cable to the chassis with a cable tie as shown in the figure. (See Figure 6-4.)

6. Connect the LCD data cable to the Display Adapter board. (See Figure 6-3.)
7. Twist the LCD backlight cable 5 revolutions and connect the cable to the Display Adapter board at J204.
8. Twist the Display Adapter power cable four revolutions and connect the cable to the Display Adapter board at J202.
9. Assemble the oscilloscope by performing the installation procedure for each module that was removed.

Front-Panel Cable

You will need a torque-limiting Torx T-15 screwdriver and pliers for this procedure.

Refer to the exploded view diagram. (See page 8-8.)

Removal.

1. Remove the front-panel knobs. (See page 8-4.) (See page 8-6.)
2. Remove the power button and rear case. (See page 6-10, *Rear Case*.)
3. Remove the internal assembly. (See page 6-13, *Internal Assembly*.)
4. Remove the four screws attaching the front panel board to the chassis.
5. Open the clamp to release the front-panel cable.
6. Disconnect the front-panel cable at J202 on the Main board by pulling straight up from the connector.
7. Disconnect the front-panel cable at J1 on the Front-Panel module.

Installation.

1. Connect the front-panel cable to the Front-Panel module at J1 through the appropriate slot on the chassis.
2. Twist the cable to keep it from contacting the boards and chassis, and attach it using the cable tie.

NOTE. *Wind up the front-panel cable until it is tight; loops are okay. This keeps the cable bundle together.*

3. Connect the front-panel cable at J202 on the Main board by pushing the cable straight down into the connector.
4. Install the four screws to attach the front panel module to the chassis.
5. Assemble the oscilloscope by performing the installation procedure for each module that was removed.

Main Board Module

You will need a torque-limiting Torx T-15 long shank screwdriver, a torque wrench, and a 5/8 inch deep socket for this procedure.

Refer to the exploded view diagram. (See page 8-8.)

CAUTION. *The Main board module is particularly sensitive to ESD. Read the Preventing ESD section before removing or installing the Main board. (See page 6-1, Preventing ESD.)*

Removal.

1. Remove the power button and rear case. (See page 6-10, *Rear Case*.)

   Remove the internal assembly from the front case. (See page 6-13, *Internal Assembly*.)

2. Disconnect the following wires from the Main board by pulling straight up from the connector:
   - The power supply cable at J101. Press down on the latch while pulling up on the cable
   - The display cable at J201
   - The front-panel cable at J202
3. Use the screwdriver to remove the three screws that attach the Main board module to the internal assembly.
4. Use the socket to remove the nuts and washers from the BNC connectors.
5. Pull the board out from the front slots of the internal assembly.

Installation.

1. Work from the bottom of the internal assembly and place the front of the Main board module into the slots on the internal assembly near the BNC connectors.
2. Use the deep socket to attach the washers and nuts to each BNC connector so that the Main board is securely attached to the chassis.

   Support the BNC to prevent it from twisting the Main board, and torque the nuts to 40 in-lbs (4.5 N@m) using the torque wrench.
3. Install the three screws attaching the Main board module to the internal assembly.

4. Connect the following cables on the Main board:
   - The power supply cable at J101
   - The display cable at J201
   - The front-panel cable at J202
5. Assemble the oscilloscope by performing the installation procedure for each module that was removed.

Display Module

You will need a torque-limiting Torx T-15 screwdriver, a torque-limiting Torx T-8 screwdriver, and pliers for this procedure.

Refer to the exploded view diagram for the 2-channel or the 4-channel models. (See page 8-4.) (See page 8-6.)

CAUTION. *Do not separate the display shield from the display module. Removing the shield will destroy the attaching gasket.*

Removal.

1. Remove the power button and rear case. (See page 8-10.)
2. Remove the internal assembly from the front case. (See page 6-13, *Internal Assembly*.)
3. Disconnect the backlight cable from the Display Adapter board.
4. Disconnect the LCD data cable from the Display module.
5. Remove the power supply module. (See page 6-12, *Power Supply Module*.)
6. Remove the four screws attaching the display module to the chassis. The screws were exposed when the power supply module was removed.
7. Remove the display from the chassis.

Installation.

1. Position the Display module on the chassis.
2. Use the Torx T-8 screwdriver and install the four screws to attach the display module to the chassis. Torque the nuts to 3 in-lbs (0.33 N@m) using the torque wrench (2.864 ±0.26 in-lbs).
3. Route the backlight cable through the opening in the internal assembly.
4. Connect the backlight cable to the Display Adapter board.
5. Assemble the oscilloscope by performing the installation procedure for each module that was removed.

Front-Panel Module

You will need a torque-limiting Torx T-15 screwdriver and a flat-blade screwdriver for this procedure.

Refer to the exploded view diagram for the 2-channel models or the 4-channel models. (See page 8-4.) (See page 8-6.)

Removal.

1. Remove the power button and rear case. (See page 8-10.)
2. Remove the internal assembly from the front case. (See page 6-13, *Internal Assembly*.)
3. Disconnect the front-panel cable from J1 on the Front-Panel module.
4. Remove the five screws attaching the Front-Panel module to the internal assembly.
5. Pull the module away from the internal assembly.

Installation.

1. Connect the front-panel cable to J1 on the Front-Panel module by pushing the cable straight down into the connector.
2. Install the five screws to attach the Front-Panel module to the internal assembly.
3. Assemble the oscilloscope by performing the installation procedure for each module that was removed.

Keypad

You will need a torque-limiting Torx T-15 screwdriver for this procedure.

Refer to the exploded view diagram for the 2-channel models or the 4-channel models. (See page 8-4.) (See page 8-6.)

Removal.

1. Remove the power button and rear case. (See page 6-10, *Rear Case*.)
2. Remove the internal assembly from the front case. (See page 6-13, *Internal Assembly*.)
3. Lift the keypad switch out of the front case.

CAUTION. *Keep the electrical contacts on the back of the keypad clean. Skin oils and dust inhibit good electrical contact.*

Installation.

1. Place the front case face down on a soft surface (such as an anti-static mat).
2. Align the switch keypad into the front case using the guide posts and the holes in the keypad.

CAUTION. *Keep the electrical contacts on the back of the switch keypad clean. Skin oils and dust inhibit good electrical contact.*

3. Check that all buttons are properly seated before proceeding.
4. Assemble the oscilloscope by performing the installation procedure for each module that was removed.

Troubleshooting

This section contains information and procedures to help you isolate a defective module in the oscilloscope.

WARNING. *Before performing this or any other procedure in this manual, read the General Safety Summary and Service Safety Summary found at the beginning of this manual. Also, to prevent possible injury or damage to electrical components, read Preventing ESD. (See page 6-1, Preventing ESD.)*

Adjustment After Repair

If you replace the Main board or power supply, you must adjust the oscilloscope after repair. Refer to the chapter *Adjustment Procedures*.

Required Tools and Equipment

Use the following tools and equipment to troubleshoot the oscilloscope:

Table 6-3: Tools and equipment

Tools and equipment	Example
Oscilloscope with 1X/10X and 100X probes	Tektronix TDS2000C series oscilloscope with standard accessory 10X probe (TPP0201 or TPP0101) and optional 100X probe (P5100 or P5200)
DMM	3.5 or greater digit DMM
USB flash drive	Tektronix part number 119-7276-00, 128 MB
USB type A to type B cable	Tektronix part numbers: 174-4401-00, 0.91 meters (3 feet) 174-5194-00, 1.83 meters (6 feet)
PC with USB host post and with TekVISA (OpenChoice PC Communications) installed	PC with USB communication port

Troubleshooting Tree

To isolate a problem to a specific troubleshooting procedure, use the troubleshooting tree that is shown on the next four pages. Detailed procedures follow the tree.

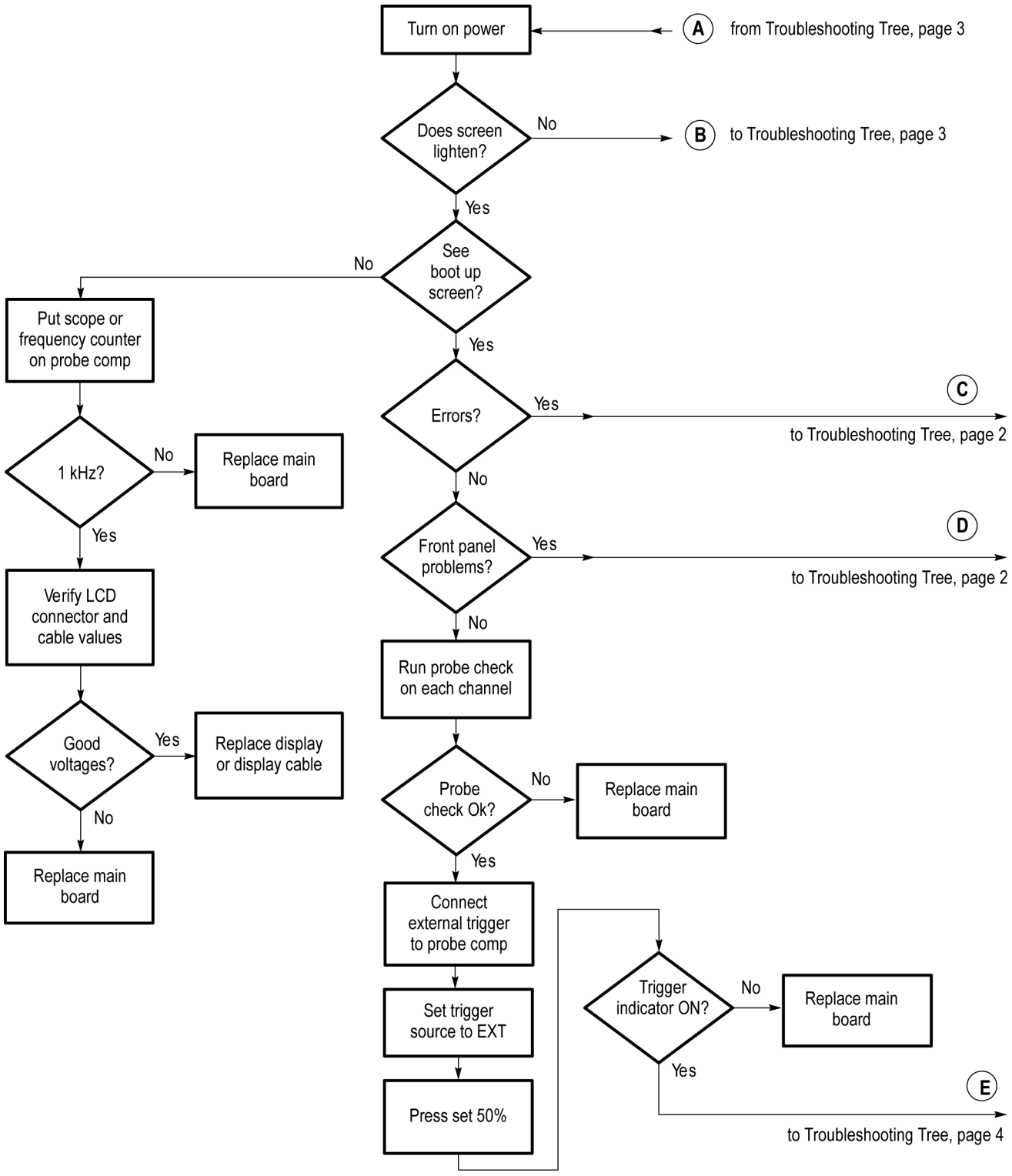


Figure 6-5: Oscilloscope troubleshooting tree (page 1 of 4)

