Service Manual

Tektronix

TFS3031 TekRanger 2
Mini Optical Time-Domain Reflectometer

070-9026-05

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

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

WARRANTY

Tektronix warrants that this product will be free from defects in materials and workmanship for a period of one (1) year from the date of shipment. If any such product proves defective during this warranty period, Tektronix, at its option, either will repair the defective product without charge for parts and labor, or will provide a replacement in exchange for the defective product.

In order to obtain service under this warranty, Customer must notify Tektronix of the defect before the expiration of the warranty period and make suitable arrangements for the performance of service. Tektronix will provide such service at Customer's site without charge during the warranty period, if the service is performed within the normal on-site service area. Tektronix will provide on-site service outside the normal on-site service area only upon prior agreement and subject to payment of all travel expenses by Customer. When or where on-site service is not available, Customer shall be responsible for packaging and shipping the defective product to the service center designated by Tektronix, with shipping charges prepaid. Tektronix shall pay for the return of the product to Customer if the shipment is to a location within the country in which the Tektronix service center is located. Customer shall be responsible for paying all shipping charges, duties, taxes, and any other charges for products returned to any other locations.

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

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

WARNING

This equipment generates, uses, and can radiate radio-frequency energy, and if not installed and used in accordance with the instructions manual, may cause interference to radio communications. It has been tested and found to comply with the limits for a Class A computing device pursuant to Subpart J of Part 15 of FCC Rules, which are designated to provide reasonable protection against such interference when operated in a commercial environment. Operation of this equipment in a residential area is likely to cause interference, in which case, the user, at his or her own expense, will be required to take whatever measures may be required to correct the interference.

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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.

Injury Precautions

WARNING. *INVISIBLE LASER RADIATION. To eliminate hazardous radiation exposure, do not use controls or adjustments, or perform procedures, other than those specified in this manual.*

Laser Radiation

The TFS3031 tests optical fibers by emitting short pulses of laser light. The interval between pulses is large compared to the pulsewidth. Although the pulsed power is in the milliwatt range, the average power is only in the microwatt range. The light is emitted by the optical port on the right side-panel, and is invisible to the human eye.

The TFS3031 is classified as a CFR Class I and IEC Class 1 laser product under the Radiation Control and Health Safety Act of 1968, and complies with 21 CFR 1040.10 and 1040.11.

Even though the TFS3031 is categorized as a CFR Class I and IEC Class 1 laser product (the lowest classification), you should avoid exposing your eyes to its light:

- Do not look into the optical port when the TFS3031 is switched on.
- Keep the dust cap on the optical port when not in use.
- Avoid looking at the free end of a test fiber (the end not connected to the TFS3031). If possible, direct the free end toward a non-reflective surface.

Optical Output

When a fiber is not connected to the optical port, the TFS3031 may emit laser light briefly in the following circumstances:During the connection status portion of the test, until the operator either terminates the test, or allows it to continue under the ‘‘connection status’’ warning. If the fiber is disconnected from the optical port during a test, the laser may remain on for up to 60 seconds.

To Avoid Fire or Personal Injury

Replace Batteries Properly. Replace batteries only with the proper type and rating specified.

Recharge Batteries Properly. Recharge batteries for the recommended charge cycle only.

Use Proper AC Adapter. Use only the AC adapter specified for this product.

Do Not Operate Without Covers. Do not operate this product with covers or panels removed.

Use Proper Fuse. Use only the fuse type and rating specified for this product.

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

Wear Eye Protection. Wear eye protection if exposure to high-intensity rays or laser radiation exists.

Do Not Operate With Suspected Failures. If you suspect there is damage to this product, have it inspected by qualified service personnel.

Do Not Operate in an Explosive Atmosphere.

Use Proper Power Cord

To avoid fire hazard, use only the power cord specified for this product.

Do Not Operate Without Covers

To avoid electric shock or fire hazard, do not operate this product with covers or panels removed.

Do Not Operate in Explosive Atmosphere

To avoid injury or fire hazard, do not operate this product in an explosive atmosphere.

Power Sources

This product is designed to operate from an internal, rechargeable nickel-cadmium (NiCad) battery, or an external power/charger adapter rated at 9 to 16 volts DC, 40 watts.

External Power

Use only the power/charger adapter that is specified for the TFS3031.

***CAUTION.** The power/charger adapter is not hermetically sealed. Do not expose it to moisture, which can penetrate and destroy it.*

Battery Do not expose the battery to fire or intense heat. Do not open or mutilate the battery. Avoid contact with released electrolyte which is corrosive and may damage eyes, skin and clothing. Check with local codes for special disposal instructions. Only the entire battery pack is replaceable. Individual cells are not replaceable.

Battery Recycling This product contains a Nickel Cadmium (NiCd) battery, which must be recycled or disposed of properly. For the location of a local battery recycler in the U.S. or Canada, please contact:

RBRC	(800) BATTERY
Rechargeable Battery Recycling Corp.	(800) 227-7379
P.O. Box 141870	www.rbrc.com
Gainesville, Florida 32614	

Fuse The TFS3031 contains a 3.5 A, 125 V, fast-acting fuse on the Power Supply board.

Product Damage Precautions

Use Proper Power Source Do not operate this product from a power source that applies more than the voltage specified.

Provide Proper Ventilation To prevent product overheating, provide proper ventilation.

Safety Terms and Symbols

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.*

Terms on the Product

These terms may appear on the product:

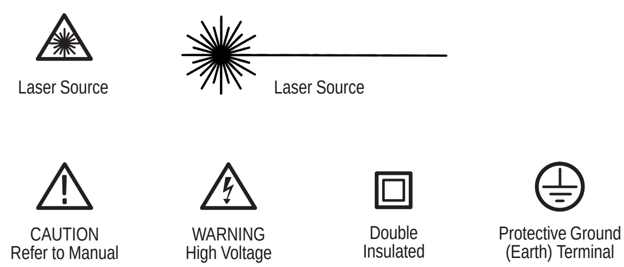
DANGER indicates an injury hazard immediately accessible as you read the marking.

WARNING indicates an injury hazard not immediately accessible as you read the marking.

CAUTION indicates a hazard to property including the product.

Symbols on the Product

The following symbols may appear on the product:



Preface

This manual is used for servicing the TFS3031 to *module level only*. It does not contain component-level service information, schematics, or parts lists.

NOTE. *This manual covers both the TekRanger and the TekRanger 2 instruments. TekRanger instruments have serial numbers below B052000. TekRanger 2 instruments have serial numbers B052000 and above.*

Section 1 includes specifications for both the TekRanger and TekRanger 2. Section 3 contains the TekRanger performance check, and section 4 contains the TekRanger 2 performance check.

All other service information in this manual is generic to both versions of the TFS3031.

Contacting Tektronix

Phone	1-800-833-9200*
Address	Tektronix, Inc. Department or name (if known) 14200 SW Karl Braun Drive P.O. Box 500 Beaverton, OR 97077 USA
Web site	www.tektronix.com
Sales support	1-800-833-9200, select option 1*
Service support	1-800-833-9200, select option 2*
Technical support	Email: support@tektronix.com 1-800-833-9200, select option 3* 1-503-627-2400 6:00 a.m. – 5:00 p.m. Pacific time

*** This phone number is toll free in North America. After office hours, please leave a voice mail message.**
Outside North America, contact a Tektronix sales office or distributor; see the Tektronix web site for a list of offices.

Assumptions

The procedures in this manual assume that you are a qualified electronics technician, and have a working knowledge of service procedures for fiber-optic test equipment.

Before Servicing

To prevent injury to yourself or damage to equipment:

- You must be a qualified service person.
- Read the *Safety Summary* at the beginning of this manual.
- Heed all warnings, cautions and notes in this manual.

What You Will Find in this Manual

- *General Information.* General product and operator information. Keyboard information. Battery recharging and replacement information. Specifications. Accessories and options.
- *System Block Diagram.* Illustration showing the modules and their interconnects.
- *Performance Check – TekRanger.* Procedures for checking that the TFS3031 TekRanger operates properly. This section applies to instruments with serial numbers below B052000.
- *Performance Check – TekRanger 2.* Procedures for checking that the TFS3031 TekRanger 2 operates properly. This section applies to instruments with serial numbers B052000 and above.
- *Maintenance.* Cleaning procedures. Instrument disassembly and module removal. General troubleshooting and fault isolation to module level.
- *Replaceable Parts.* Replaceable electrical and mechanical part numbers, and parts ordering information.

Related Documents

- The *TFS3031 TekRanger/TekRanger 2 User Manual* explains how to use the TFS3031 to test fiber-optic cables.
- The *TFS3031 TekRanger/TekRanger 2 Reference* card briefly summarizes TFS3031 functions on a single card.

Module-Level Service

Overview

This manual is used for servicing the TFS3031 (both TekRanger and TekRanger 2 instruments) to *module level only*. A module is defined as a complete circuit board assembly or other *electrical* part that performs a specific function.

When a problem is traced to a module, the usual corrective procedure is to replace the module.

This manual *does not* contain:

- Component-level troubleshooting or calibration information.
- Information pertaining to component replacement or module repair.
- Circuit board schematics.
- Component-level parts lists or information.

The Functional Modules

There are six functional modules in the TFS3031:

Table 1–1: TFS3031 Functional Modules

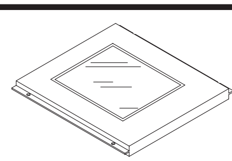
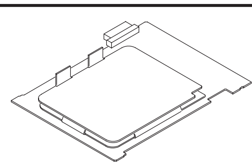
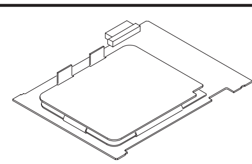
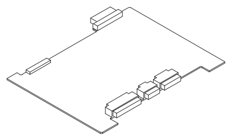
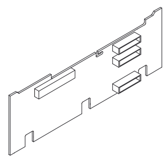
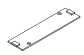
Module	Module Name	Function	Assembly Number[1]
	Display module	Display (LCD)	A1
	Multimode Optical Module assembly (includes MMDAS board and optical module)	Multimode acquisition	A2
	Singlemode Optical Module assembly (includes SMDAS board and optical module)	Singlemode acquisition	A3

Table 1–1: TFS3031 Functional Modules

Module	Module Name	Function	Assembly Number[1]
	MAIN31 board	Instrument controller	A4
	Power Supply board	Power supply	A5
	DC/AC Converter board	Powers the backlight	A6

[1] Assembly numbers and part descriptions are in Section 5.

Optical Modules

The Multimode Optical Module assembly includes the MMDAS board and its optical module. The Multimode Optical Module assembly is included in instrument options 01 and 03.

The Singlemode Optical Module assembly includes the SMDAS board and its optical module. The Singlemode Optical Module assembly is included in instrument options 04, 06, 10, and 12.

If a TFS3031 has both a singlemode and multimode option installed, the singlemode port is in the top position and multimode port is in the bottom position on the side panel. If only one option is installed, it is always in the bottom position whether singlemode or multimode.

The floppy disk drive (Option 11 instruments only) is always mounted on the optical module that is in the bottom position.

For complete listings and descriptions of all electrical modules and mechanical parts, see Section 6.

Static-Sensitive Components

CAUTION. *All modules in the TFS3031 contain components that are sensitive to electrostatic discharge (ESD)*

When servicing the TFS3031, work only at a static-free work station, and practice standard anti-static handling procedures.

Service Procedure

The direct service-related sections in this manual are:

- *Section 2. System Block Diagram.* Shows the functional relationship of the modules.
- *Section 3. Performance Check – TekRanger.* Checks TFS3031 performance to verify correct operation after repairs and adjustments have been made. This section applies to instruments with serial numbers below B052000.
- *Section 4. Performance Check – TekRanger 2.* Checks TFS3031 performance to verify correct operation after repairs and adjustments have been made. This section applies to instruments with serial numbers B052000 and above.
- *Section 5. Maintenance.* Includes:
  - Cleaning the optical port, connector adapter, and fiber connector.
  - Disassembly procedure to module level.
  - Resolving error messages displayed on the screen.
  - Troubleshooting problems to module level.
- *Section 6. Replaceable Parts.* Lists and describes replaceable electrical and mechanical parts.

Section 1. General Information. Contains product information, user information, battery recharging and replacement information, instrument specifications, accessories, and options. If you have no need for this information, go directly to the other sections.

Operator Information

This section summarizes TFS3031 connector, button, and softkey functions.

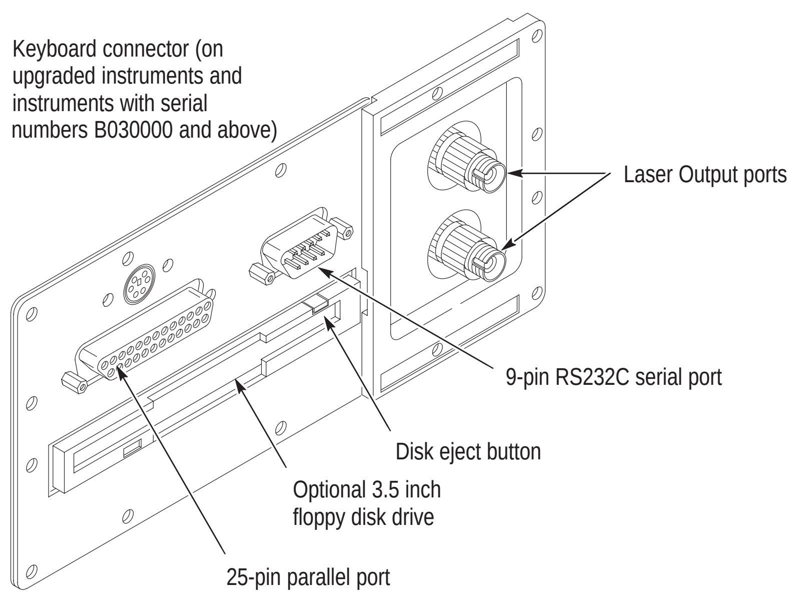
A quick review of this section will familiarize you with the basic operation of the TFS3031, which may help when servicing the instrument.

For complete operator information, refer to the *TFS3031 TekRanger/TekRanger 2 User Manual.*

WARNING. *INVISIBLE LASER RADIATION. To eliminate hazardous radiation exposure do not use controls or adjustments, or perform procedures, other than those specified in this manual.*

CAUTION. *Do not fire the laser (push the* START/STOP *button) unless a fiber is connected to the Laser Output port. Damage to internal electronics can result.*

Port Functions



Dust caps and labeling omitted from illustration

Laser Output Port and Connector Adapter

Laser Output Port

The test fiber connects to the Laser Output port located on the side panel. Laser light is emitted into the test fiber from the Laser Output port.

If both singlemode and multimode Laser Output ports are installed, the singlemode port is in top position and multimode port in bottom position. If one Laser Output port is installed, it will always be in the bottom position whether singlemode or multimode.

Singlemode instrument options are 04, 06, and 10. Multimode instrument options are 01 and 03.

Connector Adapter

The connector adapter attaches the test fiber to the Laser Output port. Connector adapters must be installed on the Laser Output port before use.

***NOTE**. The type of connector adapter and connector on the test fiber must match for proper mating. See page 1–105 for a list of connector adapter options.*

Connector Adapter Installation and Removal

Connector adapters are keyed for proper mating with the Laser Output port.

To install a connector adapter, align the keyed elements, slide the connector adapter onto the Laser Output port, and turn *clockwise* until the connector adapter is finger tight (see Figure 1–1 on page 1–6).

To remove a connector adapter, unscrew it *counterclockwise* and pull it straight off of the port.

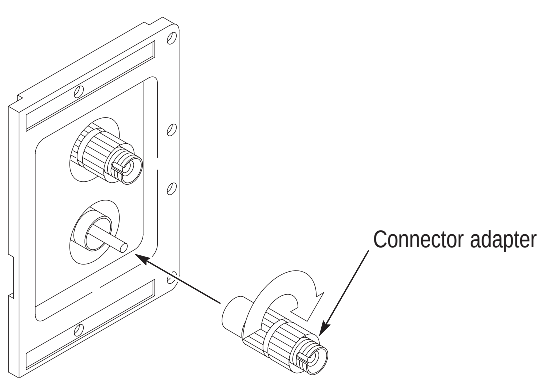


Figure 1–1: Connector Adapter Installation

***CAUTION.** Do not touch the exposed end of the Laser Output port with anything but the proper cleaning materials. See page NO TAG for cleaning instructions.*

To protect against damage, all ports should be capped with their dust caps when not in use.

RS232C Serial Port

The 9-pin RS232C serial port connects to an external serial-type printer or computer.

Parallel Port

The 25-pin parallel port connects to an external parallel-type printer.

Keyboard Connector

A mini-DIN connector is available for an optional keyboard (on upgraded instruments, and instruments with serial numbers B030000 and above). Tables of keyboard sequences that duplicate front-panel controls and functions are given later in this section.

Floppy Disk Drive

The 1.44 Mbyte, 3.5 inch floppy disk drive is for disk storage of test files and for updating the instrument software. The disk drive is an optional accessory installed as Option 11.

Remove the floppy disk from the drive when not in use.

Formatting a Floppy Disk

Both new and used floppy disks may have to be formatted. Formatting destroys any data already on a disk. To format a disk:

1. Insert an unformatted disk in the floppy disk drive.
2. Push the Store or Print softkey to access file storage. The TFS3031 checks the drive for a disk and determines if the disk can be read. An unformatted disk cannot be read.

   If the drive contains an unformatted disk, you are prompted to format by pushing the Yes softkey, or not to format by pushing the No softkey.
3. To format the disk, push the Yes softkey.

   A final yes/no confirmation prompt is displayed along with a notice that formatting the disk will destroy any data already on it.

4. Push the Yes softkey again to confirm formatting.

If you insert an unformatted disk while already in file storage, steps 2, 3, and 4 are displayed when you use the Save, Load, Copy, Delete, or Print file options that involve accessing the floppy disk (when toggling the Internal/Floppy *softkey).*

Updating the Instrument Software

1. Connect the power/charger adapter.

2. Press the SELECT, HELP, and ON/OFF buttons simultaneously.

3. Insert the appropriate language software disk into the instruments disk drive.

4. Press START/STOP to initiate the upgrade.

5. When the upgrade is complete, press ON/OFF button to re-initialize the instrument.

Power/Charger Adapter Port

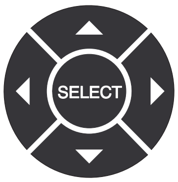
The power/charger adapter port (2.5 mm DIN), located on top of the TFS3031, connects to the power/charger adapter and optional cigarette lighter adapter cable.

The power/charger adapter recharges the NiCad battery and powers the instrument independent of the battery.

The battery must be charged before first use, and recharged at low-battery warning. See page 1–12 for battery recharging instructions.

CAUTION. *Do not connect the power/charger adapter or cigarette lighter adapter cable to the TFS3031 when the ambient temperature exceeds* 40^0 *C (*104^0 *F).*

Buttons and Keys



The SELECT button and arrow keys:

- Move the cursors, manipulate the waveform, and edit events in the waveform/table display.
- Select and change instrument setups.

The ON/OFF button powers the TFS3031 on and off.

The HELP button provides on-screen descriptive information about the current instrument function or status.

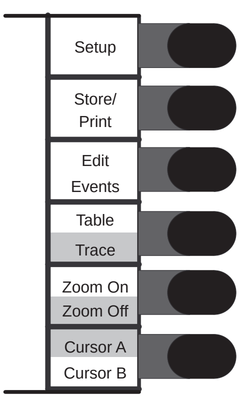
For information about a button or softkey, push HELP, then push the button or softkey in question.

Push the HELP button again to exit help.

The START/STOP button starts a test and stops a test in progress.

In Manual mode, hold down the START/STOP button for at least two seconds for real-time (continuous) testing.

CAUTION. *Do not fire the laser (push the START/STOP button) unless a fiber is connected to the Laser Output port. Severe damage to internal electronics can result.*



Softkeys control the operation of the TFS3031.

Softkeys are displayed along the right side of the screen next to their pushbuttons. Softkey functions vary according to the current operating status of the instrument.

Some softkeys toggle between dual functions, such as the Cursor A/Cursor B softkey. In dual-function cases, the currently active function is indicated by highlighted text. In this illustration, Trace, Zoom Off, and Cursor A are highlighted and are therefore active.

Keyboard Definitions

The functions of the TFS3031's front-panel controls can be duplicated using an optional keyboard connected to the keyboard connector (on upgraded instruments and instruments with serial numbers B030000 and above).

The instrument accepts text entry from the keyboard whevever a character-selection box is on the display (i.e., when entering fiber notes, a file name, or event notes). Table 1–2 lists the keyboard's text-entry functions.

Table 1–2: Keyboard Text-Entry Functions

Key	Function
Backspace	Delete the character to the left of the cursor
Delete Del (keypad)	Delete the character that the cursor is on
Home	Move the cursor to the beginning of the text being edited
End	Move cursor to the end of the text being edited
Page Down	Delete all characters from the cursor to the end of the text being edited
← →	Move the cursor to the left and right
Esc	Undo
Return	Done

When the instrument is not in text-entry mode, you can duplicate the front-panel functions listed in table 1–3.

Table 1–3: Front-Panel Functions

Key	Function
F1 through F6	Perform the same function as the corresponding front-panel softkey, as currently labeled. F1 corresponds to the top softkey, F2 to the second softkey from the top, etc.
Alt-? Alt-/	Help
Alt-S	Start/Stop
Alt-R	Start a real-time acquisition
Alt-J	Join cursors
F10 Return	Select

Battery Recharging and Replacement

CAUTION. *To prevent overheating, remove the TFS3031 from its carrying case during recharging.*

Do not open or mutilate the battery, nor expose it to fire or intense heat. It may explode. Avoid contact with electrolyte, which may damage eyes, skin, and clothing.

Do not attempt to use or recharge a battery that is leaking electrolyte, or is otherwise obviously damaged.

CAUTION. *Recharging the battery when the ambient temperature exceeds 40° C (104^{0} F) or is less than –20° C (–4° F) may cause the charging circuits to shut down. If this is happens, disconnect and reconnect the battery to reset the circuits. See page 1–15 for battery disconnection/reconnection instructions.*

Do not connect the power/charger adapter or cigarette lighter adapter cable to the TFS3031 when the ambient temperature exceeds 40^{0} C (104^{0} F). Doing so may exceed safe charging temperatures for the NiCad pack.

Low-Battery Warning

The charge level of the battery is always displayed in upper right screen.

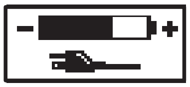
The first low-battery warning is a message displayed on the screen when about 30 minutes of normal operating time remain.

The second and last low-battery warning consists of a flashing *red* BATTERY LED on the front panel when about 10 minutes of normal operating time remain.

If you push the ON/OFF button to turn on the TFS3031 when the NiCad battery does not have enough charge to operate the instrument, the red BATTERY LED flashes for a few seconds.

When to Recharge the NiCad Battery

Recharge the NiCad battery before using the TFS3031 on battery power, and when a low-battery warning is displayed.



A‘‘battery’’ indicator that shows the charge level is always displayed in the upper right corner of the screen. In this illustration the indicator shows that about 60% of battery power remains.

A ‘‘power plug’’ indicator is displayed below the battery indicator when the power/charger adapter is connected to the instrument. The NiCad battery is always being charged when the “power plug” indicator is on.

When the TFS3031 is using battery power, an estimate of the operating time left under present operating conditions is displayed in place of the power plug indicator.

The TFS3031 cannot be damaged by continuous charging over extended periods of time at ambient temperatures of less than 40° C (104° F). When the battery reaches full charge, the TFS3031 goes to trickle charge to maintain the full charge level.

Power/Charger Adapter

Use the power/charger adapter to recharge the battery (see Figure 1–2 on page 1–13). As long as the power/charger adapter is plugged into an active power source, the battery recharges whether the TFS3031 is powered on and operating, or powered off.

The power/charger adapter accommodates 110 to 240 volt AC source, or a 9 to 16 volt DC source capable of supplying 40 watts.

The power/charger adapter may also be used to power the TFS3031 when the battery is discharged or removed.

CAUTION. *Using a power/charger adapter other than the one supplied by Tektronix may damage the TFS3031.*

Do not connect the power/charger adapter to the TFS3031 when the ambient temperature exceeds 40° C (104° F).

The power/charger adapter is not hermetically sealed. Do not expose it to moisture.

An optional 12-volt cigarette lighter adapter lets you recharge the battery in the field.

CAUTION. *Do not connect the cigarette lighter adapter cable to the TFS3031 when the ambient temperature exceeds 40° C (104° F).*

NiCad Battery Recharging Procedure

To recharge the NiCad battery, plug the power/charger adapter into the port on the top of the TFS3031, and into an appropriate active power source (see Figure 1–2).

The battery recharges as long as the power/charger adapter remains connected to the instrument and power source.

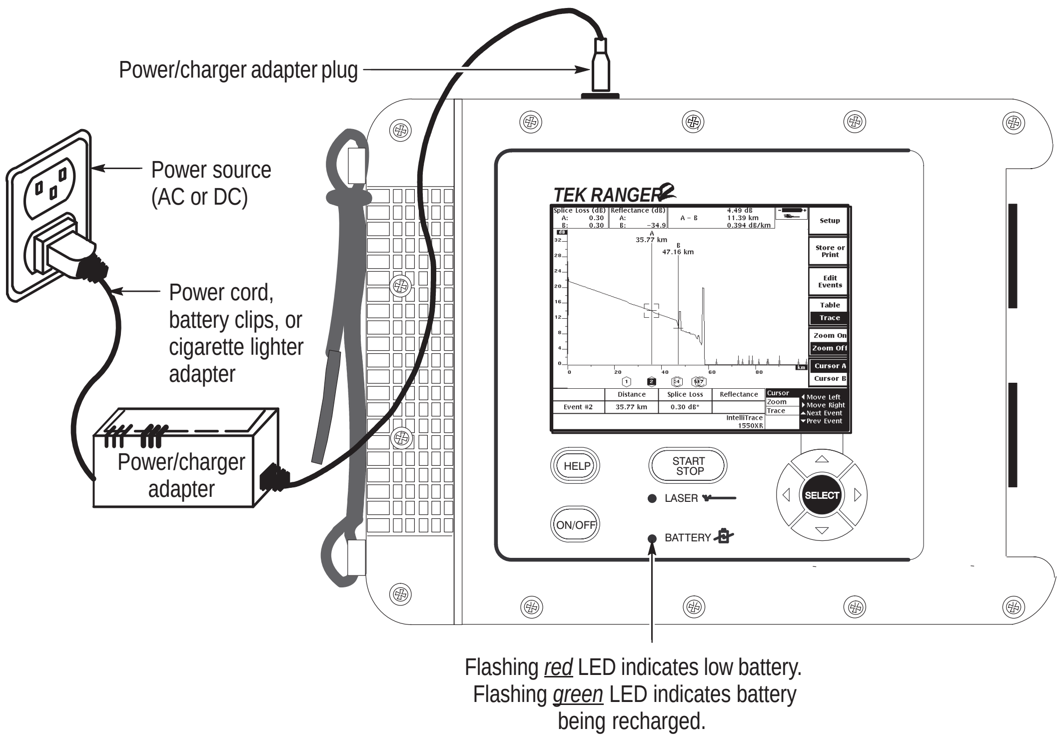


Figure 1–2: NiCad Battery Recharging Setup

- A warning message flashed on the screen indicates that about 30 minutes of normal operating time remain.
- A flashing *red* BATTERY LED on the front panel indicates that about 10 minutes of normal operating time remain. (If the BATTERY LED is flashing red at power-on and the LCD screen remains blank, there is not enough battery power to run the instrument.)
- The BATTERY LED flashes *green* when the power/charger adapter is connected and the battery is recharging.

- The BATTERY LED glows a steady *green* when the power/charger adapter is connected and the battery has reached full charge. When the battery reaches full charge, the TFS3031 goes to trickle charge to maintain the full charge level.
- The BATTERY LED is *off* when the power/charger adapter disconnected (except for the flashing red condition).
- In the upper right corner of the screen, the ‘‘battery’’ indicator always shows charge level of the battery. A ‘‘power plug’’ indicator is displayed when the power/charger adapter is plugged in and charging the battery.
- Recharging time for a completely discharged NiCad battery at room temperature is about four hours if the TFS30301 is not turned on.
- Operating time for a fully recharged Nicad battery is about 4.5 hours.
- The TFS3031 may be powered on and operated during recharging. However, recharging time will take longer.

Tips for Maximizing Battery Life

- Turn off the backlight, or set a brief backlight blanking time using the *Backlight Time* setup in the *System Setup* menu.
- Set a brief automatic power-off time using the *Power Off Time* setup in the *System Setup* menu.
- If you often use the same setups, select Last Used for power-on defaults on the *System Setup* menu to eliminate setup time each time you power on the instrument.
- Power off the TFS3031 when not in use.
- Minimize floppy-disk use under battery power. Save files to internal memory while unit is under battery power. Later when you can attach the AC adapter, copy the files as a group to floppy disk.
- Fully charge the NiCad batteries after each use.
- Operate TFS3031 without the backlight whenever possible.
- Disconnect the battery if the instrument is stored for an extended period of time (i.e., more than a month).

NiCad Battery Disconnection, Removal, and Replacement

1. Press off the TFS3031 and disconnect external power.

2. Loosen the six screws that hold the battery compartment cover in place on the back of the instrument (see Figure 1–3). The screws are captive to prevent loss.

3. Disconnect the NiCad battery cable plug and lift the battery out of the case. The plug and connector snap together.

The foam padding that surrounds the battery stays with the case.

Only the entire battery pack is replaceable. Individual cells are not replaceable.

4. Install the new battery by reversing the removal sequence.

When a NiCad battery is disconnected then reconnected, or a new NiCad battery is installed, the battery indicator in the upper right screen displays question marks until full recharge or discharge is reached. The question marks are also displayed for about 10 seconds when the unit is first turned on, as well as when the AC adapter is unplugged, until a valid time estimate is calculated.

When the battery is fully discharged, the unit automatically turns off.

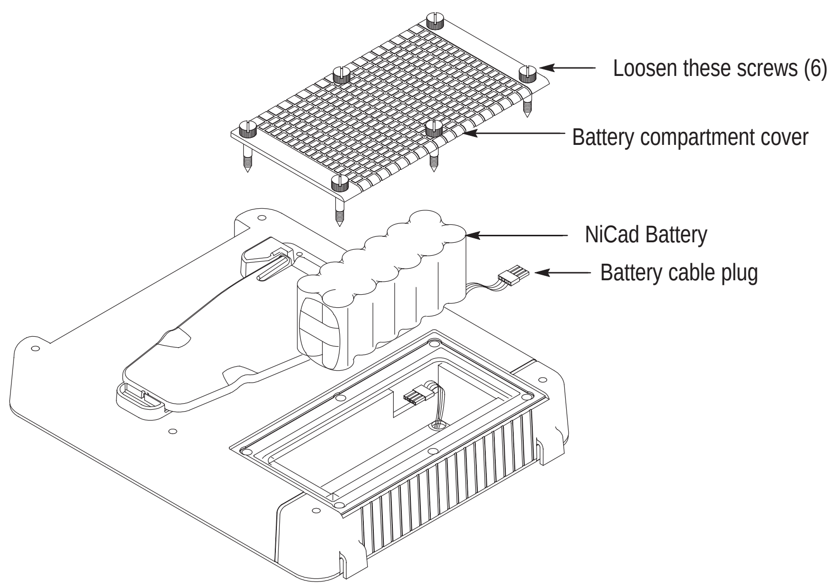


Figure 1–3: NiCad Battery Removal

Specifications – TekRanger (serial nos. below B052000)

Standard 850 nm Multimode, Options 01 and 03

Table 1–4: Optical Signal Characteristics (850 nm Multimode, Options 01 and 03)

Characteristic	Performance Requirement		Supplemental Information
Displayed Pulse Width			Measured between the −1.5 dB points relative to the top of the pulse. 10, 5, 1 meters.
Pulse Repetition Time (PRT) Pulse Width 10 m 5 m 1 m	*Minimum PRT (µs):* 184 µs 92 µs 19 µs	*Typical PRT (µs):* 200 µs 175 µs 150 µs	Minimum reflects limit for laser safety classification. Typical reflects hardware/software constraints at product introduction. The PRT is controlled by design of the software and does not need to be checked in production.
Optical Output, Wavelength	850 ±30 nm		Spectral mean or center of mass.
Optical Output, Spectral Width			10 nm FWHM typical. RMS value of spectral energy is time-averaged mode from series of pulses.
Optical Output, Amplitude			Measured at peak value emitted from front panel connector into 62.5 µm, NA=0.28, GI fiber. 3 W maximum
Laser Product Safety Classification	CFR Class I and IEC Class 1		FDA CFR 21 dated 4/1/95 and IEC 825−1 dated 11/93. < 4.0 W peak emitted from laser into laser pigtail. For calculation refer to project archive. (Initial work work was done in CNA Tektronix Engineering notebook #35, pp. 30 − 37.)
Temperature Coefficient of Laser Wavelength			(0.25 nm/°C) x (T −25° C) typical

Table 1–5: Vertical System Measurements (850 nm Multimode, Options 01 and 03)

Characteristic	Performance Requirement	Supplemental Information
Linearity		3-minute average ±0.02 dB/dB typical From 12 dB above RMS floor to 1.5 dB below maximum signal level.
Measurement Accuracy Two-Point Splice Loss LSA Fiber Loss Reflectance		3-minute average, ±0.1 dB/dB for events 10 dB above 98% noise floor, 95% confidence ±4 dB maximum error below −40 dB. 10 m to 1 m pulse width. Reflections may clip above −40 dB.

Table 1–6: Measurement Range (850 nm Multimode, Options 01 and 03)

Characteristic	Performance Requirement	Supplemental Information
Loss Threshold (dB) 0.1 0.5 1		Typical: 25 dB IntelliTrace mode averaging and analysis less than 3 minutes plus 15 seconds per event.

Table 1–7: Single-Event Distance Measurement Repeatability[1] (850 nm Multimode, Options 01 and 03)

Characteristic	Performance Requirement		Supplemental Information
Range from Front Panel (dB)	Reflective[2] *typical*	Nonreflective[3] *typical*	IntelliTrace mode
0 to 10	2.5 m	2.5 m	
> 10	5 m	15 m	

1 Multiply by 0.001% of range for timebase error. These data are for a 0.5 dB event with 95% probability.
2 Reflectance greater than −45 dB, 0.5 dB loss.
3 Reflectance less than −60 dB, 0.5 dB loss.

Table 1–8: Vertical System Dynamic Range (850 nm Multimode, Options 01 and 03)

Characteristic	Performance Requirement			Supplemental Information
Dynamic Range Pulse Width	SNR=1	98%	SNR=1 *typical*	Dynamic range SNR=1 is defined as the difference between the extrapolated backscatter level at the start of the fiber and the RMS[1] noise floor. Dynamic range 98% is defined as the difference between the extrapolated backscatter level at the start of the fiber and the 98% level of the noise. Measured using a 62.5 µm, 0.28 NA GI fiber after 3 minutes of averaging. A 0.5 dB front panel loss is assumed.
10 m	25.5	23	31	
5 m	15.5	13	18	
1 m	14.5	12	17	
Temperature Coefficient of Dynamic Range				−0.15 dB/°C for T ≠ 25° C, typical

1. RMS in this test is defined as the standard deviation.

Table 1–9: Horizontal System Dead Zone (850 nm Multimode, Options 01 and 03)

Characteristic	Performance Requirement		Supplemental Information
Attenuation Dead Zone Pulse Width		*typical:*	Attenuation dead zone is defined as the distance between the initial and final points, where the backscatter level is disrupted beyond ±0.5 dB due to encountering a single reflective event. Based on reflective event with no greater than −40 dB reflectance. Based on 62.5 µm, 0.28 NA GI fiber.
10 m	20 m	16 m	
5 m	15 m	10 m	
1 m	10 m	6 m	
Event Dead Zone Pulse Width		*typical*	Event dead zone is defined as the distance between the initial and final points, where the reflected pulse amplitude is −1.5 dB down from its peak value.
10 m	15 m	11 m	
5 m	8 m	7 m	
1 m	<5 m	2 m	

Table 1–10: Horizontal System Distance Span and Range (850 nm Multimode, Options 01 and 03)

Characteristic	Performance Requirement	Supplemental Information
Distance Span (Manual Mode) Pulse Width 10 m 5 m 1 m	 10 km 5 km 1 km	Distance span is defined as the length of the data acquisition window for a single segment acquisition in overview mode. Span is determined by the sample spacing and the number of samples possible in the acquisition window.

Table 1–11: System Measurement Accuracy (850 nm Multimode, Options 01 and 03)

Characteristic	Performance Requirement	Supplemental Information
Distance	±5.0 m	Verified on the TFS3031 Distance Accuracy Test Fixture on every instrument built in Manufacturing and on instruments that are repaired in Service. Intellitrace only. Does not take into account errors in index of refraction and cabling factor.

Table 1–12: Sample Density, Pulsewidth, and Range Combinations (850 nm Multimode, Options 01 and 03)

Pulse Width (m)	Bandwidth (MHz)[1]	Overview Sample Spacing[2]	Overview Interleave Factor[3]	Overview Measurement Spans (km)				Minimum High Density Sample Spacing
				10	4	2	1	
10	20	2.5 m	4x	●	●	●	●	1.25 m
5	20	1.25 m	8x	●	●	●	●	1.25 m
1	35	25 cm	40x		●	●	●	25 cm

Note 1: Bandwidth is chosen based on a 3x minimum bandwidth required for pulse width resolution. The minimum bandwidth is given by

$$\beta_{min} = \frac{0.35}{pw\ (meters)\ x\ 10\ ns/m}$$

Note 2: Sample spacing is chosen to obtain four or five data points on pulse.
Note 3: Interleave factor is based on a 10 MHz sampling rate.