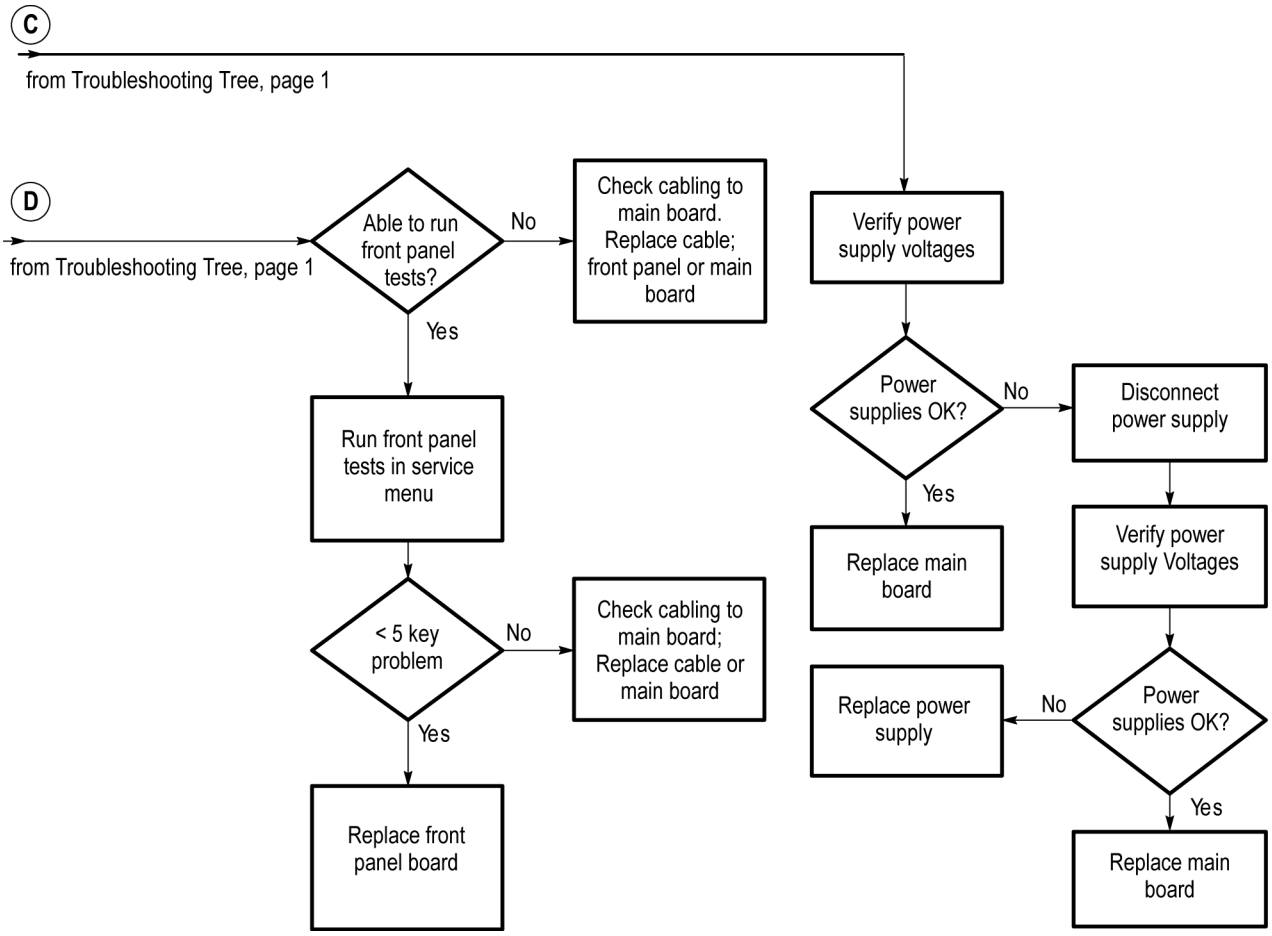


Figure 6-6: Oscilloscope troubleshooting tree (page 2 of 4)

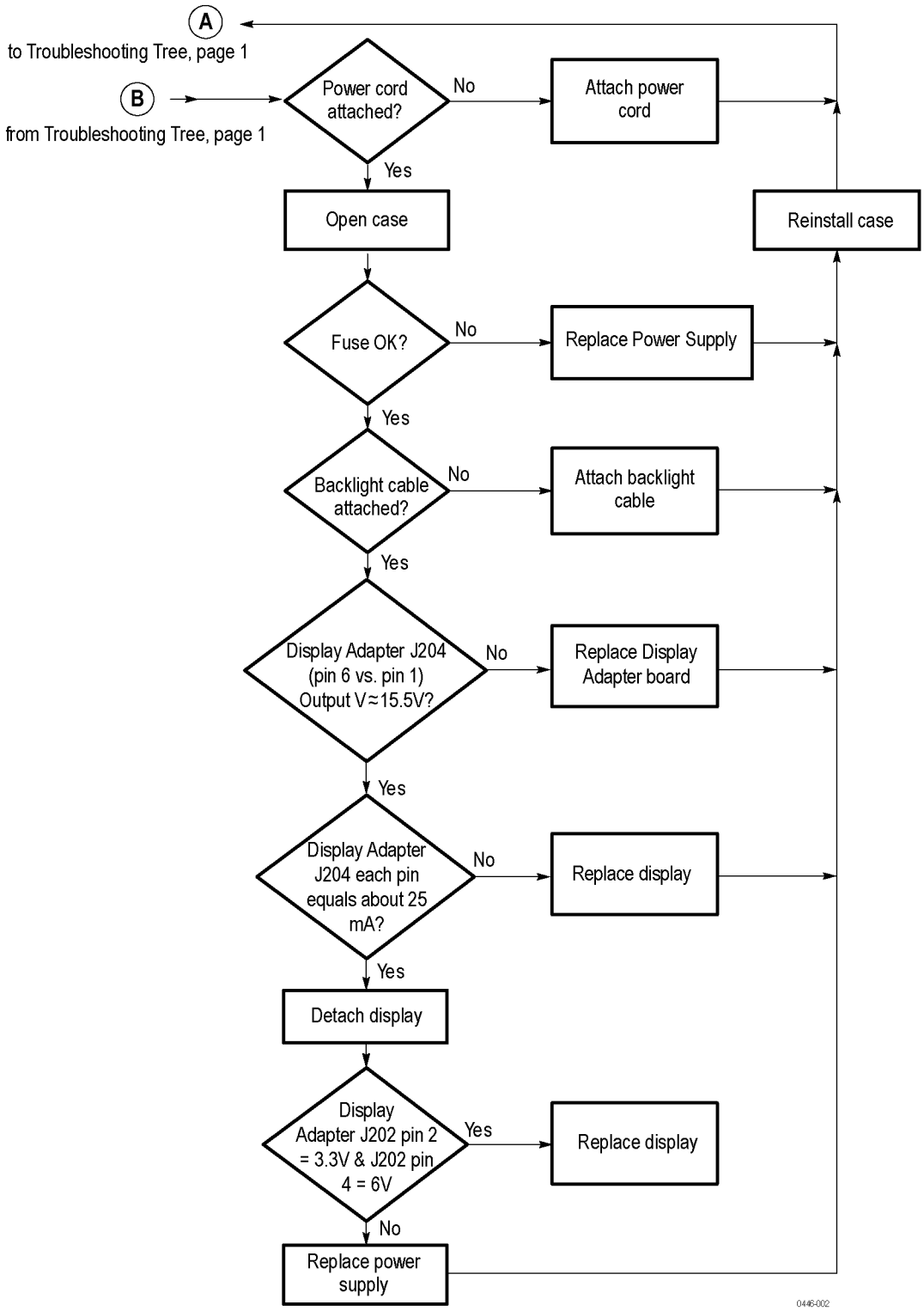
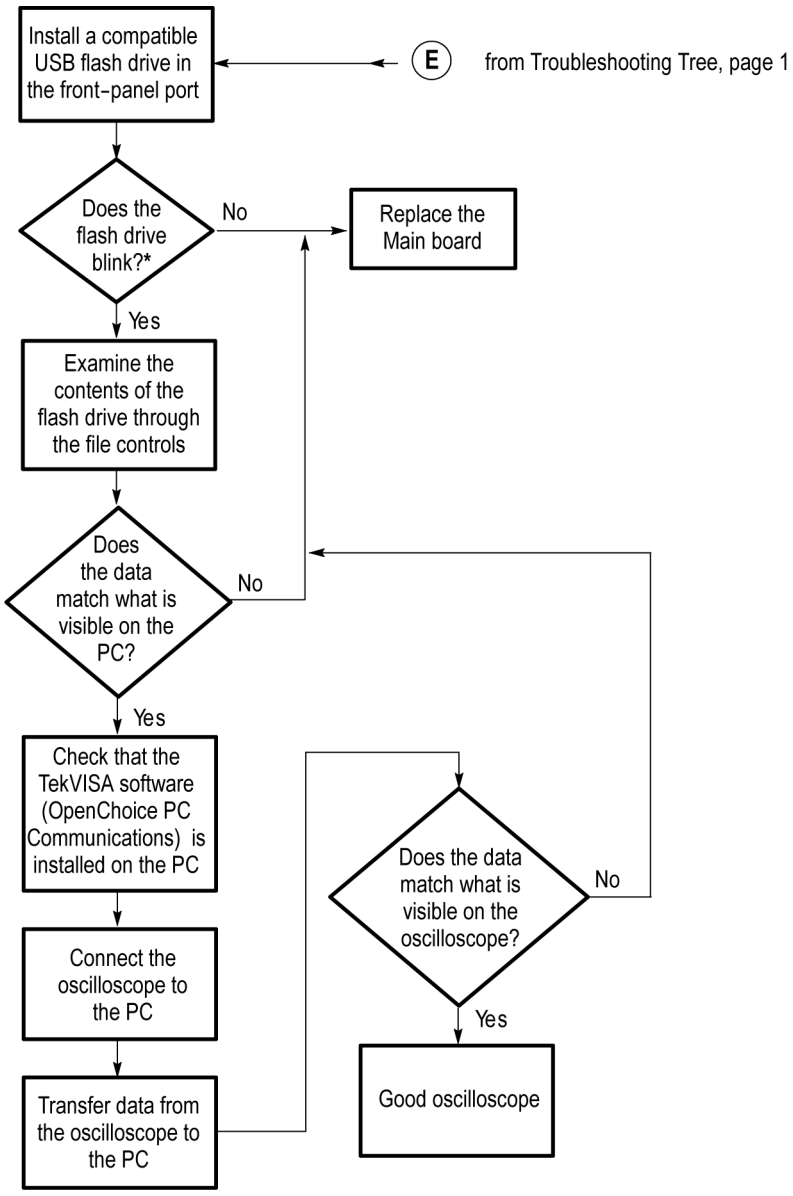


Figure 6-7: Oscilloscope troubleshooting tree (page 3 of 4)



*** The oscilloscope displays a clock symbol when the flash drive is active, and a hint line when a save or recall operation is complete.**

Figure 6-8: Oscilloscope troubleshooting tree (page 4 of 4)

Probe Comp Output

When the oscilloscope is on and operating properly, the Probe Comp output should generate a square wave, approximately 5 V in amplitude, at a 1 kHz frequency. Use the oscilloscope and use a 10X TPP0101 or TPP0201 probe to probe this output.

As shown in the following table, there are two cases of defects. Either the 1 kHz signal is on and the power supply and Main board are both active and functionally capable of doing acquisition, or one of those two modules is not performing correctly. While many different possible frequencies exist, all involve detected failures on the Main board due to Main board failure or power supply failure.

Table 6-4: Probe Comp output

Signal at Probe Comp	Possible problem
1 kHz signal, no display	Refer to *Troubleshooting the Display.* (See page 6-30, *Troubleshooting the Display*.)
Non-1 kHz signal	Refer to *Troubleshooting the Main Board*. (See page 6-37, *Troubleshooting the Main Board*.)
No signal	Refer to *Troubleshooting the Power Supply*. (See page 6-29, *Troubleshooting the Power Supply*.)

Troubleshooting the Power Supply

To troubleshoot the power supply, follow these steps:

1. Remove the rear case. (See page 6-10, *Rear Case*.)
2. Use the test oscilloscope to measure the voltages from the power supply module at J101 on the Main board module. The following table lists the voltages you should expect to see.

Table 6-5: Troubleshooting the power supply

Supply	Voltage range [1]	Maximum current draw	J101 power pins	J101 return pins	Derived supplies
35 V	30 V_{DC} to 40 V_{DC} floating. Pin 2 connected to +3.3 V on the Main board.	15 mA	1	2	+28 V LCD
+6 V	5.5 V to 6.5 V	1.0 A	4	3, 5, 8, 10	+5 V
+3.3 V	3.0 V to 3.6 V. Requires minimum load to maintain regulation.	1.8 A	6, 7	3, 5, 8, 10	3.3 V, +2.5 V
-4 V	-5.0 V to -3.5 V	0.8 A	9	3, 5, 8, 10	-2.5 V
Line trigger	-2 V to 6 V open circuit. ±1 diode drop when attached to the Main board.	1 mA	11	3, 5, 8, 10	Line trigger

[1] With 3 W minimum load; still functions with no load.

3. If all of the voltages are present, the Main board is probably defective. Replace it.
4. If all or some of the voltages are missing, turn off the oscilloscope and disconnect the cable at connector J101 on the Main board module.
5. Turn on the oscilloscope and check the voltages at the loose end of the cable disconnected from J101, checking for the same voltages as in step 2.
6. If all of the voltages are missing, check the line fuse on the power supply module. If the fuse is defective, replace the power supply module.
7. If the fuse is okay, and all or some of the voltages are missing, the power supply module is probably defective. Replace it.

Troubleshooting the Display

To troubleshoot a nonfunctional display, follow these steps:

1. Remove the rear case. (See page 6-10, *Rear Case*.)
2. Turn on the oscilloscope and verify that the display lights up. If it does not, either the display or power supply is defective. If this procedure is not conclusive, continue with *Troubleshooting the Power Supply.* (See page 6-29, *Troubleshooting the Power Supply*.)

NOTE. *Without a functional display module, the simplest way to verify that the oscilloscope is on and functioning is to check for a signal at the output. The Probe Comp output generates approximately a 5 V, 1 kHz square wave.*

3. Use the test oscilloscope and the TPP0201 probe to probe the display cable connector at J201 on the Main board. The following table describes the signals you should expect to see.

   See the exploded diagrams in *Replaceable Parts* for the location and orientation of the connector on the Main board.

Table 6-6: Troubleshooting the display

Signal at J201	Description, Color
Pin 1 (marked with ◄)	No fixed pattern. Depends on display data.
Pin 2	No fixed pattern. Depends on display data.
Pin 3	No fixed pattern. Depends on display data.
Pin 4	No fixed pattern. Depends on display data.
Pin 5	No fixed pattern. Depends on display data.
Pin 6	No fixed pattern. Depends on display data.
Pin 7	No fixed pattern. Depends on display data.
Pin 8	No fixed pattern. Depends on display data.
Pin 9	26.5 V_{DC} [1]
Pin 10	Ground
Pin 11	+3.3 V_{DC}
Pin 12	HI when display active
Pin 13	Data rate clock. 1.36 MHz Square wave
Pin 14	Line rate clock 11.4 kHz, 500 ns high pulse from low baseline
Pin 15	Frame rate clock 43 Hz, 350 ns high pulse from low baseline
Pin 16	Floating
Pin 17	Ground
Pin 18	Ground

[1] Value varies with temperature, contrast setting, and display type.

5. If all the signals are present, the display module is probably defective. Replace it.

6. If all or some of the signals are missing, turn off the oscilloscope and disconnect the display cable at J201 on the Main board. Carefully pull the cable straight up from the connector to avoid damage.
7. Turn on the oscilloscope.
8. Probe the pins of J201, checking for the same signals as in step 3.
9. If any of the signals are missing, the Main board module is probably defective. Replace it.

Troubleshooting the Backlight

To troubleshoot a nonfunctional backlight, follow these steps:

1. Remove the rear case. (See page 6-10, *Rear Case*.)
2. Turn on the oscilloscope.
3. Check that the power supply P2 connector generates +3.3 V and +6 V. If either reading is not correct, the power supply module is probably defective. Replace it.

WARNING. *To avoid electrical shock, do not touch the backlight connectors (J204 on the Display Adapter board). (See Figure 6-4.)*

5. Check that the voltage output between J204-1 and J204-6 on the Display Adapter board generates around 15.5 V. If the reading is not correct, the Display Adapter module is probably defective. Replace it.

6. Check that the current output at J204 of the Display Adapter board for each wire is around 25 mA. If the reading is not correct, the Display Adapter module is probably defective. Replace it.

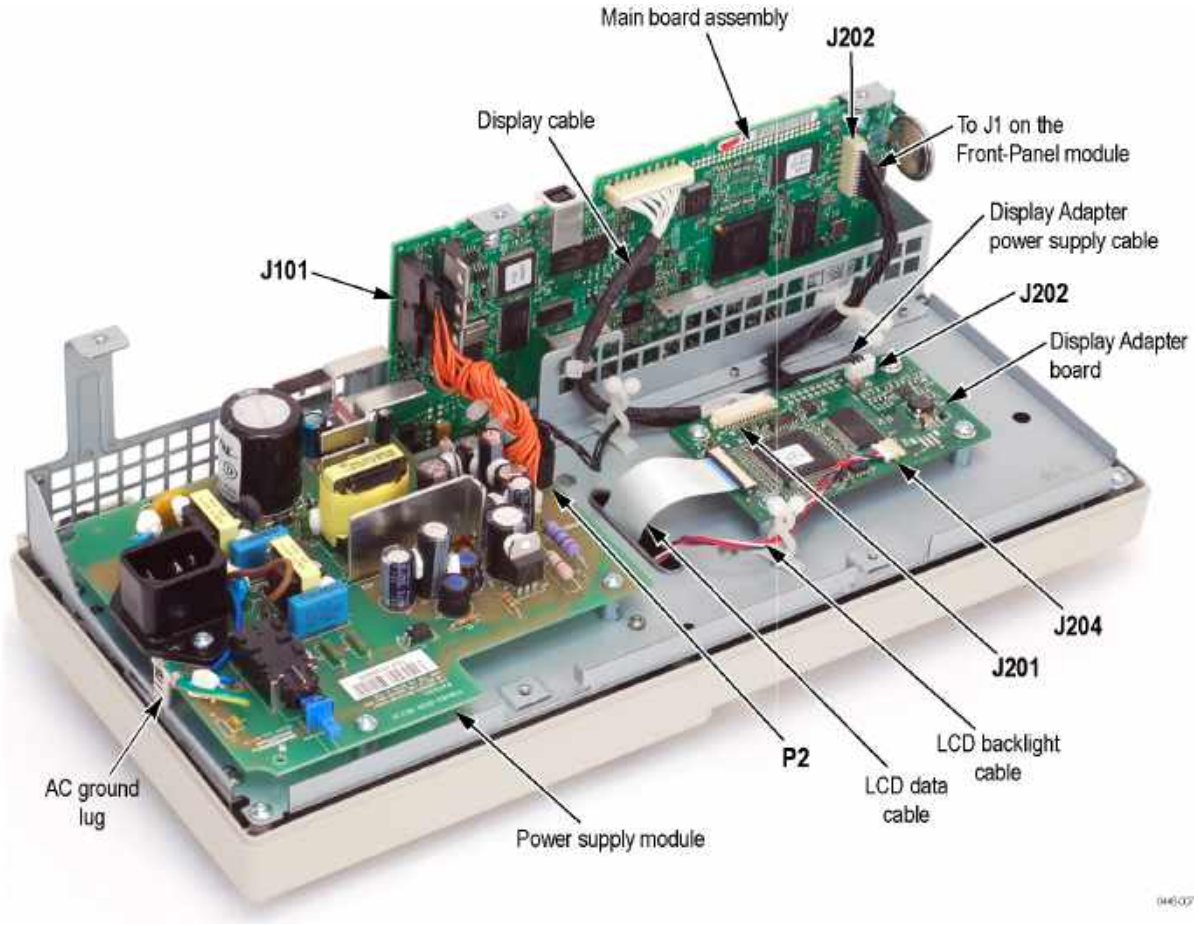


Figure 6-9: Measuring the backlight voltage

Troubleshooting the Front Panel

To troubleshoot an improperly functioning front panel, follow these steps:

1. To execute the internal diagnostic tests, remove all input signals from the oscilloscope, and enable the Service menu. (See page 5-2, *Enable the Service Menu*.)
2. Push the **UTILITY** button and push the **Service** option button. The following options appear:

Table 6-7: Troubleshooting the front panel – service

Menu	Comments
Factory Cal	Steps through the calibration routine steps.
Total Init	Writes factory default settings to all saved setups, writes factory default data to all reference waveforms, turns off Service Mode, and performs the same actions as the front-panel Default Setup button.
Service Diag.	Displays the service diagnostics menus.
Service Mode Off	Disables the Service menu.