Table 1–13: Bandwidth and Transient Characteristics (850 nm Multimode, Options 01 and 03)

Bandwidth (MHz)	Risetime	Falltime
35	1 m = 10 ns	1 m/10 dB
20	1.75 m = 17.5 ns	1.75 m/10 dB

Standard 1300 nm Multimode, Option 03

Table 1–14: Optical Signal Characteristics (1300 nm Multimode, Option 03)

Characteristic	Performance Requirement	Supplemental Information
Displayed Pulse Width		Measured between the −1.5 dB points relative to the top of the pulse. 100, 50, 20, 10, 5, 1 meters
Pulse Repetition Time (PRT) Pulse Width 100 m 50 m 20 m 10 m 5 m 1 m	*Minimum PRT (us):* / *Typical PRT (us):* 62 us / 650 us 31 us / 600 us 13 us / 550 us 7 us / 500 us 4 us / 450 us 1 us / 400 us	Minimum reflects limit for laser safety classification. Typical reflects hardware/software constraints at product introduction. The PRT is controlled by design of the software and does not need to be checked in production.
Optical Output, Wavelength	1300 ±30 nm	Spectral mean or center of mass.
Optical Output, Spectral Width		10 nm FWHM typical. RMS value of spectral energy is time-averaged mode from series of pulses.
Optical Output, Amplitude		Measured at peak value emitted from front panel connector into 62.5 μm, NA=0.28, GI fiber. 250 mW maximum
Laser Product Safety Classification	CFR Class I and IEC Class 1	FDA CFR 21 dated 4/1/95 and IEC 825−1 dated 11/93. < 1.0 W peak emitted from laser into laser pigtail. For calculation refer to project archive. (Initial work work was done in CNA Tektronix Engineering notebook #35, pp. 59 – 62.)
Temperature Coefficient of Laser Wavelength		(0.4 nm/°C) x (T −25° C) typical

1.1.1 Vertical System Measurements (1300 nm Multimode, Option 03)

Characteristic	Performance Requirement	Supplemental Information
Linearity		3-minute average. ±0.02 dB/dB typical From 12 dB above RMS floor to 1.5 dB below maximum signal level.
Measurement Accuracy Two-Point Splice Loss LSA Fiber Loss Reflectance		3-minute average, ±0.1 dB/dB for events 10 dB above 98% noise floor, 95% confidence. ±4 dB maximum error below −40 dB. 10 m to 1 m pulse width. Reflections may clip above −40 dB.

1.1.2 Measurement Range (1300 nm Multimode, Option 03)

Characteristic	Performance Requirement	Supplemental Information
Loss Threshold (dB) 0.1 0.5 1	Measurement Range (dB) *typical* 16 18 20	IntelliTrace mode averaging and analysis less than 3 minutes plus 15 seconds per event.

1.1.3 Single-Event Distance Measurement Repeatability[1] (1300 nm Multimode, Option 03)

Characteristic	Performance Requirement		Supplemental Information
Range from Front Panel (dB) 0 to 10 > 10	Reflective[2] *typical* 10 m 20 m	Nonreflective[3] *typical* 10 m 60 m	IntelliTrace mode

[1] Multiply by 0.001% of range for timebase error. These data are for a 0.5 dB event with 95% probability.
[2] Reflectance greater than −45 dB, 0.5 dB loss.
[3] Reflectance less than −60 dB, 0.5 dB loss.

Table 1–15: Vertical System Dynamic Range (1300 nm Multimode, Option 03)

Characteristic	Performance Requirement			Supplemental Information
Dynamic Range Pulse Width	SNR=1	98%	SNR=1 *typical*	Dynamic range SNR=1 is defined as the difference between the extrapolated backscatter level at the start of the fiber and the RMS[1] noise floor. Dynamic range 98% is defined as the difference between the extrapolated backscatter level at the start of the fiber and the 98% level of the noise. Measured using a 62.5 µm, 0.28 NA GI fiber after 3 minutes of averaging. A 0.5 dB front panel loss is assumed.
100 m	21.5	19	28	
50 m	13.5	11	18	
20 m	14.5	12	19	
10 m	13	10.5	17	
5 m	11.5	9	15.5	
1 m	11.5	9	15.5	
Temperature Coefficient of Dynamic Range				−0.15 dB/°C for T ≠ 25° C, typical

1. RMS in this test is defined as the standard deviation.

Table 1–16: System Measurement Accuracy (1300 nm Multimode, Option 03)

Characteristic	Performance Requirement	Supplemental Information
Distance	±5.0 m	Verified on the TFS3031 Distance Accuracy Test Fixture on every instrument built in Manufacturing and on instruments that are repaired in Service. Intellitrace only. Does not take into account errors in index of refraction and cabling factor.

Table 1–17: Horizontal System Dead Zone (1300 nm Multimode, Option 03)

Characteristic	Performance Requirement		Supplemental Information
Attenuation Dead Zone Pulse Width		*typical:*	Attenuation dead zone is defined as the distance between the initial and final points, where the backscatter level is disrupted beyond ±0.5 dB due to encountering a single reflective event. Based on reflective event with no greater than −40 dB reflectance. Based on 62.5 μm, 0.28 NA GI fiber.
100 m	150 m	130 m	
50 m	100 m	70 m	
20 m	50 m	35 m	
10 m	30 m	16 m	
5 m	20 m	10 m	
1 m	15 m	8 m	
Event Dead Zone Pulse Width	*CG:*	*typical:*	Event dead zone is defined as the distance between the initial and final points, where the reflected pulse amplitude is −1.5 dB down from its peak value.
100 m	120 m	110 m	
50 m	60 m	50 m	
20 m	30	25 m	
10 m	15 m	12 m	
5 m	8 m	6 m	
1 m	<5 m	3 m	

Table 1–18: Horizontal System Distance Span and Range (1300 nm Multimode, Option 03)

Characteristic	Performance Requirement	Supplemental Information
Distance Span (Manual Mode) Pulse width		Distance span is defined as the length of the data acquisition window for a single segment acquisition in overview mode. Span is determined by the sample spacing and the number of samples possible in the acquisition window.
100 m	40 km	
50 m	40 km	
20 m	20 km	
10 m	10 km	
5 m	5 km	
1 m	1 km	

Table 1–19: Sample Density, Pulsewidth, and Range Combinations (1300 nm Multimode, Option 03)

Pulse Width (m)	Bandwidth (MHz)[1]	Overview Sample Spacing[2]	Overview Interleave Factor[3]	Overview Measurement Spans (km)						Minimum High Density Sample Spacing
				40	20	10	4	2	1	
100	5	10 m	1x	●	●	●	●			1.25 m
50	20	10 m	1x	●	●	●	●	●		1.25 m
20	20	5 m	2x		●	●	●	●	●	1.25 m
10	20	2.5 m	4x		●	●	●	●	●	1.25 m
5	20	1.25 m	8x			●	●	●	●	1.25 m
1	35	25 cm	40x				●	●	●	25 cm

Note 1: Bandwidth is chosen based on a 3x minimum bandwidth required for pulse width resolution. The minimum bandwidth is given by

$$\beta_{min} = \frac{0.35}{pw\ (meters)\ x\ 10\ ns/m}$$

Note 2: Sample spacing is chosen to obtain four data points on pulse.
Note 3: Interleave factor is based on a 10 MHz sampling rate.

Table 1–20: Bandwidth and Transient Characteristics (1300 nm Multimode, Option 03)

Bandwidth (MHz)	Risetime	Falltime
35	1 m = 10 ns	1 m/10 dB
20	1.75 m = 17.5 ns	1.75 m/10 dB
5	7 m = 70 ns	7 m/10 dB

Standard 1310 nm Singlemode, Options 04 and 06

Table 1–21: Optical Signal Characteristics (Standard 1310 nm Singlemode, Options 04 and 06)

Characteristic	Performance Requirement	Supplemental Information
Displayed Pulsewidth		Measured between the −1.5 dB points relative to the top of the pulse. 2000, 1000, 500, 100, 50, 20, 10, 5, 1 meters
Pulse Repetition Rate (Range) 160 km 80 km 40 km 20 km 10 km 5 km 2 km 1 km		Minimum specified values: 1600 μs 800 μs 400 μs 200 μs 100 μs 50 μs 20 μs 10 μs
Optical Output, Wavelength	1310 ±20 nm	Spectral mean or center-of-mass.
Optical Output, Spectral Width		10 nm RMS value of spectral energy is time-averaged mode from series of pulses.
Optical Output, Amplitude		Measured at peak value emitted from front panel connector into 9 μm, NA=0.1, SM fiber. 70 mW maximum.
Laser Product Safety Classification	CFR Class I and IEC Class 1	Per FDA and IEC
Temperature Coefficient of Laser Wavelength		(0.4 nm/°C) x (T −25° C)

Table 1–22: Vertical System Measurements (Standard 1310 nm Singlemode, Options 04 and 06)

Characteristic	Performance Requirement	Supplemental Information
Linearity		3-minute average. ±0.02 dB/dB typical From 9 dB above RMS floor to 1.5 dB below maximum signal level.
Measurement Accuracy Two-Point Splice Loss LSA Fiber Loss Reflectance		3 minute average, ± 0.1 dB/dB for events 10 dB above 98% noise floor, 95% confidence ±4 dB maximum error below −40 dB. 10 m to 1 m pulsewidth. Reflections may clip above −40 dB.

Table 1–23: Measurement Range (Standard 1310 nm Singlemode, Options 04 and 06)

Characteristic		Performance Requirement		Supplemental Information
Loss Threshold (dB)	Max PW	Measurement Range (dB) Minimum	Typical	IntelliTrace mode averaging and analysis less than 3 minutes. For isolated nonreflective event or grouped NR-reflective events. Reflective event return loss >−40 dB; distance >4 km past NR event. (This means that a small, nonreflective event followed closely by a small, reflective event will reduce the repeatability of finding these two events).
0.05	500 m	10	13	
0.2	2000 m	18	20	
0.5	2000 m	20	22	
1.0	2000 m	21	23	

Table 1–24: Single-Event Distance Measurement Repeatability[1] (Standard 1310 nm Singlemode, Options 04 and 06)

Characteristic	Performance Requirement		Supplemental Information
Range from Front Panel (dB)	Reflective[2]	Nonreflective[3]	IntelliTrace mode
0 to 1.5	2.5 m	2.5 m	
1.5 to (DR[4]–8)	20 m	20 m	
(DR–8) to DR	40 m	160 m	

[1] Multiply by 0.001% of range for timebase error. These data are for a 0.5 dB event with 95% probability on a single unit.
[2] Reflectance greater than −45 dB, 0.5 dB loss.
[3] Reflectance less than −60 dB, 0.5 dB loss.
[4] DR is the dynamic range for 2000-m pulse width from table 1−25. DR is the 98% dynamic range, defined as dynamic range SNR=1 minus 1.5.

Table 1–25: Vertical System Dynamic Range (Standard 1310 nm Singlemode, Options 04 and 06)

Characteristic	Performance Requirement		Supplemental Information
Dynamic Range Pulsewidth	SNR=1	Typical	Dynamic range SNR=1 is defined as the difference between the extrapolated backscatter level at the start of the fiber and the RMS noise level. Measured using a 4-km test fiber (Corning SMF-28, 8.5 µm core, 0.12 NA) after 3 minutes of averaging. Based on high APD and amplifier gains. Low APD gain reduces 4 dB. Low amplifier gain reduces 5 dB. A 0.5-dB front panel loss is assumed.
2000 m	26 dB	28 dB	
1000 m	23 dB		
500 m	21 dB	24 dB	
100 m	14.5 dB		
50 m	13 dB		
20 m	10 dB		
10 m	8.5 dB		
5 m	7 dB		
1 m	2.5		
Temperature Coefficient of Dynamic Range			-0.15 dB/°C for T $\neq$ 25° C

Table 1–26: Horizontal System Dead Zone (Standard 1310 nm Singlemode, Options 04 and 06)

Characteristic	Performance Requirement		Supplemental Information
Attenuation Dead Zone Pulsewidth		Typical	Attenuation dead zone is defined as the distance between the initial and final points, where the backscatter level is disrupted beyond ±0.5 dB due to encountering a single reflective event. Based on reflective event with no greater than −40 dB reflectance. Based on 9 μm, 0.1 NA SM fiber.
2000 m	2300 m		
1000 m	1350 m		
500 m	600 m		
100 m	175 m		
50 m	100 m		
20 m	40 m		
10 m	30 m	20 m	
5 m	45 m		
1 m	80 m		
Event Dead Zone Pulsewidth			Event dead zone is defined as the distance between the initial and final points, where the reflected pulse amplitude is −1.5 dB down from its peak value. Based upon reflective event with no greater than −40 dB reflectance.
2000 m	2250 m		
1000 m	1200 m		
500 m	700 m		
100 m	115 m		
50 m	65 m		
20 m	30 m		
10 m	20 m		
5 m	8 m		
1 m	<5 m		

Table 1–27: Horizontal System Distance Span and Range (Standard 1310 nm Singlemode, Options 04 and 06)

Characteristic	Performance Requirement	Supplemental Information
Distance Span (Manual Mode) Pulsewidth		Distance span is defined as the length of the data acquisition window for a single segment acquisition in overview mode. Span is determined by the sample spacing and the number of samples possible in the acquisition window.
2000 m	160 km	
1000 m	160 km	
500 m	80 km	
100 m	40 km	
50 m	40 km	
20 m	20 km	
10 m	10 km	
5 m	5 km	
1 m	1 km	

Table 1–28: Sample Density, Pulsewidth, and Range Combinations (Standard 1310 nm Singlemode, Options 04 and 06)

Pulsewidth (m)	Bandwidth (MHz)[1]	Overview Sample Spacing[2]	Overview Interleave Factor[3]	Overview Measurement Spans (km)								Minimum High Density Sample Spacing
				160	80	40	20	8	4	2	1	
2000	0.3	40 m	1x	●	●	●	●					1.25 m
1000	0.3	40 m	1x	●	●	●	●	●				1.25 m
500	5	20 m	1x	●	●	●	●	●	●			1.25 m
100	5	10 m	1x		●	●	●	●	●	●		1.25 m
50	5	10 m	1x		●	●	●	●	●	●	●	1.25 m
20	17	5 m	2x		●	●	●	●	●	●	●	1.25 m
10	17	2.5 m	4x				●	●	●	●	●	1.25 m
5	17	1.25 m	8x				●	●	●	●	●	1.25 m
1	35	25 cm	40x						●	●	●	25 cm

Note 1: Bandwidth is chosen based on a 3x minimum bandwidth required for pulsewidth resolution. The minimum bandwidth is given by

$$\beta_{min} = \frac{0.35}{pw\ (meters)\ x\ 10\ ns/m}$$

Note 2: Sample spacing is chosen to obtain four data points on pulse.
Note 3: Interleave factor is based on a 10 MHz sampling rate.

Table 1–29: Bandwidth and Transient Characteristics (Standard 1310 nm Singlemode, Options 04 and 06)

Bandwidth (MHz)	Risetime	Fallslope
35	1 m = 10 ns	2.1 m/10 dB
17	2 m = 21 ns	4.3 m/10 dB
5	7 m = 70 ns	14.7 m/10 dB
0.3	117 m = 1170 ns	245 m/ 10 dB

Standard 1550 nm Singlemode, Option 06

Table 1–30: Optical Signal Characteristics (Standard 1550 nm Singlemode, Option 06)

Characteristic	Performance Requirement	Supplemental Information
Displayed Pulsewidth		Measured between the −1.5 dB points relative to the top of the pulse. 2000, 1000, 500, 100, 50, 20, 10, 5, 1 meters
Pulse Repetition Rate (Range) 160 km 80 km 40 km 20 km 10 km 5 km 2 km 1 km		Minimum specified values: 1600 μs 800 μs 400 μs 200 μs 100 μs 50 μs 20 μs 10 μs
Optical Output, Wavelength	1550 ±20 nm	Spectral mean or center-of-mass.
Optical Output, Spectral Width		10 nm RMS value of spectral energy is time-averaged mode from series of pulses.
Optical Output, Amplitude		Measured at peak value emitted from front panel connector into 9 μm, NA=0.1, SM fiber. 60 mW maximum.
Laser Product Safety Classification	CFR Class I and IEC Class 1	Per FDA and IEC
Temperature Coefficient of Laser Wavelength		(0.4 nm/°C) x (T −25° C)

Table 1–31: Vertical System Measurements (Standard 1550 nm Singlemode, Option 06)

Characteristic	Performance Requirement	Supplemental Information
Linearity		3-minute average. ±0.02 dB/dB typical From 9 dB above RMS floor to 1.5 dB below maximum signal level.
Measurement Accuracy Two-Point Splice Loss LSA Fiber Loss Reflectance		3-minute average, ±0.1 dB/dB for events 10 dB above 98% noise floor, 95% confidence ±4 dB maximum error below −40 dB. 10 m to 1 m pulsewidth. Reflections may clip above −40 dB.

Table 1–32: Measurement Range (Standard 1550 nm Singlemode, Option 06)

Characteristic		Performance Requirement		Supplemental Information
Loss Threshold (dB)	Max PW	Measurement Range (dB) Minimum	Typical	IntelliTrace mode averaging and analysis less than 3 minutes. For isolated nonreflective event or grouped NR-reflective events. Reflective event return loss >−40 dB; distance >1 km past NR event. (This means that a small, nonreflective event followed closely by a small, reflective event will reduce the repeatability of finding these two events).
0.05	500 m	9	11	
0.2	2000 m	16	18	
0.5	2000 m	18	20	
1.0	2000 m	19	21	

Table 1–33: Single-Event Distance Measurement Repeatability[1] (Standard 1550 nm Singlemode, Option 06)

Characteristic	Performance Requirement		Supplemental Information
Range from Front Panel (dB)	Reflective[2]	Nonreflective[3]	IntelliTrace mode
0 to 1	2.5 m	2.5 m	
1 to (DR[4]–8)	20 m	20 m	
(DR–8) to DR	40 m	160 m	

[1] Multiply by 0.001% of range for timebase error. These data are for a 0.5 dB event with 95% probability on a single unit.
[2] Reflectance greater than −45 dB, 0.5 dB loss.
[3] Reflectance less than −60 dB, 0.5 dB loss.
[4] DR is the dynamic range for 2000-m pulse width from table 1−34. DR is the 98% dynamic range, defined as dynamic range SNR=1 minus 1.5.

Table 1–34: Vertical System Dynamic Range (Standard 1550 nm Singlemode, Option 06)

Characteristic	Performance Requirement		Supplemental Information
Dynamic Range Pulsewidth	SNR=1	Typical	Dynamic range SNR=1 is defined as the difference between the extrapolated backscatter level at the start of the fiber and the RMS noise level. Based on high APD and amplifier gains. Low APD gain reduces 4 dB. Low amplifier gain reduces 5 dB. Measured using a 4 km test fiber (Corning SMF-28, 8.5 µm core, 0.12 NA) after 3 minutes of averaging. A 0.5 dB front panel loss is assumed.
2000 m	24 dB	26 dB	
1000 m	21.5 dB		
500 m	20 dB	22 dB	
100 m	13 dB		
50 m	11.5 dB		
20 m	8 dB		
10 m	6.5 dB		
5 m	5 dB		
1 m	1 dB		
Temperature Coefficient of Dynamic Range			−0.15 dB/°C for T $\neq$ 25° C

Table 1–35: Horizontal System Dead Zone (Standard 1550 nm Singlemode, Option 06)

Characteristic	Performance Requirement		Supplemental Information
Attenuation Dead Zone Pulsewidth		Typical	Event dead zone is defined as the distance between the initial and final points, where the backscatter level is disrupted beyond ±0.5 dB due to encountering a single reflective event. Based on reflective event with no greater than −40 dB reflectance. Based on 9 µm, 0.1 NA SM fiber.
2000 m	2300 m		
1000	1350 m		
500 m	600 m		
100 m	175 m		
50 m	100 m		
20 m	40 m		
10 m	30 m	20 m	
5 m	45 m		
1 m	80 m		
Event Dead Zone Pulsewidth			Event dead zone is defined as the distance between the initial and final points, where the reflected pulse amplitude is −1.5 dB down from its peak value. Based upon reflective event with no greater than −40 dB reflectance.
2000 m	2250 m		
1000 m	1200 m		
500 m	700 m		
100 m	115 m		
50 m	65 m		
20 m	30 m		
10 m	20 m		
5 m	8 m		
1 m	<5 m		

Table 1–36: Horizontal System Distance Span and Range (Standard 1550 nm Singlemode, Option 06)

Characteristic	Performance Requirement	Supplemental Information
Distance Span (Manual Mode) Pulsewidth		Distance span is defined as the length of the data acquisition window for a single segment acquisition in overview mode. Span is determined by the sample spacing and the number of samples possible in the acquisition window.
2000 m	160 km	
1000 m	160 km	
500 m	80 km	
100 m	40 km	
50 m	40 km	
20 m	20 km	
10 m	10 km	
5 m	5 km	
1 m	1 km	

Table 1–37: Sample Density, Pulsewidth, and Range Combinations (Standard 1550 nm Singlemode, Option 06)

Pulsewidth (m)	Bandwidth (MHz)[1]	Overview Sample Spacing[2]	Overview Interleave Factor[3]	Overview Measurement Spans (km)								Minimum High Density Sample Spacing
				160	80	40	20	8	4	2	1	
2000	0.3	40 m	1x	●	●	●	●					1.25 m
1000	0.3	40 m	1x	●	●	●	●	●				1.25 m
500	5	20 m	1x	●	●	●	●	●	●			1.25 m
100	5	10 m	1x		●	●	●	●	●	●		1.25 m
50	5	10 m	1x		●	●	●	●	●	●	●	1.25 m
20	17	5 m	2x		●	●	●	●	●	●	●	1.25 m
10	17	2.5 m	4x				●	●	●	●	●	1.25 m
5	17	1.25 m	8x				●	●	●	●	●	1.25 m
1	35	25 cm	40x						●	●	●	25 cm

Note 1: Bandwidth is chosen based on a 3x minimum bandwidth required for pulsewidth resolution. The minimum bandwidth is given by

$$\beta_{min} = \frac{0.35}{pw\ (meters)\ x\ 10\ ns/m}$$

Note 2: Sample spacing is chosen to obtain four data points on pulse.
Note 3: Interleave factor is based on a 10 MHz sampling rate.

Table 1–38: Bandwidth and Transient Characteristics (Standard 1550 nm Singlemode, Option 06)

Bandwidth (MHz)	Risetime	Fallslope
35	1 m = 10 ns	2.1 m/10 dB
17	2 m = 21 ns	4.3 m/10 dB
5	7 m = 70 ns	14.7 m/10 dB
0.3	117 m = 1170 ns	245 m/ 10 dB

Extended Range 1310 nm Singlemode, Option 08

Table 1–39: Optical Signal Characteristics (Extended Range 1310 nm Singlemode, Option 08)

Characteristic	Performance Requirement	Supplemental Information
Displayed Pulsewidth		Measured between the −1.5 dB points relative to the top of the pulse. 2000,1000, 500, 100, 50, 20, 10, 5, 1 meters
Pulse Repetition Rate (Range) 160 km 80 km 40 km 20 km 10 km 5 km 2 km 1 km		Minimum specified values: 1600 μs 800 μs 400 μs 200 μs 100 μs 50 μs 20 μs 10 μs
Optical Output, Wavelength	1310 ±20 nm	Spectral mean or center-of-mass.
Optical Output, Spectral Width		10 nm RMS value of spectral energy is time-averaged mode from series of pulses.
Optical Output, Amplitude		Measured at peak value emitted from front panel connector into 9 μm, NA=0.1, SM fiber. 110 mW maximum.
Laser Product Safety Classification	CFR Class I and IEC Class 1	Per FDA and IEC
Temperature Coefficient of Laser Wavelength		(0.4 nm/^{o}C) x (T −25^{o} C)

Table 1–40: Vertical System Measurements (Extended Range 1310 nm Singlemode, Option 08)

Characteristic	Performance Requirement	Supplemental Information
Linearity		3-minute average. ±0.02 dB/dB typical From 9 dB above RMS floor to 1.5 dB below maximum signal level.
Measurement Accuracy Two-Point Splice Loss LSA Fiber Loss Reflectance		3-minute average, ±0.1 dB/dB for events 10 dB above the 98% noise floor, 95% confidence. ±4 dB maximum error below −40 dB. 10 m to 1 m pulsewidth. Reflections may clip above −40 dB.

Table 1–41: Measurement Range (Extended Range 1310 nm Singlemode, Option 08)

Characteristic		Performance Requirement		Supplemental Information
Loss Threshold (dB)	Max PW	Measurement Range (dB) Minimum	Typical	IntelliTrace mode averaging and analysis less than 3 minutes. For isolated nonreflective event or grouped NR-reflective events. Reflective event return loss >−40 dB; distance >1 km past NR event. (This means that a small, nonreflective event followed closely by a small, reflective event will reduce the repeatability of finding these two events).
0.05	500 m	14	17	
0.2	2000 m	22	24	
0.5	2000 m	24	26	
1.0	2000 m	25	27	

Table 1–42: Single-Event Distance Measurement Repeatability[1] (Extended Range 1310 nm Singlemode, Option 08)

Characteristic	Performance Requirement		Supplemental Information
Range from Front Panel (dB)	Reflective[2]	Nonreflective[3]	IntelliTrace mode
0 to 1.5	2.5 m	2.5 m	
1.5 to (DR[4]–8)	20 m	20 m	
(DR–8) to DR	40 m	160 m	

[1] *Multiply by 0.001% of range for timebase error. These data are for a 0.5 dB event with 95% probability on a single unit.*
[2] *Reflectance greater than −45 dB, 0.5 dB loss.*
[3] *Reflectance less than −60 dB, 0.5 dB loss.*
[4] *DR is the dynamic range for 2000-m pulse width from table 1−43. DR is the 98% dynamic range, defined as dynamic range SNR=1 minus 1.5.*

Table 1–43: Vertical System Dynamic Range (Extended Range 1310 nm Singlemode, Option 08)

Characteristic	Performance Requirement		Supplemental Information
Dynamic Range Pulsewidth	SNR=1	Typical	Dynamic range SNR=1 is defined as the difference between the extrapolated backscatter level at the start of the fiber and the RMS noise level. Based on high APD and amplifier gains. Low APD gain reduces 4 dB. Low amplifier gain reduces 5 dB. Measured using a 4 km test fiber (Corning SMF-28, 8.5 µm core, 0.12 NA) after 3 minutes of averaging. A 0.5 dB front panel loss is assumed.
2000	30 dB	32 dB	
1000 m	28 dB		
500 m	25 dB	28 dB	
100 m	19.5 dB		
50 m	18 dB		
20 m	15 dB		
10 m	13.5 dB		
5 m	12 dB		
1 m	7.5 dB		
Temperature Coefficient of Dynamic Range			−0.15 dB/°C for $T \neq 25°$ C

Table 1–44: Horizontal System Dead Zone (Extended Range 1310 nm Singlemode, Option 08)

Characteristic	Performance Requirement	Typical	Supplemental Information
Attenuation Dead Zone Pulsewidth			Attenuation dead zone is defined as the distance between the initial and final points, where the backscatter level is disrupted beyond ±0.5 dB due to encountering a single reflective event. Based on reflective event with no greater than −40 dB reflectance. Based on 9 µm, 0.1 NA SM fiber.
2000 m	2300 m		
1000 m	1350 m		
500 m	600 m		
100 m	175 m		
50 m	100 m		
20 m	40 m		
10 m	30 m	20 m	
5 m	45 m		
1 m	80 m		
Event Dead Zone Pulsewidth			Event dead zone is defined as the distance between the initial and final points, where the reflected pulse amplitude is −1.5 dB down from its peak value. Based on reflective event with no greater than −40 dB reflectance.
2000 m	2250 m		
1000 m	1200 m		
500 m	700 m		
100 m	115 m		
50 m	65 m		
20 m	30 m		
10 m	20 m		
5 m	8 m		
1 m	<5 m		

Table 1–45: Horizontal System Distance Span and Range (Extended Range 1310 nm Singlemode, Option 08)

Characteristic	Performance Requirement	Supplemental Information
Distance Span (Manual Mode) Pulsewidth		Distance span is defined as the length of the data acquisition window for a single segment acquisition in overview mode. Span is determined by the sample spacing and the number of samples possible in the acquisition window.
2000 m	160 km	
1000 m	160 km	
500 m	80 km	
100 m	40 km	
50 m	40 km	
20 m	20 km	
10 m	10 km	
5 m	5 km	
1 m	1 km	

Table 1–46: Sample Density, Pulsewidth, and Range Combinations (Extended Range 1310 nm Singlemode, Option 08)

Pulsewidth (m)	Bandwidth (MHz)[1]	Overview Sample Spacing[2]	Overview Interleave Factor[3]	Overview Measurement Spans (km)								Minimum High Density Sample Spacing
				160	80	40	20	8	4	2	1	
2000	0.3	40 m	1x	●	●	●	●					1.25 m
1000	0.3	40 m	1x	●	●	●	●	●				1.25 m
500	5	20 m	1x	●	●	●	●	●	●			1.25 m
100	5	10 m	1x		●	●	●	●	●	●		1.25 m
50	5	10 m	1x		●	●	●	●	●	●	●	1.25 m
20	17	5 m	2x		●	●	●	●	●	●	●	1.25 m
10	17	2.5 m	4x				●	●	●	●	●	1.25 m
5	17	1.25 m	8x					●	●	●	●	1.25 m
1	35	25 cm	40x						●	●	●	25 cm

Note 1: Bandwidth is chosen based on a 3x minimum bandwidth required for pulsewidth resolution. The minimum bandwidth is given by

$$\beta_{min} = \frac{0.35}{pw\ (meters)\ x\ 10\ ns/m}$$

Note 2: Sample spacing is chosen to obtain four data points on pulse.
Note 3: Interleave factor is based on a 10 MHz sampling rate.

Table 1–47: Bandwidth and Transient Characteristics (Extended Range 1310 nm Singlemode, Option 08)

Bandwidth (MHz)	Risetime	Fallslope
35	1 m = 10 ns	21.5 m/10 dB
17	2 m = 21 ns	4.3 m/10 dB
5	7 m = 70 ns	14.7 m/10 dB
0.3	117 m = 1170 ns	245 m/ 10 dB

Extended Range 1550 nm Singlemode, Option 08

Table 1–48: Optical Signal Characteristics (Extended Range 1550 nm Singlemode, Option 08)

Characteristic	Performance Requirement	Supplemental Information
Displayed Pulsewidth		Measured between the −1.5 dB points relative to the top of the pulse. 2000,1000, 500, 100, 50, 20, 10, 5, 1 meters
Pulse Repetition Rate (Range) 160 km 80 km 40 km 20 km 10 km 5 km 2 km 1 km		Minimum specified values: 1600 µs 800 µs 400 µs 200 µs 100 µs 50 µs 20 µs 10 µs
Optical Output, Wavelength	1550 ±20 nm	Spectral mean or center-of-mass.
Optical Output, Spectral Width		10 nm RMS value of spectral energy is time-averaged mode from series of pulses.
Optical Output, Amplitude		Measured at peak value emitted from front panel connector into 9 µm, NA=0.1, SM fiber. 80 mW maximum.
Laser Product Safety Classification	CFR Class I and IEC Class 1	Per FDA and IEC
Temperature Coefficient of Laser Wavelength		(0.4 nm/°C) x (T −25° C)

Table 1–49: Vertical System Measurements (Extended Range 1550 nm Singlemode, Option 08)

Characteristic	Performance Requirement	Supplemental Information
Linearity		3-minute average. ±0.02 dB/dB typical From 9 dB above RMS floor to 1.5 dB below maximum signal level.
Measurement Accuracy Two-Point Splice Loss LSA Fiber Loss Reflectance		3-minute average, ±0.1 dB/dB for events 10 dB above the 98% noise floor, 95% confidence. ±4 dB maximum error below −40 dB. 10 m to 1 m pulsewidth. Reflections may clip above –40 dB.

Table 1–50: Measurement Range (Extended Range 1550 nm Singlemode, Option 08)

Characteristic		Performance Requirement		Supplemental Information
Loss Threshold (dB)	Max PW	Measurement Range (dB) Minimum	 Typical	IntelliTrace mode averaging and analysis less than 3 minutes. For isolated nonreflective event or grouped NR-reflective events. Reflective event return loss >−40 dB; distance >1 km past NR event. (This means that a small, nonreflective event followed closely by a small, reflective event will reduce the repeatability of finding these two events).
0.05	500 m	13	15	
0.2	2000 m	20	22	
0.5	2000 m	22	24	
1.0	2000 m	23	25	

Table 1–51: Single-Event Distance Measurement Repeatability[1] (Extended Range 1550 nm Singlemode, Option 08)

Characteristic	Performance Requirement		Supplemental Information
Range from Front Panel (dB)	Reflective[2]	Nonreflective[3]	IntelliTrace mode
0 to 1	2.5 m	2.5 m	
1 to (DR[4]–8)	20 m	20 m	
(DR–8) to DR	40 m	160 m	

[1] Multiply by 0.001% of range for timebase error. These data are for a 0.5 dB event with 95% probability on a single unit.
[2] Reflectance greater than −45 dB, 0.5 dB loss.
[3] Reflectance less than −60 dB, 0.5 dB loss.
[4] DR is the dynamic range for 2000-m pulse width from table 1−52. DR is the 98% dynamic range, defined as dynamic range SNR=1 minus 1.5.

Table 1–52: Vertical System Dynamic Range (Extended Range 1550 nm Singlemode, Option 08)

Characteristic	Performance Requirement		Supplemental Information
Dynamic Range Pulsewidth	SNR=1	Typical	Dynamic range SNR=1 is defined as the difference between the extrapolated backscatter level at the start of the fiber and the RMS noise level. Based on high APD and amplifier gains. Low APD gain reduces 4 dB. Low amplifier gain reduces 5 dB. Measured using a 4 km test fiber (Corning SMF-28, 8.5 µm core, 0.12 NA) after 3 minutes of averaging. A 0.5 dB front panel loss is assumed.
2000 m	28 dB	30 dB	
1000 m	26 dB		
500 m	24 dB	26 dB	
100 m	18 dB		
50 m	16.5 dB		
20 m	13 dB		
10 m	11.5 dB		
5 m	10 dB		
1 m	5.5 dB		
Temperature Coefficient of Dynamic Range			−0.15 dB/°C for T $\neq$ 25° C

Table 1–53: Horizontal System Dead Zone (Extended Range 1550 nm Singlemode, Option 08)

Characteristic	Performance Requirement	Typical	Supplemental Information
Attenuation Dead Zone Pulsewidth			Attenuation dead zone is defined as the distance between the initial and final points, where the backscatter level is disrupted beyond ±0.5 dB due to encountering a single reflective event. Based on reflective event with no greater than −40 dB reflectance. Based on 9 µm, 0.1 NA SM fiber.
2000 m	2300 m		
1000 m	1350 m		
500 m	600 m		
100 m	175 m		
50 m	100 m		
20 m	40 m		
10 m	30 m	20 m	
5 m	45 m		
1 m	80 m		
Event Dead Zone Pulsewidth			Event dead zone is defined as the distance between the initial and final points, where the reflected pulse amplitude is −1.5 dB down from its peak value. Based upon reflective event with no greater than −40 dB reflectance.
2000 m	2250 m		
1000 m	1200 m		
500 m	700 m		
100 m	115 m		
50 m	65 m		
20 m	30 m		
10 m	20 m		
5 m	8 m		
1 m	<5 m		

Table 1–54: Horizontal System Distance Span and Range (Extended Range 1550 nm Singlemode, Option 08)

Characteristic	Performance Requirement	Supplemental Information
Distance Span (Manual Mode) Pulsewidth		Distance span is defined as the length of the data acquisition window for a single segment acquisition in overview mode. Span is determined by the sample spacing and the number of samples possible in the acquisition window.
2000 m	160 km	
1000 m	160 km	
500 m	80 km	
100 m	40 km	
50 m	40 km	
20 m	20 km	
10 m	10 km	
5 m	5 km	
1 m	1 km	

Table 1–55: Sample Density, Pulsewidth, and Range Combinations (Extended Range 1550 nm Singlemode, Option 08)

Pulsewidth (m)	Bandwidth (MHz)[1]	Overview Sample Spacing[2]	Overview Interleave Factor[3]	Overview Measurement Spans (km)								Minimum High Density Sample Spacing
				160	80	40	20	8	4	2	1	
2000	0.3	40 m	1x	●	●	●	●					1.25 m
1000	0.3	40 m	1x	●	●	●	●	●				1.25 m
500	5	20 m	1x	●	●	●	●	●	●			1.25 m
100	5	10 m	1x		●	●	●	●	●	●		1.25 m
50	5	10 m	1x		●	●	●	●	●	●	●	1.25 m
20	17	5 m	2x		●	●	●	●	●	●	●	1.25 m
10	17	2.5 m	4x				●	●	●	●	●	1.25 m
5	17	1.25 m	8x					●	●	●	●	1.25 m
1	35	25 cm	40x						●	●	●	25 cm

Note 1: Bandwidth is chosen based on a 3x minimum bandwidth required for pulsewidth resolution. The minimum bandwidth is given by

$$\beta_{min} = \frac{0.35}{pw\ (meters)\ x\ 10\ ns/m}$$

Note 2: Sample spacing is chosen to obtain four data points on pulse.
Note 3: Interleave factor is based on a 10 MHz sampling rate.