3. Select **Service Diag**. The following options appear:

Table 6-8: Troubleshooting the front panel – Service Diag

Menu	Comments
Mfg. Tests	Displays a front-panel simulation used to check that all front panel controls are operational.
Loop Diag.	Opens a menu that enables you to rerun a subset of the power-on self tests.
Peek/Poke	For engineering use only.
Clear Error Log	Removes all Error Log entries from memory and sets the power cycle count to zero.

4. Select **Mfg. Tests** to start the front-panel controls test. The following options appear:

Table 6-9: Troubleshooting the front panel – Mfg. test

Menu	Comments
Test FP	Displays a front-panel simulation used to check the operation of all front panel controls. All buttons must be pushed and all knobs must be turned in both directions before you can exit this test.
Test Screen	Checks the display screen pixels with different patterns from each push of the button.
Contrast	Allows you to check the display contrast operation across 100% of the hardware range.

Table 6-9: Troubleshooting the front panel – Mfg. test (cont.)

Menu	Comments
Warm-up Timer	Ensures a ten-minute warm-up time for the oscilloscope before executing the calibration procedure.
Stop Test	Exits the front-panel test (Test FP) and the screen test (Test Screen).

5. Select **Test FP** to start the front-panel controls test.
6. Push each button and rotate each knob to verify the operation of all controls. If all buttons and knobs have passed the test, pushing the lower menu button (EXIT) exits the test.
7. If any button fails to operate, inspect and/or clean the switch keypad and the front panel board contacts. If cleaning does not solve the problem, the switch keypad, front panel board, or Main board may be defective. Follow the remaining steps in this procedure to isolate the problem.
8. Replace the switch keypad and retest the buttons. If the problem persists, go to step 9.
9. Use the test oscilloscope and the TPP0201 probe to probe the front-panel cable connector at J202 on the Main board (2-channel models) or J1 (4-channel models). The following table describes the signals you should expect to see.

Table 6-10: Expected signals at J202

Signal at J202	Description
1 FPLED_P	LED latch line 6.44 kHz. High with 120 ns low pulses. Location of pulse relative to FPCLR_12_P determines which lights are lit.
2 FPCLR_12_P	Clear Front Panel Scan line A 6.44 kHz. Low pulsing high with 50 ns pulses. Determines beginning of a scan sequence for first half of front panel.
3 FPCLK_12_P	Front Panel Clock line A 405 kHz. High with 50 ns pulses going low. Each clock after FPCLR_12_P increments the scan location by one.
4 FPDATA12P	Front Panel Scan Data line A No fixed pattern. Stable when triggered from FPCLR_12_P. Pattern depends on rotation of knobs being scanned.
5 GND	0 V (ground)
6 FPTHERMSTR_P	Front Panel Temp Sense About 2 V_{DC} depending on temperature, contrast setting, and display type.
7 FP_PWR	5.0 V_{DC}
8 FPTHERMGND_P	Temp Sense Return Ground.
9 GND	0 V (ground)

Table 6-10: Expected signals at J202 (cont.)

Signal at J202	Description
10 FPDATA_34_P [1]	Front Panel Scan Data line B No fixed pattern. Stable when triggered from FPCLR_34_P. Pattern depends on rotation of knobs being scanned.
11 FPCLR_34_P [2]	Front Panel Clock line B 405 kHz. High with 50 ns pulses going low. Each clock after FPCLR_34_P increments the scan location by one.
12 FPCLK_34_P [2]	Clear Front Panel Scan line B 6.44 kHz. Low pulsing high with 50 ns pulses. Determines beginning of a scan sequence for second half of front panel.

[1] Unused and open on 2-channel models.

[2] Unused and tied low on 2-channel models.

11. If all of the signals are present, the Front-Panel board is probably defective. Replace it.

12. If some or all of the signals are missing, continue with step 13.

13. Turn off the oscilloscope and disconnect the front-panel cable from the Main board at connector J202.

14. Turn on the oscilloscope and check connector J202 for the same signals as in step 3.

15. If some or all of the signals are missing, the Main board is probably defective. Replace it.

Troubleshooting the Main Board

To troubleshoot the Main board (acquisition module), follow these steps:

1. Remove the rear case. (See page 6-10, *Rear Case*.)
2. Use the test oscilloscope to measure the voltages from the power supply module at J101 on the Main board module. The following table lists the voltages you should expect to see.

Table 6-11: Troubleshooting the Main board

Supply	Voltage range [1]	Maximum current draw	J101 power pins	J101 return pins	Derived supplies
35 V	30 V_{DC} to 40 V_{DC} floating. Pin 2 connected to +3.3 V on the Main board.	15 mA	1	2	+28 V LCD
+6 V	5.5 V to 6.5 V	1.0 A	4	3, 5, 8, 10	+5 V
+3.3 V	3.0 V to 3.6 V. Requires minimum load to maintain regulation.	1.8 A	6, 7	3, 5, 8, 10	3.3 V, +2.5 V
-4 V	-5.0 V to -3.5 V	0.8 A	9	3, 5, 8, 10	-2.5 V
Line trigger	-2 V to 6 V open circuit. ±1 diode drop when attached to the Main board.	1 mA	11	3, 5, 8, 10	Line trigger

[1] With 3 W minimum load; still functions with no load.

3. If all of the voltages are present, the Main board is probably defective. Replace it.

Running Diagnostics

The oscilloscope runs an extensive self-diagnostic routine at every power-on. Running the diagnostics from the Service menu will provide no additional information and therefore is not needed. The menu selections are only used during manufacturing of the oscilloscope.

Troubleshooting Input Connections

Follow these steps to troubleshoot the input connections only if the oscilloscope appears to function normally in every way, but an input signal is not getting into the oscilloscope as expected.

1. Remove the rear case. (See page 6-10, *Rear Case*.)
2. Check that the coaxial connections to the back side of the BNC connectors are intact. Use the DMM to measure continuity from the front side of the BNC connector to the point where it attaches to the Main board.

NOTE. *The ground side of the BNC has three connections (two mounting lugs and one signal wire) while the center connection has one. Incomplete or poor connection of the ground side may cause AC signal quality problems without affecting DC measurement capability.*

3. If no problem is found and the trouble persists, the Main board is probably defective in some way that the internal diagnostics cannot detect. Replace it.

Troubleshooting the USB Interface

To troubleshoot the USB interface, if the acquisition is working, and the USB is not, replace the Main board.

Using the Error Log

Failures that occur during the power-up diagnostics or normal oscilloscope operation place an entry in the error log.

Accessing the error log. The error log list can be accessed anytime by pushing the UTILITY button and selecting Error Log.

The following table lists the error codes and probable causes. (See Table 6-12.)

Table 6-12: List of error codes

Error code	Description	Probable cause
0 DI	Diagnostics internal error	Contact Tektronix
1 DI	ADG522 diagnostics failed	Main board or power supply failure
2 DI	PROM diagnostics failed	Main board or power supply failure
3 DI	MEMORY diagnostics failed	Main board or power supply failure
4 DI	Ch 1 diagnostics failed	Main board or power supply failure
5 DI	Ch 2 diagnostics failed	Main board or power supply failure
6 DI	Line trigger diagnostics failed	Main board or power supply failure
7 DI	ADG421 diagnostics failed	Main board or power supply failure
12 DI	Ch 3 diagnostics failed	Main board or power supply failure
13 DI	Ch 4 diagnostics failed	Main board or power supply failure
14 DI	ADG421 #2 diagnostics failed	Main board or power supply failure
15 DI	ADG522 #2 diagnostics failed	Main board or power supply failure
16 DI	DRAM2 diagnostics failed	Main board or power supply failure
17 DI	USB diagnostics failed	Main board or power supply failure
255	Software	Contact Tektronix

Clearing the error log. To clear the error log after fixing a problem, follow these steps:

1. Enable the Service menus. (See page 5-2, *Enable the Service Menu*.)
2. Push the **UTILITY** button and push the **Service** option button to display the Service menu.
3. Push the **Service Diag.** option button to display the Diagnostics menu.
4. Push the **Clear Error Log** option button to clear the error log of past failures. This also sets the Power Cycle count to zero.

Repackaging Instructions

Use these procedures to repackage the oscilloscope for shipment or storage.

Packaging

Use a corrugated cardboard shipping carton having a test strength of at least 125 kg (275 pounds), and with an inside dimension at least 15.25 cm (six inches) greater than the oscilloscope dimensions. Make sure that the oscilloscope is adequately padded with a cushioning material like foam, paper, or bubble wrap. The oscilloscope should not move around inside the carton when the carton is sealed.

If the oscilloscope is being shipped to a Tektronix Service Center, enclose the following information:

- The owner address
- Name and phone number of a contact person
- Type and serial number of the oscilloscope
- Reason for returning
- 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.

Storage

The oscilloscope should be stored in a clean, dry environment. The following environmental characteristics apply for both shipping and storage (oscilloscope not operating):

- Temperature range: -40 °C to +71 °C (-40 °F to 159.8 °F)
- Altitude: To 3,000 m (approximately 10,000 ft)

The chapter on *Specifications* lists the environmental characteristics. (See page 1-1, *Specifications*.)

Diagrams

This section describes the electrical operation of the TDS2000C series oscilloscopes using the major circuit blocks or modules. The oscilloscope module interconnections are shown in the figure. (See Figure 7-1.)