Table 1–56: Bandwidth and Transient Characteristics (Extended Range 1550 nm Singlemode, Option 08)

Bandwidth (MHz)	Risetime	Fallslope
35	1 m = 10 ns	1.5 m/10 dB
17	2 m = 21 ns	3.7 m/10 dB
5	7 m = 70 ns	14.7 m/10 dB
0.3	117 m = 1170 ns	245 m/ 10 dB

Extended Range 1550 nm Singlemode, Option 09

Table 1–57: Optical Signal Characteristics (Extended Range 1550 nm Singlemode, Option 09)

Characteristic	Performance Requirement	Supplemental Information
Displayed Pulsewidth		Measured between the −1.5 dB points relative to the top of the pulse. 2000,1000, 500, 100, 50, 20, 10, 5, 1 meters
Pulse Repetition Rate (Range) 160 km 80 km 40 km 20 km 10 km 5 km 2 km 1 km		Minimum specified values: 1600 μs 800 μs 400 μs 200 μs 100 μs 50 μs 20 μs 10 μs
Optical Output, Wavelength	1550 ±20 nm	Spectral mean or center-of-mass.
Optical Output, Spectral Width		10 nm RMS value of spectral energy is time-averaged mode from series of pulses.
Optical Output, Amplitude		Measured at peak value emitted from front panel connector into 9 μm, NA=0.1, SM fiber. 145 mW maximum.
Laser Product Safety Classification	CFR Class I and IEC Class 1	Per FDA and IEC
Temperature Coefficient of Laser Wavelength		(0.4 nm/°C) x (T −25° C)

Table 1–58: Vertical System Measurements (Extended Range 1550 nm Singlemode, Option 09)

Characteristic	Performance Requirement	Supplemental Information
Linearity		3-minute average. ±0.02 dB/dB typical From 9 dB above RMS floor to 1.5 dB below maximum signal level.
Measurement Accuracy Two-Point Splice Loss LSA Fiber Loss Reflectance		3-minute average, ±0.1 dB/dB for events 10 dB above the 98% noise floor, 95% confidence. ±4 dB maximum error below −40 dB. 10 m to 1 m pulsewidth. Reflections may clip above –40 dB.

Table 1–59: Measurement Range (Extended Range 1550 nm Singlemode, Option 09)

Characteristic		Performance Requirement		Supplemental Information
Loss Threshold (dB)	Max PW	Measurement Range (dB) Minimum	 Typical	IntelliTrace mode averaging and analysis less than 5 minutes. For isolated nonreflective event or grouped NR-reflective events. Reflective event return loss >−40 dB; distance >1 km past NR event. (This means that a small, nonreflective event followed closely by a small, reflective event will reduce the repeatability of finding these two events).
0.05	500 m	17	18	
0.2	2000 m	22	23	
0.5	2000 m	24	25	
1	2000 m	25	26	

Table 1–60: Single-Event Distance Measurement Repeatability[1] (Extended Range 1550 nm Singlemode, Option 09)

Characteristic	Performance Requirement		Supplemental Information
Range from Front Panel (dB)	Reflective[2]	Nonreflective[3]	IntelliTrace mode
0 to 5	5 m	5 m	
5 to 12	10 m	10 m	
12 to 14	20 m	40 m	
14 to >20	40 m	160 m	

[1] *Multiply by 0.001% of range for timebase error. These data are for a 0.5 dB event with 95% probability on a single unit.*
[2] *Reflectance greater than −45 dB, 0.5 dB loss.*
[3] *Reflectance less than −60 dB, 0.5 dB loss.*

Table 1–61: Vertical System Dynamic Range (Extended Range 1550 nm Singlemode, Option 09)

Characteristic	Performance Requirement		Supplemental Information
Dynamic Range Pulsewidth	SNR=1	Typical	Dynamic range SNR=1 is defined as the difference between the extrapolated backscatter level at the start of the fiber and the RMS noise level.
2000 m	30 dB	31 dB	
1000 m	29 dB		
500 m	28 dB	29 dB	Based on high APD and amplifier gains. Low APD gain reduces 4 dB. Low amplifier gain reduces 5 dB.
100 m	21 dB		
50 m	19 dB		
20 m	16 dB		Measured using a 4-km test fiber (Corning SMF-28, 8.5 µm core, 0.12 NA) after 3 minutes of averaging.
10 m	14.5 dB		
5 m	13 dB		A 0.5-dB front panel loss is assumed.
1 m	8.5 dB		
Temperature Coefficient of Dynamic Range			−0.15 dB/°C for T $\neq$ 25° C

Table 1–62: Horizontal System Dead Zone (Extended Range 1550 nm Singlemode, Option 09)

Characteristic	Performance Requirement		Supplemental Information
Attenuation Dead Zone Pulsewidth		Typical	Attenuation dead zone is defined as the distance between the initial and final points, where the backscatter level is disrupted beyond ±0.5 dB due to encountering a single reflective event. Based on reflective event with no greater than −40 dB reflectance. Based on 9 μm, 0.1 NA SM fiber.
2000 m	2300 m		
1000 m	1350 m		
500 m	600 m		
100 m	175 m		
50 m	100 m		
20 m	40 m		
10 m	30 m	20 m	
5 m	45 m		
1 m	80 m		
Event Dead Zone Pulsewidth			Event dead zone is defined as the distance between the initial and final points, where the reflected pulse amplitude is −1.5 dB down from its peak value. Based upon reflective event with no greater than −40 dB reflectance.
2000 m	2250 m		
1000 m	1200 m		
500 m	700 m		
100 m	115 m		
50 m	65 m		
20 m	30 m		
10 m	20 m		
5 m	8 m		
1 m	<5 m		

Table 1–63: Horizontal System Distance Span and Range (Extended Range 1550 nm Singlemode, Option 09)

Characteristic	Performance Requirement	Supplemental Information
Distance Span (Manual Mode) Pulsewidth		Distance span is defined as the length of the data acquisition window for a single segment acquisition in overview mode. Span is determined by the sample spacing and the number of samples possible in the acquisition window.
2000 m	160 km	
1000 m	160 km	
500 m	80 km	
100 m	40 km	
50 m	40 km	
20 m	20 km	
10 m	10 km	
5 m	5 km	
1 m	1 km	

Table 1–64: Sample Density, Pulsewidth, and Range Combinations (Extended Range 1550 nm Singlemode, Option 09)

Pulsewidth (m)	Bandwidth (MHz)[1]	Overview Sample Spacing[2]	Overview Interleave Factor[3]	Overview Measurement Spans (km)								Minimum High Density Sample Spacing
				160	80	40	20	8	4	2	1	
2000	0.3	40 m	1x	●	●	●	●					1.25 m
1000	0.3	40 m	1x	●	●	●	●	●				1.25 m
500	5	20 m	1x	●	●	●	●	●	●			1.25 m
100	5	10 m	1x		●	●	●	●	●	●		1.25 m
50	5	10 m	1x		●	●	●	●	●	●	●	1.25 m
20	17	5 m	2x		●	●	●	●	●	●	●	1.25 m
10	17	2.5 m	4x				●	●	●	●	●	1.25 m
5	17	1.25 m	8x					●	●	●	●	1.25 m
1	35	25 cm	40x						●	●	●	25 cm

Note 1: Bandwidth is chosen based on a 3x minimum bandwidth required for pulsewidth resolution. The minimum bandwidth is given by

$$\beta_{min} = \frac{0.35}{pw\ (meters)\ x\ 10\ ns/m}$$

Note 2: Sample spacing is chosen to obtain four data points on pulse.
Note 3: Interleave factor is based on a 10 MHz sampling rate.

Table 1–65: Bandwidth and Transient Characteristics (Extended Range 1550 nm Singlemode, Option 09)

Bandwidth (MHz)	Risetime	Fallslope
35	1 m = 10 ns	2.1 m/10 dB
17	2 m = 21 ns	4.3 m/10 dB
5	7 m = 70 ns	14.7 m/10 dB
0.3	117 m = 1170 ns	245 m/ 10 dB

Power

Battery Pack	14.4 V, 2.8 amp/hr, NiCad
Battery Charge Time (Discharged Battery)	4 hours nonoperating at room temperature
Typical Battery Life (In Instrument) Normal Use Shelf Life	 4.5 hours typical[1] 70% cap after 1 mo at 20° C 50% cap after 8 days at 50° C
Power/Charger Adapter Output	15.5 VDC, 43 W max
DC Input	9 to16 VDC, 43 W max
Power Consumption	Max 35 W; typical 8 to 10 W Inrush current < 5 A for 75 ms.

[1] Backlight off, acquire IntelliTrace waveform, review (1 minute), add comments (2 minutes), save to internal storage, set up for next acquisition (2 minutes), repeat.

Display

Readout Resolution Distance Loss	 0.25 m (0.8 ft) minimum 0.001 dB
Measurement Readout Range Distance Loss	 0.001 km to 160 km (93.2 miles) 0.001 dB to 22.0 dB

Size and Weight

Weight Single-port instrument w/battery only Single-port instrument incl. std. accessories Dual-port instrument w/battery only Dual-port instrument incl. std. accessories	 <4.31 kg (<9.5 lbs) <5.90 kg (<13 lbs) <4.77 kg (<10.5 lbs) <6.22 kg (<13.7 lbs)
Dimensions	29.21 cm wide X 11.4 cm high X 24.1 cm long (11.5 in wide X 4.5 in high X 9.5 in long)

RS232C Serial Port

DB9 Configuration as DTE (Same as PC/AT Cable)	EIA RS232C levels IBM AT style DB9 male DB9 connector pinouts: 1 DCD (in) 2 RD (in) 3 TD (out) 4 DTR (out) 5 signal ground 6 DSR (in) 7 RTS (out) 8 CTS (in) 9 RI (in)
Flow Control	None, RTS/CTS, XON/XOFF, DTR
Data Rates	1200; 2400; 4800; 9600; 19200, 38400 baud
Printers Supported	Epson, Seiko DPU411, HP ThinkJet, HP LaserJet, HP DeskJet, PostScript

Parallel Port

25-Pin female D Subminiature	Standard PC type parallel printer interface.
Printers Supported	Epson, Seiko DPU411, HP ThinkJet, HP LaserJet, HP DeskJet, PostScript

Keyboard Port

6-pin mini-DIN	IBM PS2-style connector
Keyboards supported	IBM PC-AT type (compatibility and EMC specifications guaranteed only with Tektronix keyboard option 19) Languages: USA, French, German, Spanish, Portuguese, Italian, Finnish
Power capability	500 mA maximum available for keyboard (at 5 VDC). (If above this level, keyboard power turns off. Power to instrument must be cycled off, then on to restore keyboard power.)

Environmental[1]

Characteristic	Performance Requirement	Supplemental Information
Temperature	Operating: 0° C to 40° C (32° F to 104° F) Nonoperating: –20° C to 60° C (-4° F to 140° F)	Test per Tek 062-2847-00, Class 3, with the exception of the temperature extremes.
Option 11	Operating (disk read/write): 5° C to 40° C (41° F to 104° F) Nonoperating: –20° C to 60° C (-4° F to 140° F)	
Humidity		Test per Tek 062-2847-00, Class 3, with the exception of the humidity limits.
	Operating: 10 to 95% relative humidity, noncondensing Nonoperating: 10 to 95% relative humidity, noncondensing	Maximum wet bulb temperature: 40° C (104° F) Maximum wet bulb temperature: 40° C (104° F)
Option 11	Operating (disk read/write): 20 to 80% noncondensing Nonoperating: 10 to 90% noncondensing	Maximum wet bulb temperature: 29.4° C (85° F) Maximum wet bulb temperature: 40° C (104° F)
Altitude (Maximum)	Operating: 15,000 ft (4.6 km) Nonoperating: 50,000 ft (15.2 km)	Test per Tek 062-2847-00, Class 3
Water Resistance[3]	Drip proof	Test per MIL-T-28800E, Type III, Class 3, Style C
Random Vibration[2]	Operating (when Option 11 not installed): Frequency range: 5 to 500 Hz Acceleration: 0.31 GRMS Nonoperating: Frequency range: 5 to 500 Hz Acceleration: 2.46 GRMS	Test per Tek 062-2858-00, Class 3
Sine Vibration[2]	Operating: Frequency sweep: 10 to 500 Hz Acceleration: 1.5 G maximum	Test per Bellcore TR-NWT-001138
Option 11	Operating (disk read/write): Frequency sweep: 10 to 100 Hz Acceleration: 1.5 G maximum Frequency sweep: 100 to 200 Hz Acceleration: 1 G maximum Frequency sweep: 200 to 500 Hz Acceleration: 0.5 G maximum	

Characteristic	Performance Requirement	Supplemental Information
Bench Handling, Operating	Height: 4 inches (10 cm) Orientation: all sides Surface: solid work bench Duration: 1 drop per edge	Test per MIL-T-28800E, Type III, Class 3, Style C
Drop, Free Fall, Nonoperating[2]	Height: 30 inches Orientation: on its back Surface: concrete Duration: 1 drop Bellcore TR–NWT–001138, paragraph 5.2.1.3	Test per BellcoreTR-NWT-001138
Shock (Maximum)[2] Option 11	Operating: 50 G Operating (disk read/write): 5 G	Test per Tek 062-2858-00, Class 3
Package Product Shock/Vibration/Drop, Nonoperating	Tek 062-2858-00	Test per Tek 062-2858-00, distribution cycle 1 with the exception of increasing the drop height to 30 inches per Bellcore TR-NWT-001138
Hard Carrying Case Drop, Nonoperating	Height: 30 inches Orientation: all sides and corners Surface: concrete Duration: 14 total drops	Test per Bellcore TR-NWT-001138
EMC Emissions:		
Radiated Emissions	FCC Part 15, Subpart B, Class A EN55011, Class A	Test per MP-4 (1987) Test per CISPR 11, Class A
Power Harmonic	EN60555–2	Test per EN60555-2
Conducted Emissions	FCC Part 15, Subpart B, Class A EN55011, Class A	Test per MP-4 (1987) Test per CISPR 11, Class A
Immunity:		
Electrostatic Discharge	IEC 801-2	Test per IEC 801-2
RF Radiated	IEC 801-3	Test Per IEC 801-3
Fast Transients	IEC 801-4	Test Per IEC 801-4
Surge	IEC 801-5	Test per IEC 801-5
Dust Resistance	Instrument is dust resistant by design	Bellcore TR-NWT-001138
Fungus Inert	Enclosure and electronics are fungus inert by design	As specified per MIL-T-28800E, Type III, Class 3, Style C

[1] During nonoperating environmental conditions, remove either the power/charger adapter power cord or cigarette lighter adapter power cord from the power/charger adapter port on the instrument.
[2] For Option 11 instruments, remove disk from disk drive.
[3] Instrument in soft carrying case with front flap closed.

Specifications – TekRanger 2 (serial nos. B052000 and above)

Standard 850 nm Multimode, Options 01 and 03

Table 1–66: Optical Signal Characteristics (850 nm Multimode, Options 01 and 03)

Characteristic	Performance Requirement	Supplemental Information
Displayed Pulse Width		Measured between the −3.0 dB points relative to the top of the pulse. 10, 5, 1 meters.
Pulse Repetition Time (PRT) Pulse Width 10 m 5 m 1 m	*Minimum PRT (µs):* *Typical PRT (µs):* 184 µs 200 µs 92 µs 175 µs 19 µs 150 µs	Minimum reflects limit for laser safety classification. Typical reflects hardware/software constraints at product introduction. Controlled by system software and not directly checked in the performance verification procedure.
Optical Output, Wavelength	850 ±30 nm	Spectral mean or center of mass provided by laser manufacturer.
Optical Output, Spectral Width		10 nm FWHM typical. RMS value of spectral energy is time-averaged mode from series of pulses.
Optical Output, Amplitude		Measured at peak value emitted from front panel connector into 62.5 µm, NA=0.28, GI fiber. 3 W maximum
Laser Product Safety Classification	CFR Class I and IEC Class 1	FDA CFR 21 dated 4/1/95 and IEC 825−1 dated 11/93. < 4.0 W peak emitted from laser into laser pigtail. For calculation refer to project archive. (Initial work work was done in CNA Tektronix Engineering notebook #35, pp. 30 – 37.)
Temperature Coefficient of Laser Wavelength		(0.25 nm/^{o}C) x (T −25^{o} C) typical

Table 1–67: Vertical System Measurements (850 nm Multimode, Options 01 and 03)

Characteristic	Performance Requirement	Supplemental Information
Linearity	±0.02 dB/dB typical	3-minute average From 12 dB above RMS floor to 1.5 dB below maximum signal level.
Measurement Repeatability Two-Point Splice Loss LSA Fiber Loss	±0.1 dB/dB typical	3-minute average For events 10 dB above 98% noise floor, 95% confidence.
Reflectance	±2 dB typical	Non-clipped reflection.

Table 1–68: Single-Event Distance Measurement Repeatability[1] (850 nm Multimode, Options 01 and 03)

Characteristic	Performance Requirement		Supplemental Information
Range from Front Panel (dB)	Reflective[2] *typical*	Nonreflective[3] *typical*	IntelliTrace mode
0 to 10	2.5 m	2.5 m	
> 10	5 m	15 m	

[1] Multiply by 0.001% of range for timebase error. These data are for a 0.5 dB event with 95% probability.
[2] Reflectance greater than –45 dB, 0.5 dB loss.
[3] Reflectance less than –60 dB, 0.5 dB loss.

Table 1–69: Vertical System Dynamic Range (850 nm Multimode, Options 01 and 03)

Characteristic	Performance Requirement		Supplemental Information
Dynamic Range Pulse Width		*typical:*	SNR =1. Dynamic range SNR=1 is defined as the difference between the extrapolated backscatter level at the start of the fiber and the RMS[1] noise floor.
10 m	27 dB	31 dB	
5 m		24.5 dB	
1 m	17.0 dB	21 dB	Dynamic range 98% is defined as the difference between the extrapolated backscatter level at the start of the fiber and the 98% level of the noise. (DR 98%) = (DR SNR=1) - 1.5 dB. Measured using a 62.5 μm, 0.28 NA GI fiber after 3 minutes of averaging. A 0.5 dB front panel loss is assumed.
Temperature Coefficient of Dynamic Range			−0.15 dB/°C for T ≠ 25° C, typical

1. RMS in this test is defined as the standard deviation.

Table 1–70: System Measurement Accuracy (850 nm Multimode, Options 01 and 03)

Characteristic	Performance Requirement	Supplemental Information
Distance	±5.0 m	Verified on the TFS3031 Distance Accuracy Test Fixture on every instrument built in Manufacturing and on instruments that are repaired in Service. Intellitrace only. Does not take into account errors in index of refraction and cabling factor.

Table 1–71: Horizontal System Dead Zone (850 nm Multimode, Options 01 and 03)

Characteristic	Performance Requirement		Supplemental Information
Attenuation Dead Zone Pulse Width		*typical:*	Attenuation dead zone is defined as the distance between the initial and final points, where the backscatter level is disrupted beyond ±0.5 dB due to encountering a single reflective event. Based on reflective event with no greater than −40 dB reflectance. Based on 62.5 µm, 0.28 NA GI fiber.
10 m	20 m	16 m	
5 m		10 m	
1 m	14 m	8.0 m	
Event Dead Zone Pulse Width		*typical*	Event dead zone is defined as the distance between the initial and final points, where the reflected pulse amplitude is −3.0 dB down from its peak value.
10 m	19 m	11 m	
5 m		7 m	
1 m	<5 m	3.5 m	

Table 1–72: Horizontal System Distance Span and Range (850 nm Multimode, Options 01 and 03)

Characteristic	Performance Requirement	Supplemental Information
Distance Span (Manual Mode) Pulse Width		Distance span is defined as the length of the data acquisition window for a single segment acquisition in overview mode. Span is determined by the sample spacing and the number of samples possible in the acquisition window. Controlled by system software and not directly checked in the performance verification procedure.
10 m	10 km	
5 m	5 km	
1 m	1 km	

Table 1–73: Sample Density, Pulsewidth, and Range Combinations (850 nm Multimode, Options 01 and 03)

Pulse Width (m)	Bandwidth (MHz)[1]	Overview Sample Spacing[2]	Overview Interleave Factor[3]	Overview Measurement Spans (km)				Minimum High Density Sample Spacing
				10	4	2	1	
10	20	2.5 m	4x	•	•	•	•	1.25 m
5	20	1.25 m	8x	•	•	•	•	1.25 m
1	35	25 cm	40x		•	•	•	25 cm

Note 1: Bandwidth is chosen based on a 3x minimum bandwidth required for pulse width resolution. The minimum bandwidth is given by

$$\beta_{min} = \frac{0.35}{pw\ (meters)\ x\ 10\ ns/m}$$

Note 2: Sample spacing is chosen to obtain four or five data points on pulse.
Note 3: Interleave factor is based on a 10 MHz sampling rate.

Table 1–74: Bandwidth and Transient Characteristics (850 nm Multimode, Options 01 and 03)

Bandwidth (MHz)	Risetime	Falltime	
35	1 m = 10 ns	1 m/10 dB	Controlled by system software and not directly checked in the performance verification procedure.
20	1.75 m = 17.5 ns	1.75 m/10 dB	

Standard 1300 nm Multimode, Option 03

Table 1–75: Optical Signal Characteristics (1300 nm Multimode, Option 03)

Characteristic	Performance Requirement	Supplemental Information
Displayed Pulse Width		Measured between the −3.0 dB points relative to the top of the pulse. 100, 50, 20, 10, 5, 1 meters
Pulse Repetition Time (PRT) Pulse Width 100 m 50 m 20 m 10 m 5 m 1 m	*Minimum PRT (us):* / *Typical PRT (us):* 62 us / 650 us 31 us / 600 us 13 us / 550 us 7 us / 500 us 4 us / 450 us 1 us / 400 us	Minimum reflects limit for laser safety classification. Typical reflects hardware/software constraints at product introduction. Controlled by system software and not directly checked in the performance verification procedure.
Optical Output, Wavelength	1300 ±30 nm	Spectral mean or center of mass provided by laser manufacturer.
Optical Output, Spectral Width		10 nm FWHM typical. RMS value of spectral energy is time-averaged mode from series of pulses.
Optical Output, Amplitude		Measured at peak value emitted from front panel connector into 62.5 μm, NA=0.28, GI fiber. 250 mW maximum
Laser Product Safety Classification	CFR Class I and IEC Class 1	FDA CFR 21 dated 4/1/95 and IEC 825−1 dated 11/93. < 1.0 W peak emitted from laser into laser pigtail. For calculation refer to project archive. (Initial work work was done in CNA Tektronix Engineering notebook #35, pp. 59 – 62.)
Temperature Coefficient of Laser Wavelength		(0.4 nm/°C) x (T −25° C) typical

Table 1–76: Vertical System Measurements (1300 nm Multimode, Option 03)

Characteristic	Performance Requirement	Supplemental Information
Linearity	±0.02 dB/dB typical	3-minute average From 12 dB above RMS floor to 1.5 dB below maximum signal level.
Measurement Repeatability Two-Point Splice Loss LSA Fiber Loss	±0.1 dB/dB typical	3-minute average For events 10 dB above 98% noise floor, 95% confidence.
Reflectance	±2 dB typical	Non-clipped reflection.

Table 1–77: Measurement Range (1300 nm Multimode, Option 03)

Characteristic	Performance Requirement	Supplemental Information
Loss Threshold (dB) 0.5		Typical 22dB IntelliTrace mode averaging and analysis less than 3 minutes plus 15 seconds per event. Measurement range determined as a result of dynamic range test results, and not directly checked in the performance verification procedure. Fiber must have enough loss and length for last segment to be taken with 100-m pulse width and high system gain.

Table 1–78: Single-Event Distance Measurement Repeatability[1] (1300 nm Multimode, Option 03)

Characteristic	Performance Requirement		Supplemental Information
Range from Front Panel (dB) 0 to 10 > 10	Reflective[2] *typical* 10 m 20 m	Nonreflective[3] *typical* 10 m 60 m	IntelliTrace mode

[1] Multiply by 0.001% of range for timebase error. These data are for a 0.5 dB event with 95% probability.
[2] Reflectance greater than –45 dB, 0.5 dB loss.
[3] Reflectance less than –60 dB, 0.5 dB loss.

Table 1–79: Vertical System Dynamic Range (1300 nm Multimode, Option 03)

Characteristic	Performance Requirement		Supplemental Information
Dynamic Range Pulse Width		*typical*	SNR=1. Dynamic range SNR=1 is defined as the difference between the extrapolated backscatter level at the start of the fiber and the RMS[1] noise floor.
100 m	24 dB	29 dB	
50 m		18 dB	
20 m		19 dB	Dynamic range 98% is defined as the difference between the extrapolated backscatter level at the start of the fiber and the 98% level of the noise.
10 m		17 dB	
5 m		15.5 dB	
1 m	12 dB	15 dB	(DR 98%) = (DR SNR=1) - 1.5 dB. Measured using a 62.5 μm, 0.28 NA GI fiber after 3 minutes of averaging. A 0.5 dB front panel loss is assumed.
Temperature Coefficient of Dynamic Range			−0.15 dB/°C for T ≠ 25° C, typical

1. RMS in this test is defined as the standard deviation.

Table 1–80: Horizontal System Dead Zone (1300 nm Multimode, Option 03)

Characteristic	Performance Requirement		Supplemental Information
Attenuation Dead Zone Pulse Width		*typical:*	Attenuation dead zone is defined as the distance between the initial and final points, where the backscatter level is disrupted beyond ±0.5 dB due to encountering a single reflective event. Based on reflective event with no greater than −40 dB reflectance. Based on 62.5 μm, 0.28 NA GI fiber.
100 m		130 m	
50 m		70 m	
20 m		35 m	
10 m	30 m	16 m	
5 m		10 m	
1 m	15 m	8 m	
Event Dead Zone Pulse Width		*typical:*	Event dead zone is defined as the distance between the initial and final points, where the reflected pulse amplitude is −1.5 dB down from its peak value.
100 m		110 m	
50 m		50 m	
20 m		25 m	
10 m	15 m	12 m	
5 m		6 m	
1 m	7 m	3.5 m	

Table 1–81: Horizontal System Distance Span and Range (1300 nm Multimode, Option 03)

Characteristic	Performance Requirement	Supplemental Information
Distance Span (Manual Mode) Pulse width		Distance span is defined as the length of the data acquisition window for a single segment acquisition in overview mode. Span is determined by the sample spacing and the number of samples possible in the acquisition window. Controlled by system software and not directly checked in the performance verification procedure.
100 m	40 km	
50 m	40 km	
20 m	20 km	
10 m	10 km	
5 m	5 km	
1 m	1 km	

Table 1–82: System Measurement Accuracy (1300 nm Multimode, Options 03)

Characteristic	Performance Requirement	Supplemental Information
Distance	±5.0 m	Verified on the TFS3031 Distance Accuracy Test Fixture on every instrument built in Manufacturing and on instruments that are repaired in Service. Intellitrace only. Does not take into account errors in index of refraction and cabling factor.

Table 1–83: Sample Density, Pulsewidth, and Range Combinations (1300 nm Multimode, Option 03)

Pulse Width (m)	Bandwidth (MHz)[1]	Overview Sample Spacing[2]	Overview Interleave Factor[3]	Overview Measurement Spans (km)						Minimum High Density Sample Spacing
				40	20	10	4	2	1	
100	5	10 m	1x	●	●	●	●			1.25 m
50	20	10 m	1x	●	●	●	●	●		1.25 m
20	20	5 m	2x		●	●	●	●	●	1.25 m
10	20	2.5 m	4x		●	●	●	●	●	1.25 m
5	20	1.25 m	8x			●	●	●	●	1.25 m
1	35	25 cm	40x				●	●	●	25 cm

Note 1: Bandwidth is chosen based on a 3x minimum bandwidth required for pulse width resolution. The minimum bandwidth is given by

$$\beta_{min} = \frac{0.35}{pw\ (meters)\ x\ 10\ ns/m}$$

Note 2: Sample spacing is chosen to obtain four data points on pulse.
Note 3: Interleave factor is based on a 10 MHz sampling rate.

Table 1–84: Bandwidth and Transient Characteristics (1300 nm Multimode, Option 03)

Bandwidth (MHz)	Risetime	Falltime	
35	1 m = 10 ns	1 m/10 dB	Controlled by system software and not directly checked in the performance verification procedure.
20	1.75 m = 17.5 ns	1.75 m/10 dB	
5	7 m = 70 ns	7 m/10 dB	

Standard 1310 nm Singlemode, Options 04 and 06

Table 1–85: Optical Signal Characteristics (Standard 1310 nm Singlemode, Options 04 and 06)

Characteristic	Performance Requirement	Supplemental Information
Displayed Pulsewidth		Measured between the −3.0 dB points relative to the top of the pulse. 2000, 1000, 500, 200,100, 50, 20, 10, 5, 1 meters
Pulse Repetition Rate (Range) 160 km 80 km 40 km 20 km 10 km 5 km 2 km 1 km		Minimum specified values: 1600 μs 800 μs 400 μs 200 μs 100 μs 50 μs 20 μs 10 μs
Optical Output, Wavelength	1310 ±20 nm	Spectral mean or center-of-mass provided by laser manufacturer.
Optical Output, Spectral Width		10 nm RMS value of spectral energy is time-averaged mode from series of pulses.
Optical Output, Amplitude		Measured at peak value emitted from front panel connector into 9 μm, NA=0.1, SM fiber. 70 mW maximum.
Laser Product Safety Classification	CFR Class I and IEC Class 1	Per FDA and IEC
Temperature Coefficient of Laser Wavelength		(0.4 nm/°C) x (T −25° C) typical.

Table 1–86: Vertical System Measurements (Standard 1310 nm Singlemode, Options 04 and 06)

Characteristic	Performance Requirement	Supplemental Information
Linearity	±0.02 dB/dB typical from 15 dB to 2 dB below backscatter at front panel; ±0.05 dB/dB typical from 10 dB to 1 dB below backscatter at front panel.	3-minute average
Measurement Repeatability Two-Point Splice Loss LSA Fiber Loss	±0.1 dB/dB typical	3 minute average For events 10 dB above 98% noise floor, 95% confidence
Reflectance	Maximum ±4 dB, typical ±2 dB	Non-clipped reflection. Meets or exceeds Bellcore GR-196-CORE.

Table 1–87: Single-Event Distance Measurement Repeatability[1] (Standard 1310 nm Singlemode, Options 04 and 06)

Characteristic	Performance Requirement		Supplemental Information
Range from Front Panel (dB) 0 to 1.5 1.5 to (DR[4]–8) (DR–8) to DR	Reflective[2] *typical:* 2.5 m 20 m 40 m	Nonreflective[3] *typical:* 2.5 m 20 m 160 m	IntelliTrace mode

[1] *Multiply by 0.001% of range for timebase error. These data are for a 0.5 dB event with 95% probability on a single unit.*
[2] *Reflectance greater than −45 dB, 0.5 dB loss.*
[3] *Reflectance less than −60 dB, 0.5 dB loss.*
[4] *DR is the dynamic range for 2000-m pulse width from table 1−25. DR is the 98% dynamic range, defined as dynamic range SNR=1 minus 1.5.*

Table 1–88: System Measurement Accuracy (Standard 1310 nm Singlemode, Options 04 and 06)

Characteristic	Performance Requirement	Supplemental Information
Distance	±10 m, ±4 m typical	Measured on NIST traceable calibration system.
Loss	±0.05 dB, ±0.01 dB typical	Measured on NIST traceable calibration system.

Table 1–89: Vertical System Dynamic Range (Standard 1310 nm Singlemode, Options 04 and 06)

Characteristic	Performance Requirement		Supplemental Information
Dynamic Range Pulsewidth	SNR=1	Typical	SNR=1. Dynamic range SNR=1 is defined as the difference between the extrapolated backscatter level at the start of the fiber and the RMS noise level. Measured using a 4-km test fiber (Corning SMF-28, 8.5 µm core, 0.12 NA) after 3 minutes of averaging. Based on high APD and amplifier gains. Low APD gain reduces 4 dB. Low amplifier gain reduces 5 dB. A 0.5-dB front panel loss is assumed. For 100, 200, 500, 100, and 2000-m pulse widths, fiber must have enough loss so the second segment is taken with high system gain.
2000 m	26 dB	30 dB	
1000 m		28.5 dB	
500 m	23 dB	26 dB	
200 m		24 dB	
100 m		22.5 dB	
50 m		21 dB	
20 m	11 dB	14 dB	
10 m		12.5 dB	
5 m		11 dB	
1 m		7.5 dB	
Temperature Coefficient of Dynamic Range			-0.15 dB/°C for T $\neq$ 25° C, typical.

Table 1–90: Horizontal System Dead Zone (Standard 1310 nm Singlemode, Options 04 and 06)

Characteristic	Performance Requirement		Supplemental Information
Attenuation Dead Zone Pulsewidth		*typical*	Attenuation dead zone is defined as the distance between the initial and final points, where the backscatter level is disrupted beyond ±0.5 dB due to encountering a single reflective event. Based on reflective event with no greater than −40 dB reflectance. Based on 9 µm, 0.1 NA SM fiber.
2000 m		2300 m	
1000 m		1350 m	
500 m		600 m	
200 m		290 m	
100 m		175 m	
50 m		100 m	
20 m		46 m	
10 m	36 m	23 m	
5 m		18 m	
1 m		15 m	
Event Dead Zone Pulsewidth		*typical*	Event dead zone is defined as the distance between the initial and final points, where the reflected pulse amplitude is −3.0 dB down from its peak value. Based upon reflective event with no greater than −40 dB reflectance. One-meter spec based on testing to justify that the end of a 5-m jumper can be detected.
2000 m		2250 m	
1000 m		1200 m	
500 m		700 m	
200 m		250 m	
100 m		115 m	
50 m		65 m	
20 m		30 m	
10 m	29 m	6 m	
5 m		8 m	
1 m		5 m	

Table 1–91: Horizontal System Distance Span and Range (Standard 1310 nm Singlemode, Options 04 and 06)

Characteristic	Performance Requirement	Supplemental Information
Distance Span (Manual Mode) Pulsewidth		Distance span is defined as the length of the data acquisition window for a single segment acquisition in overview mode. Span is determined by the sample spacing and the number of samples possible in the acquisition window. Controlled by system software and not directly checked in the performance verification procedure.
2000 m	80 km	
1000 m	80 km	
500 m	80 km	
200 m	80 km	
100 m	40 km	
50 m	40 km	
20 m	20 km	
10 m	10 km	
5 m	5 km	
1 m	1 km	

Table 1–92: Sample Density, Pulsewidth, and Range Combinations (Standard 1310 nm Singlemode, Options 04 and 06)

Pulsewidth (m)	Bandwidth (MHz)[1]	Overview Sample Spacing[2]	Overview Interleave Factor[3]	Overview Measurement Spans (km)								Minimum High Density Sample Spacing
				160	80	40	20	8	4	2	1	
2000	0.3	40 m	1x	●	●	●	●					1.25 m
1000	0.3	40 m	1x	●	●	●	●	●				1.25 m
500	0.3	20 m	1x	●	●	●	●	●	●			1.25 m
200	5	20 m	1x	●	●	●	●	●	●			1.25 m
100	5	10 m	1x		●	●	●	●	●	●		1.25 m
50	5	10 m	1x		●	●	●	●	●	●	●	1.25 m
20	17	5 m	2x		●	●	●	●	●	●	●	1.25 m
10	17	2.5 m	4x				●	●	●	●	●	1.25 m
5	17	1.25 m	8x				●	●	●	●	●	1.25 m
1	35	25 cm	40x						●	●	●	25 cm

Note 1: Bandwidth is chosen based on a 3x minimum bandwidth required for pulsewidth resolution. The minimum bandwidth is given by

$$\beta_{min} = \frac{0.35}{pw\ (meters)\ x\ 10\ ns/m}$$

Note 2: Sample spacing is chosen to obtain four data points on pulse.
Note 3: Interleave factor is based on a 10 MHz sampling rate.

Table 1–93: Bandwidth and Transient Characteristics (Standard 1310 nm Singlemode, Options 04 and 06)

Bandwidth (MHz)	Risetime	Fallslope	
35	1 m = 10 ns	2.1 m/10 dB	Controlled by system software and not directly checked in the performance verification procedure.
17	2 m = 21 ns	4.3 m/10 dB	
5	7 m = 70 ns	14.7 m/10 dB	
0.3	117 m = 1170 ns	245 m/ 10 dB	

Standard 1550 nm Singlemode, Option 06

Table 1–94: Optical Signal Characteristics (Standard 1550 nm Singlemode, Option 06)

Characteristic	Performance Requirement	Supplemental Information
Displayed Pulsewidth		Measured between the −3.0 dB points relative to the top of the pulse. 2000, 1000, 500, 200, 100, 50, 20, 10, 5, 1 meters
Pulse Repetition Rate (Range) 160 km 80 km 40 km 20 km 10 km 5 km 2 km 1 km		Minimum specified values: 1600 μs 800 μs 400 μs 200 μs 100 μs 50 μs 20 μs 10 μs
Optical Output, Wavelength	1625 ±20 nm	Spectral mean or center-of-mass provided by laser manufacturer.
Optical Output, Spectral Width		10 nm RMS value of spectral energy is time-averaged mode from series of pulses.
Optical Output, Amplitude		Measured at peak value emitted from front panel connector into 9 μm, NA=0.1, SM fiber. 60 mW maximum.
Laser Product Safety Classification	CFR Class I and IEC Class 1	Per FDA and IEC.
Temperature Coefficient of Laser Wavelength		(0.4 nm/°C) x (T −25° C) typical.

Table 1–95: Vertical System Measurements (Standard 1550 nm Singlemode, Option 06)

Characteristic	Performance Requirement	Supplemental Information
Linearity	±0.02 dB/dB typical from 15 dB to 2 dB below backscatter at front panel; ±0.05 dB/dB from 10 dB to 1 dB below backscatter at front panel	3-minute average
Measurement Accuracy Two-Point Splice Loss LSA Fiber Loss	±0.1 dB/dB	3-minute average For events 10 dB above 98% noise floor, 95% confidence.
Reflectance	±4 dB maximum error, ±2 dB typical	Non-clipped reflection Meets or exceeds Bellcore GR-196-CORE.