The shaded area in the figure represents modules and circuits used only in 4-channel oscilloscopes.

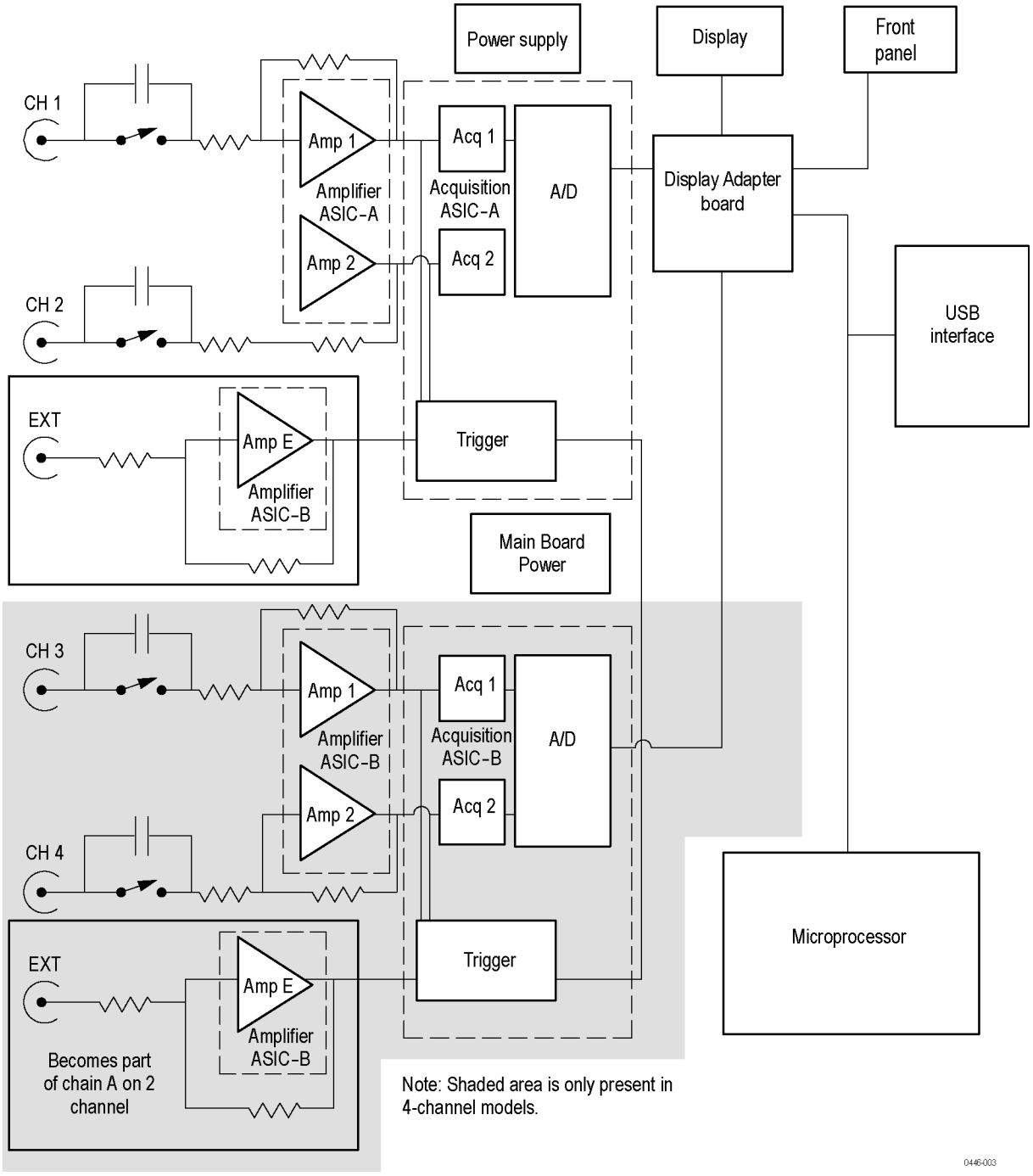


Figure 7-1: TDS2000C series block diagram

Replaceable Parts

Replaceable Parts

This chapter contains a list of the replaceable modules for the TDS2000C oscilloscopes. Use this list to identify and order replacement parts.

Parts Ordering Information

Replacement parts are available through your local Tektronix field office or representative.

Changes to Tektronix products are sometimes made to accommodate improved components as they become available and to give you the benefit of the latest 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 you order a part that has been replaced with a different or improved part, your local Tektronix field office or representative will contact you concerning any change in part number.

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

Part Number Revision Level

Tektronix part numbers contain two digits that show the revision level of the part. For some parts in this manual, you will find the letters XX in place of the revision level number.

When you order parts, Tektronix will provide you with the most current part for your product type, serial number, and modification (if applicable). At the time of your order, Tektronix will determine the part number revision level needed for your product, based on the information you provide.

Module Servicing

Modules can be serviced by selecting one of the following two options. Contact your local Tektronix service center or representative for repair assistance.

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 1-800-833-9200 and select option 2.

New modules. You may purchase replacement modules in the same way as other replacement parts.

Using the Replaceable Parts List

This section contains a list of the mechanical and/or electrical components that are replaceable for the oscilloscope. Use this list to identify and order replacement parts. The following table describes each column in the parts list.

Table 8-1: Replaceable parts list

Column	Column name	Description
1	Figure & Index Number	Items in this section are referenced by figure and index numbers to the exploded view illustrations that follow.
2	Tektronix Part Number	Use this part number when ordering replacement parts from Tektronix.
3 and 4	Serial Number	Column three indicates the serial number at which the part was first effective. Column four indicates the serial number at which the part was discontinued. No entries indicates the part is good for all serial numbers.
5	Qty	This indicates the quantity of parts used.
6	Name & Description	An item name is separated from the description by a colon (:). Because of space limitations, an item name may sometimes appear as incomplete. Use the U.S. Federal Catalog handbook H6-1 for further item name identification.

Abbreviations

Abbreviations conform to American National Standard ANSI Y1.1-1972.

Parts Lists and Exploded Views

The following tables show the module-level exploded views of the TDS2000C oscilloscopes. Following each exploded view is the list of components, indexed by the numbers in the figure.

Table 8-2: Replaceable parts list, 2-channel models

Figure and index no.	Tektronix part no.	Serial no. effective	Serial no. discont'd	Qty.	Name and description
8-1					2-CHANNEL MODELS
-1	850-0156-00			1	FRONT CASE ASSY; COVER, W/FEET; TDS2001C, TDS2002C, TDS2012C, TDS2022C
-2	366-0863-00			1	ASSEMBLY, KNOB; 0.685 DIAMETER
-3	366-0862-00			1	ASSEMBLY, KNOB; 0.470 DIAMETER
-4	335-2308-00			1	MARKER, IDENTIFICATION 2CH LANGUAGE, FRENCH
	335-2309-00			1	MARKER, IDENTIFICATION 2CH LANGUAGE, ITALIAN
	335-2310-00			1	MARKER, IDENTIFICATION 2CH LANGUAGE, GERMAN
	335-2311-00			1	MARKER, IDENTIFICATION 2CH LANGUAGE, SPANISH
	335-2312-00			1	MARKER, IDENTIFICATION 2CH LANGUAGE, JAPANESE
	335-2313-00			1	MARKER, IDENTIFICATION 2CH LANGUAGE, PORTUGUESE
	335-2314-00			1	MARKER, IDENTIFICATION 2CH LANGUAGE, SIMPLIFIED CHINESE
	335-2315-00			1	MARKER, IDENTIFICATION 2CH LANGUAGE, TRADITIONAL CHINESE
	335-2316-00			1	MARKER, IDENTIFICATION 2CH LANGUAGE, KOREAN
	335-2317-00			1	MARKER, IDENTIFICATION 2CH LANGUAGE, RUSSIAN
-5	260-2904-70			1	SWITCH, KEYPAD; ELASTOMERIC, FRONT PANEL, 2CH COLOR, BONDED
-6	211-1272-00			9	SCREW, MACHINE; 6-32 X 0.250, PNH, STL, ZNPL, T-15 TORX DR
-7	870-0188-02			1	CIRCUIT BD ASSY; FRONT PANEL BOARD 2CH, 389- 3835-00 WIRED
-8	441-2454-02			1	CHASSIS ASSY; 2 CHANNEL; SAFETY CONTROLLED
-9	878-0391-70			1	CIRCUIT BD ASSY; DISPLAY ADAPTER BOARD; 389429600; BONDED
-10	870-0560-01			1	CIRCUIT BD ASSY; MAIN, 2 CH, 50 MHZ, TESTED & CONFIGURED, COLOR, 389-4131-00 WIRED; TDS2001C
	870-0561-01			1	CIRCUIT BD ASSY; MAIN, 2 CH, 70 MHZ, TESTED & CONFIGURED, COLOR, 389-4131-00 WIRED; TDS2002C
	870-0562-01			1	CIRCUIT BD ASSY; MAIN, 2 CH, 100 MHZ, TESTED & CONFIGURED, COLOR, 389-4131-00 WIRED; TDS2012C
	870-0563-01			1	CIRCUIT BD ASSY; MAIN, 2 CH, 200 MHZ, TESTED & CONFIGURED, COLOR, 389-4131-00 WIRED; TDS2022C
-11	210-1039-00			1	WASHER, LOCK; 0.521 ID, INT, 0.025 THK, STEEL, ZINC FINISH
-12	220-0265-00			1	NUT, PLAIN, HEX; 0.5-28 X 0.625 HEX, BRS CD PL
-13	211-1216-00			4	SCREW, PT; K-30, 3MM, PAN HEAD, T-8, COLOR
-14	850-0115-70			1	DISPLAY ASSY; COLOR
-15	348-1525-00			1	FOOT; FRONT, SANTOPRENE, BLACK, 64 DEROMETER, TEXTURED
-16	131-6417-00			1	CONTACT, ELEC; GROUNDING, 0.600 L X 0.250 W X 0.220 D, ELECTROLESS NICKEL PLATE
-17	131-6521-00			1	CONTACT, ELEC; EMI, CLIP-ON, 0.38 L X 0.460 W (2 CONTACTS) X 0.45 HIGH, ELECTROLESS NICKEL PLATE