Table 1–96: Single-Event Distance Measurement Repeatability[1] (Standard 1550 nm Singlemode, Option 06)

Characteristic	Performance Requirement		Supplemental Information
Range from Front Panel (dB)	Reflective[2]	Nonreflective[3]	
	typical:	*typical:*	IntelliTrace mode
0 to 1.5	2.5 m	2.5 m	
1.5 to (DR[4]–8)	20 m	20 m	
(DR–8) to DR	40 m	160 m	

1 Multiply by 0.001% of range for timebase error. These data are for a 0.5 dB event with 95% probability on a single unit.
2 Reflectance greater than −45 dB, 0.5 dB loss.
3 Reflectance less than −60 dB, 0.5 dB loss.
4 DR is the dynamic range for 2000-m pulse width from table 1−34. DR is the 98% dynamic range, defined as dynamic range SNR=1 minus 1.5.

Table 1–97: System Measurement Accuracy (Standard 1550 nm Singlemode, Option 06)

Characteristic	Performance Requirement	Supplemental Information
Distance	±10 m, ±4 m typical	Measured on NIST traceable calibration system.
Loss	±0.05 dB, ±0.01 dB typical	Measured on NIST traceable calibration system.

Table 1–98: Vertical System Dynamic Range (Standard 1550 nm Singlemode, Option 06)

Characteristic	Performance Requirement		Supplemental Information
Dynamic Range		*typical*	SNR=1. Dynamic range SNR=1 is defined as the difference between the extrapolated backscatter level at the start of the fiber and the RMS noise level.
Pulsewidth			
2000 m	25 dB	28 dB	
1000 m		26 dB	
500 m	21 dB	24 dB	Based on high APD and amplifier gains. Low APD gain reduces 4 dB. Low amplifier gain reduces 5 dB.
200 m		22 dB	
100 m		20.5 dB	
50 m		18 dB	Measured using a 4 km test fiber (Corning SMF-28, 8.5 µm core, 0.12 NA) after 3 minutes of averaging.
20 m	13 dB	14.5 dB	
10 m		14.5 dB	A 0.5 dB front panel loss is assumed.
5 m		13 dB	
1 m		9 dB	For 100, 200, 500, 1000, and 2000-m pulse widths, fiber must have enough loss so the second segment is taken with high system gain.
Temperature Coefficient of Dynamic Range			-0.15 dB/°C for T $\neq$ 25° C, typical

Table 1–99: Horizontal System Dead Zone (Standard 1550 nm Singlemode, Option 06)

Characteristic	Performance Requirement		Supplemental Information
Attenuation Dead Zone Pulsewidth		*typical*	Attenuation dead zone is defined as the distance between the initial and final points, where the backscatter level is disrupted beyond ±0.5 dB due to encountering a single reflective event. Based on reflective event with no greater than −40 dB reflectance. Based on 9 µm, 0.1 NA SM fiber.
2000 m		2300 m	
1000		1350 m	
500 m		600 m	
200 m			
100 m		175 m	
50 m		100 m	
20 m		46 m	
10 m	36 m	23 m	
5 m		18 m	
1 m		15 m	
Event Dead Zone Pulsewidth		*typical*	Event dead zone is defined as the distance between the initial and final points, where the reflected pulse amplitude is −3.0 dB down from its peak value. Based upon reflective event with no greater than −40 dB reflectance. One-meter spec pased on testing to justify that the end of a 5-meter jumper can be detected. Controlled by system software and not directly checked in the performance verification procedure.
2000 m		2250 m	
1000 m		1200 m	
500 m		700 m	
200 m			
100 m		115 m	
50 m		65 m	
20 m		30 m	
10 m	29 m	6 m	
5 m		8 m	
1 m		5 m	

Table 1–100: Horizontal System Distance Span and Range (Standard 1550 nm Singlemode, Option 06)

Characteristic	Performance Requirement	Supplemental Information
Distance Span (Manual Mode) Pulsewidth		Distance span is defined as the length of the data acquisition window for a single segment acquisition in overview mode. Span is determined by the sample spacing and the number of samples possible in the acquisition window. Controlled by system software and not directly checked in performance verification procedure.
2000 m	80 km	
1000 m	80 km	
500 m	80 km	
200 m	80 km	
100 m	40 km	
50 m	40 km	
20 m	20 km	
10 m	10 km	
5 m	5 km	
1 m	1 km	

Table 1–101: Sample Density, Pulsewidth, and Range Combinations (Standard 1550 nm Singlemode, Option 06)

Pulsewidth (m)	Bandwidth (MHz)[1]	Overview Sample Spacing[2]	Overview Interleave Factor[3]	Overview Measurement Spans (km)								Minimum High Density Sample Spacing
				160	80	40	20	8	4	2	1	
2000	0.3	40 m	1x	●	●	●	●					1.25 m
1000	0.3	40 m	1x	●	●	●	●	●				1.25 m
500	0.3	20 m	1x	●	●	●	●	●	●			1.25 m
200	5	20 m	1x	●	●	●	●	●	●			1.25 m
100	5	10 m	1x		●	●	●	●	●	●		1.25 m
50	5	10 m	1x		●	●	●	●	●	●	●	1.25 m
20	17	5 m	2x		●	●	●	●	●	●	●	1.25 m
10	17	2.5 m	4x				●	●	●	●	●	1.25 m
5	17	1.25 m	8x				●	●	●	●	●	1.25 m
1	35	25 cm	40x						●	●	●	25 cm

Note 1: Bandwidth is chosen based on a 3x minimum bandwidth required for pulsewidth resolution. The minimum bandwidth is given by

$$\beta_{min} = \frac{0.35}{pw\ (meters)\ x\ 10\ ns/m}$$

Note 2: Sample spacing is chosen to obtain four data points on pulse.
Note 3: Interleave factor is based on a 10 MHz sampling rate.

Table 1–102: Bandwidth and Transient Characteristics (Standard 1550 nm Singlemode, Option 06)

Bandwidth (MHz)	Risetime	Fallslope	
35	1 m = 10 ns	2.1 m/10 dB	Controlled by software. Not directly checked in the performance verification procedure.
17	2 m = 21 ns	4.3 m/10 dB	
5	7 m = 70 ns	14.7 m/10 dB	
0.3	117 m = 1170 ns	245 m/ 10 dB	

Extended Range 1310/1550 nm Singlemode, Option 10

Table 1–103: Optical Signal Characteristics (Extended Range 1310/1550 nm Singlemode, Option 10)

Characteristic	Performance Requirement	Supplemental Information
Displayed Pulsewidth		Measured between the −3.0 dB points relative to the top of the pulse. 3200, 2000,1000, 500, 200, 100, 50, 20, 10, 5, 1 meters
Pulse Repetition Rate (Range) 240 km 160 km 80 km 40 km 20 km 10 km 5 km 2 km 1 km		Minimum specified values: 2400 µs 1600 µs 800 µs 400 µs 200 µs 100 µs 50 µs 20 µs 10 µs
Optical Output, Wavelength	1310 ±20 nm 1625 ±20 nm	Spectral mean or center-of-mass provided by laser manufacturer.
Optical Output, Spectral Width		10 nm RMS value of spectral energy is time-averaged mode from series of pulses.
Optical Output, Amplitude		Measured at peak value emitted from front panel connector into 9 µm, NA=0.1, SM fiber. 100 mW maximum.
Laser Product Safety Classification	CFR Class I and IEC Class 1	Per FDA and IEC.
Temperature Coefficient of Laser Wavelength		(0.4 nm/°C) x (T −25° C) typical.

Table 1–104: Vertical System Measurements (Extended Range 1310/1550 nm Singlemode, Option 10)

Characteristic	Performance Requirement	Supplemental Information
Linearity	±0.02 dB/dB typical from 15 dB to 2 dB below backscatter at front panel; ±0.05 dB/dB typical from 10 dB to 1 dB below backscatter at front panel	3-minute average
Measurement Accuracy Two-Point Splice Loss LSA Fiber Loss	±0.1 dB/dB typical	3-minute average For events 10 dB above the 98% noise floor, 95% confidence.
Reflectance	±4 dB maximum; ±2 dB typical	Non-clipped reflection Meets or exceeds Bellcore GR-196-CORE

Table 1–105: Single-Event Distance Measurement Repeatability[1] (Extended Range 1310/1550 nm Singlemode, Option 10)

Characteristic	Performance Requirement		Supplemental Information
Range from Front Panel (dB)	Reflective[2] *typical:*	Nonreflective[3] *typical:*	IntelliTrace mode
0 to 1.5	2.5 m	2.5 m	
1.5 to (DR[4]–8)	20 m	20 m	
(DR–8) to DR	40 m	160 m	

[1] Multiply by 0.001% of range for timebase error. These data are for a 0.5 dB event with 95% probability on a single unit.
[2] Reflectance greater than −45 dB, 0.5 dB loss.
[3] Reflectance less than −60 dB, 0.5 dB loss.
[4] DR is the dynamic range for 2000-m pulse width from table 1−52. DR is the 98% dynamic range, defined as dynamic range SNR=1 minus 1.5.

Table 1–106: System Measurement Accuracy (Extended Range 1310/1550 nm Singlemode, Option 10)

Characteristic	Performance Requirement	Supplemental Information
Distance	±10 m, ±4 m typical	Measured on NIST traceable calibration system.
Loss	±0.05 dB, ±0.01 dB typical	Measured on NIST traceable calibration system.

Table 1–107: Vertical System Dynamic Range (Extended Range 1310/1550 nm Singlemode, Option 10)

Characteristic	Performance Requirement		Supplemental Information
Dynamic Range Pulsewidth		Typical	SNR=1. Dynamic range SNR=1 is defined as the difference between the extrapolated backscatter level at the start of the fiber and the RMS noise level. Based on high APD and amplifier gains. Low APD gain reduces 4 dB. Low amplifier gain reduces 5 dB. 3-minute of average 0.5-dB front-panel loss assumed. For 100, 200, 500, 1000, 2000, and 3200-m pulse widths, fiber must have enough loss so the second segment is taken with high system gain. For 3200-m pulse width, maximum dynamic range is limited to 36.5 dB. Clipping may be observed for up to 20 km with 2000- and 3200-m pulse widths with dynamic range of 3200-m pulse width $\geq$35 dB.
3200 m	32 dB	35 dB (1310) 33.5 dB (1550)	
2000 m		34 dB	
1000 m		32.5 dB	
500 m	25 dB	30 dB	
200 m		29 dB	
100 m		27.5 dB	
50 m		23 dB	
20 m	14 dB	15 dB	
10 m		19.5 dB	
5 m		18 dB	
1 m		14.5 dB	
Temperature Coefficient of Dynamic Range			-0.15 dB/^{o}C for T $\neq$ 25^{o} C, typical

Table 1–108: Horizontal System Dead Zone (Extended Range 1550 nm Singlemode, Option 08)

Characteristic	Performance Requirement		Supplemental Information
Attenuation Dead Zone Pulsewidth		*typical*	Attenuation dead zone is defined as the distance between the initial and final points, where the backscatter level is disrupted beyond ±0.5 dB due to encountering a single reflective event. Based on reflective events with no greater than −40 dB reflectance. Based on 9 µm, 0.1 NA SM fiber.
3200 m		3500 m	
2000 m		2300 m	
1000 m		1350 m	
500 m		600 m	
200 m			
100 m		175 m	
50 m		100 m	
20 m		46 m	
10 m	36 m	16 m	
5 m		18 m	
1 m		15 m	
Event Dead Zone Pulsewidth			Event dead zone is defined as the distance between the initial and final points, where the reflected pulse amplitude is −3.0 dB down from its peak value. Based upon reflective events with no greater than −40 dB reflectance. One-meter spec based on testing to justify that the end of a 5-meter jumper can be detected.
3200 m		3500 m	
2000 m		2250 m	
1000 m		1200 m	
500 m		700 m	
200 m			
100 m		115 m	
50 m		65 m	
20 m		30 m	
10 m	29 m	6 m	
5 m		8 m	
1 m		5 m	

Table 1–109: Horizontal System Distance Span and Range (Extended Range 1550 nm Singlemode, Option 08)

Characteristic	Performance Requirement	Supplemental Information
Distance Span (Manual Mode) Pulsewidth		Distance span is defined as the length of the data acquisition window for a single segment acquisition in overview mode. Span is determined by the sample spacing and the number of samples possible in the acquisition window. Controlled by software. Not directly checked in the performance verification procedure.
3200 m	120 km	
2000 m	120 km	
1000 m	120 km	
500 m	80 km	
200 m	80 km	
100 m	40 km	
50 m	40 km	
20 m	20 km	
10 m	10 km	
5 m	5 km	
1 m	1 km	

Table 1–110: Sample Density, Pulsewidth, and Range Combinations (Extended Range 1550 nm Singlemode, Option 08)

Pulsewidth (m)	Bandwidth (MHz)[1]	Overview Sample Spacing[2]	Overview Interleave Factor[3]	Overview Measurement Spans (km)									Minimum High Density Sample Spacing
				240	160	80	40	20	8	4	2	1	
3200	0.1	40 m	1x	●	●	●	●	●					1.25 m
2000	0.1	40 m	1x	●	●	●	●	●					1.25 m
1000	0.1	40 m	1x		●	●	●	●	●				1.25 m
500	0.1	20 m	1x		●	●	●	●	●	●			1.25 m
200	5	20 m	1x		●	●	●	●	●	●			1.25 m
100	5	10 m	1x			●	●	●	●	●	●		1.25 m
50	5	10 m	1x			●	●	●	●	●	●	●	1.25 m
20	17	5 m	2x			●	●	●	●	●	●	●	1.25 m
10	17	2.5 m	4x					●	●	●	●	●	1.25 m
5	17	1.25 m	8x					●	●	●	●	●	1.25 m
1	35	25 cm	40x							●	●	●	25 cm

Note 1: Bandwidth is chosen based on a 3x minimum bandwidth required for pulsewidth resolution. The minimum bandwidth is given by

$$\beta_{min} = \frac{0.35}{pw\ (meters)\ x\ 10\ ns/m}$$

Note 2: Sample spacing is chosen to obtain four data points on pulse.
Note 3: Interleave factor is based on a 10 MHz sampling rate.

Table 1–111: Bandwidth and Transient Characteristics (Extended Range 1550 nm Singlemode, Option 08)

Bandwidth (MHz)	Risetime	Fallslope	
35	1 m = 10 ns	2.1 m/10 dB	Controlled by software. Not directly checked in the performance verification procedure.
17	2 m = 21 ns	4.3 m/10 dB	
5	7 m = 70 ns	14.7 m/10 dB	
0.1	117 m = 1170 ns	245 m/ 10 dB	

1625 nm Singlemode, Option 12

Table 1–112: Optical Signal Characteristics (1625 nm Singlemode, Option 12)

Characteristic	Performance Requirement	Supplemental Information
Displayed Pulsewidth		Measured between the −3.0 dB points relative to the top of the pulse. 3200, 2000,1000, 500, 200, 100, 50, 20, 10, 5, 1 meters
Pulse Repetition Rate (Range) 240 km 160 km 80 km 40 km 20 km 10 km 5 km 2 km 1 km		Minimum specified values: 2400 µs 1600 µs 800 µs 400 µs 200 µs 100 µs 50 µs 20 µs 10 µs
Optical Output, Wavelength	1625 ±20 nm	Spectral mean or center-of-mass provided by laser manufacturer.
Optical Output, Spectral Width		10 nm RMS value of spectral energy is time-averaged mode from series of pulses.
Optical Output, Amplitude		Measured at peak value emitted from front panel connector into 9 µm, NA=0.1, SM fiber. 100 mW maximum.
Laser Product Safety Classification	CFR Class I and IEC Class 1	Per FDA and IEC.
Temperature Coefficient of Laser Wavelength		(0.4 nm/°C) x (T −25° C) typical.

Table 1–113: Vertical System Measurements (1625 nm Singlemode, Option 12)

Characteristic	Performance Requirement	Supplemental Information
Linearity	Manual acquisitions: Typically ±0.02 dB/dB from 15 dB to 2 dB below backscatter at front panel; ±0.05 dB/dB typical from 10 dB to 1 dB below backscatter at front panel	3-minute average.
Measurement Accuracy Two-Point Splice Loss LSA Fiber Loss	±0.1 dB/dB typical	3-minute average For events 10 dB above the 98% noise floor, 95% confidence.
Reflectance		Non-clipped reflection. ±4 dB typical Meets or exceeds Bellcore GR-196-CORE

Table 1–114: Single-Event Distance Measurement Repeatability[1] (1625 nm Singlemode, Option 12)

Characteristic	Performance Requirement		Supplemental Information
Range from Front Panel (dB)	Reflective[2] *typical:*	Nonreflective[3] *typical:*	IntelliTrace mode
0 to 1.5	2.5 m	2.5 m	
1.5 to (DR[4]–8)	20 m	20 m	
(DR–8) to DR	40 m	160 m	

[1] Multiply by 0.001% of range for timebase error. These data are for a 0.5 dB event with 95% probability on a single unit.
[2] Reflectance greater than −45 dB, 0.5 dB loss.
[3] Reflectance less than −60 dB, 0.5 dB loss.
[4] DR is the dynamic range for 2000-m pulse width from table 1−52. DR is the 98% dynamic range, defined as dynamic range SNR=1 minus 1.5.

Table 1–115: Vertical System Dynamic Range (1625 nm Singlemode, Option 12)

Characteristic	Performance Requirement		Supplemental Information
Dynamic Range Pulsewidth		Typical	SNR=1. Dynamic range SNR=1 is defined as the difference between the extrapolated backscatter level at the start of the fiber and the RMS noise level. Based on high APD and amplifier gains. Low APD gain reduces 4 dB. Low amplifier gain reduces 5 dB. 3-minute of average 0.5-dB front-panel loss assumed. For 100, 200, 500, 1000, 2000, and 3200-m pulse widths, fiber must have enough loss so the second segment is taken with high system gain. For 3200-m pulse width, maximum dynamic range is limited to 36.5 dB. Clipping may be observed for up to 20 km with 2000- and 3200-m pulse widths with dynamic range of 3200-m pulse width $\geq$35 dB.
3200 m	31 dB	32.0 dB	
2000 m		29 dB	
1000 m		27.5 dB	
500 m	25 dB	25 dB	
200 m		24 dB	
100 m		22.5 dB	
50 m		18 dB	
20 m	14 dB	10 dB	
10 m		14.5 dB	
5 m		13 dB	
1 m		9.5 dB	
Temperature Coefficient of Dynamic Range			-0.15 dB/^{o}C for T $\neq$ 25^{o} C, typical

Table 1–116: Horizontal System Dead Zone (1625 nm Singlemode, Option 12)

Characteristic	Performance Requirement		Supplemental Information
Attenuation Dead Zone Pulsewidth		*typical*	Attenuation dead zone is defined as the distance between the initial and final points, where the backscatter level is disrupted beyond ±0.5 dB due to encountering a single reflective event. Based on reflective events with no greater than −40 dB reflectance. Based on 9 μm, 0.1 NA SM fiber.
3200 m			
2000 m			
1000 m			
500 m			
200 m			
100 m			
50 m			
20 m			
10 m	36 m	16 m	
5 m			
1 m			
Event Dead Zone Pulsewidth			Event dead zone is defined as the distance between the initial and final points, where the reflected pulse amplitude is −3.0 dB down from its peak value. Based upon reflective events with no greater than −40 dB reflectance.
3200 m			
2000 m			
1000 m			
500 m			
200 m			
100 m			
50 m			
20 m			
10 m	29 m	5 m	
5 m			
1 m			

Table 1–117: Horizontal System Distance Span and Range (1625 nm Singlemode, Option 12)

Characteristic	Performance Requirement	Supplemental Information
Distance Span (Manual Mode) Pulsewidth		Distance span is defined as the length of the data acquisition window for a single segment acquisition in overview mode. Span is determined by the sample spacing and the number of samples possible in the acquisition window. Controlled by software. Not directly checked in the performance verification procedure.
3200 m	120 km	
2000 m	120 km	
1000 m	120 km	
500 m	80 km	
200 m	80 km	
100 m	40 km	
50 m	40 km	
20 m	20 km	
10 m	10 km	
5 m	5 km	
1 m	1 km	

Table 1–118: Sample Density, Pulsewidth, and Range Combinations (1625 nm Singlemode, Option 12)

Pulsewidth (m)	Bandwidth (MHz)[1]	Overview Sample Spacing[2]	Overview Interleave Factor[3]	Overview Measurement Spans (km)									Minimum High Density Sample Spacing
				240	160	80	40	20	8	4	2	1	
3200	0.1	40 m	1x	•	•	•	•	•					1.25 m
2000	0.1	40 m	1x	•	•	•	•	•					1.25 m
1000	0.1	40 m	1x		•	•	•	•	•				1.25 m
500	0.1	20 m	1x		•	•	•	•	•	•			1.25 m
200	5	20 m	1x		•	•	•	•	•	•			1.25 m
100	5	10 m	1x			•	•	•	•	•	•		1.25 m
50	5	10 m	1x			•	•	•	•	•	•	•	1.25 m
20	17	5 m	2x			•	•	•	•	•	•	•	1.25 m
10	17	2.5 m	4x					•	•	•	•	•	1.25 m
5	17	1.25 m	8x					•	•	•	•	•	1.25 m
1	35	25 cm	40x							•	•	•	25 cm

Note 1: Bandwidth is chosen based on a 3x minimum bandwidth required for pulsewidth resolution. The minimum bandwidth is given by

$$\beta_{min} = \frac{0.35}{pw\ (meters)\ x\ 10\ ns/m}$$

Note 2: Sample spacing is chosen to obtain four data points on pulse.
Note 3: Interleave factor is based on a 10 MHz sampling rate.

Table 1–119: Bandwidth and Transient Characteristics (1625 nm Singlemode, Option 12)

Bandwidth (MHz)	Risetime	Fallslope	
35	1 m = 10 ns	2.1 m/10 dB	Controlled by software. Not directly checked in the performance verification procedure.
17	2 m = 21 ns	4.3 m/10 dB	
5	7 m = 70 ns	14.7 m/10 dB	
0.1	117 m = 1170 ns	245 m/ 10 dB	

Power

Battery Pack	14.4 V, 2.8 amp/hr, NiCad
Battery Charge Time (Discharged Battery)	 4 hours nonoperating at room temperature, typical
Typical Battery Life (In Instrument) Normal Use Shelf Life	 4.5 hours typical[1] 70% cap after 1 mo at 20º C 50% cap after 8 days at 50º C
Power/Charger Adapter Output	15.5 VDC, 43 W max
DC Input	9 to16 VDC, 43 W max
Power Consumption	Max 35 W; typical 8 to 10 W Inrush current < 5 A for 75 ms.

[1] Backlight off, acquire IntelliTrace waveform, review (1 minute), add comments (2 minutes), save to internal storage, set up for next acquisition (2 minutes), repeat.

Display

Readout Resolution Distance Loss	 0.25 m (0.8 ft) minimum 0.001 dB
Measurement Readout Range Distance Loss	 0.001 km to 160 km (93.2 miles) 0 to 40 dB

Size and Weight

Weight Single-port instrument w/battery only Single-port instrument incl. std. accessories Dual-port instrument w/battery only Dual-port instrument incl. std. accessories	 <4.31 kg (<9.5 lbs) <5.90 kg (<13 lbs) <4.77 kg (<10.5 lbs) <6.22 kg (<13.7 lbs)
Dimensions	29.21 cm wide X 11.4 cm high X 24.1 cm long (11.5 in wide X 4.5 in high X 9.5 in long)

RS232C Serial Port

DB9 Configuration as DTE (Same as PC/AT Cable)	EIA RS232C levels IBM AT style DB9 male DB9 connector pinouts: 1 DCD (in) 2 RD (in) 3 TD (out) 4 DTR (out) 5 signal ground 6 DSR (in) 7 RTS (out) 8 CTS (in) 9 RI (in)
Flow Control	None, RTS/CTS, XON/XOFF, DTR
Data Rates	1200; 2400; 4800; 9600; 19200, 38400 baud
Printers Supported	Epson, Tek HC411, HP ThinkJet, HP LaserJet, HP DeskJet, PostScript

Parallel Port

25-Pin female D Subminiature	Standard PC type parallel printer interface.
Printers Supported	Epson, Tek HC411, HP ThinkJet, HP LaserJet, HP DeskJet, PostScript

Keyboard Port

6-pin mini-DIN	IBM PS2-style connector
Keyboards supported	IBM PC-AT type (complete compatibility and EMC specifications guaranteed only with Tektronix keyboard option 19) Languages: USA, French, German, Spanish, Portuguese, Italian, Finnish
Power capability	500 mA maximum available for keyboard (at 5 VDC). (If above this level, keyboard power turns off. Power to instrument must be cycled off, then on to restore keyboard power.)

Environmental[1]

Characteristic	Performance Requirement	Supplemental Information
Temperature	Operating: 0° C to 40° C (32° F to 104° F) Nonoperating: –20° C to 60° C (-4° F to 140° F)	Test per Tek 062-2847-00, Class 3, with the exception of the temperature extremes.
Option 11	Operating (disk read/write): 5° C to 40° C (41° F to 104° F) Nonoperating: –20° C to 60° C (-4° F to 140° F)	
Humidity		Test per Tek 062-2847-00, Class 3, with the exception of the humidity limits.
	Operating: 5 to 95% relative humidity, noncondensing Nonoperating: 5 to 95% relative humidity, noncondensing	Maximum wet bulb temperature: 40° C (104° F) Maximum wet bulb temperature: 40° C (104° F)
Option 11	Operating (disk read/write): 20 to 80% noncondensing Nonoperating: 5 to 90% noncondensing	Maximum wet bulb temperature: 29.4° C (85° F) Maximum wet bulb temperature: 40° C (104° F)
Altitude (Maximum)	Operating: 3000 meters Nonoperating: 50,000 ft (15.2 km)	Test per Tek 062-2847-00, Class 3
Water Resistance[3]	Drip proof	Test per MIL-T-28800E, Type III, Class 3, Style C
Random Vibration[2]	Operating (when Option 11 not installed): Frequency range: 5 to 500 Hz Acceleration: 0.31 GRMS Nonoperating: Frequency range: 5 to 500 Hz Acceleration: 2.46 GRMS	Test per Tek 062-2858-00, Class 3
Sine Vibration[3]	Operating: Frequency sweep: 10 to 500 Hz Acceleration: 1.5 G maximum	Test per Bellcore GR-196-CORE
Option 11	Operating (disk read/write): Frequency sweep: 10 to 500 Hz Acceleration: 0.6 G maximum Nonoperating Frequency sweep: 10 to 500 Hz Acceleration: 1.5 G maximum	

Characteristic	Performance Requirement	Supplemental Information
Bench Handling, Operating	Height: 4 inches (10 cm) Orientation: all sides Surface: solid work bench Duration: 1 drop per edge	Test per MIL-T-28800E, Type III, Class 3, Style C
Drop, Free Fall, Nonoperating[2, 3]	Height: 30 inches Orientation: on its back Surface: concrete Duration: 1 drop	Test per Bellcore GR-196-CORE
Shock (Maximum)[2] Option 11	Operating: 50 G Operating (disk read/write): 5 G (10 ms) not hard error Nonoperating: 50 G (10 ms)	Test per Tek 062-2858-00, Class 3
Package Product Shock/Vibration/Drop, Nonoperating	Tek 062-2858-00	Test per Tek 062-2858-00, distribution cycle 1 with the exception of increasing the drop height to 30 inches per Bellcore GR-196-CORE
Hard Carrying Case Drop, Nonoperating	Height: 30 inches Orientation: all sides and corners Surface: concrete Duration: 14 total drops	Test per Bellcore GR-196-CORE
Dust Resistance	Instrument is dust resistant by design	Bellcore GR-196-CORE
Fungus Inert	Enclosure and electronics are fungus inert by design	As specified per MIL-T-28800E, Type III, Class 3, Style C

[1] During nonoperating environmental conditions, remove either the power/charger adapter power cord or cigarette lighter adapter power cord from the power/charger adapter port on the instrument.
[2] For Option 11 instruments, remove disk from disk drive.
[3] Instrument in soft carrying case with front flap closed.

Table 1–120: Certifications and compliances

Category	Standards or description	
EC Declaration of Conformity – EMC	Meets intent of Directive 89/336/EEC for Electromagnetic Compatibility. Compliance was demonstrated to the following specifications as listed in the Official Journal of the European Union:	
	EN 50081-1 Emissions:	
	EN 55022	Class B Radiated and Conducted Emissions
	EN 60555-2	AC Power Line Harmonic Emissions
	EN 50082-1 Immunity:	
	IEC 801-2	Electrostatic Discharge Immunity
	IEC 801-3	RF Electromagnetic Field Immunity
	IEC 801-4	Electrical Fast Transient/Burst Immunity
	IEC 801-5	Power Line Surge Immunity
Australia/New Zealand Declaration of Conformity – EMC	Complies with EMC provision of Radiocommunications Act per the following standard(s):	
	AS/NZS 2064.1/2	Industrial, Scientific, and Medical Equipment: 1992
EMC Compliance	Meets the intent of Directive 89/336/EEC for Electromagnetic Compatibility when it is used with the product(s) stated in the specifications table. Refer to the EMC specification published for the stated products. May not meet the intent of the directive if used with other products.	
FCC Compliance	Emissions comply with FCC Code of Federal Regulations 47, Part 15, Subpart B, Class A Limits.	
EC Declaration of Conformity – Low Voltage	Compliance was demonstrated to the following specification as listed in the Official Journal of the European Union:	
	Low Voltage Directive 73/23/EEC, amended by 93/69/EEC	
	EN 61010-1:1993/A2	Safety requirements for electrical equipment for measurement control and laboratory use (with 1st and 2nd Ammendments).
U.S. Nationally Recognized Testing Laboratory Listing	UL3111-1	Standard for electrical measuring and test equipment.
Canadian Certification	CAN/CSA C22.2 No. 1010.1	Safety requirements for electrical equipment for measurement, control, and laboratory use.
Additional Compliance	ANSI/ISA S82.01:1994	Safety standard for electrical and electronic test, measuring, controlling, and related equipment.
	IEC61010-1	Safety requirements for electrical equipment for measurement, control, and laboratory use.
	IEC60825-1	Safety of Laser products.
	21 CFR, Part 1040	Code of Federal regulations, Laser products.

Table 1–120: Certifications and compliances (cont.)

Category	Standards or description	
Installation (Overvoltage) Category	CAT I	Secondary (signal level) or battery operated circuits of electronic equipment.
	CAT II	Local-level mains (wall sockets). Equipment at this level includes appliances, portable tools, and similar products. Equipment is usually cord-connected.
Pollution Degree	Pollution Degree 2	Normally only dry, nonconductive pollution occurs. Occasionally a temporary conductivity that is caused by condensation must be expected. This location is a typical office/home environment. Temporary condensation occurs only when the product is out of service.
	Pollution Degree 3	Conductive pollution, or dry, nonconductive pollution that becomes conductive due to condensation. These are sheltered locations where neither temperature nor humidity is controlled. The area is protected from direct sunshine, rain, or direct wind.
Safety Certification Compliance		
Temperature, operating	+5 to +40° C	
Altitude (maximum operating)	2000 meters	
Equipment Type	Test and measuring	
Safety Class	Class 2 (as defined in IEC 61010-1, Annex H) – Double Insulated	
Overvoltage Category	Overvoltage Category II (as defined in IEC 61010-1, Annex J)	
Pollution Degree	Pollution Degree 3 (as defined in IEC 61010-1).	

Accessories and Options

Table 1–121: Standard Accessories

Accessory	Tektronix Part Number
User Manual	070–9027–xx
Reference Card	063–2096–xx
Power/Charger Adapter	119–4545–01
Power Cord for Power/ Charger Adapter 120 Volt USA and Canada only or 100 Volt Japan only	 161–0228–00 161–0288–00
Soft Carrying Case w/Battery Storage Label (334–9394–xx)	016–1215–02
Shoulder Strap for Soft Carrying Case	346–0284–00
Tektronix Optical Cleaner (isopropyl alcohol packs w/application note)	020–2357–xx

Table 1–122: Optional Accessories

Accessory	Tektronix Part Number
Power/Charger Adapter Power Cord 220 V Europe (Option A1) 240 V United Kingdom (Option A2) 240 V Australia (Option A3) 220 V Switzerland (Option A5) 100 V Japan (Option A6)	 161–0066–09 161–0066–10 161–0066–11 161–0154–00 161–0288–00
Spare NiCad Battery	146–0112–00
Hard Travel Case	016–1210–00
Finder,Fault Penlight Style, Rifocs 163L, Low Cost VEF	015–0684–00
Adapter,Fiber Series Bare Fiber, Rifocs 934–125	015–0685–00
Adapter,Fiber Series Bare Fiber With Fiber Cleaver-Rifocs 934K–125	015–0686–00
RS232C Serial Cable (2 Meters Long) for PC/AT DB9F/DB9F Null	012–1379–00
DB25/Centronics Parallel Printer Cable, Seiko Style (3 Meters Long)	012–1214–00
Test Data Storage (TDS) PC Software (for transferring files from TFS3031 to PC) (Includes Serial Cable and User Instructions)	FSTIP
FMTAP Trace Analysis Software Package for Personal Computer (Includes User Instructions)	FMTAP
12 Volt Battery Clips (for Power/Charger Adapter)	198–5809–00
Cigarette Lighter Adapter (for Power/Charger Adapter)	198–5810–00
Service Manual (Module Level)	070–9026–xx
Tektronix HC411 Printer with 120 Volt Adapter	HC411 03*
Tektronix HC411 Printer with 220 Volt European-Style Adapter	HC411 03 A1*
Keyboard (for upgraded instruments and instruments with serial numbers B030000 and above)	118–9402–00

*Not approved for use in countries requiring CE certification. See EC Declaration of Conformity at the front of this manual.

Table 1–123: Configuration Options

Option Number	Instrument Includes:
11	3.5 inch floppy disk drive
1S	FMTAP/FSTIP software
1T	Hard transit case
1R	19 inch rackmount
19	Keyboard
2T	TOP130 LED source 850/1300 nm (w/connector option)
3T	TOP140 laser source 1310 nm (w/connector option)
4T	TOP150 laser source 1550 nm (w/connector option)
5T	TOP200 optical power meter 850/1300/1550 nm (w/connector option)
6T	TOP300 visual fault finder 635 nm (w/connector option)
7T	TOP160 dual-wavelength laser source 1310/1550 nm (w/connector option)
8T	TOP220 optical power meter 980/1310/1550 nm (w/connector option)
9T	TOP400 optical attenuator (w/connector option)
L1	French language option (includes French user manual 070–9507–xx and quick-reference card 063–1839–xx)
L2	Italian language option (includes Italian user manual 070–9587–xx and quick-reference card 063–1843–xx)
L3	German language option (includes German user manual 070–9588–xx and quick-reference card 063–1993–xx)
L4	Spanish language option (includes Spanish user manual (070–9589–xx and quick-reference card 063–1837–xx)
L5	Japanese language option (includes Japanese user manual 070–9590–xx)
L6	Portuguese language option (includes Portuguese user manual 070–9593–xx and quick-reference card 063–1842–xx)
L7	PRC Chinese language option (includes PRC Chinese user manual 070–9591–xx)
L8	Standard Chinese language option (includes Standard Chinese user manual 070–9592–xx)
LF	Finnish language option (includes Finnish user manual 070–9689–xx and quick-reference card 063–2553–xx)
LD	Dutch user manual (070–9985–xx)

Table 1–124: Power/Charger Adapter Cord Options

Option Number	Power Cord
A1	220 V Europe
A2	240 V United Kingdom
A3	240 V Australia
A4	220 V North American
A5	220 V Switzerland
A6	100 V Japan
A99	No Power Cord Supplied

Table 1–125: Laser Output Port Options

Option Number	Optical Port
01	850 nm Multimode
03	Dual-Wavelength 850/1300 nm Multimode
04	Standard 1310 nm Singlemode
06	Standard Dual-Wavelength 1310/1550 nm Singlemode
10	Extended Range Dual-Wavelength 1310/1550 nm Singlemode
12	1625 nm Singlemode

Table 1–126: Connector Adapter Options

Option Number Singlemode	Multimode	Connector Adapter	Tektronix Part Number
30	20	Biconic	119–4515–00
31	21	FCPC	119–4516–00
32	22	D4PC	119–4514–00
34	24	STPC	119–4513–00
35	25	DINPC 47256	119–4546–00
36	26	Diamond 3.5	119–4558–00
38	28	SCPC	119–4518–00
41	—	FC/APC[1]	119–5115–00
42	—	SC/APC[1]	119–5154–00
43	—	E–2000/APC[1]	119–5164–00
44	—	ST/APC[1]	119–5888–00
45	—	DIN/APC[1]	119–5887–00

[1] Angle polish connector adapters (singlemode options 41 through 45) cannot be interchanged with any of the other connector adapters.

Table 1–127: Performance Check Software

Software	Tektronix Part Number
Performance Check Software	119–5130–xx

See Section 3 for performance check procedure.

Table 1–128: Operating System Software

Software	Tektronix Part Number
English	063–3296–xx
French, Italian, German, Spanish, Portuguese	063–3297–xx
Japanese	063–3298–xx
PRC Chinese	063–3299–xx
Standard Chinese	063–3300–xx
Finnish	063–3301–xx

Theory of Operation

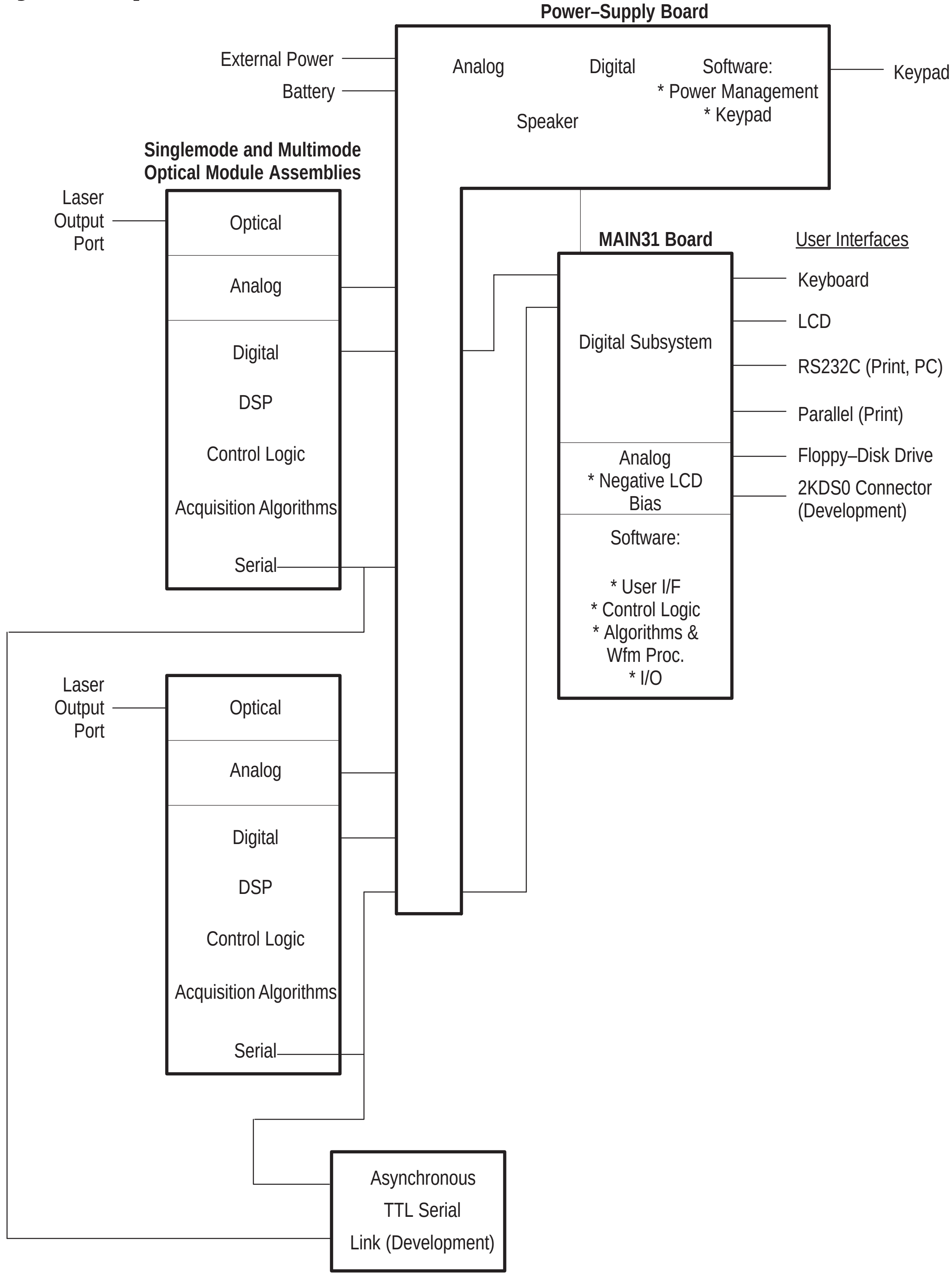


Figure 2–1: System Block Diagram

Theory of Operation

The TFS3031 consists of the following major components:

- User interface

  Keypad
  Liquid-crystal display (LCD)
  Floppy-disk drive
  Serial port
  Parallel port
  Singlemode optical port (optional)
  Multimode optical port (optional)
  Keyboard

- Battery
- External power port
- Internal printed circuit boards

  Singlemode data-acquisition system (SMDAS) board (optional)
  Multimode data-acquisition system (MMDAS) board (optional)
  Power-supply board
  Main board
  LCD backlight power-inverter board

Data Acquisition Boards

The SMDAS and MMDAS boards contain the optical components, laser drivers, detector amplifiers, data-acquisition hardware, high-voltage supplies, and acquisition processors. The processors on the SMDAS and MMDAS boards fire the lasers, collect waveform data, and communicate with the main board.

Commands from the main board tell the SMDAS and MMDAS boards what settings to use and when to collect waveform data. The SMDAS and MMDAS boards then collect the waveform data and send the waveform data back to the main board over a serial interface.

The main board contains calibration constants for the SMDAS and MMDAS boards. Therefore, a software-calibration command must be performed if the main board, SMDAS, or MMDAS board is replaced.

Power-Supply Board

The power-supply board provides power for all the boards. The power-supply board also supplies the communications channel between boards. The microprocessor on the power-supply board controls battery charging, beeper support, LCD backlight, LCD contrast, and the front-panel LEDs. This board monitors the battery voltage, temperature, and current flow continuously to predict remaining battery capacity and to adjust the charge rate for best performance.

The microprocessor on the power-supply board decodes key presses on the keypad and sends the key-press information to the main board.

The power-supply board receives commands from the main board and power switch to enable or disable power to the SMDAS board, MMDAS board, main board, and LCD backlight.

The LCD bias voltage, which controls LCD contrast, is generated on the power-supply board. The power-supply board receives LCD contrast commands from the main board, adjusts for temperature variations, and provides the correct positive bias voltage to the main board to pass on to the LCD.

For instruments with serial numbers B030000 and above, the main board inverts and scales the positive LCD bias voltage supplied by the power-supply board to generate a negative LCD bias (contrast) for the LCD.

Main Board

The main board is the link to the user. It interprets user keypad and external keyboard presses and sends commands to the SMDAS, MMDAS, and power-supply boards to acquire data and control LCD backlight and LCD contrast. It receives data from the SMDAS, MMDAS, and power-supply boards, performs event analysis, and provides data to the user through the LCD, the serial port, and the parallel port.

The main board stores and recalls waveform and system data using the floppy disk drive and internal memory. The main board contains the real-time clock and the main system software. Time, data, and configuration information needs to be reprogrammed if this board is replaced. The main board controls downloading of new system software. This board performs power-on diagnostics to detect errors, to decide which options are installed, and to decide what capabilities the instrument has.

The main board contains calibration constants for the SMDAS and MMDAS boards. Therefore a software calibration command must be performed if the main board, SMDAS, or MMDAS board is replaced.

For instruments with serial numbers B030000 and above, the main board inverts and scales the positive LCD bias voltage supplied by the power-supply board to generate a negative LCD bias (contrast) for the LCD.

LCD Backlight Power-Inverter Board

Power for the LCD backlight comes from the power-supply board and is converted to the appropriate high voltage by the LCD backlight power-inverter board.

Performance Check – TekRanger

Introduction

These performance checks ensure that the TFS3031 TekRanger is operating properly and conforms to instrument specifications as listed under *Specifications – TekRanger (serial nos. below B052000)* in Section 1. This perrformance check procedure applies to TekRanger instruments with serial numbers below B052000. For the TekRanger 2 performance check, refer to section 4.

The performance check should be done after an instrument has been serviced.

If you are unfamiliar with how the TFS3031 works, it may help to review the *TFS3031 User Manual* or *Reference Card* before doing the performance check.

Performance Test Software After Board Replacement

If the MAIN31 board or one of the optical module assemblies is replaced, performance of the TFS3031 must be characterized to ensure optimum performance of the event-detection algorithms. This is done by using the performance test software housed on a floppy disk. See Table 1–127 on page 1–105 for the performance test software part number.

An IBM-compatible PC (386 or better) with a serial port is required for this characterization. To use the performance test software, see the instructions in the *readme* file that comes with the software package.

Equipment Required for Performance Check

- Power/charger adapter (standard accessory included with the TFS3031).
- FC connector adapter installed on the laser output port under test.
- Singlemode fiber test fixtures appropriate for the laser output port under test. The singlemode test fixtures are:
  - Singlemode dynamic-range test fixture
  - Singlemode event-detection fiber test fixture
  - Singlemode dead-zone test fixture
- Multimode fiber test fixtures appropriate for the laser output port under test. The multimode test fixtures are:
  - Multimode dynamic range test fixture
  - Multimode event-detection and dead-zone test fixture

- Tektronix performance check software

  The fiber test fixtures are *not* supplied by Tektronix. See instructions starting on page 3–6 for information about how to build your own fixtures. A characterization and tolerance data sheet for all events on the event-detection test fixtures is required prior to use.

  The performance check software is an optional accessory for the TFS3031, part number 119–5130–xx.

Adjustments

There are no user or service adjustments required in the TFS3031.

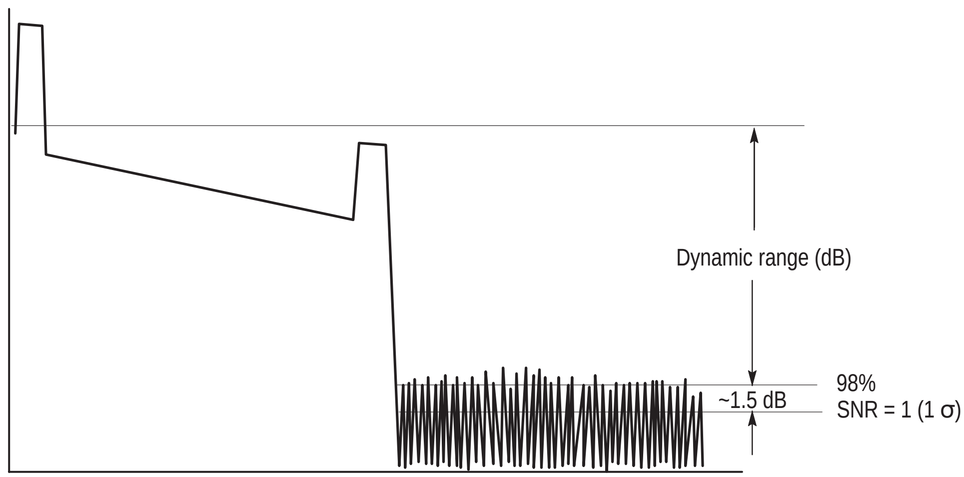
CAUTION. *Do not attempt to adjust any potentiometers on the optical module assemblies. All adjustments are optimized for peak performance. Any increase in laser drive current or detector bias may result in damage to the device.*

Test Descriptions

Dynamic Range

Dynamic range is a measure of signal-to-noise ratio for an OTDR. There are several methods in popular use to measure dynamic range. Nearly all methods compare the backscatter signal at the front panel with the noise past the end of the fiber. Various definitions for noise floor are in use, including:

- 1-sigma noise level
- 98% noise level (2-sigma noise level)
- Noise peak
- 0.3 dB above noise peak
- Minimum level where a 0.5-dB splice can be measured (similar to measurement range)



Each of these definitions for noise floor have good points and bad points. The definition for noise floor for the TFS3031 is the 1-sigma level. The 1-sigma level is the level where the signal from the backscatter is equal to the standard deviation of the noise. At this level it is difficult to distinguish between a splice and noise unless additional averaging or filtering is used.

Because the backscatter signal depends on wavelength, fiber type, fiber numeric aperture, pulse width, and front-panel connector loss, it is important to avoid specialty fibers and dirty or damaged connectors when making dynamic-range measurements.

It is difficult to measure the noise floor without using a computer. For this reason, software is available to assist with dynamic-range measurements. The TFS3031 provides data in dB units, so the computer must antilog the data, calculate the standard deviation, then convert the result back to dB units.

Dynamic range : $DR = S0 - 1\sigma$

DR is the calculated dynamic range in dB
S0 is the backscatter level extrapolated to the front panel (i.e., distance = 0) in dB.
1σ is the standard deviation of the noise past the end of the fiber in dB.

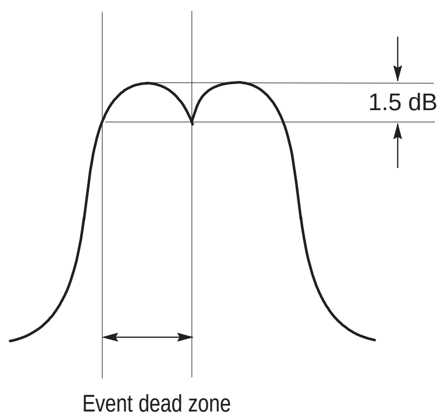
Event Detection

Noise is always present on the measured waveform. This noise causes location and loss measurements to vary slightly from one measurement to the next. The event-detection test measures the repeatability of measuring a series of events on a special test fiber. Many of the characteristics of event detection depend on software event-detection algorithms. These algorithms do not change over the life of the instrument unless the instrument software is upgraded to a newer version.

Some of the characteristics of event detection depend on signal level and noise level, which can degrade as lasers age and as the front-panel optical connector becomes worn or damaged. This second group of characteristics will degrade both dynamic-range tests and event-detection tests. These characteristics, which do not depend on the software algorithms, are influenced by the same fiber and connector characteristics as the dynamic-range tests.

Event Dead Zone

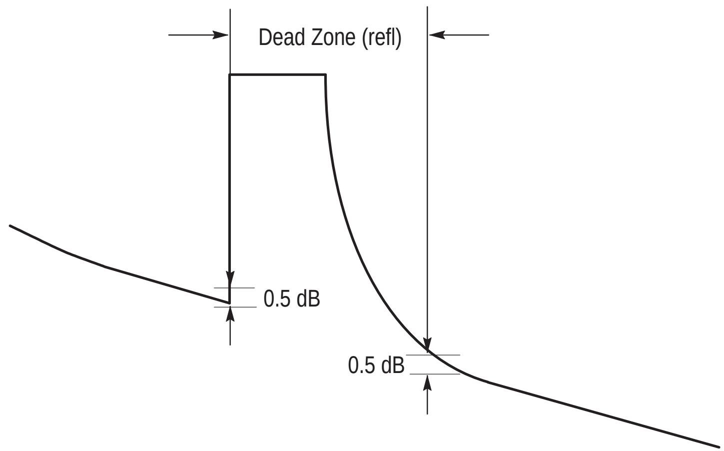
Event dead zone is a measure of the instrument's ability to display both the rising edges and the falling edges of two closely spaced reflective events. The specification calls for a drop in the waveform signal of 1.5 dB between two reflections. When the signal following the first reflection drops 1.5 dB, the rising edge of the second reflection can be accurately located.



Although it would be nice to verify the event-detection specification by physically moving two reflective events closer together until there is only a 1.5-dB dip between events, this is difficult to do. An alternate method is to measure the displayed pulse width from a reflection, 1.5 dB below the peak. This alternate measurement works well when the rise and fall time of the outgoing laser pulse is much faster than the rise and fall time of the pulse measuring system. If the pulse measuring system is faster than the outgoing laser pulse, then the alternate method should measure the displayed pulse width from a reflection 3 dB below the peak instead of 1.5 dB.

Attenuation Dead Zone

Attenuation dead zone is a measure of the distance around a reflective event where fiber backscatter measurements are not valid. A typical reflective event creates a signal which is several orders of magnitude larger than the backscatter signal. Once the signal from the reflective event ends, the OTDR requires some time for the displayed waveform to return to the backscatter level and allow accurate fiber backscatter measurements. This distance starts when the waveform deviates from the backscatter by 0.5 dB around the start of the event, and ends when the waveform finally recovers to within 0.5 dB of backscatter following the event.



Attenuation dead zone should measure the recovery time of the OTDR due to the reflective event, and ignore noise unrelated to the event. The attenuation dead zone measurement attempts to ignore random noise and real fiber imperfections that appear on the fiber backscatter waveform. The measurement should include any noise or error resulting from the reflective event such as undershoot on the waveform before the reflective event, nonlinearity, offset, and undershoot or ring on the waveform after the reflective event. Random noise can be reduced by increasing the number of averages used in the measurement. Fiber imperfections due to splices, mode distribution changes, point defects, and dimensional variations are sometimes easy to identify by changing the measurement pulse width. A fiber imperfection will look similar and remain at the same distance when the pulse width is changed.

Singlemode Event-Detection Test Fixture Build Description

Overview

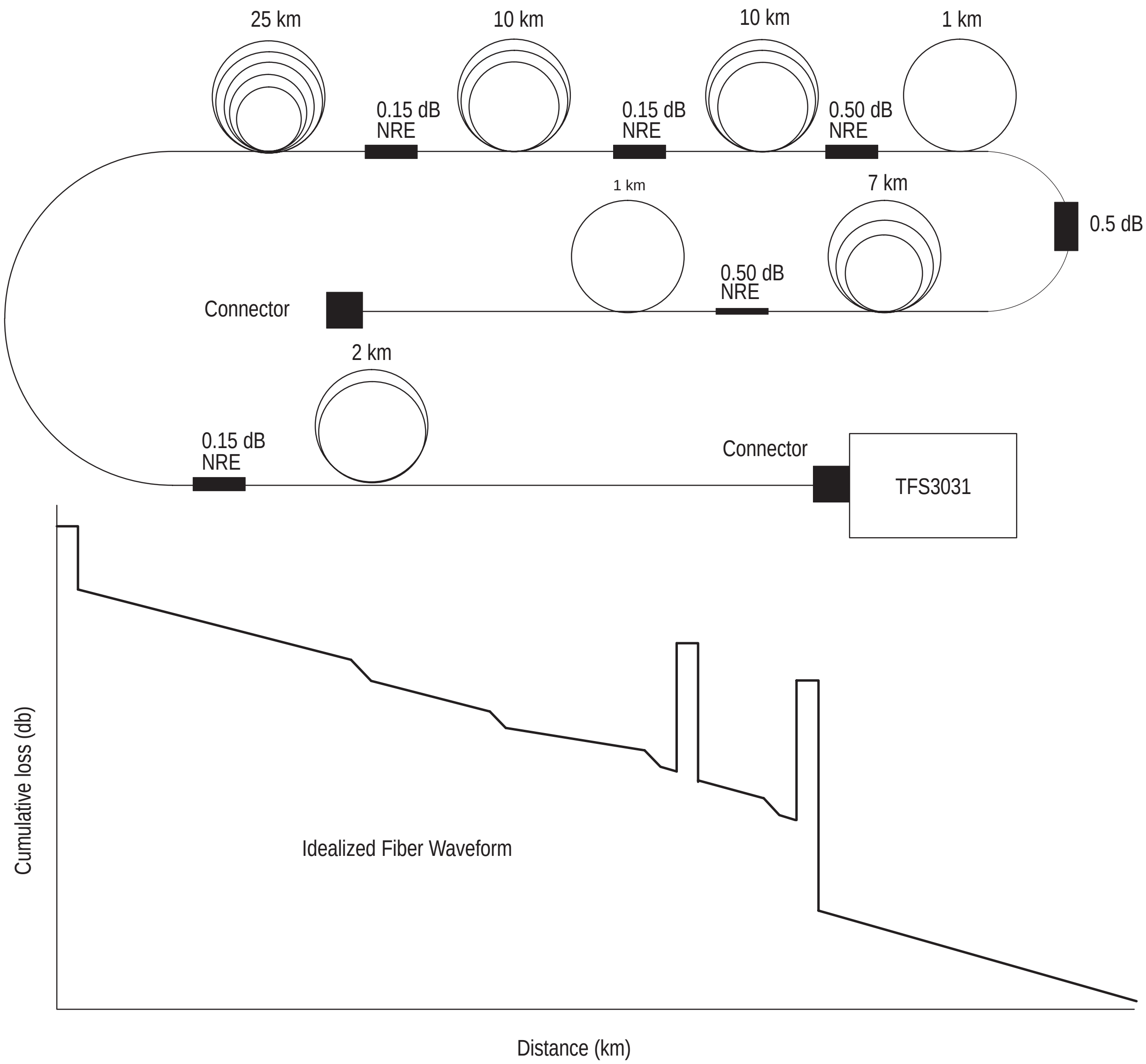


Figure 3–1: Singlemode Event-Detection Test Fixture Layout

The singlemode event-detection test fixture uses about 56 km of singlemode, nondispersion-shifted fiber.

The fixture consists of two connector pigtails (FCPC), two 0.5 dB fusion splices, three 0.15 dB fusion splices, one Norland UV-cured mechanical splice, and several construction splices that are 0.1 dB or less.

The fixture waveform consists of a series of reflective and nonreflective events. The events, and their tolerances and losses are summarized in Table 3–1.

Table 3–1: Singlemode Fiber Test Fixture Specifications[1]

Event #	Event Type	Distance from Front Panel (km)	Tolerance on Distance to Previous Event (km)	Event Loss (db)	Cumulative Loss Just Before Event (db)[2]
1	DRE	2.000	+0.100, –0.000	0.15	0.70
2	NRE	27.000	+0.100, –0.000	0.15	9.60
3	NRE	37.000	+0.100, –0.000	0.15	13.25
4	NRE	47.000	+0.100, –0.000	0.50	16.90
5	REF	48.000	+0.100, –0.000	0.50	17.75
6	NRE	55.000	+0.100, –0.000	0.50	20.70
7	REF	56.000	+0.100, –0.000	end	21.55

[1] This table is based on 0.35 dB/km fiber loss at 1310 nm.
[2] Does not include connection at front panel.

- All splices with a nominal loss of 0.5 dB have a splice-loss tolerance of +0.100, –0.000 dB. Splices with no loss specification are less than 0.1 dB. Splice losses and tolerances are for 1310 ± 10 nm.
- All splices with a nominal loss of 0.15 dB have a splice-loss tolerance of ± 0.05 dB.
- Fiber bends are prohibited for nonreflective events. Only fusion splices are acceptable for nonreflective events.
- All connectors are FCPC with return loss less than –35 dB, and insertion loss less than 0.5 dB.
- The fiber used in the test fixture is singlemode, 1310 and 1550 nm, nondispersion-shifted (standard Corning singlemode SMF-28 fiber or equivalent).
- The reflective event at 48 km is fabricated using a Norland UV-cured mechanical splice (or equivalent). Reflectance is less than –35 dB.

Statistical Characterization of Singlemode Test Fixture

To characterize test fixture distances and losses, test the fixture using a large number (approximately 40 units) of identically configured TFS3031 instruments.

Each instrument is connected to the fixture. Scan the fiber at least five times with each instrument.

Scatter plots are constructed showing loss vs. distance data points for each event. If 40 instruments are used, and each instrument is allowed to scan the fiber five times, the total number of data points is 200.

Figure 4–8 is an example scatter plot for a 50 m event.

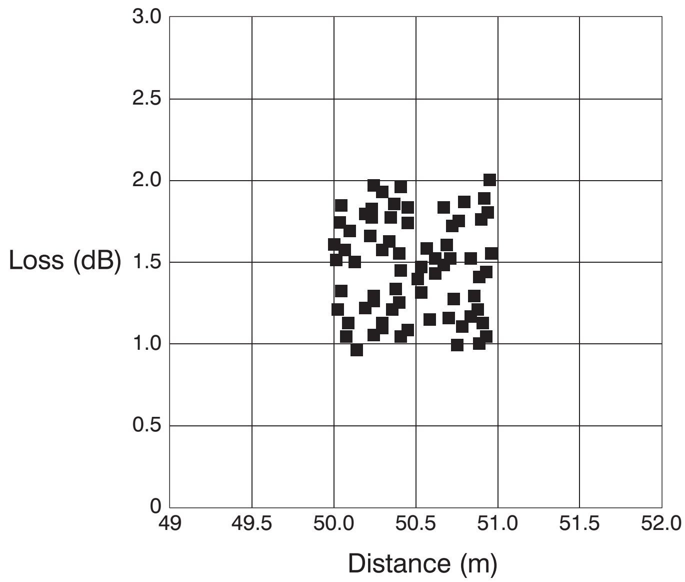


Figure 3–2: Scatter Plot for 50 m Event

Once the data points are gathered, a confidence area can be drawn so that 95 percent of all subsequent data will fall within the area. The suggested area corresponds to the $\pm$1.96-σ limits of a Gaussian distribution.

The confidence of the location of each event can then be determined by using this formula:

$$\textit{Location Confidence} = \overline{X} \pm 2\,\sigma$$

Where: $\overline{X}$ = sample mean for all tests.

σ = sample standard deviation for all tests.

Example: $\overline{X}$ = 48.045, σ = 0.0045.

Location confidence: = 48.045 $\pm$1.96δ

= 48.045 $\pm$1.96 X 0.0045

= 48.045 $\pm$0.00882

Or,

48.045 – 0.00882 = 48.03618 (lower confidence limit)

48.045 + 0.00882 = 48.05382 (upper confidence limit)

The location confidence range calculated by the above formula is the range on either side of a sample mean where 95 percent of the measurements of a properly functioning unit are located.

Singlemode Dynamic-Range Test Fixture Build Description

The singlemode dynamic-range test fixture consists of 25 kilometers of event-free, 9/125 singlemode, 1310/1550 nm, nondispersion-shifted fiber (standard Corning SMF-28 or equivalent).

Singlemode Dead-Zone Test Fixture Build Description

Material required:

- 3.9-km spool of Corning SMF-28 singlemode optical fiber
- 4.4-km spool of Corning SMF-28 singlemode optical fiber
- Two dual-wavelength (1310/1550 nm) fiber multiplexers
- Dual-window (1310/1550 nm) fiber splitter with a 5 percent/95 percent splitter ratio
- 3-meter jacketed optical fiber (SMF-28 fiber) pigtail with FCPC connector on one end.
- Two sleeves suitable for encapsulating cleaved fiber ends and preventing contamination
- Six splice-protection housings
- Cabinet suitable for protecting the finished fixture

Tools and equipment required:

- Optical fiber stripper for removing fiber buffer
- Optical fiber cleaver
- Optical fiber fusion splicer
- Optical time-domain reflectometer, Tektronix TFP2A with FS1315 singlemode optical module
- Hand tools as required to assemble cabinet

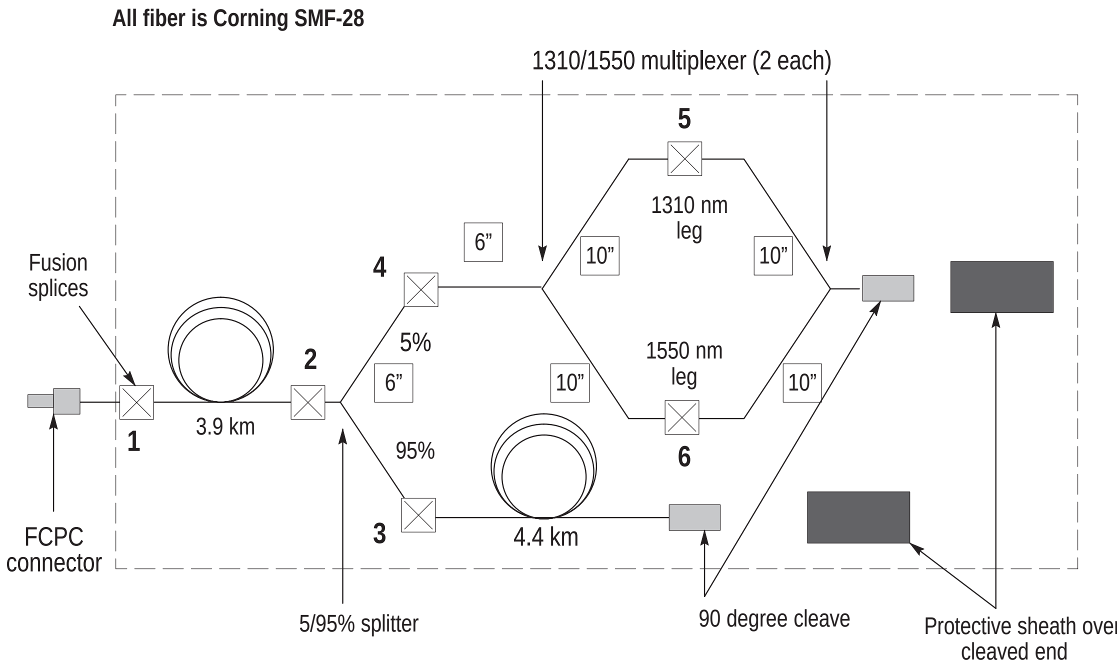


Figure 3–3: Singlemode Dead-Zone Test Fixture

1. Prepare and fusion-splice the connectorized pigtail to one end of the 3.9-km fiber spool (splice #1). Protect the splice using an appropriate splice-protection device.
2. Identify the common fiber (input) on the 5/95-percent splitter, and prepare and fusion-splice this fiber to the opposite end of the 3.9-km fiber (splice #2). Protect the splice using an appropriate splice-protection device.
3. Identify the 95-percent output fiber of the 5/95-percent splitter and prepare and fusion-splice this fiber to one end of the 4.4-km fiber spool (splice #3). Protect the splice using an appropriate splice-protection device.
4. Identify the 5-percent output fiber of the 5/95-percent splitter and prepare and fusion-splice this fiber to the input fiber of one of the fiber multiplexers (splice #4). *Keep the total length of these fibers under 12 inches total (six inches each).* Protect the splice using an appropriate splice-protection device.
5. Identify the 1310-nm output fiber of both multiplexers and prepare and fusion-splice these two fibers (splice #5). *Keep the total length of these two fibers (length between the two multiplexers) under 20 inches.* Do not remove these fibers from the fusion splicer at this time.
6. Identify the input fiber (output fiber in figure) of the second multiplexer. Prepare this fiber with a 90-degree cleave and place a protective sheath over the cleaved fiber.

7. Connect the FCPC connector to the OTDR. *Do not use an interface or jumper cable.* Measure the 1310-nm reflectance (return loss) at the event located at 3.9 km. (See figure 3–4.)

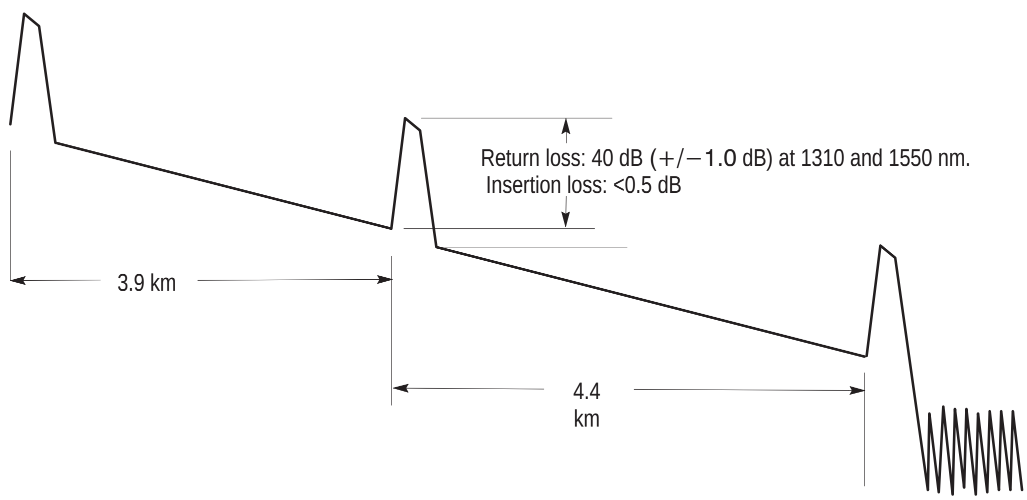


Figure 3–4: Desired OTDR Signature

8. If the reflectance as read on the OTDR is under –43 dB or above –35 dB, the previous steps have not been followed correctly, or there is a defective component. Confirm that the fibers have been used and spliced properly in each step above, correct any errors, and repeat the measurement.

9. If the reflectance is under 40 dB, re-splice (tune) the splice made in step 5 until 40 db ($\pm$ 1 dB) is obtained. Remove the splice from the fusion splicer and protect the splice with an appropriate splice-protection device.

10. Identify the 1550 fibers on each of the multiplexers. *The length of these fibers must match ($\pm$ 2 inches) the 1310 fibers (step 5).* Prepare and splice these fibers together (splice #6). Do not remove them from the splicer at this time.

11. Switch the OTDR to the 1550-nm wavelength and measure the 1550-nm reflectance (return loss) from the event at 3.9 km.

12. If the reflectance is under 40 dB, re-splice (tune) the splice made in step 10 until 40 dB ($\pm$ 1 dB) is obtained. Remove the splice from the fusion splicer and protect the splice with an appropriate splice-protection device.

13. Mount the fiber fixture in a suitable enclosure. Leave the FCPC connector and cable protruding from the fixture (do not use a bulkhead feedthrough). The fixture must be connected to the instrument to be tested without using an interface cable.

Periodic Maintenance

At six-month intervals, measure the reflectance at each wavelength to confirm the reflectance is 40 dB ($\pm$ 1 dB).

Multimode Dynamic-Range Test Fixture

The multimode dynamic-range test fixture consists of 4.4 to 8.8 kilometers of 62.5/125 μm fiber, with connectors and fusion splices as shown below.

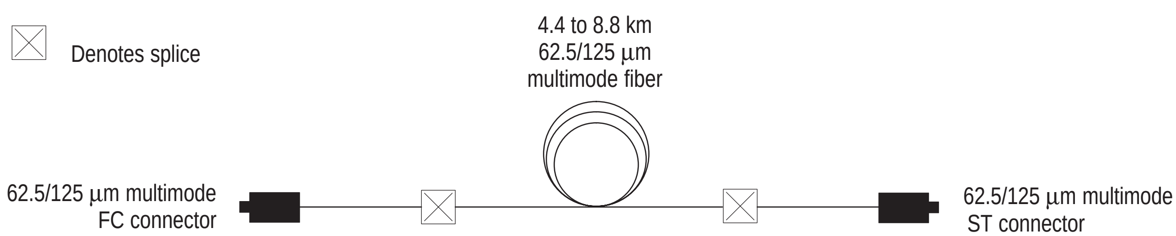


Figure 3–5: Multimode Dynamic-Range Test Fixture

Multimode Event-Detection and Dead-Zone Test Fixture

Construct the multimode event-detection and dead-zone test fixture as shown in figure 3–6.

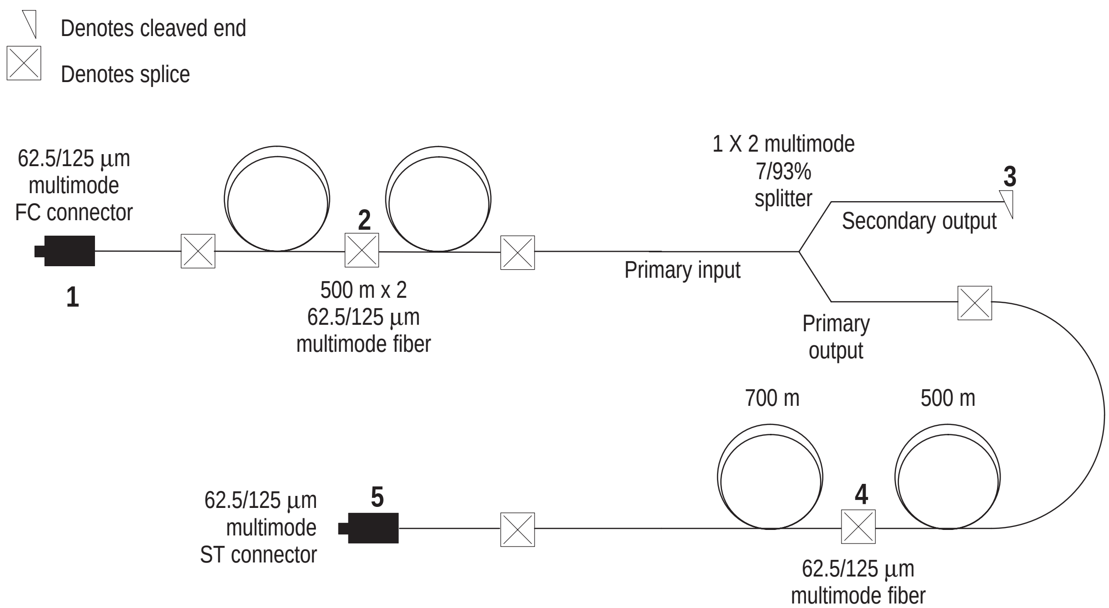


Figure 3–6: Multimode Event-Detection and Dead-Zone Test Fixture

1. To create non-reflective events, perform multiple arcs on the fusion splice until the desired loss is obtained for non-reflective events. Measure the splice loss of the event using an OTDR.
2. To create a repeatable reflective –40-dB event, cleave the 7% leg of the splitter. Measure the event return loss using an OTDR. The desired event return loss is –40 dB $\pm$ 2 dB.

Statistical Characterization of Multimode Test Fixture

To characterize the multimode event-detection and dead-zone test fixture, refer to the statistical characterization of the singlemode event-detection test fixture, on page 4–13.