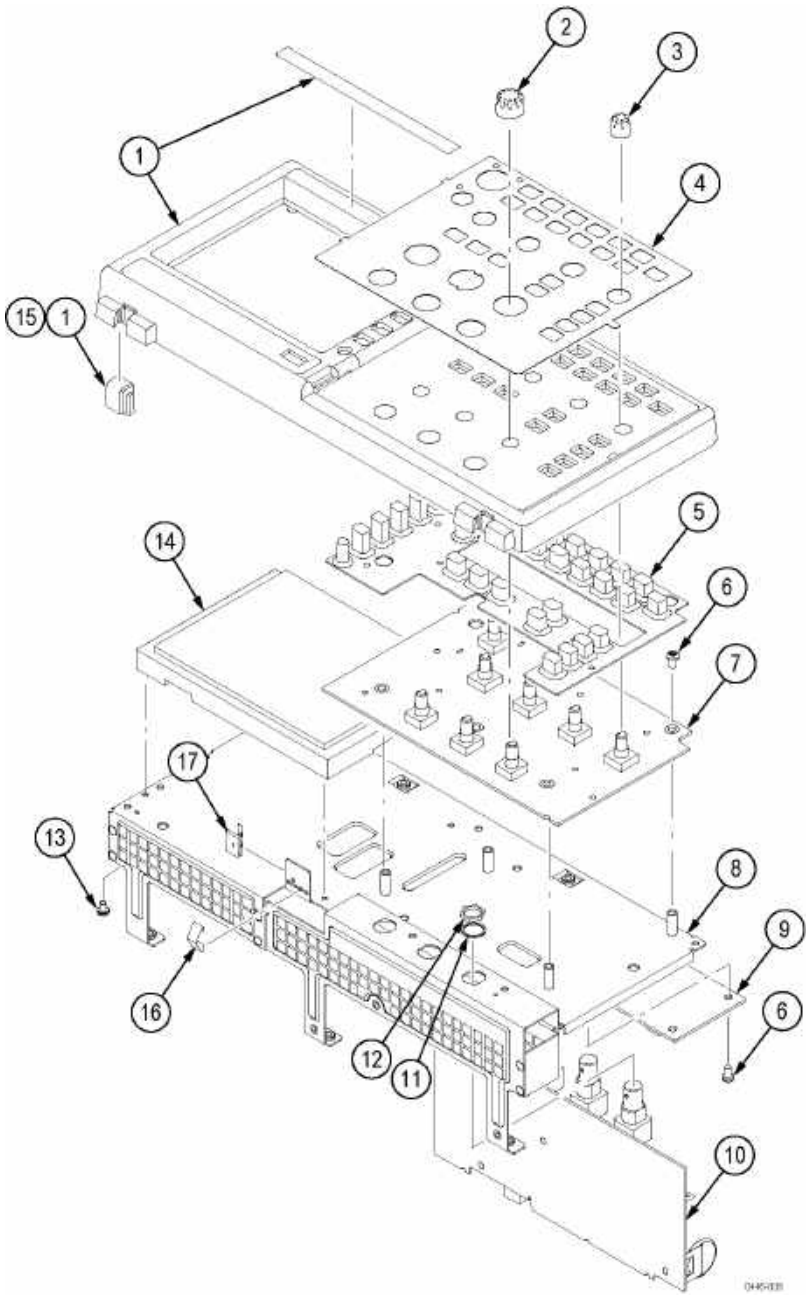


Figure 8-1: Exploded diagram, 2-channel models

Table 8-3: Replaceable parts list, 4-channel models

Figure and index no.	Tektronix part no.	Serial no. effective	Serial no. discont'd	Qty.	Name and description
8-2					4-CHANNEL MODELS
-1	850-0157-00			1	FRONT CASE ASSY; COVER, W/FEET; TDS2004C, TDS2014C, TDS2024C; COLOR
-2	366-0863-00			1	ASSEMBLY, KNOB; 0.685 DIAMETER
-3	366-0862-00			1	ASSEMBLY, KNOB; 0.470 DIAMETER
-4	335-2318-00			1	MARKER, IDENTIFICATION 4CH LANGUAGE, FRENCH
	335-2319-00			1	MARKER, IDENTIFICATION 4CH LANGUAGE, ITALIAN
	335-2320-00			1	MARKER, IDENTIFICATION 4CH LANGUAGE, GERMAN
	335-2321-00			1	MARKER, IDENTIFICATION 4CH LANGUAGE, SPANISH
	335-2322-00			1	MARKER, IDENTIFICATION 4CH LANGUAGE, JAPANESE
	335-2323-00			1	MARKER, IDENTIFICATION 4CH LANGUAGE, PORTUGUESE
	335-2324-00			1	MARKER, IDENTIFICATION 4CH LANGUAGE, SIMPLIFIED CHINESE
	335-2325-00			1	MARKER, IDENTIFICATION 4CH LANGUAGE, TRADITIONAL CHINESE
	335-2326-00			1	MARKER, IDENTIFICATION 4CH LANGUAGE, KOREAN
	335-2327-00			1	MARKER, IDENTIFICATION 4CH LANGUAGE, RUSSIAN
-5	260-2905-70			1	SWITCH, KEYPAD; ELASTOMERIC, FRONT PANEL, 4 CH COLOR, BONDED
-6	211-1272-00			9	SCREW, MACHINE; 6-32 X 0.250, PNH, STL, ZNPL, T- 15 TORX DR
-7	870-0190-02			1	CIRCUIT BD ASSY; FRONT PANEL BOARD 4CH, 389-3836-00 WIRED
-8	441-2455-00			1	CHASSIS ASSY; 4 CHANNEL
-9	878-0391-70			1	CIRCUIT BD ASSY; DISPLAY ADAPTER BOARD; 389429600; BONDED
-10	870-0564-01			1	CIRCUIT BD ASSY; MAIN, 4 CH, 70 MHZ, TESTED & CONFIGURED, COLOR, 389-4132-00 WIRED; TDS2004C
	870-0565-01			1	CIRCUIT BD ASSY; MAIN, 4 CH, 100 MHZ, TESTED & CONFIGURED, COLOR, 389-4132-00 WIRED; TDS2014C
	870-0566-01			1	CIRCUIT BD ASSY; MAIN, 4 CH, 200 MHZ, TESTED & CONFIGURED, COLOR, 389-4132-00 WIRED; TDS2024C
-11	210-1039-00			1	WASHER, LOCK; 0.521 ID, INT, 0.025 THK, STEEL, ZINC FINISH
-12	220-0265-00			1	NUT, PLAIN, HEX; 0.5-28 X 0.625 HEX, BRS, NKL PL
-13	211-1216-00			4	SCREW, PAN HEAD, PT, T8 (3MM X 1.34 X 4.3MM)
-14	850-0115–70			1	DISPLAY ASSY; COLOR
-15	348-1525-00			1	FOOT; FRONT, SANTOPRENE, BLACK, 64 DEROMETER, TEXTURED
-16	131-6417-00			1	CONTACT, ELEC; GROUNDING, 0.600 L X 0.250 W X 0.220 D, ELECTROLESS NICKEL PLATE
-17	131-6521-00			1	CONTACT, ELEC; EMI, CLIP-ON, 0.38 L X 0.460 W (2 CONTACTS) X 0.45 HIGH, ELECTROLESS NICKEL PLATE