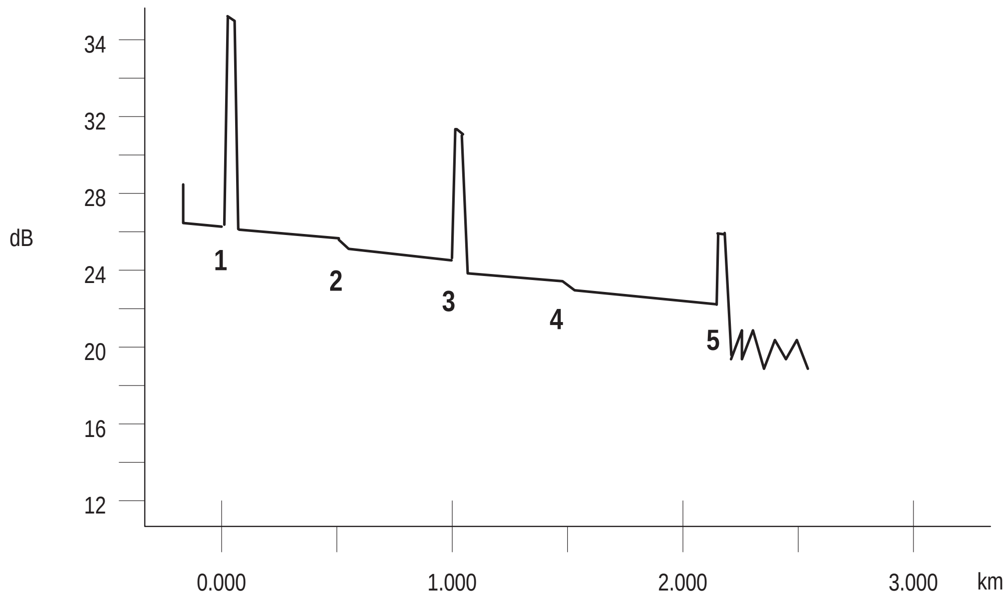
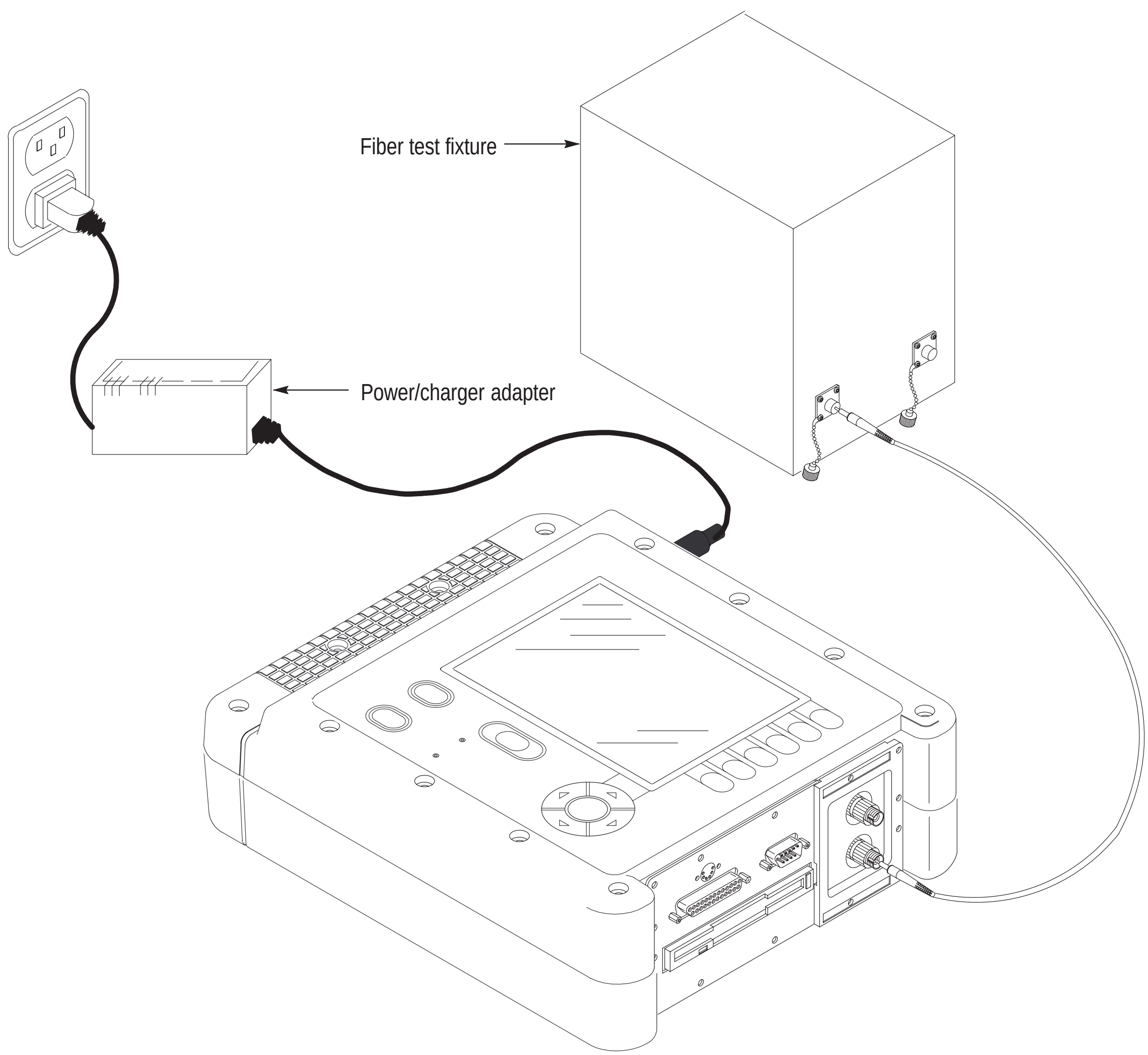


Figure 3–7: Multimode Event-Detection and Dead-Zone Test Fixture: OTDR Trace

Setup

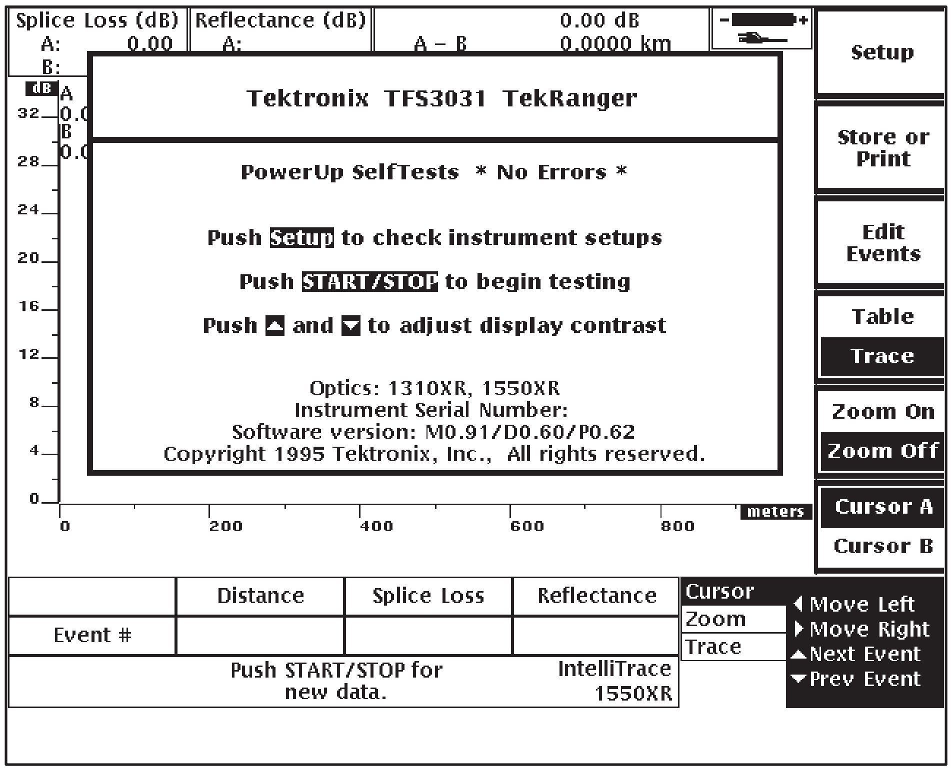
CAUTION. *Do not fire the laser (push the* START/STOP *button) unless a fiber is connected to the Laser Output port. Damage to internal electronics can result.*

1. Connect the power/charger adapter to the TFS3031 and a suitable AC power source.
2. Attach the connector adapter to the laser output port under test.
3. Connect the singlemode fiber test fixture to the laser output port under test.



Power-On Initialization Check

Push the ON/OFF button to power on the TFS3031. This power-on screen indicates successful initialization, and shows that all subsystems are operating properly.



Power/Charger Adapter Check

When the power/charger adapter is *disconnected*, and the TFS3031 has less than 10 minutes of operating time left on the battery, the BATTERY LED on the front panel should flash *red*.

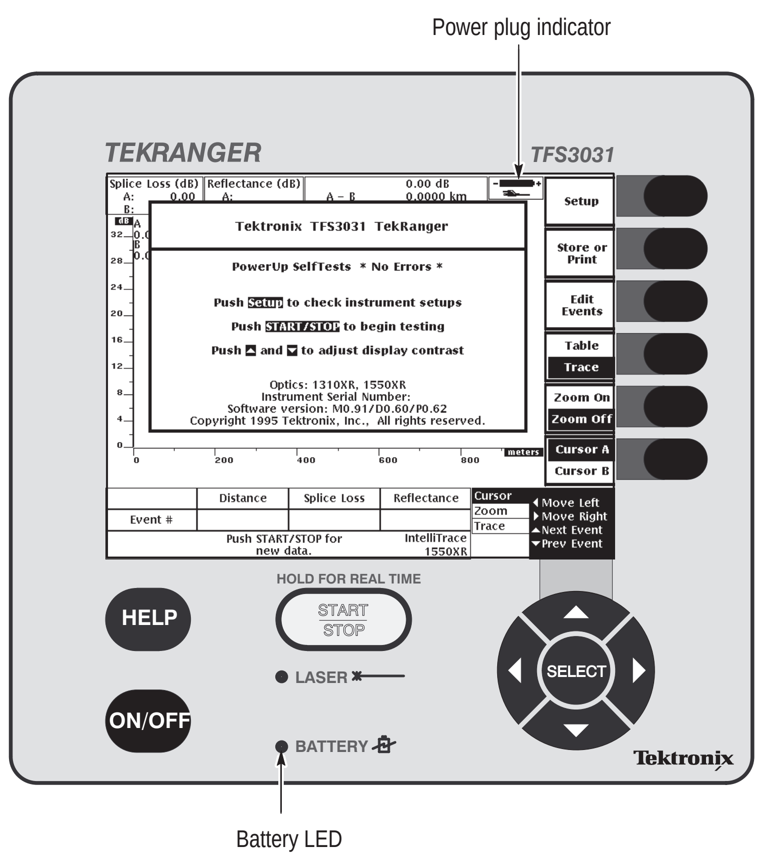
When the power/charger adapter is *connected* and charging the battery, the BATTERY LED on the front panel should flash *green*, and a ‘‘power plug’’ indicator should be displayed in upper right screen.

When the power/charger adapter is *connected* to a fully charged battery, the BATTERY LED should glow a steady *green*.

If the main software is version M4.10 or later, question marks (??:??) are displayed for about 10 seconds after disconnecting the power/charger adapter or when the unit is first turned on, until a valid time estimate is calculated.

1. Disconnect the power/charger adapter. The TFS3031 remains on (unless the battery is fully discharged). The *green* BATTERY LED turns off, and the power plug indicator is replaced by ??:??, followed by the time estimate.

2. Reconnect the power/charger adapter. The *green* BATTERY LED resumes flashing, and the power plug indicator reappears on the screen.



Floppy Disk Drive Check

This check is to be performed only on instruments that have the optional floppy disk drive.

1. Make sure that the waveform is displayed from the previous optical check (push the Table/Trace softkey to display the waveform).
2. Push the Store or Print softkey to access the *Store/Print – Save* option.
3. Insert a *formatted* disk in the disk drive.
4. Push the Internal/Floppy softkey to access floppy disk storage.

   The TFS3031 checks the drive for a disk and determines if the disk is formatted (can be read). If the disk is *unformatted*, format the disk as follows:

   a. You are prompted to format the disk by pushing the Yes softkey, or not to format by pushing the No softkey.

   b. To format the disk push the Yes softkey.

      A final yes/no confirmation prompt is displayed along with a notice that formatting the disk will destroy any data already on it.

   c. Push the Yes softkey again to confirm formatting.

5. Push the Save File softkey to save the current waveform and event table on the floppy disk. An elapsed time is displayed during saving.
6. After the file has been saved, power off the TFS3031 and disconnect the power/charger adapter.
7. Power the TFS3031 on again.
8. After initialization, push the Store or Print softkey to re-access storage. The floppy disk should still be accessed.
9. Push the SELECT button to choose the *Load* option. The Load option loads a file from storage onto the screen for viewing.
10. Push the Load File softkey to load the file stored on floppy disk onto the screen.
11. Push the Exit softkey to exit storage and display the waveform and event table that has just been loaded onto the screen.

Keyboard Check (option 19)

1. Connect external keyboard to the TFS3031 (upgraded instruments and instruments with serial numbers B030000 and above).
2. Three LEDs on the keyboard light up for about two seconds, then turn off. This indicates that keyboard power is available.
3. Press F1 on the keyboard. This should have the same effect as pressing softkey 1 (the uppermost softkey) on the instrument front panel.

NOTE. *There are 500 mA available for the keyboard (at 5 VDC). If a keyboard that draws more power is plugged into the instrument, keyboard power is turned off. The instrument must be turned off, then back on again to restore keyboard power.*

Singlemode Dynamic Range Check

NOTE. *If the instrument has two laser output ports, this check must be done on both ports. If the instrument has two wavelengths, this check must be done on both wavelengths.*

The singlemode dynamic range check is an automated test using an IBM-compatible personal computer (386 or better) with a serial port, and the Tektronix performance test software package (part number 119–5130–xx).

To use the performance test software, see the instructions contained in the *readme* file that comes with the software package.

The software pseudo-code is as follows:

1. In the setups menus, set Fiber Scan to *Manual*, Pulsewidth to *2 km* (the first of four different pulsewidth settings), and Averages to *256.*
2. Push the START/STOP button to start a test. Allow the test to complete.
3. Use linear fit to determine the scattering level at the front panel (distance = 0). This is the *S* value.
4. In the Test setup menu, set the Averages setup to *3 minutes*.
5. Start the test at a distance greater than 100 km.
6. Push the START/STOP button to start the test. Allow the test to complete.
7. Use the standard deviation calculation on antilogged noise data, and convert the result back to the log domain. This is the σ value.
8. Dynamic range is $DR = S - \sigma$.
9. Repeat the test for Pulsewidth setups of 500 m, 20 m, and 5 m.
10. Verify that the automated test passes without reporting errors.

Singlemode Event-Detection Check

***NOTE**. If the instrument has two Laser Output ports, this check must be done on both ports. If the instrument has two wavelengths, this check must be done on both wavelengths.*

1. The singlemode event-detection test fixture should be connected to the TFS3031 laser output port under test.
2. Put the TFS3031 in IntelliTrace operating mode:
   a. Push the Setup softkey to access the setup menus.
   b. Push the SELECT button to choose the *Test* setup.
   c. Use the arrow keys to select the *Fiber Scan: IntelliTrace* setup.
   d. Push the Exit softkey to exit setups.
3. Push the START/STOP button to begin the fiber test. Allow the test to complete.
4. When the test is complete, push the Table/Trace softkey to display the event table.
5. Verify that all events were detected except the event at 55 km, and distance and loss measurements are correct and within tolerance.

   If an event is not detected the first time, repeat the test several times until the missing event is detected and reported accurately 95% of the time.

Singlemode Dead-Zone Check

NOTE. *If the instrument has two laser output ports, this check must be done on both ports. If the instrument has two wavelengths, this check must be done on both wavelengths.*

1. Connect the singlemode dead-zone test fixture to the TFS3031 laser output port under test.
2. Push the ON/OFF button to power on the TFS3031.
3. Push the Setup softkey to access the setup menus.
4. Select the following setups in the Test Setup menu:
   - Fiber scan: *Manual*
   - Test range: *8 km*
   - Pulsewidth: *10 m*
   - Averages: *4,096*
5. Push the START/STOP button to begin a test.
6. When the test is complete, use the SELECT button *Cursor* and *Zoom* options to select a single event on the fiber for zooming, then push the Zoom On softkey to magnify the event.
7. Use the SELECT button *Cursor* option to position the active cursor on the backscatter area that follows the event.
8. Hold down the Cursor A/Cursor B softkey to join both active and inactive cursors at the location of the active cursor.
9. Push the Cursor A/Cursor B softkey to select the other cursor as the active cursor.
10. Move the active cursor to the event in question until the Cursor A–B reading at top screen reads 0.5 dB.

    If the cursors are separated by more than 100 m, a correction is needed for the fiber loss between the cursors. The Cursor A–B reading of 0.5 dB would be adjusted as follows:

    0.5 dB + (fiber loss in db/km · distance between cursors in km)

    Example: If the cursors are separated by 1 km and the fiber loss is 0.35 db/km, the adjusted Cursor A–B reading would be:

    0.5 dB + (0.35 dB/km · 1 km) = 0.85 dB.

11. Push the Cursor A/Cursor B softkey to again select the first cursor as the active cursor.

12. Position the active cursor on the steepest part of the rising edge of the pulse of the event in question.

13. The Cursor A–B reading at top screen is the attenuation dead zone.

14. Position the two cursors so they are 1.5 dB down from the peak of the reflection on either side of the pulse.

15. The Cursor A–B reading at top screen is the event dead zone.

16. Repeat steps 4 through 15 with a Pulsewidth setup of *20 m*.

17. Disconnect the singlemode dead-zone test fixture.

Multimode Dynamic Range Check

***NOTE**. If the instrument has two laser output ports, this check must be done on both ports. If the instrument has two wavelengths, this check must be done on both wavelengths.*

The multimode dynamic range check is an automated test using an IBM-compatible personal computer (386 or better) with a serial port, and the Tektronix performance test software package (part number 119–5130–xx).

To use the performance test software, see the instructions contained in the *readme* file that comes with the software package.

The software pseudo-code is as follows:

1. In the setups menus, set Fiber Scan to *Manual*, Pulsewidth to the longest pulse width available for the current wavelength, and Averages to *256.*
2. Push the START/STOP button to start a test. Allow the test to complete.
3. Use linear fit to determine the scattering level at the front panel (distance = 0). This is the *S* value.
4. In the Test setup menu, set the Averages setup to *3 minutes*.
5. Start the test at a distance greater than 8 km for 850 nm (30 km for 1300 nm).
6. Push the START/STOP button to start the test. Allow the test to complete.
7. Use the standard deviation calculation on antilogged noise data, and convert the result back to the log domain. This is the σ value.
8. Dynamic range is $DR = S - \sigma$.
9. Repeat the test for all Pulsewidth setups for each wavelength.
10. Verify that the automated test passes without reporting errors.

Multimode Event-Detection Check

NOTE. *If the instrument has two Laser Output ports, this check must be done on both ports. If the instrument has two wavelengths, this check must be done on both wavelengths.*

1. The multimode event-detection/dead-zone test fixture should be connected to the TFS3031 laser output port under test.
2. Put the TFS3031 in IntelliTrace operating mode:
   a. Push the Setup softkey to access the setup menus.
   b. Push the SELECT button to choose the *Test* setup.
   c. Use the arrow keys to select the *Fiber Scan: IntelliTrace* setup.
   d. Push the Exit softkey to exit setups.
3. Push the START/STOP button to begin the fiber test. Allow the test to complete.
4. When the test is complete, push the Table/Trace softkey to display the event table.
5. Verify that all events were detected and distance and loss measurements are correct and within tolerance.

   If an event is not detected the first time, repeat the test several times until the missing event is detected and reported accurately 95% of the time.

Multimode Dead-Zone Check

***NOTE**. If the instrument has two laser output ports, this check must be done on both ports. If the instrument has two wavelengths, this check must be done on both wavelengths.*

1. Connect the multimode event-detection/dead-zone test fixture to the TFS3031 laser output port under test.
2. Push the ON/OFF button to power on the TFS3031.
3. Push the Setup softkey to access the setup menus.
4. Select the following setups in the Test Setup menu:
   - Fiber scan: *Manual*
   - Test range: *4 km*
   - Pulsewidth: *10 m*
   - Averages: *4,096*
5. Push the START/STOP button to begin a test.
6. When the test is complete, use the SELECT button *Cursor* and *Zoom* options to select a single event on the fiber for zooming, then push the Zoom On softkey to magnify the event.
7. Use the SELECT button *Cursor* option to position the active cursor on the backscatter area that follows the event.
8. Hold down the Cursor A/Cursor B softkey to join both active and inactive cursors at the location of the active cursor.
9. Push the Cursor A/Cursor B softkey to select the other cursor as the active cursor.
10. Move the active cursor to the event in question until the Cursor A–B reading at top screen reads 0.5 dB.

    If the cursors are separated by more than 20 m, a correction is needed for the fiber loss between the cursors. The Cursor A–B reading of 0.5 dB would be adjusted as follows:

    0.5 dB + (fiber loss in db/km · distance between cursors in km)

    For example, if the cursors are separated by 100 m and the fiber loss is 2.5 db/km, the adjusted Cursor A–B reading would be:

    0.5 dB + (2.5 dB/km · 0.1 km) = 0.75 dB.

11. Push the Cursor A/Cursor B softkey to again select the first cursor as the active cursor.
12. Position the active cursor on the steepest part of the rising edge of the pulse of the event in question.
13. The Cursor A–B reading at top screen is the attenuation dead zone.
14. Position the two cursors so they are 1.5 dB down from the peak of the reflection on either side of the pulse.
15. The Cursor A–B reading at top screen is the event dead zone.
16. Repeat steps 4 through 15 with Pulsewidth setups of *5 m* and *1 m*.
17. Power off the TFS3031 and disconnect the multimode dead-zone/event-detection test fixture.

Multimode Distance Accuracy Check

The multimode distance accuracy check is a test using a test fixture made up of a 2.2 km length of multimode fiber with known length (time of flight).

1. Connect the multimode fiber of known length to the instrument multimode port.

2. Make the following selections in the Setup menu:

- Wavelength: *850 nm or 1300 nm* (based on instrument options)
- Fiber Scan: *IntelliTrace*
- IR: *1.4776 at 850 nm and 1.4719 at 1300 nm*

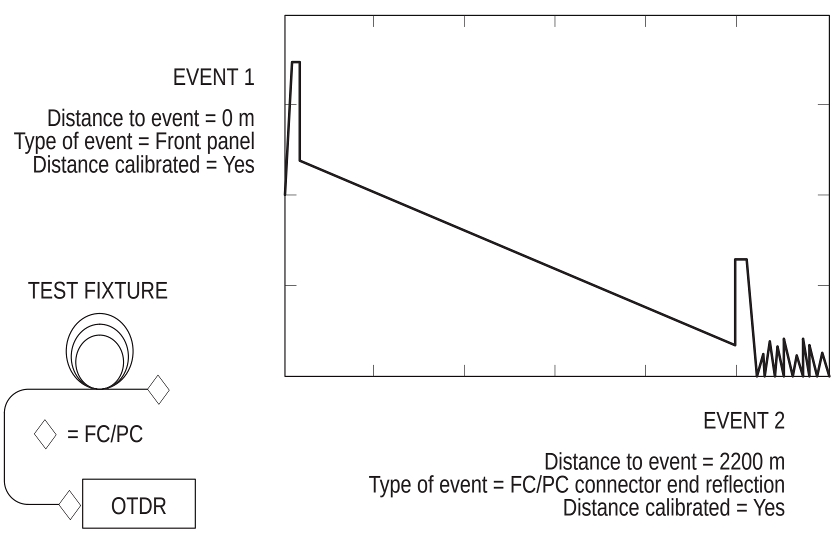
3. Exit the Setup menu.

4. Push the START/STOP button to start an IntelliTrace acquisition.

5. When the acquisition is complete, compare the distance to event number two in the TFS3031 event table to the known distance to the end of the multimode fiber. This distance should be within the distance tolerance in the specifications.

The following configuration illustrates the test fixture. There is one roll of fiber 2.2 km (± 200 m) in length. The length of the fiber is measured by the standard time-of-flight method. This gives a propagation delay which can be mathematically translated into a known length at a given (assumed) group index.

This simulated waveform shows the location and description of the multimode events captured on the OTDR.



—— ***This concludes the performance check*** ——

Performance Check – TekRanger 2

Introduction

These performance checks ensure that the TFS3031 TekRanger 2 is operating properly and conforms to instrument specifications as listed under *Specifications – TekRanger 2 (serial nos. B052000 and above)* in Section 1. This performance check procedure applies to TekRanger 2 instruments, with serial numbers B052000 and above. (For the TekRanger performance check, instruments with serial numbers below B052000, refer to section 3.)

The performance check should be done after an instrument has been serviced.

If you are unfamiliar with how the TFS3031 works, it may help to review the *TFS3031 User Manual* or *Reference Card* before doing the performance check.

Equipment Required for Performance Check

- Power/charger adapter (standard accessory included with the TFS3031)
- ST/PC connector adapter installed on multimode output port
- FC/PC connector adapter installed on singlemode output port
- FC/APC connector adapter installed on singlemode output port (if instrument under test is option 41 or 42 angle-polish option)
- Singlemode fiber test fixtures appropriate for the laser output port under test. The singlemode test fixtures are:
  - Singlemode range test fixture
  - Singlemode dead-zone test fixture
  - Singlemode reflectance test fixture
  - Singlemode loss and distance test fixture
- Multimode fiber test fixtures appropriate for the laser output port under test. The multimode test fixtures are:
  - Multimode dynamic range test fixture
  - Multimode event-detection and dead-zone test fixture
- FC/PC to FC/PC singlemode jumper cable, 1-meter length
- FC/APC to FC/PC singlemode jumper cable, 1-meter length (if the instrument under test is option 41 or 42 angle-polish option)

- ST/PC to ST/PC multimode jumper cable, 1-meter length

  The fiber test fixtures are *not* supplied by Tektronix. See instructions starting on page 4–6 for information about how to build your own fixtures. A characterization and tolerance data sheet for all events on the event-detection test fixtures is required prior to use.

Adjustments

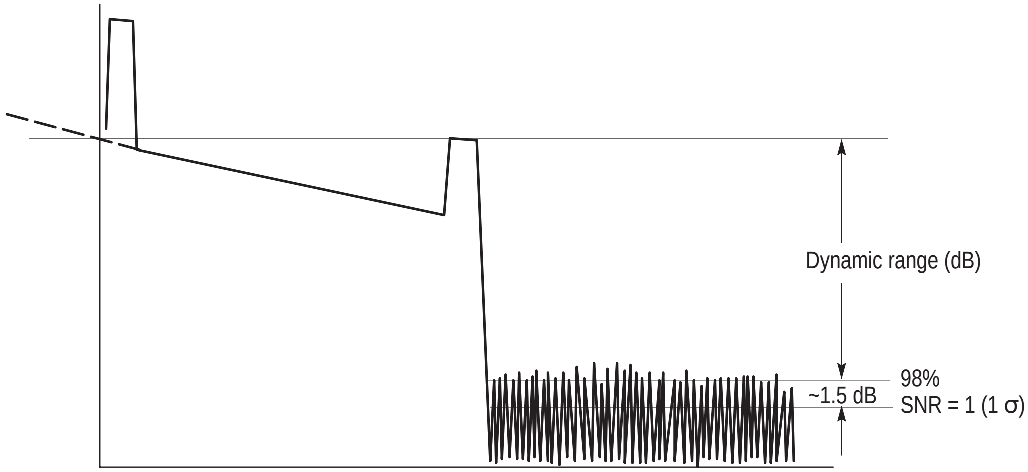
There are no user or service adjustments required in the TFS3031.

CAUTION. *Do not attempt to adjust any potentiometers on the optical module assemblies. All adjustments are optimized for peak performance. Any increase in laser drive current or detector bias may result in damage to the device.*

Test Descriptions

Dynamic Range

Dynamic range is a measure of signal-to-noise ratio for an OTDR. There are several methods in popular use to measure dynamic range. Nearly all methods compare the backscatter signal at the front panel with the noise past the end of the fiber. The dynamic range of the TFS3031 is defined (in dB) as the difference between the backscatter level at the TFS3031 front-panel connector (0 meters) and the OTDR's SNR=1 noise level. The SNR=1 noise level is the 98% noise level less 1.5 dB. The 98% noise level is the level above which there are ten noise spikes out of 500l. The noise level is measured beyond the end of the fiber and any effects of the end reflection.



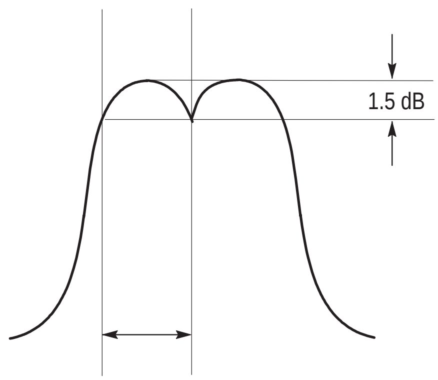
Event Detection

Noise is always present on the measured waveform. This noise causes location and loss measurements to vary slightly from one measurement to the next. The event-detection test measures the repeatability of measuring a series of events on a special test fiber. Many of the characteristics of event detection depend on software event-detection algorithms. These algorithms do not change over the life of the instrument unless the instrument software is upgraded to a newer version.

Some of the characteristics of event detection depend on signal level and noise level, which can degrade as lasers age and as the front-panel optical connector becomes worn or damaged. This second group of characteristics will degrade both dynamic-range tests and event-detection tests. These characteristics, which do not depend on the software algorithms, are influenced by the same fiber and connector characteristics as the dynamic-range tests.

Event Dead Zone

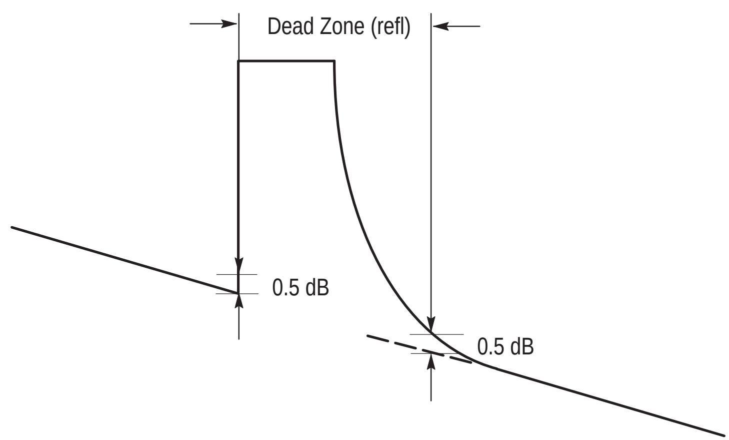
Event dead zone is the minimum distance after a -40-dB reflective event before the instrument can accurately measure another reflective event. The specification calls for a drop in the waveform signal of 1.5 dB between two reflections. When the signal following the first reflection drops 1.5 dB, the rising edge of the second reflection can be accurately located.



Although it would be nice to verify the event-detection specification by physically moving two reflective events closer together until there is only a 1.5-dB dip between events, this is difficult to do. An alternate method is to measure the displayed pulse width from a reflection, 1.5 dB below the peak. This alternate measurement works well when the rise and fall time of the outgoing laser pulse is much faster than the rise and fall time of the pulse measuring system. If the pulse measuring system is faster than the outgoing laser pulse, then the alternate method should measure the displayed pulse width from a reflection 3 dB below the peak instead of 1.5 dB.

Attenuation Dead Zone

Loss dead zone is a measure of the distance around a reflective event where fiber backscatter measurements are not valid. A typical reflective event creates a signal that is several orders of magnitude larger than the backscatter signal. After the signal from the reflective event ends, the OTDR requires some time for the displayed waveform to return to the backscatter level and allow accurate fiber backscatter measurements. The loss dead zone is measured from the point where the waveform deviates from the backscatter by 0.5 dB at the start of a -40-dB event to the point where the waveform recovers to within 0.5 dB of backscatter following the event.



Reflectance

Reflectance is the ratio of the reflected power, P_r, to the incident power, P_i, at any specific point or event on an optical fiber. In dB, reflectance is the 10 log of the ratio of the reflected power divided by the incident power. The reflectance accuracy of the TFS3031 is measured against a traceable backreflection standard (JDS Fitel BR1). The backreflector is set to a known backreflection level of -40 dB and the TFS3031 measures the reflection. The measurement must be within 4 dB of the actual value.

Event Loss and Distance Accuracy

Tektronix has developed a unique process to allow the event loss and distance accuracy of the TFS3031 singlemode options to be traceable to NIST (National Institute of Standards and Technology). For the first time in an OTDR, this provides a check of the instrument's ability to measure accurately the distance to an event and the loss of that event. The process uses precisely characterized fibers with events with calibrated losses at calibrated locations on the fibers.

Singlemode Range Test Fixture

This test fixture is used to verify measurement range and dynamic range. Overall, it consists of six 25-km segments of Corning SMF28 fiber interconnected with 1-m jumpers. The fixture is to have no more than 48 dB end-to-end loss at 1550 nm.

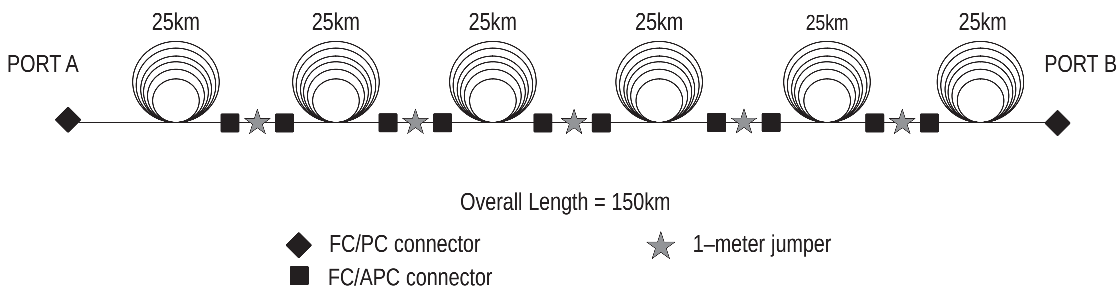


Figure 4–1: TFS3031 Range Test Fixture

Singlemode Dead-Zone Test Fixture

The dead-zone test fixture is used to verify event and attenuation dead zone. It consists of two 1.1-km (±100 m) spools of Corning SMF28 singlemode fiber including:

- 95/5 singlemode coupler
- 1310nm/1550 nm WDM
- FC/PC connector

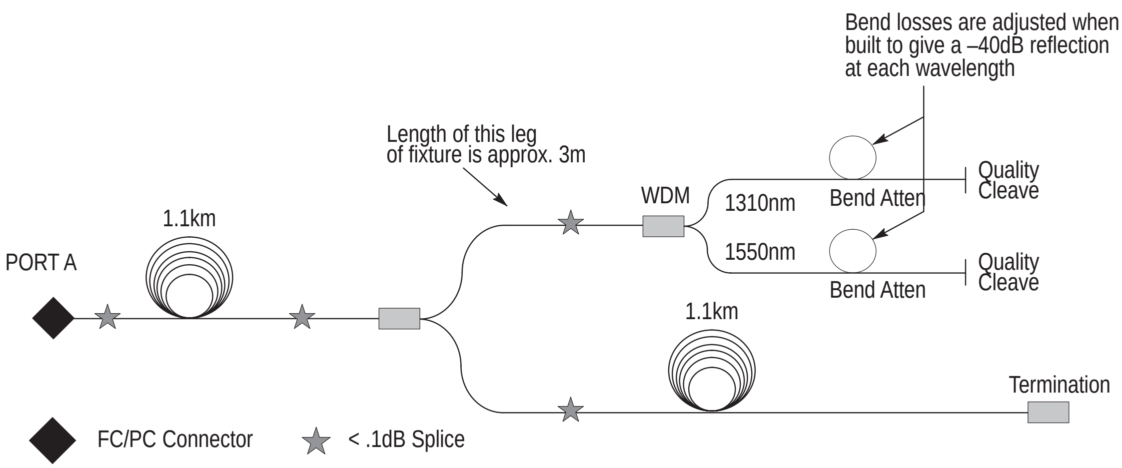


Figure 4–2: Singlemode Dead-Zone Test Fixture

Assemble and characterize this fixture as follows:

1. Fusion splice an FC/PC connector to one end of the first 1.1-km spool of Corning SMF28 singlemode fiber.
2. Fusion splice the other end of the first 1.1-km spool to the input of the 95/5 coupler.
3. Fusion splice one end of the second 1.1-km spool of fiber to the 95% port of the 95/5 coupler.
4. Terminate the other end of the second 1.1-km spool of fiber by wrapping and securing the end of the fiber eight times around a two-inch section of a 0.3-inch diameter mandrel.
5. Fusion splice the 5% leg of the 95/5 coupler to the input of the WDM.
6. Cut the 1310-nm and 1550-nm legs of the WDM to one meter.

7. Cleave the 1310-nm and 1550-nm legs of the WDM. Inspect these cleaves under a microscope to insure cleave quality.

8. Permanently protect cleaves from contamination.

9. Connect a Tektronix TFP2A with an FS1315 module to the FC/PC connector. (The TFP2A must have firmware version 1.03M or higher.)

10. Turn on power to the TFP2A.

11. Press MODULE SELECT to select the 1310-nm module.

12. Press the Change Settings softkey to enter the menu system and set the following parameters:

    Pulse Width: 5 m HR
    Max Range: 1.5 km
    Number of Averages: 1 minute

13. Press Exit.

14. Press START/STOP to acquire a waveform.

15. Position the active cursor on the reflection at 1.1 km.

16. Press the EXPAND button to expand the view.

17. Use the vertical and horizontal SIZE knobs to adjust the expansion window so that approximately 50 m before the reflection and 50 m after the reflection are visible, and that the top and bottom of the reflection are visible.

18. Position the active cursor at the rising edge of the reflection.

19. Press the Return Loss softkey, then the Event Return Loss softkey to display the event's reflectance.

20. Make a loop in the 1310-nm leg of the WDM, and adjust the loop size so the TFP2A reports a reflectance of -40 dB ±1 dB. (This is an iterative process. Adjust, measure, repeat until the TFP2A reports -40 dB.)

21. Permanently secure the bend.

22. Repeat steps 9 through 21 at 1550 nm on the TFP2A and the 1550-nm leg on the WDM.

Singlemode Reflectance Test Fixture

The reflectance test fixture is used to verify the reflectance accuracy of the TFS3031. It consists of one 2.2-km (±250 m) spool of Corning SMF28 singlemode fiber, including:

- JDS Fitel BR1 variable backreflector with FC/APC connector
- FC/PC connector

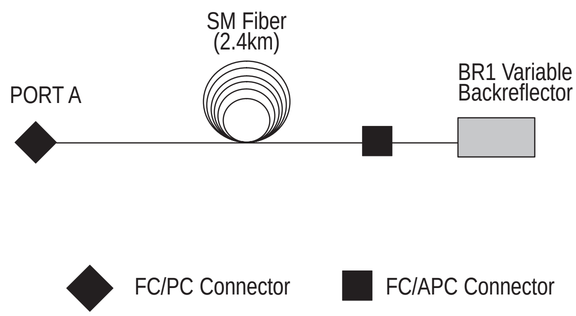


Figure 4–3: TFS3031 Singlemode Reflectance Test Fixture

Assemble this fixture as follows:

1. Fusion splice the FC/PC connector to one end of the 2.2-km spool of Corning SMF28 singlemode fiber.
2. Fusion splice the FC/APC connector to the other end of the 2.2-km spool.
3. Connect the backreflector directly to the FC/APC connector.

Singlemode Loss and Distance Accuracy Test Fixture

This test fixture is used to verify the loss and distance accuracy of the TFS3031. It consists of two 4.4-km spools and one 8.8-km spool of Corning SMF28 singlemode fiber.

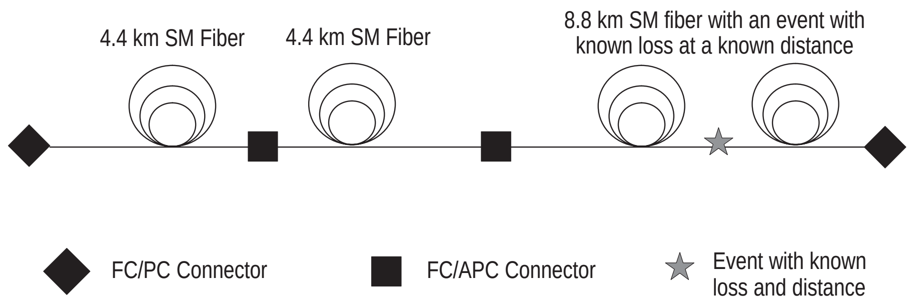


Figure 4–4: TFS3031 Singlemode Loss and Distance Accuracy Test Fixture

Assemble this fixture as follows:

1. Fusion splice the FC/PC connector to one end of the 4.4-km spool of Corning SMF28 singlemode fiber.
2. Fusion splice an FC/APC connector to the opposite end of this spool.
3. Fusion splice an FC/APC connector to both ends of the second 4.4-km spool of Corning SMF28 fiber.
4. Fusion splice an FC/PC connector to one end of the 8.8-km spool of Corning SMF28 fiber.
5. Fusion splice an FC/APC connector to the opposite end of the 8.8-km spool.
6. At approximately the midpoint (4.4 km) of the 8.8-km spool, fabricate a nonreflective event of 0.5 dB (±0.1 dB). Absolute location and loss values are not critical, however actual values must be known to within ±0.01 dB and ±0.5 m.
7. Measure the actual location and loss of the event and record for use when verifying the TFS3031.

Multimode Dynamic-Range Test Fixture

The multimode dynamic-range test fixture consists of 8.8 kilometers of 62.5/125 μm fiber, with connectors and fusion splices as shown below.

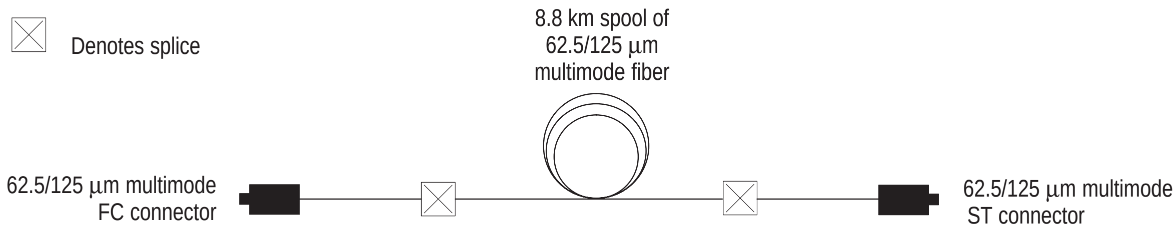


Figure 4–5: Multimode Dynamic-Range Test Fixture

Multimode Event-Detection and Dead-Zone Test Fixture

Construct the multimode event-detection and dead-zone test fixture as shown in figure 4–6.

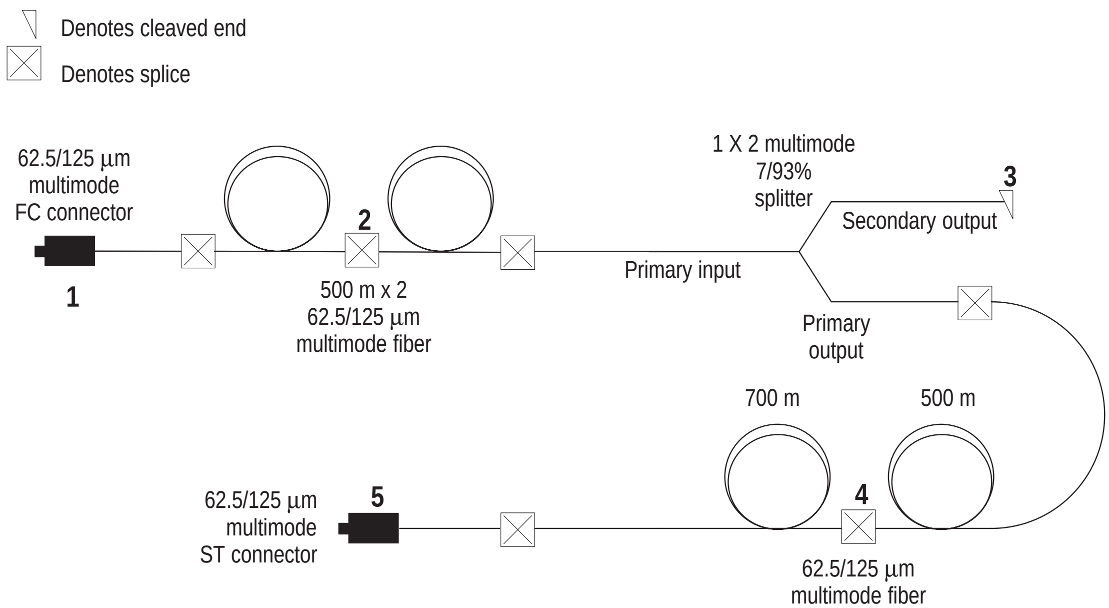


Figure 4–6: Multimode Event-Detection and Dead-Zone Test Fixture

1. To create non-reflective events, perform multiple arcs on the fusion splice until the desired loss is obtained for non-reflective events. Measure the splice loss of the event using an OTDR.

2. To create a repeatable reflective –40-dB event, cleave the 7% leg of the splitter. Measure the event return loss using an OTDR. The desired event return loss is –40 dB $\pm$ 2 dB.

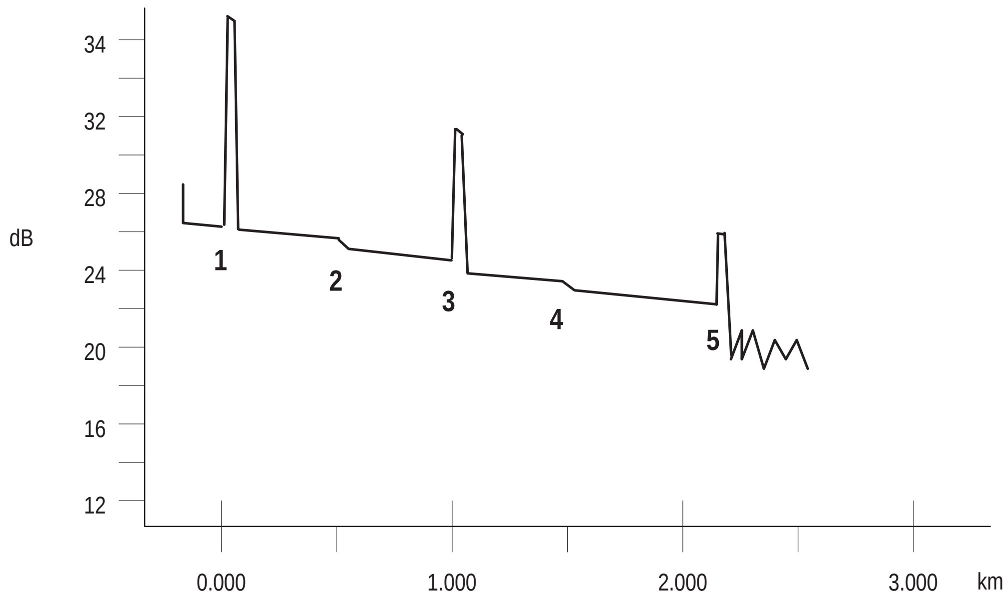


Figure 4–7: Multimode Event-Detection and Dead-Zone Test Fixture: OTDR Trace

Statistical Characterization of Multimode Test Fixture

To characterize test fixture distances and losses, test the fixture using a large number (approximately 40 units) of identically configured TFS3031 instruments.

Each instrument is connected to the fixture. Scan the fiber at least five times with each instrument.

Scatter plots are constructed showing loss vs. distance data points for each event. If 40 instruments are used, and each instrument is allowed to scan the fiber five times, the total number of data points is 200.

Figure 4–8 is an example scatter plot for a 50 m event.

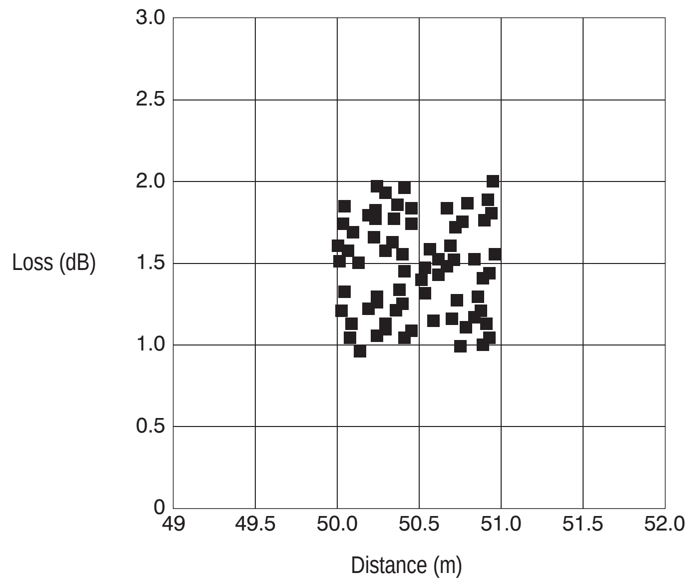


Figure 4–8: Scatter Plot for 50 m Event

Once the data points are gathered, a confidence area can be drawn so that 95 percent of all subsequent data will fall within the area. The suggested area corresponds to the $\pm$1.96-σ limits of a Gaussian distribution.

The confidence of the location of each event can then be determined by using this formula:

Location Confidence = $\overline{X} \pm 2\ \sigma$

Where: $\overline{X}$ = sample mean for all tests.

σ = sample standard deviation for all tests.

Example: $\overline{X}$ = 48.045, σ = 0.0045.

Location confidence: = 48.045 $\pm$1.96δ

= 48.045 $\pm$1.96 X 0.0045

= 48.045 $\pm$0.00882

Or,

48.045 - 0.00882 = 48.03618 (lower confidence limit)

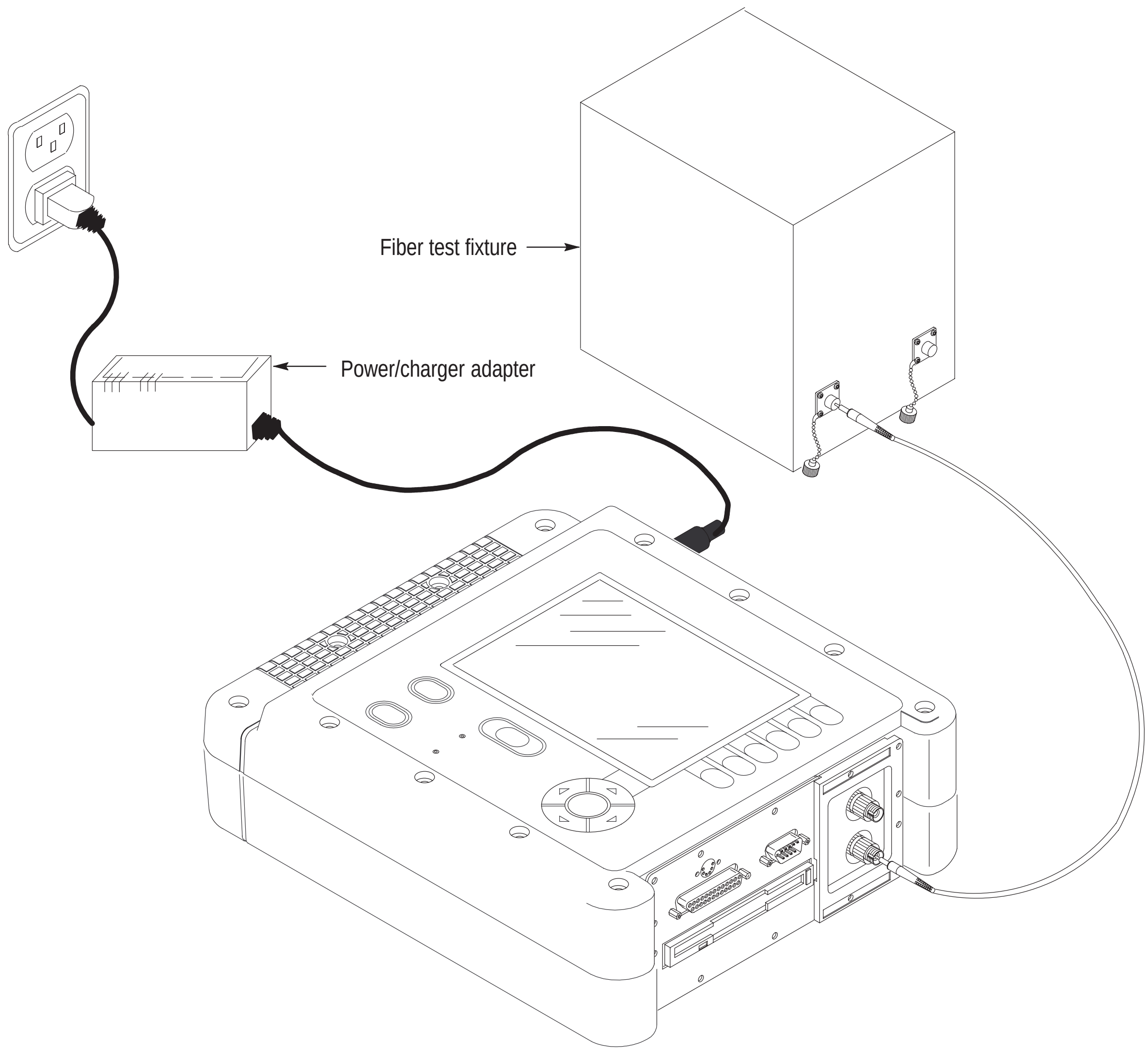
48.045 + 0.00882 = 48.05382 (upper confidence limit)

The location confidence range calculated by the above formula is the range on either side of a sample mean where 95 percent of the measurements of a properly functioning unit are located.

Setup

CAUTION. *Do not fire the laser (push the* START/STOP *button) unless a fiber is connected to the Laser Output port. Damage to internal electronics can result.*

1. Connect the power/charger adapter to the TFS3031 and a suitable AC power source.
2. Attach the connector adapter to the laser output port under test.
3. Clean and connect the appropriate fiber test fixture to the laser output port under test.



4. Check that loss at the front-panel connection is minimized (0.75 dB or less).

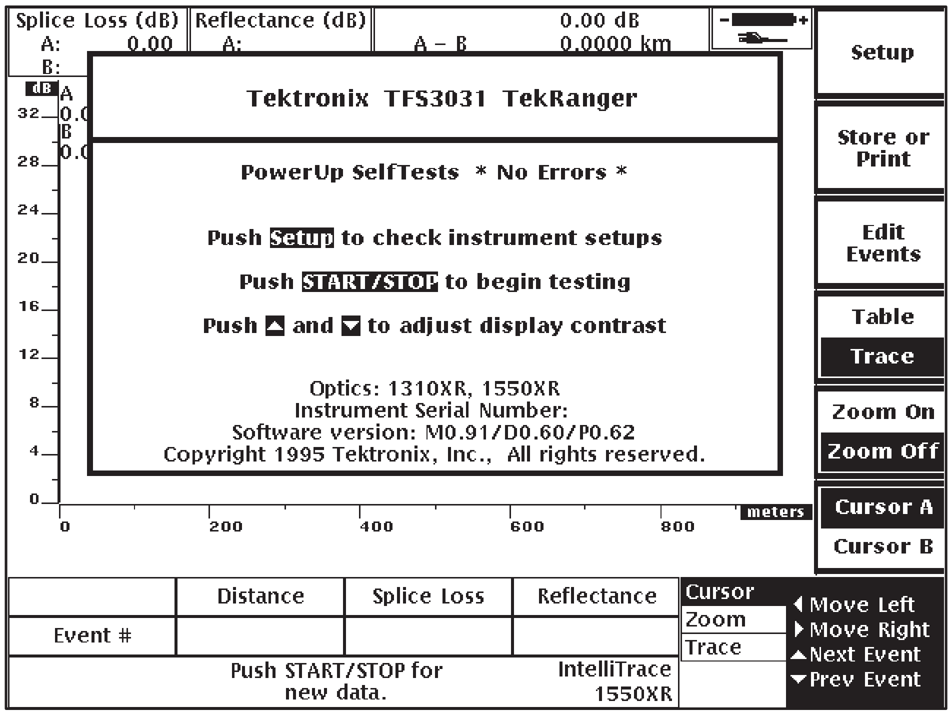
   a. Press the Setup softkey to display the Test Setup menu, and set the range to 1 km and the pulse width to 5 m. Press Exit.

   b. Press and hold the START/STOP button to start a real-time acquisition.

   c. If front-panel loss is greater than 0.75 dB, clean the fiber connector and the laser output port.

Power-On Initialization Check

Push the **ON/OFF** button to power on the TFS3031. This power-on screen indicates successful initialization, and shows that all subsystems are operating properly.



***NOTE**. Software versions may be different from the version shown in the illustration above.*

Power/Charger Adapter Check

The charge level of the battery is always displayed in the upper right screen. When the power/charger adapter is connected and charging the battery, the BATTERY LED on the front panel flashes green, and a "power plug" indicator is displayed below the battery indicator.

When the power/charger adapter is connected and the battery is fully charged, the BATTERY LED glows a steady green.

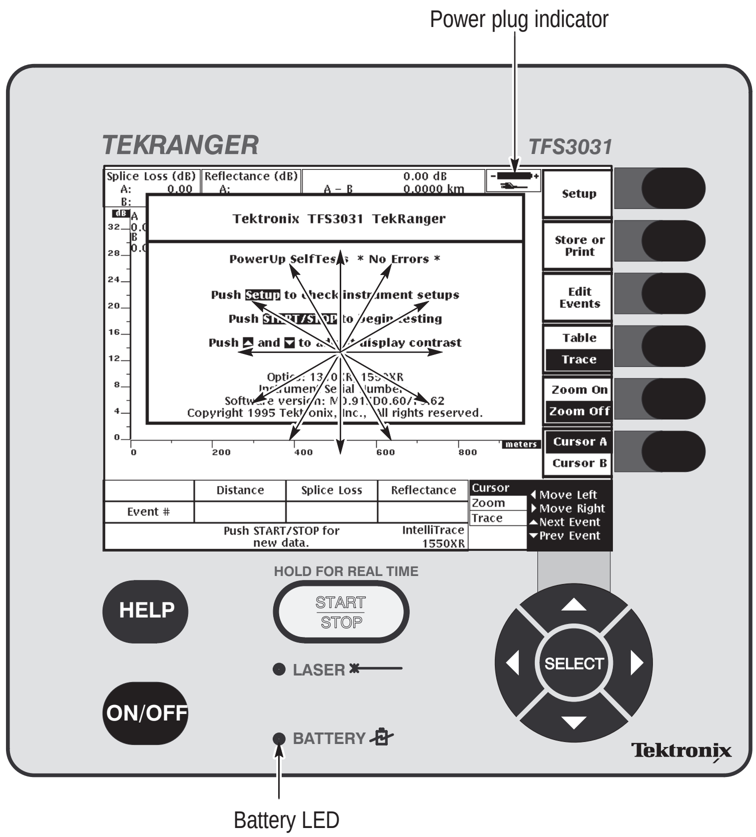
Question marks (??:??) display in place of the power plug indicator for about ten seconds after the power/charger adapter is disconnected, and when the unit is first turned on. The question marks are replaced by an estimate of operating time left (if under battery power) or the power plug indicator (if connected to the power/charger adapter or external DC power source).

As long as the power/charger adapter is plugged into an active power source, the battery recharges whether the TFS3031 is powered on and operating, or powered off.

The power/charger adapter can also be used to power the TFS3031 when the battery is removed.

To check the power/charger adapter:

1. Disconnect the power/charger adapter. The TFS3031 remains on (unless the battery is fully discharged). The *green* BATTERY LED turns off, and the power plug indicator is replaced by ??:??, followed by the time estimate.
2. Reconnect the power/charger adapter. The *green* BATTERY LED resumes flashing, and the power plug indicator reappears on the screen.


Power plug indicator
TEKRANGER
TFS3031
Tektronix TFS3031 TekRanger
Setup
Store or Print
Edit Events
Table
Trace
Zoom On
Zoom Off
Cursor A
Cursor B
Distance
Splice Loss
Reflectance
Event #
Push START/STOP for new data.
IntelliTrace 1550XR
Cursor
Zoom
Trace
Move Left
Move Right
Next Event
Prev Event
HOLD FOR REAL TIME
HELP
START STOP
LASER
ON/OFF
BATTERY
SELECT
Tektronix
Battery LED

Floppy Disk Drive Check (Option 11)

This check is to be performed only on instruments that have the optional floppy disk drive.

1. Make sure that the waveform is displayed from the previous optical check (push the Table/Trace softkey to display the waveform).
2. Push the Store or Print softkey to access the *Store/Print* - *Save* option.
3. Insert a *formatted* disk in the disk drive.
4. Push the Internal/Floppy softkey to access floppy disk storage.

   The TFS3031 checks the drive for a disk and determines if the disk is formatted (can be read). If the disk is *unformatted*, format the disk as follows:

   a. You are prompted to format the disk by pushing the Yes softkey, or not to format by pushing the No softkey.

   b. To format the disk push the Yes softkey.

      A final yes/no confirmation prompt is displayed along with a notice that formatting the disk will destroy any data already on it.

   c. Push the Yes softkey again to confirm formatting.
5. Push the Save File softkey to save the current waveform and event table on the floppy disk. An elapsed time is displayed during saving.
6. After the file has been saved, power off the TFS3031 and disconnect the power/charger adapter.
7. Power the TFS3031 on again.
8. After initialization, push the Store or Print softkey to re-access storage. The floppy disk should still be accessed.
9. Push the SELECT button to choose the *Load* option. The Load option loads a file from storage onto the screen for viewing.
10. Push the Load File softkey to load the file stored on floppy disk onto the screen.
11. Push the Exit softkey to exit storage and display the waveform and event table that has just been loaded onto the screen.

Keyboard Check (Option 19)

1. Connect external keyboard to the TFS3031 (upgraded instruments and instruments with serial numbers B030000 and above).
2. Three LEDs on the keyboard light up for about two seconds, then turn off. This indicates that keyboard power is available.
3. Press F1 on the keyboard. This should have the same effect as pressing softkey 1 (the uppermost softkey) on the instrument front panel.

***NOTE**. There are 500 mA available for the keyboard (at 5 VDC). If a keyboard that draws more power is plugged into the instrument, keyboard power is turned off. The instrument must be turned off, then back on again to restore keyboard power.*

Singlemode Dynamic Range Check

***NOTE**. If the instrument has two wavelengths, this check must be done on both wavelengths.*

Longest Pulse Width

The longest pulse width is 2000 m for options 04 and 06, and 3200 m for option 10 and Option 12.

1. Clean the connectors on the TFS3031 and the TFS3031 singlemode range test fixture.
2. Connect the TFS3031 to the dynamic-range test fixture and turn on power to the instrument.
3. Check that loss at the front-panel connection is minimized (0.75 dB or less).
   a. Press the Setup softkey to display the Test Setup menu, and set the range to 1 km and the pulse width to 5 m. Select 1550 wavelength, 1310 if option 04, or 1625 if option 12. Press Exit.
   b. Press and hold the START/STOP button to start a real-time acquisition.
   c. If front-panel loss is greater than 0.75 dB, clean the fiber connector and the laser output port.
4. Press the Setup softkey, then press SELECT if necessary to display the Test Setup menu.
5. Select 1550-nm wavelength (1310 nm if option 04, or 1625 nm if option 12).
6. Select the following test setups on the TFS3031:

   Fiber Scan: Manual
   Test Range: 160 km, or 240 km if option 10
   Pulse Width: 2000 m, or 3200 if option 10
   Averages: approximately 3 minutes (as close as possible without being less than three minutes)
7. Press the Exit softkey.
8. Press the START/STOP button.
9. When the waveform acquisition is complete, you should see a waveform similar to the one in figure 4–9.

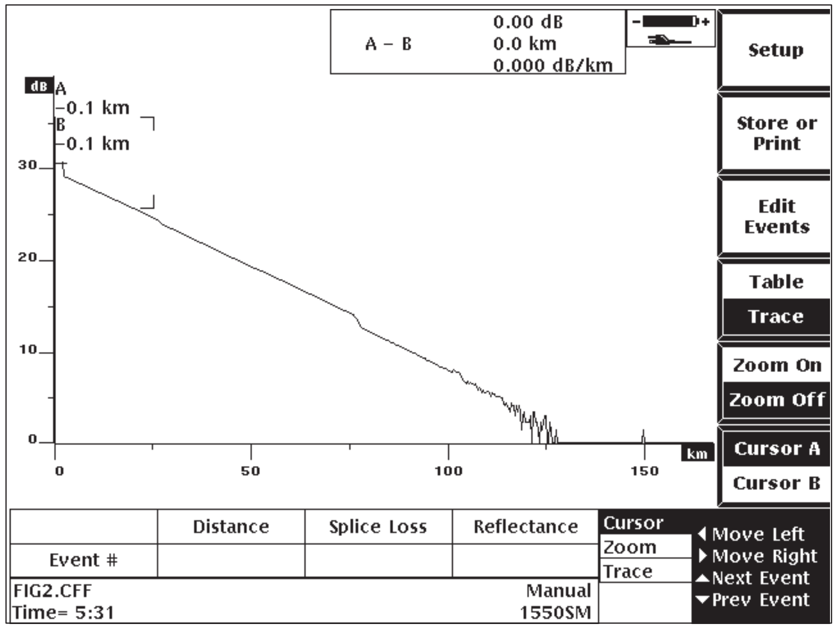


Figure 4–9: Singlemode Dynamic-Range Test Waveform, Longest Pulse Width

10. Press the Zoom On softkey to zoom into the front section of the pulse.

11. Extrapolate the zero-meter backscatter intercept by drawing a straight line on the backscatter across the incident pulse to the zero-meter point. See figure 4–10. Note where this line intersects the loss axis, about 29.75 dB in the example shown below.

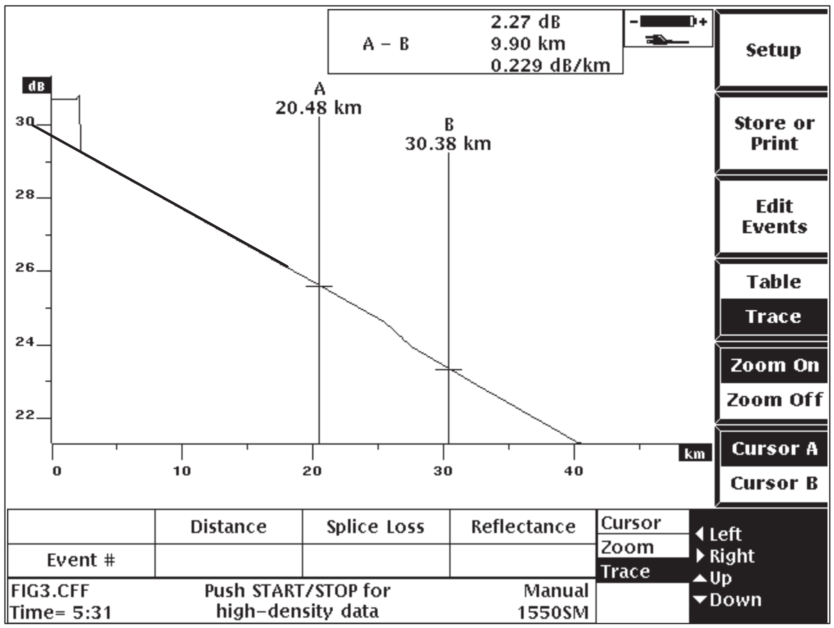


Figure 4–10: Singlemode Dynamic-Range Check, Longest Pulse Width, Zero Intercept

12. Press Zoom Off to turn off zoom. Press SELECT to highlight the cursor function, then use the arrow keys to move cursor A to145 km (225 for option 10).

13. Press and hold the Cursor A/Cursor B softkey to join the two cursors.

14. Move cursor B to 160 km (240 for option 10).

15. Press Zoom On. Press SELECT to highlight the zoom function, then use the arrow keys to adjust the zoom so that 30 km of the noise is on the screen.

If necessary, press the SELECT button to highlight the trace function, then use the arrow keys to center the trace on the screen so the tops of the noise peaks are visible.

16. Identify the ten highest points and draw a line parallel with the distance axis so the ten highest points fall above the line. See figure 4–11.

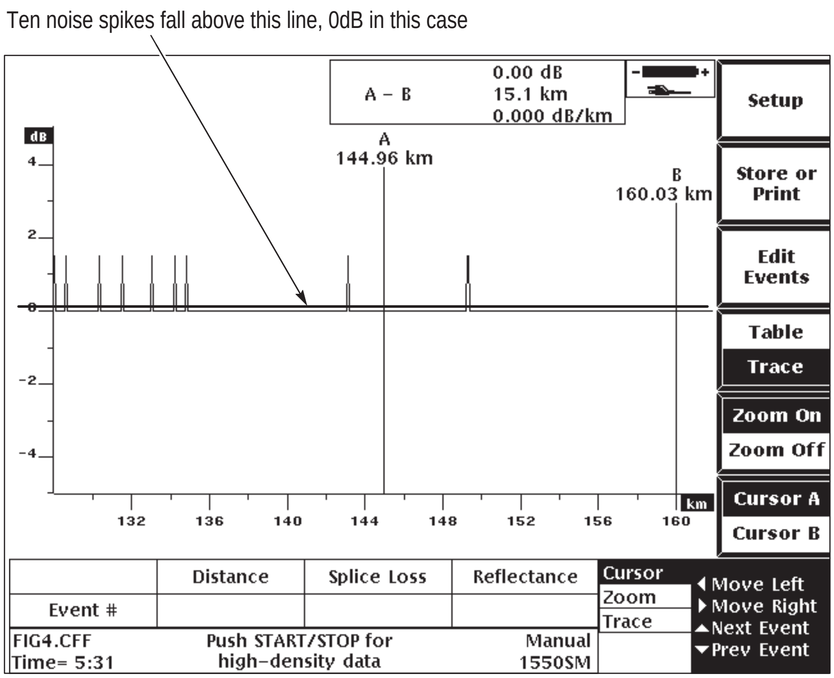


Figure 4–11: Singlemode Dynamic-Range Check, Longest Pulse Width, 98% Noise Level

17. Note where this line intersects the loss axis. This is the 98% noise level.

18. Subtract 1.5 dB from the number noted in the previous step to calculate the SNR=1 noise level.

    The SNR=1 noise level cannot be less than zero. If the 98% noise level is 1.5 dB or less, the SNR=1 noise level is zero.

19. To calculate the SNR=1 dynamic range level, subtract the SNR=1 noise level from the zero-meter level. In the example shown here, the SNR=1 dynamic range is 29.75 - 0 = 29.75 dB.

20. Verify that the measured dynamic range is equal to or greater than the specification for the wavelength and pulse width being tested.

21. Repeat steps 3 through 20 at 1310 nm and 1625 nm if the unit is an option 06, option 10 or option 12.

500-Meter Pulse Width

1. Clean the connector on the TFS3031 and the TFS3031 singlemode dynamic-range test fixture.
2. Connect the TFS3031 to the dynamic-range test fixture and turn on power to the instrument.
3. Check that loss at the front-panel connection is minimized (0.75 dB or less).
   a. Press the Setup softkey to display the Test Setup menu, and set the range to 1 km and the pulse width to 5 m. Select 1550 wavelength, or 1310 if an option 04 or 1625 if option 12. Press Exit.
   b. Press and hold the START/STOP button to start a real-time acquisition.
   c. If front-panel loss is greater than 0.75 dB, clean the fiber connector and the laser output port.
4. Press the Setup softkey, then press SELECT if necessary to display the Test Setup menu.
5. Select 1550-nm wavelength (1310 nm if option 04, or 1625 nm if option 12).
6. Select the following test setups on the TFS3031:

   Fiber Scan: Manual
   Test Range: 160 km
   Pulse Width: 500 m
   Averages: approx. 3 minutes (as close as possible without being less than three minutes)
7. Press the Exit softkey.
8. Press the START/STOP button.

9. When the waveform acquisition is complete, you should see a waveform similar to the one in figure 4–12.

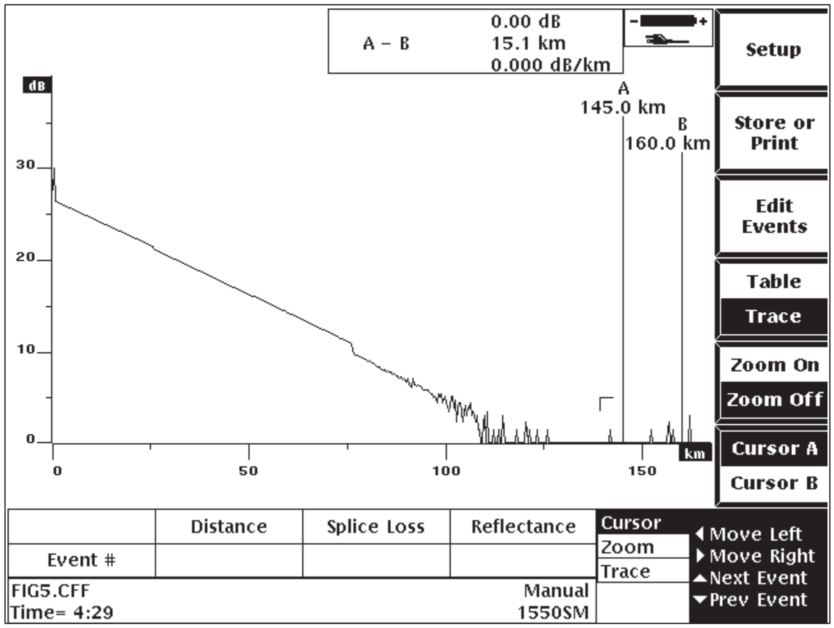


Figure 4–12: Singlemode Dynamic-Range Test Waveform, 500-m Pulse Width

10. Press the Zoom On softkey to zoom into the front section of the pulse.

11. Extrapolate the zero-meter backscatter intercept by drawing a straight line on the backscatter across the incident pulse to the zero-meter point. See figure 4–13. Note where this line intersects the loss axis, 26.6 dB in the example shown below.

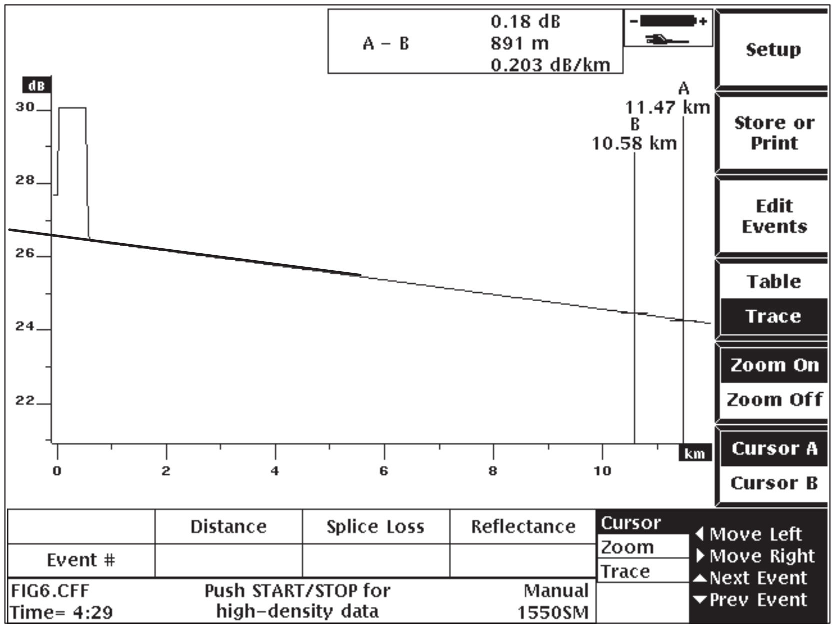


Figure 4–13: Singlemode Dynamic-Range Check, 500-m Pulse Width, Zero Intercept

12. Press Zoom Off to turn off zoom. Press SELECT to highlight the cursor function, then use the arrow keys to move cursor A to160 km.

13. Press and hold the Cursor A/Cursor B softkey to join the two cursors.

14. Select cursor B and move it to 153 km.

15. Select cursor A.

16. Press Zoom On. Press the SELECT button to highlight the zoom function, and use the arrow keys to adjust the zoom so that 7 km display on the screen.

If necessary, press the SELECT button to highlight the trace function, then use the arrow keys to center the trace on the screen so the tops of the noise peaks are visible.

17. Identify the seven highest points and draw a line parallel with the distance axis so the seven highest points fall above the line. See figure 4–14.