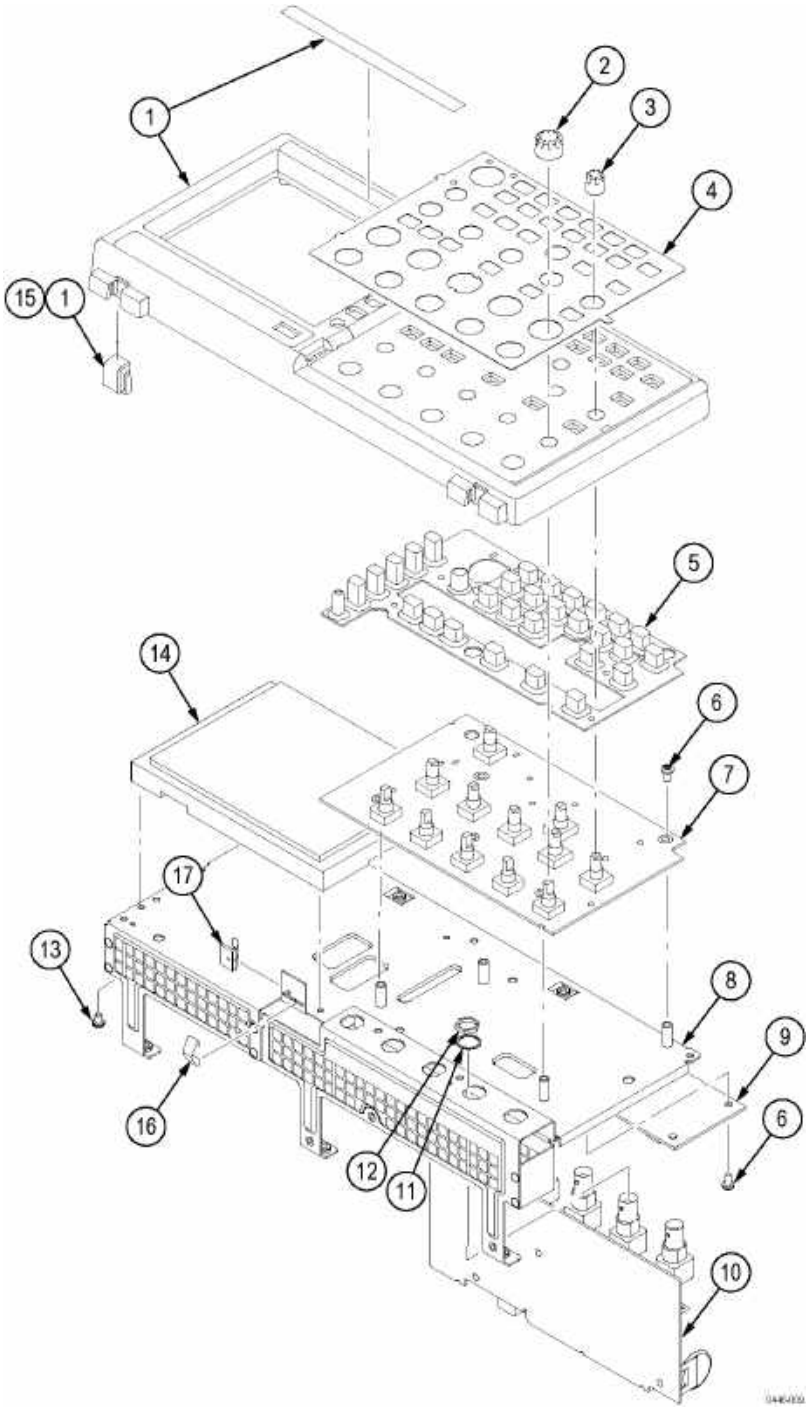


Figure 8-2: Exploded diagram, 4-channel models

Table 8-4: Replaceable parts list, power supply module, cables, and wires

Fig. & index number	Tektronix part number	Serial no. effective	Serial no. discont'd	Qty	Name & description
8-3					POWER SUPPLY, CABLES, WIRES
-1	346-0299-00			1	CABLE TIE; BAND
-2	174-5859-00			1	CA ASSY; DISPLAY CABLE
-3	211-1272-00			10	SCREW, MACHINE; 6-32 X 0.250, PNH, STL, ZNPL, T- 15 TORX DR
-4	174-4658-00			1	CA ASSY, SP; DISCRETE, 26 AWG, 5.5 L, FEMALE, 1 X 12, 0.059 (1.5 MM) CTR, DUAL ENDED, FRONT PANEL
-5	346-1673-00			1	CLAMP, CABLE; NYLON 6/6, COLOR NATURAL
-6	174-5819-00			1	CA ASSY, FPC/FFC; LCD DATA CABLE
-7	211-1275-00			2	SCREW, MACHINE; W/HEAVY PATCH THREADLOCKING MATERIAL; 6-32 X 0.312 L, PNH, STL, ZNPL, T15
-8	119-7609-70			1	POWER SUPPLY: CUSTOM AC-DC, 85-275 VAC 45-440HZ IN, +6 V 1.0 A, +3.3 V 1.8 A, -4 V 0.8 A, 35 V 0.015 A OUT, LINE TRIGGER SIGNAL, SAFETY CONTROLLED
-9	276-0387-00			2	CORE, EMI; EMI SUPPRESSION FERRITE; SPLIT ROUND CABLE, IMPED 130 OHM AT 100 MHZ, 0.197 DIA HOLE 4-CHANNEL MODELS ONLY (installed on the Display cable)

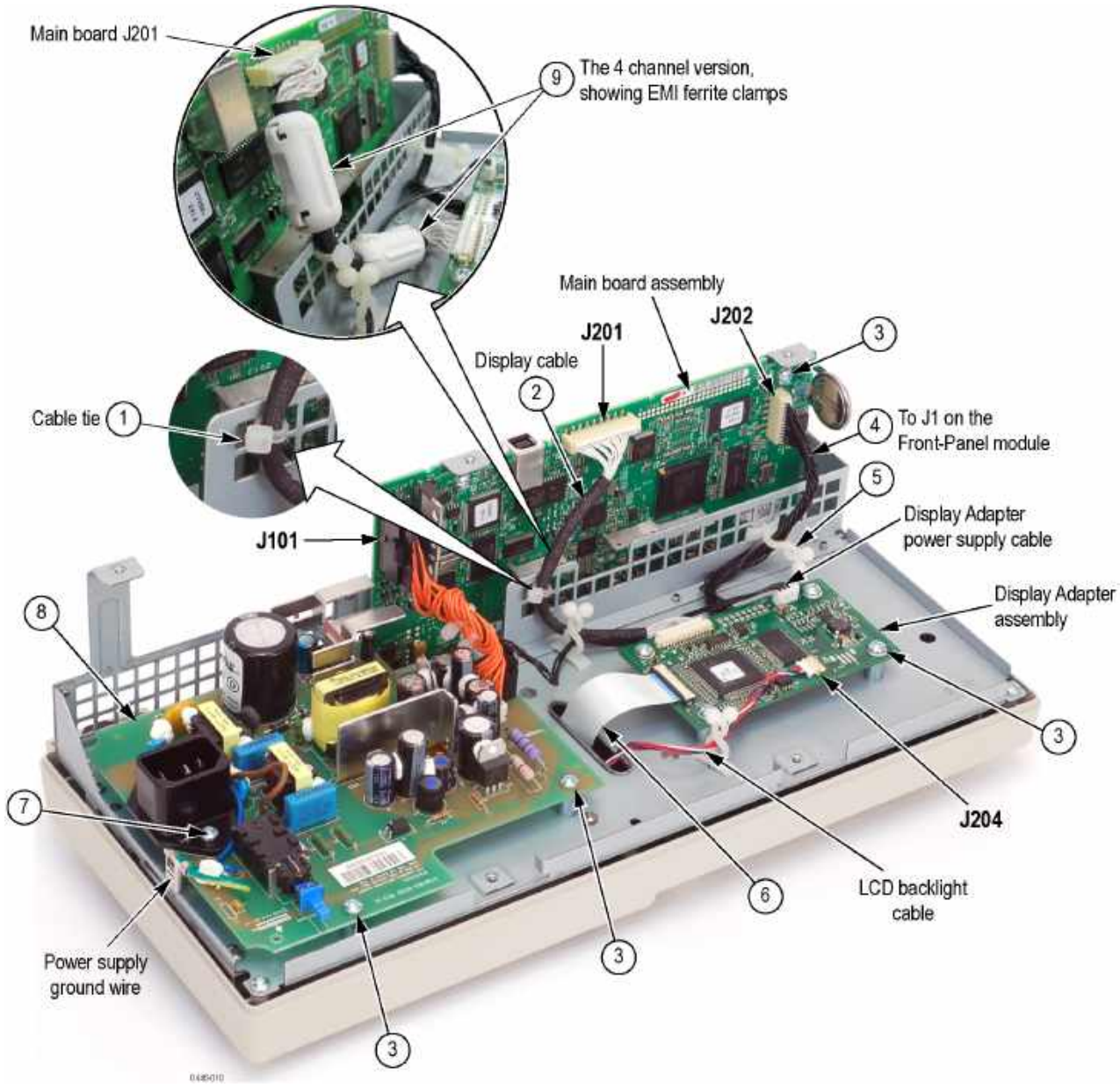


Figure 8-3: Power supply module, cables, and wires (2-ch model shown, with 4-ch model in circle)

Table 8-5: Replaceable parts list, back case and trim

Fig. & index number	Tektronix part number	Serial no. effective	Serial no. discont'd	Qty	Name & description
8-4					BACK CASE, TRIM
-1	850-0154-00			1	REAR CASE ASSY: COVER WITH FEET AND HANDLE
-2	348-1703-00			1	FOOT, FRONT: FLIPMPC/ABS, SILVER GRAY
-3	348-1704-00			1	FOOT, REAR: SANTOPRENE, BLACK
-4	211-1272-00			5	SCREW, MACHINE: 6-32 X 0.250, PNH, STL, ZNPL, T-15 TORX DR
-5	200-5105-00			2	COVER, ESD PROTECTION
-6	366-0856-00			1	PUSH BUTTON, POWER
-7	211-1273-00			5	SCREW, PT; K35-1.57, PAN HEAD, T-15

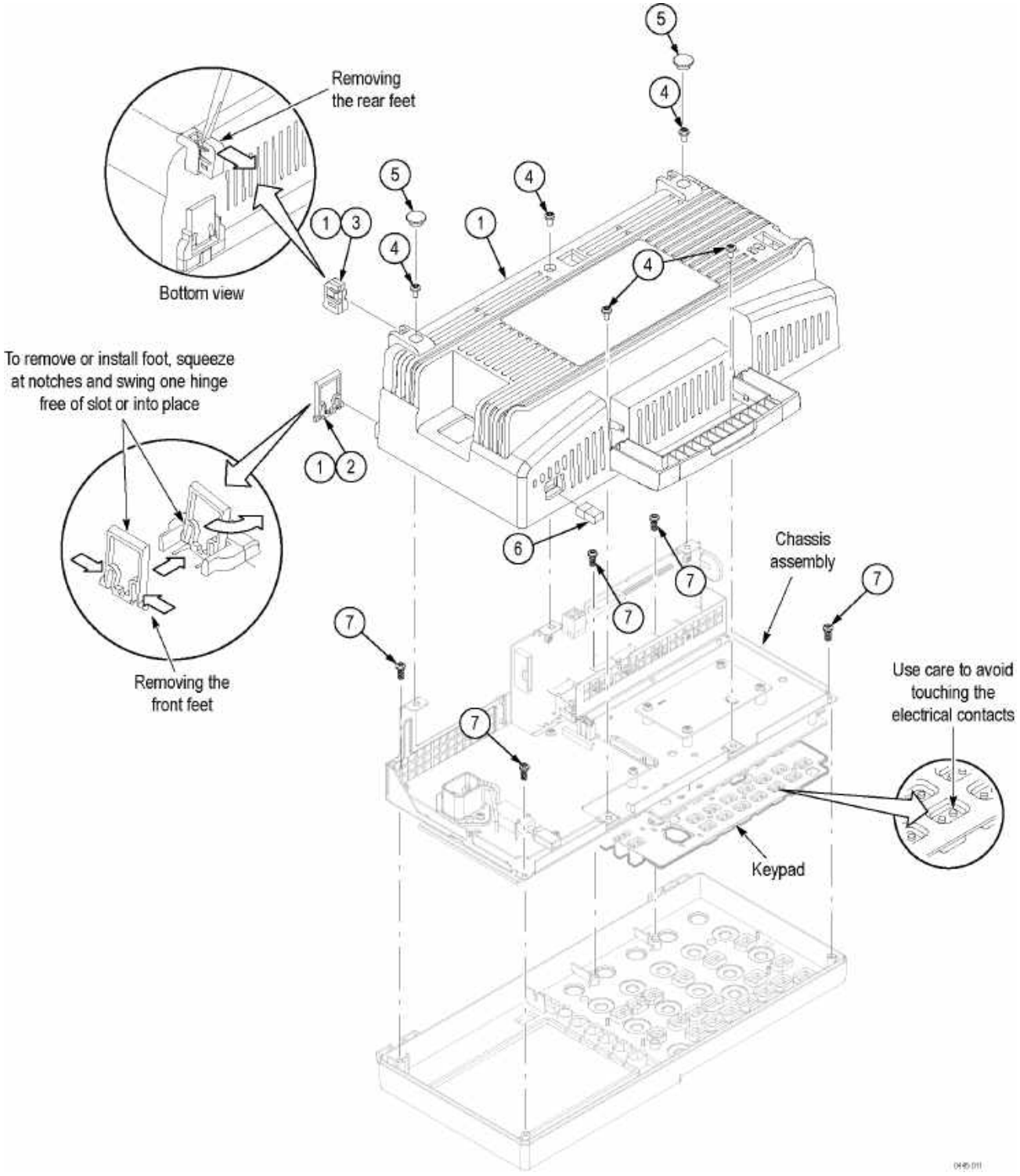


Figure 8-4: Exploded diagram, back case and trim

Appendix A: Example of a Vertical Position Accuracy Test Spreadsheet

This appendix contains a filled-in example of the vertical position accuracy (VPA) test spreadsheet that is used. (See page 4-10, *Check Vertical Position Accuracy*.)

The PDF version of the TDS2000C service manual (Tektronix part number 077-0446-00, this manual) includes an empty VPA test spreadsheet for your convenience. To access and save the test spreadsheet:

1. Go to the Tektronix Web site (www.tektronix.com) and click the **Manuals** link (in the left column on the screen).
2. Enter **077044600** in the **Search By Keyword** field and then click **Go**.
3. Click the **TDS2000C Series Service Manual** link.
4. Click the **Download File** button and follow on-screen instructions to save the PDF file to your PC.
5. Open the PDF file in Adobe Reader (version 7 or later).
6. Click the **paper clip** icon (lower left of the screen) to display the Attachments panel. If the paper clip icon is not shown, click **View > Navigation Panels > Attachments**.
7. Double-click the **VPA Test Table.xls** file.
8. Click **OK** in the **Launch Attachment** dialog box. The test spreadsheet opens in your spreadsheet application and shows the **Blank Test Record** spreadsheet tab.
9. Click **File > Save As** to save the file to a name and location that you enter. You can now use the spreadsheet to enter values for the vertical position accuracy test.

Example Filled-In Vertical Position Accuracy Test Spreadsheet

Table A-1: Vertical position accuracy test spreadsheet

	A	B	C	D	E	F	G	H	I
1	Approximate Test Voltage	DVM Measured Voltage	Oscilloscope Measured Voltage	Error	Lower Limit	Upper Limit	Margin		
2	2.00			0.000	‡	‡	‡	Volts/div	0.05
3	1.96			0.000	‡	‡	‡		
4	1.92			0.000	‡	‡	‡	Offset as a fractional division	0.1

Table A-1: Vertical position accuracy test spreadsheet (cont.)

	A	B	C	D	E	F	G	H	I
5	1.88			0.000	‡	‡	‡	Offset in volts	0.005
6	1.84			0.000	‡	‡	‡	Total voltage offset	0.01=I2*I4+I5
7	1.80	1.80	1.79	0.010	-0.028	0.028	0.018		
8	1.76	1.76	1.75	0.010	-0.0276	0.0276	0.018	Gain error	1%
9	1.72	1.72	1.72	0.000	-0.0272	0.0272	0.027		
10	1.68	1.68	1.68	0.000	-0.0268	0.0268	0.027	Equation for cell D7	=B7-C7
11	1.64	1.64	1.64	0.000	-0.0264	0.0264	0.026	Equation for cell E7	=-F7
12	1.60	1.6	1.6	0.000	-0.026	0.026	0.026	Equation for cell F7	=(ABS(B7)*I8 + I6)
13	1.56	1.56	1.56	0.000	-0.0256	0.0256	0.026		
14	1.52	1.52	1.52	0.000	-0.0252	0.0252	0.025	Equation for cell G7	=MIN (D7-E7,F7-D7)
15	1.48	1.48	1.49	-0.010	-0.0248	0.0248	0.015		
16	1.44	1.44	1.45	-0.010	-0.0244	0.0244	0.014	Minimum margin	0.007=MIN (G7:G97)
17	1.40	1.4	1.41	-0.010	-0.024	0.024	0.014		
18	1.36	1.36	1.37	-0.010	-0.0236	0.0236	0.014		
19	1.32	1.32	1.33	-0.010	-0.0232	0.0232	0.013		
20	1.28	1.28	1.29	-0.010	-0.0228	0.0228	0.013		
21	1.24	1.24	1.25	-0.010	-0.0224	0.0224	0.012		
22	1.20	1.2	1.21	-0.010	-0.022	0.022	0.012		
23	1.16	1.16	1.17	-0.010	-0.0216	0.0216	0.012		
24	1.12	1.12	1.13	-0.010	-0.0212	0.0212	0.011		
25	1.08	1.08	1.09	-0.010	-0.0208	0.0208	0.011		
26	1.04	1.04	1.05	-0.010	-0.0204	0.0204	0.010		
27	1.00	1	1.01	-0.010	-0.02	0.02	0.010		
28	0.96	0.96	0.966	-0.006	-0.0196	0.0196	0.014		
29	0.92	0.92	0.926	-0.006	-0.0192	0.0192	0.013		
30	0.88	0.88	0.886	-0.006	-0.0188	0.0188	0.013		
31	0.84	0.84	0.845	-0.005	-0.0184	0.0184	0.013		

Table A-1: Vertical position accuracy test spreadsheet (cont.)

32	0.80	0.8	0.805	-0.005	-0.018	0.018	0.013
33	0.76	0.76	0.764	-0.004	-0.0176	0.0176	0.014
34	0.72	0.72	0.724	-0.004	-0.0172	0.0172	0.013
35	0.68	0.68	0.683	-0.003	-0.0168	0.0168	0.014
36	0.64	0.64	0.643	-0.003	-0.0164	0.0164	0.013
37	0.60	0.6	0.6	0.000	-0.016	0.016	0.016
38	0.56	0.56	0.561	-0.001	-0.0156	0.0156	0.015
39	0.52	0.52	0.521	-0.001	-0.0152	0.0152	0.014
40	0.48	0.48	0.481	-0.001	-0.0148	0.0148	0.014
41	0.44	0.44	0.44	0.000	-0.0144	0.0144	0.014
42	0.40	0.4	0.401	-0.001	-0.014	0.014	0.013
43	0.36	0.36	0.361	-0.001	-0.0136	0.0136	0.013
44	0.32	0.32	0.32	0.000	-0.0132	0.0132	0.013
45	0.28	0.28	0.281	-0.001	-0.0128	0.0128	0.012
46	0.24	0.24	0.244	-0.004	-0.0124	0.0124	0.008
47	0.20	0.2	0.204	-0.004	-0.012	0.012	0.008
48	0.16	0.16	0.163	-0.003	-0.0116	0.0116	0.009
49	0.12	0.12	0.123	-0.003	-0.0112	0.0112	0.008
50	0.08	0.08	0.083	-0.003	-0.0108	0.0108	0.008
51	0.04	0.04	0.043	-0.003	-0.0104	0.0104	0.007
52	0.00	0	0.002	-0.002	-0.01	0.01	0.008
53	-0.04	-0.04	-0.039	-0.001	-0.0104	0.0104	0.009
54	-0.08	-0.079	-0.079	0.000	-0.01079	0.01079	0.011
55	-0.12	-0.12	-0.118	-0.002	-0.0112	0.0112	0.009
56	-0.16	-0.159	-0.159	0.000	-0.01159	0.01159	0.012
57	-0.20	-0.199	-0.198	-0.001	-0.01199	0.01199	0.011
58	-0.24	-0.239	-0.238	-0.001	-0.01239	0.01239	0.011
59	-0.28	-0.279	-0.274	-0.005	-0.01279	0.01279	0.008
60	-0.32	-0.319	-0.314	-0.005	-0.01319	0.01319	0.008
61	-0.36	-0.359	-0.353	-0.006	-0.01359	0.01359	0.008
62	-0.40	-0.399	-0.393	-0.006	-0.01399	0.01399	0.008
63	-0.44	-0.439	-0.432	-0.007	-0.01439	0.01439	0.007
64	-0.48	-0.48	-0.473	-0.007	-0.0148	0.0148	0.008
65	-0.52	-0.52	-0.513	-0.007	-0.0152	0.0152	0.008
66	-0.56	-0.56	-0.552	-0.008	-0.0156	0.0156	0.008
67	-0.6	-0.6	-0.592	-0.008	-0.016	0.016	0.008
68	-0.64	-0.64	-0.633	-0.007	-0.0164	0.0164	0.009
69	-0.68	-0.68	-0.673	-0.007	-0.0168	0.0168	0.010

Table A-1: Vertical position accuracy test spreadsheet (cont.)

70	-0.72	-0.72	-0.713	-0.007	-0.0172	0.0172	0.010
71	-0.76	-0.76	-0.754	-0.006	-0.0176	0.0176	0.012
72	-0.80	-0.8	-0.794	-0.006	-0.018	0.018	0.012
73	-0.84	-0.84	-0.835	-0.005	-0.0184	0.0184	0.013
74	-0.88	-0.88	-0.875	-0.005	-0.0188	0.0188	0.014
75	-0.92	-0.92	-0.915	-0.005	-0.0192	0.0192	0.014
76	-0.96	-0.96	-0.956	-0.004	-0.0196	0.0196	0.016
77	-1.00	-1	-0.996	-0.004	-0.02	0.02	0.016
78	-1.04	-1.04	-1.04	0.000	-0.0204	0.0204	0.020
79	-1.08	-1.08	-1.08	0.000	-0.0208	0.0208	0.021
80	-1.12	-1.12	-1.12	0.000	-0.0212	0.0212	0.021
81	-1.16	-1.16	-1.16	0.000	-0.0216	0.0216	0.022
82	-1.20	-1.2	-1.2	0.000	-0.022	0.022	0.022
83	-1.24	-1.24	-1.24	0.000	-0.0224	0.0224	0.022
84	-1.28	-1.28	-1.28	0.000	-0.0228	0.0228	0.023
85	-1.32	-1.32	-1.32	0.000	-0.0232	0.0232	0.023
86	-1.36	-1.36	-1.36	0.000	-0.0236	0.0236	0.024
87	-1.40	-1.4	-1.4	0.000	-0.024	0.024	0.024
88	-1.44	-1.44	-1.44	0.000	-0.0244	0.0244	0.024
89	-1.48	-1.48	-1.48	0.000	-0.0248	0.0248	0.025
90	-1.52	-1.52	-1.52	0.000	-0.0252	0.0252	0.025
91	-1.56	-1.56	-1.56	0.000	-0.0256	0.0256	0.026
92	-1.60	-1.6	-1.6	0.000	-0.026	0.026	0.026
93	-1.64	-1.64	-1.64	0.000	-0.0264	0.0264	0.026
94	-1.68	-1.68	-1.68	0.000	-0.0268	0.0268	0.027
95	-1.72	-1.72	-1.72	0.000	-0.0272	0.0272	0.027
96	-1.76	-1.76	-1.75	-0.010	-0.0276	0.0276	0.018
97	-1.80	-1.8	-1.79	-0.010	-0.028	0.028	0.018
98	-1.84				‡	‡	‡
99	-1.88				‡	‡	‡
100	-1.92				‡	‡	‡
101	-1.96				‡	‡	‡
Paanchaali@2300 102					‡	‡	‡

‡ These test values are outside of the range in the specification.