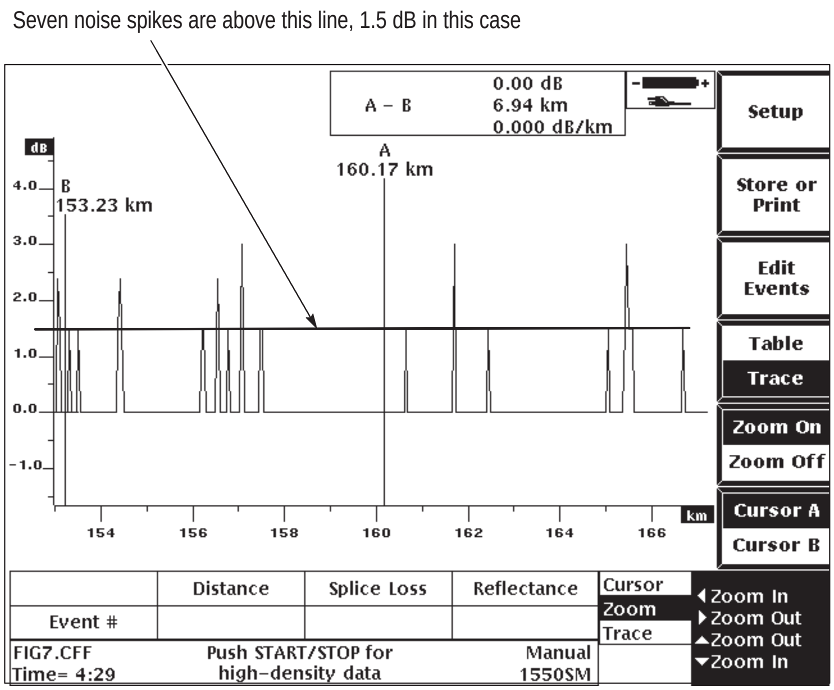


Figure 4–14: Singlemode Dynamic-Range Check, 500-m Pulse Width, 98% Noise Level

18. Note where this line intersects the loss axis. This is the 98% noise level.

19. Subtract 1.5 dB from the number noted in the previous step to calculate the SNR=1 noise level.

The SNR=1 noise level cannot be less than zero. If the 98% noise level is 1.5 dB or less, the SNR=1 noise level is zero.

20. To calculate the SNR=1 dynamic range level, subtract the SNR=1 noise level from the zero-meter level. In the example shown here, the SNR=1 dynamic range is 26.6 - 0 = 26.6 dB.

21. Verify that the measured dynamic range is equal to or greater than the specification for the wavelength and pulse width being tested.

22. Repeat steps 3 through 21 at 1310 nm and 1625 nm if the unit is an option 06, option 10, or option 12.

20-Meter Pulse Width

1. Clean the connector on the TFS3031 and the TFS3031 singlemode dynamic-range test fixture.
2. Connect the TFS3031 to the dynamic-range test fixture and turn on power to the instrument.
3. Check that loss at the front-panel connection is minimized (0.75 dB or less).
   a. Press the Setup softkey to display the Test Setup menu, and set the range to 1 km and the pulse width to 5 m. Select 1550 wavelength (1310 if option 04 or 1625 if option 12.). Press Exit.
   b. Press and hold the START/STOP button to start a real-time acquisition.
   c. If front-panel loss is greater than 0.75 dB, clean the fiber connector and the laser output port.
4. Press the Setup softkey, then press SELECT if necessary to display the Test Setup menu.
5. Select 1550-nm wavelength. (1310 nm if option 04, or 1625 nm if option 12.)
6. Select the following test setups on the TFS3031:

   Fiber Scan: Manual
   Test Range: 80 km
   Pulse Width: 20 m
   Averages: approx. 3 minutes (as close as possible without being less than three minutes)
7. Press the Exit softkey.
8. Press the START/STOP button.

9. When the waveform acquisition is complete, you should see a waveform similar to the one in figure 4–15.

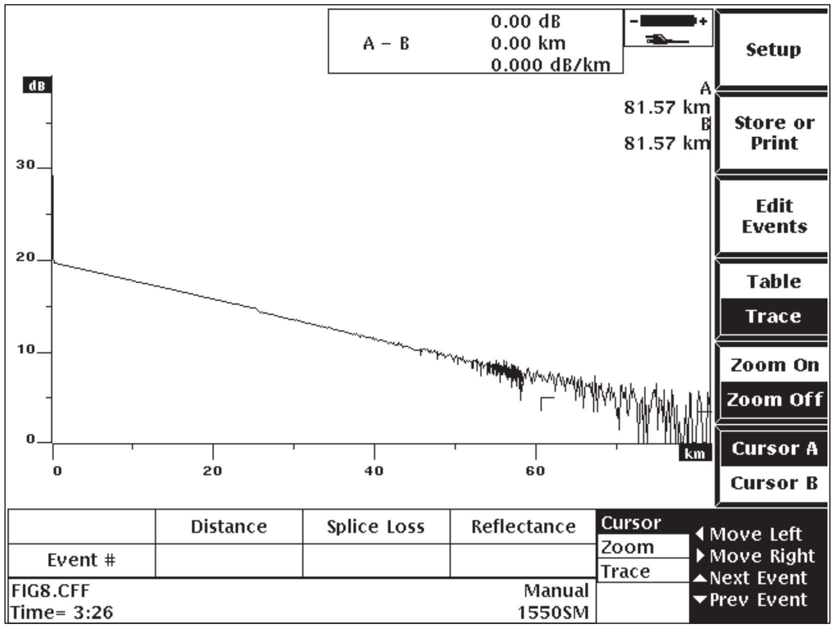


Figure 4–15: Singlemode Dynamic-Range Test Waveform, 20-m Pulse Width

10. Press the Zoom On softkey to zoom into the front section of the pulse.

11. Extrapolate the zero-meter backscatter intercept by drawing a straight line on the backscatter across the incident pulse to the zero-meter point. See figure 4–16. Note where this line intersects the loss axis, 19.8 dB in the example shown below.

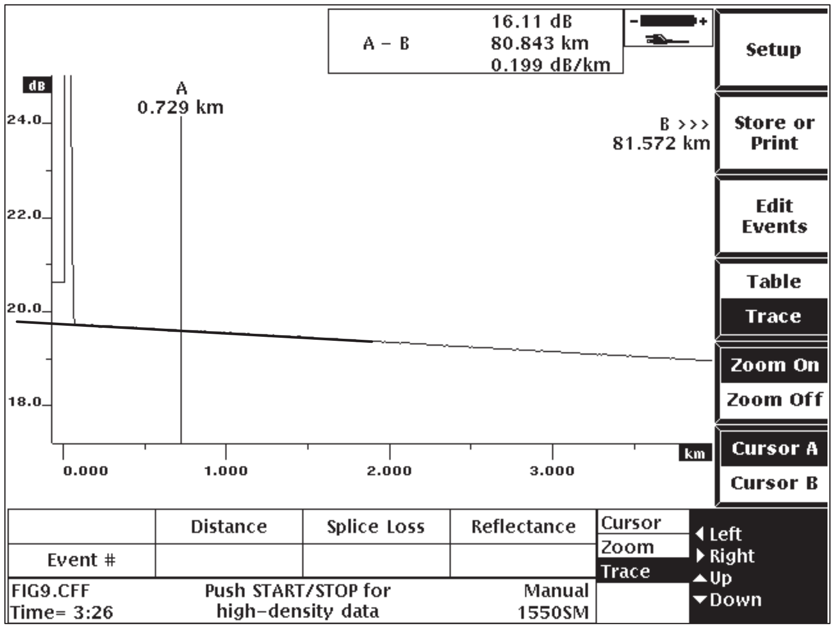


Figure 4–16: Singlemode Dynamic-Range Check, 20-m Pulse Width, Zero Intercept

12. Press Zoom Off to turn off zoom. Press SELECT to highlight the cursor function, then use the arrow keys to move cursor A to 76 km.

13. Press and hold the Cursor A/Cursor B softkey to join the two cursors.

14. Select cursor B and move it to 74.75 km.

15. Select cursor A.

16. Press SELECT to highlight the zoom function, then use the arrow keys to adjust the zoom box so that it covers all noise peaks and comes just to cursor B.

17. Press Zoom On. Adjust the zoom so that 2.5 km of noise is displayed.

18. Identify the ten highest points and draw a line parallel with the distance axis so the ten highest points fall above the line. See figure 4–17.

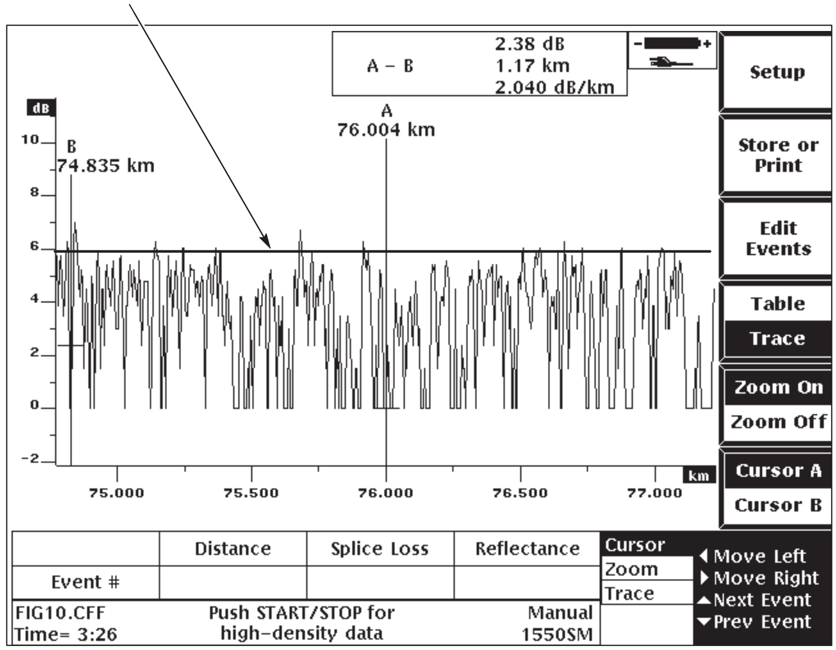


Figure 4–17: Singlemode Dynamic-Range Check, 20-m Pulse Width, 98% Noise Level

19. Note where this line intersects the loss axis. This is the 98% noise level.

20. Subtract 1.5 dB from the number noted in the previous step to calculate the SNR=1 noise level.

The SNR=1 noise level cannot be less than zero. If the 98% noise level is 1.5 or less, the SNR=1 noise level is zero.

In this example, the SNR=1 noise level is 6.0 - 1.5 = 4.5 dB

21. To calculate the SNR=1 dynamic range level, subtract the SNR=1 noise level from the zero-meter level. In the example shown here, the SNR=1 dynamic range is 19.8 - 4.5 = 15.3 dB.

22. Verify that the measured dynamic range is equal to or greater than the specification for the wavelength and pulse width being tested.

23. Repeat steps 3 through 22 at 1310 nm and 1625 nm if the unit is an option 06, option 10, or option 12.

Singlemode Dead-Zone Check

1. Clean the connector on the TFS3031 and the TFS3031 singlemode dead-zone test fixture.
2. Connect the TFS3031 to the dead-zone test fixture and turn on power to the instrument.
3. Check that loss at the front-panel connection is minimized (0.75 dB or less).
   a. Press the Setup softkey to display the Test Setup menu, and set the range to 1 km and the pulse width to 5 m. Select 1550 wavelength. (1310 if option 04, or 1625 if option 12.) Press Exit.
   b. Press and hold the START/STOP button to start a real-time acquisition.
   c. If front-panel loss is greater than 0.75 dB, clean the fiber connector and the laser output port.
4. Press the Setup softkey, then press SELECT if necessary to display the Test Setup menu.
5. Select 1550-nm wavelength. (1310 nm if option 04, or 1625 nm if option 12.)
6. Select the following test setups on the TFS3031:

   Fiber Scan: Manual
   Test Range: 2 km
   Pulse Width: 10 m
   Averages: approx. 3 minutes (as close as possible without being less than three minutes)
7. Press the Exit softkey.
8. Press the START/STOP button.

9. When the acquisition is complete, you should see a waveform like the one shown in figure 4–18.

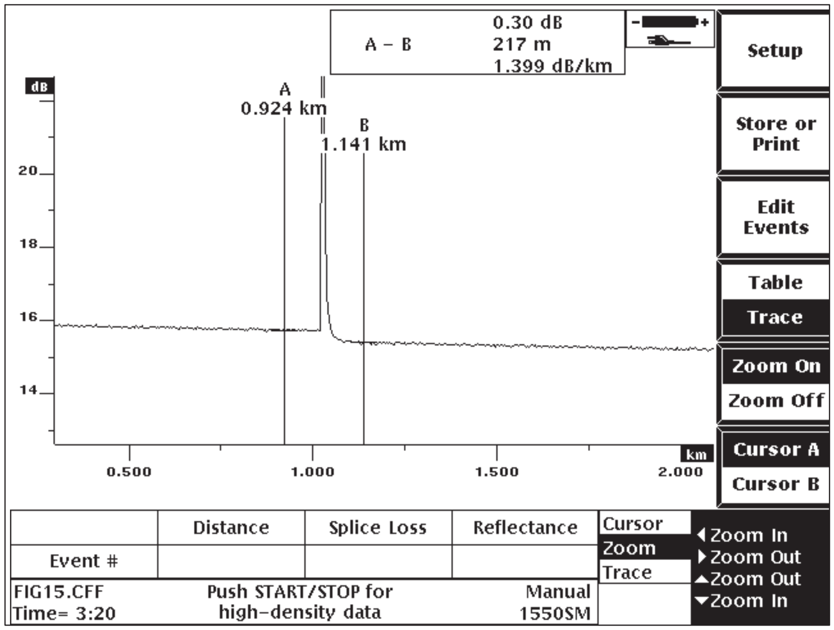


Figure 4–18: Singlemode Dead-Zone Test Waveform

10. Press SELECT to select the zoom function, then use the arrow keys to zoom in on the event at 1 km so that the top of the pulse is visible and the window shows approximately 100 m. See figure 4–19.

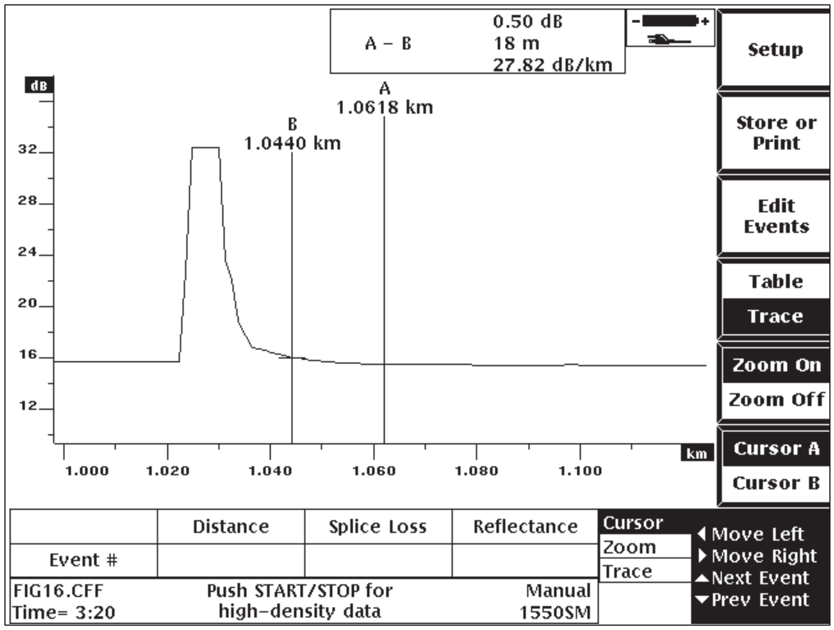


Figure 4–19: Singlemode Dead-Zone Check, Reflection at 1 km

11. Press SELECT to select the cursor function, then use the arrow keys to position cursor A at approximately 50 meters past the rising edge of the reflection.

12. Press and hold the Cursor A/Cursor B softkey to join the cursors.

13. Select cursor B and use the arrow keys to move the cursor towards the pulse until the loss difference between cursor A and cursor B is 0.5 dB. (Select the point where the difference is 0.5 dB and no greater.)

14. Select cursor A and move it to the start of the pulse. See figure 4–20.

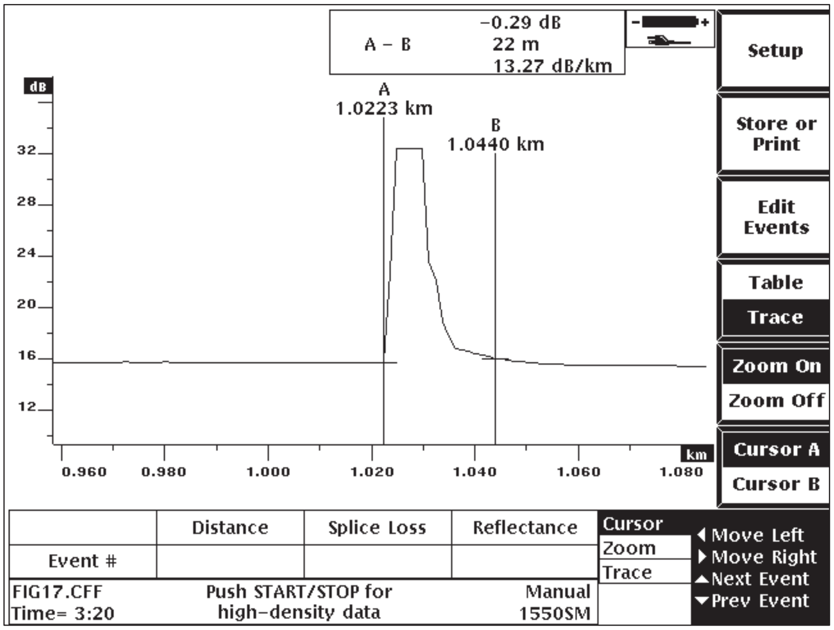


Figure 4–20: Singlemode Attenuation Dead Zone

15. The attenuation dead zone is the distance difference between cursors A and B, 22 m in this example.

16. Verify that the attenuation dead-zone measurement is equal to or less than the specifications for the wavelength and pulse width being tested.

17. Move cursor A to the highest point on the pulse. See figure 4–21.

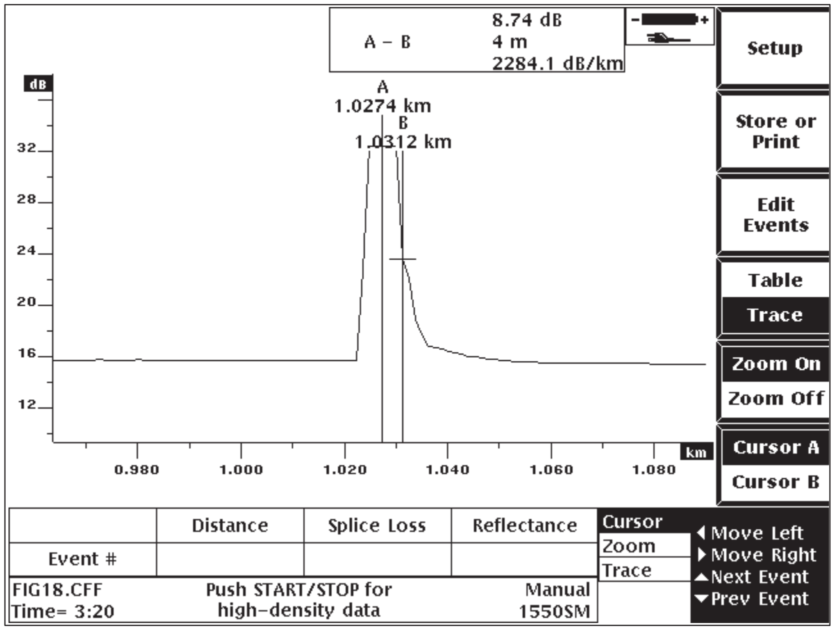


Figure 4–21: Singlemode Event Dead-Zone Check

18. Select cursor B and move it toward cursor A to the first point where the loss difference between the two cursors is at least 3 dB.

19. Select cursor A and move it to the start of the pulse. See figure 4–22.

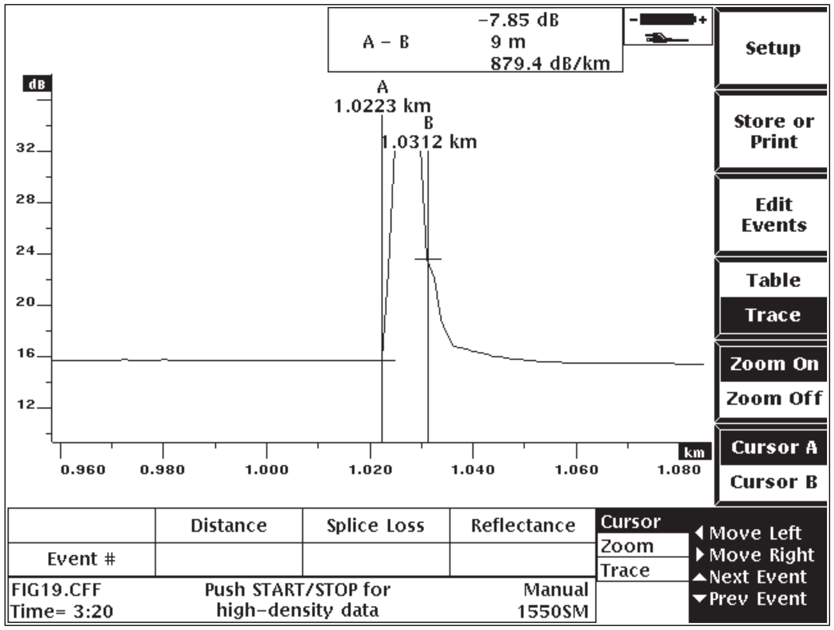


Figure 4–22: Singlemode Event Dead Zone

20. The event dead zone is the distance difference between cursors A and B, 15 m in this example.

21. Verify that the event dead-zone measurement is equal to or less than the specifications for the wavelength and pulse width being tested.

22. Repeat steps 3 through 21 for 1310 nm or 1625 nm if the unit is an option 06, option 10, or option 12.

Singlemode Reflectance-Accuracy Check (Options 04, 06, and 10)

1. Clean the connector on the TFS3031 and the TFS3031 singlemode reflectance test fixture.
2. Connect the TFS3031 to the reflectance test fixture and turn on power to the instrument.
3. Check that loss at the front-panel connection is minimized (0.75 dB or less).
   a. Press the Setup softkey to display the Test Setup menu, and set the range to 1 km and the pulse width to 5 m. Select 1550 wavelength, or 1310 if option 04. Press Exit.
   b. Press and hold the START/STOP button to start a real-time acquisition.
   c. If front-panel loss is greater than 0.75 dB, clean the fiber connector and the laser output port.
4. Set the reflectance test fixture for -40 dB at the wavelength of the laser being tested (1550 or 1310 nm).
5. Press the Setup softkey, then press SELECT if necessary to display the Test Setup menu.
6. Select 1550-nm wavelength, or 1310 nm if option 04.
7. Select the following test setups on the TFS3031:

   Fiber Scan: Manual
   Test Range: 20 km
   Pulse Width: 20 m
   Averages: 256
8. Press the SELECT button to go to the Format menu.
9. Set the reflectance setting ON.
10. Press the Exit softkey.

11. Press the START/STOP button. The waveform should look like the one in figure 4–23.

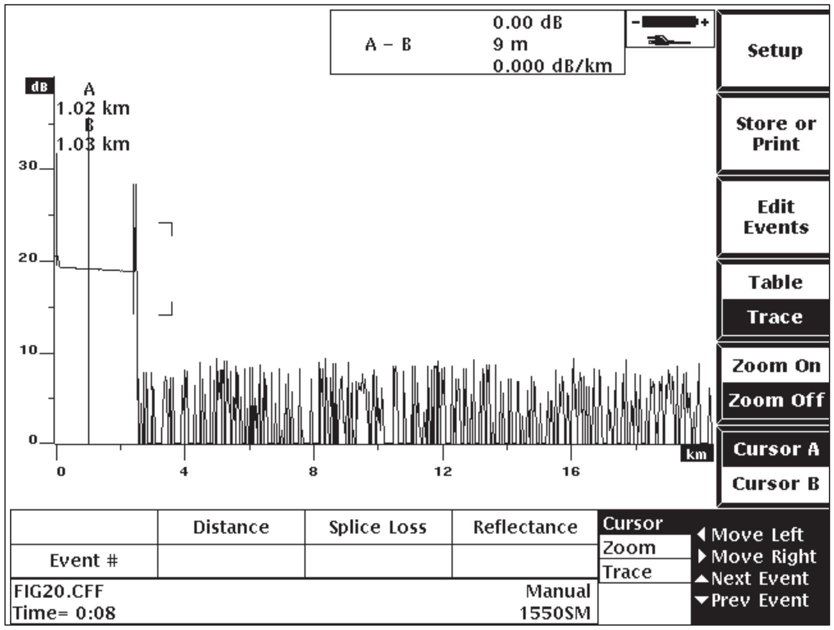


Figure 4–23: Singlemode Reflectance Test Waveform

12. Press the SELECT button to select the cursor function. Use the arrow keys to position cursor A approximately at the start of the end reflection.

13. Press the Zoom On softkey, then press the SELECT button to select the zoom function. Use the arrow keys to adjust the zoom box to show approximately 1 km of fiber with the end reflection fully visible.

14. Press the SELECT button to select the cursor function, then use the arrow keys to position cursor A at the rising edge of the end reflection. See figure 4–24.

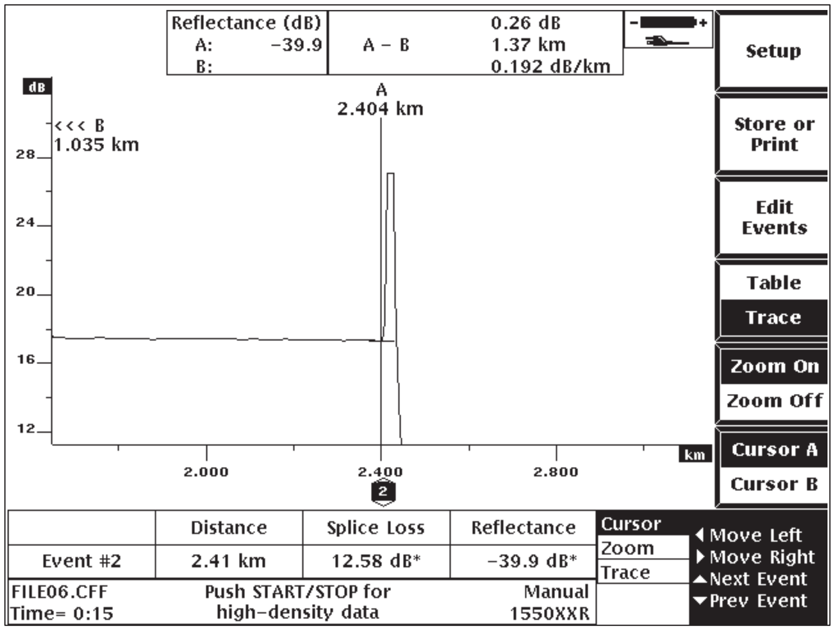


Figure 4–24: Singlemode Reflectance Check

15. Check the reflectance value displayed on the instrument at the top of the screen. This value should be -40 dB ±4 dB.

16. Repeat steps 3 through 15 for 1310 if option 06 or 10.

Singlemode Distance and Loss Measurement Accuracy Check

1. Clean the connectors on the TFS3031 and the TFS3031 singlemode loss and distance accuracy test fixture.
2. Connect the TFS3031 to the loss and distance accuracy test fixture and turn on power to the instrument.
3. Check that loss at the front-panel connection is minimized (0.75 dB or less).
   a. Press the Setup softkey to display the Test Setup menu, and set the range to 1 km and the pulse width to 5 m. Select 1550 wavelength, or 1310 if option 04. Press Exit.
   b. Press and hold the START/STOP button to start a real-time acquisition.
   c. If front-panel loss is greater than 0.75 dB, clean the fiber connector and the laser output port.
4. Press the Setup softkey, then press SELECT if necessary to display the Test Setup menu.
5. Select 1550-nm wavelength, or 1310 nm if option 04.
6. Set the Fiber Scan setup to IntelliTrace.
7. Press the Exit softkey.
8. Press the START/STOP button to start an acquisition.
9. When the acquisition is complete, verify that the loss and distance reported on the event table is within tolerance:

   Loss must be within ±0.03 dB (±uncertainty of the “calibrated” event)
   Distance must be within ±10 meters (±uncertainty of the “calibrated” event)
10. Repeat steps 4 through 9 for 1310 nm if option 06 or 10.

Multimode Dynamic Range Check

Longest Pulse Width

1. Clean the connector on the TFS3031 and the TFS3031 multimode dynamic-range test fixture.
2. Connect the TFS3031 to the multimode dynamic-range test fixture and turn on power to the instrument.
3. Check that loss at the front-panel connection is minimized (0.75 dB or less).
   - **a.** Press the Setup softkey to display the Test Setup menu, and set the range to 1 km and the pulse width to 5 m. Select 1300 wavelength, or 850 if option 01. Press Exit.
   - **b.** Press and hold the START/STOP button to start a real-time acquisition.
   - **c.** If front-panel loss is greater than 0.75 dB, clean the fiber connector and the laser output port.
4. Press the Setup softkey, then press SELECT if necessary to display the Test Setup menu.
5. Select 1300nm wavelength, or 850 nm if option 01.
6. Select the following test setups on the TFS3031:

   Fiber Scan: Manual
   Test Range: 10 km for 850; 20 km for 1300 nm
   Pulse Width: 10 m for 850 nm; 100 m for 1300 nm
   Averages: approx. 3 minutes (as close as possible without being less than three minutes)
7. Press the Exit softkey.

8. Press the START/STOP button. The waveform should look like the one in figure 4–25.

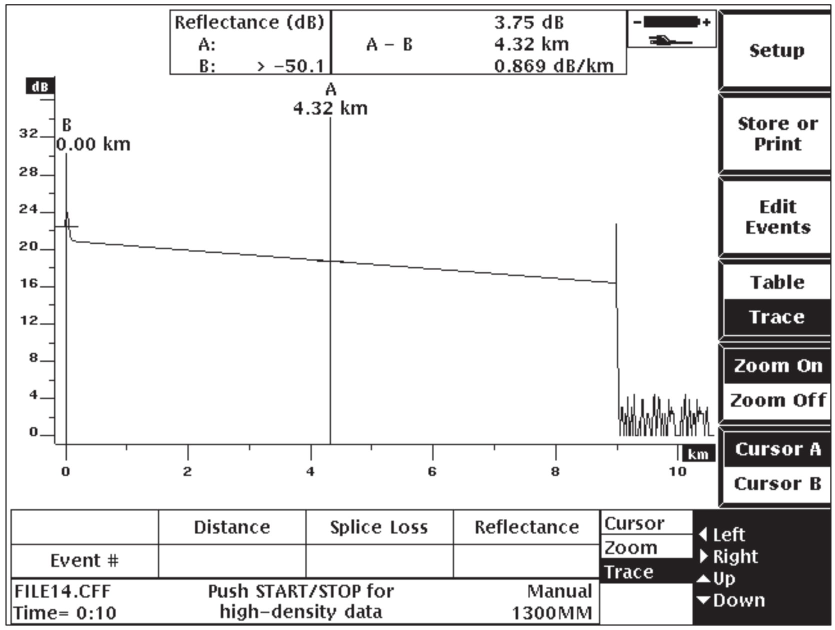


Figure 4–25: Multimode Range Test Fixture Trace, Longest Pulse Width

9. Press the Zoom On softkey to zoom into the front section of the pulse.

10. Extrapolate the zero-meter backscatter intercept by drawing a straight line on the backscatter across the incident pulse to the zero-meter point. See figure 4–26. Note where this line intersects the loss axis, 21 dB in the example shown below.

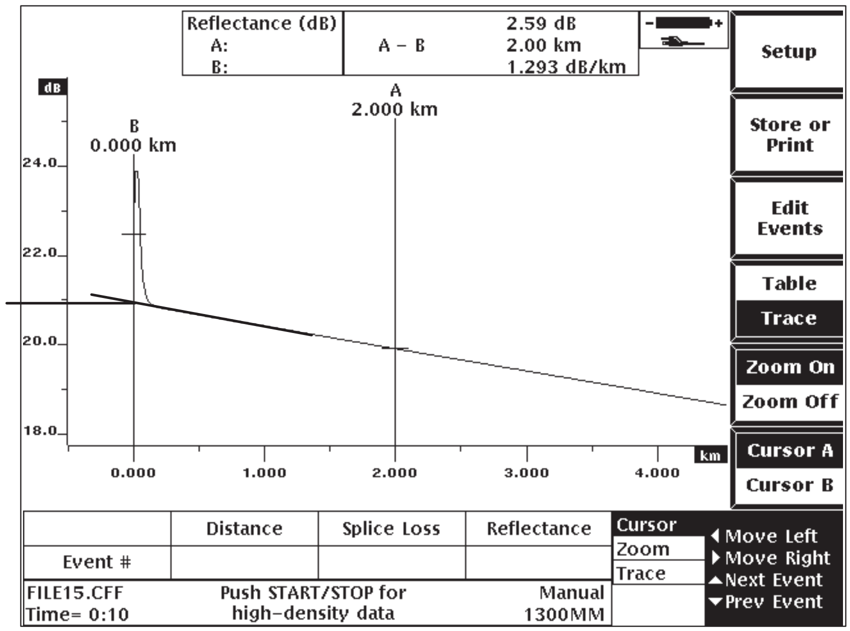


Figure 4–26: Multimode Dynamic-Range Check Zero Intercept, Longest Pulse Width

11. Press Zoom Off to turn off zoom. Press SELECT to highlight the cursor function, then use the arrow keys to move cursor A to 16 km for 1300 nm, or to 9.5 km for 850 nm.

12. Press and hold the Cursor A/Cursor B softkey to join the two cursors.

13. Move cursor B to 16.1 km for 1300 nm, or to 9.6 for 850 nm.

14. Press Zoom On. Press SELECT to highlight the zoom function, then use the arrow keys to adjust the zoom so that 200 m of the noise is on the screen for 1300 nm, and 100 m of noise is visible for 850 nm. Select the trace function and use the arrow keys to move the trace if necessary, in order to see the tops of the noise spikes.

15. Identify the ten highest points and draw a line parallel with the distance axis so the ten highest points fall above the line. See figure 4–27.

If ten noise spikes are not visible, use zero as the 98% noise level.

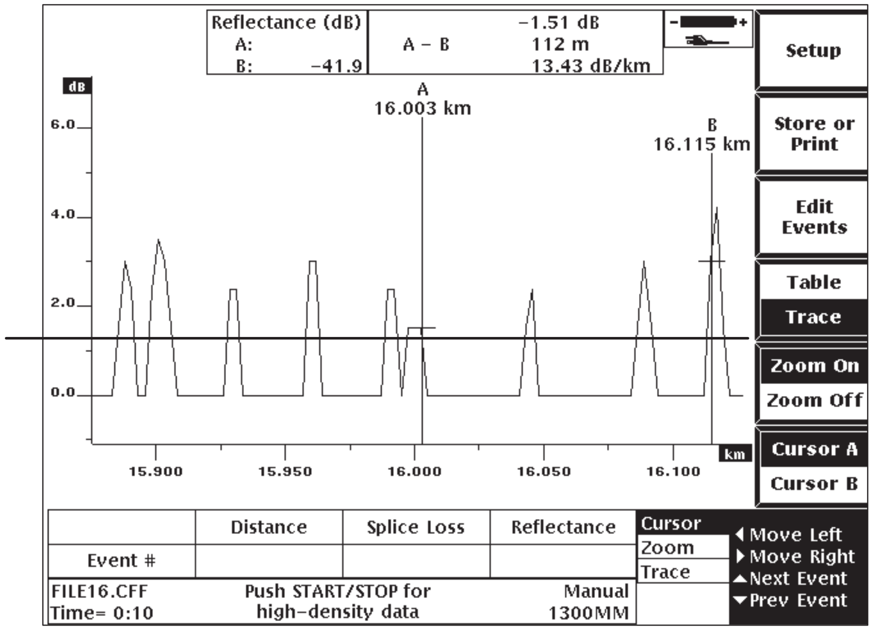


Figure 4–27: Multimode Dynamic-Range Check 98% Noise Level, Longest Pulse Width

16. Note where this line intersects the loss axis. This is the 98% noise level.

17. Subtract 1.5 dB from the number noted in the previous step to calculate the SNR=1 noise level.

The SNR=1 noise level cannot be less than zero. If the 98% noise level is 1.5 dB or less, the SNR=1 noise level is zero.

18. To calculate the SNR=1 dynamic range level, subtract the SNR=1 noise level from the zero-meter level obtained in step 10. In the example shown here, the SNR=1 dynamic range is 21 - 0 = 21 dB.

19. Verify that the measured dynamic range is equal to or greater than the specification for the wavelength and pulse width being tested.

20. Repeat steps 3 through 19 at 850 nm if the unit is an option 03.

1-Meter Pulse Width

1. Clean the connector on the TFS3031 and the TFS3031 multimode dynamic-range test fixture.
2. Connect the TFS3031 to the dynamic-range test fixture and turn on power to the instrument.
3. Check that loss at the front-panel connection is minimized (0.75 dB or less).
   - **a.** Press the Setup softkey to display the Test Setup menu, and set the range to 1 km and the pulse width to 5 m. Select 1300 wavelength, or 850 if option 01. Press Exit.
   - **b.** Press and hold the START/STOP button to start a real-time acquisition.
   - **c.** If front-panel loss is greater than 0.75 dB, clean the fiber connector and the laser output port.
4. Press the Setup softkey, then press SELECT if necessary to display the Test Setup menu.
5. Select 1300nm wavelength, or 850 nm if option 01.
6. Select the following test setups on the TFS3031:

   Fiber Scan: Manual
   Test Range: 10 km
   Pulse Width: 1 m
   Averages: approx. 3 minutes (as close as possible without being less than three minutes)
7. Press the Exit softkey.

8. Press the START/STOP button. The waveform should look like the one in figure 4–28.

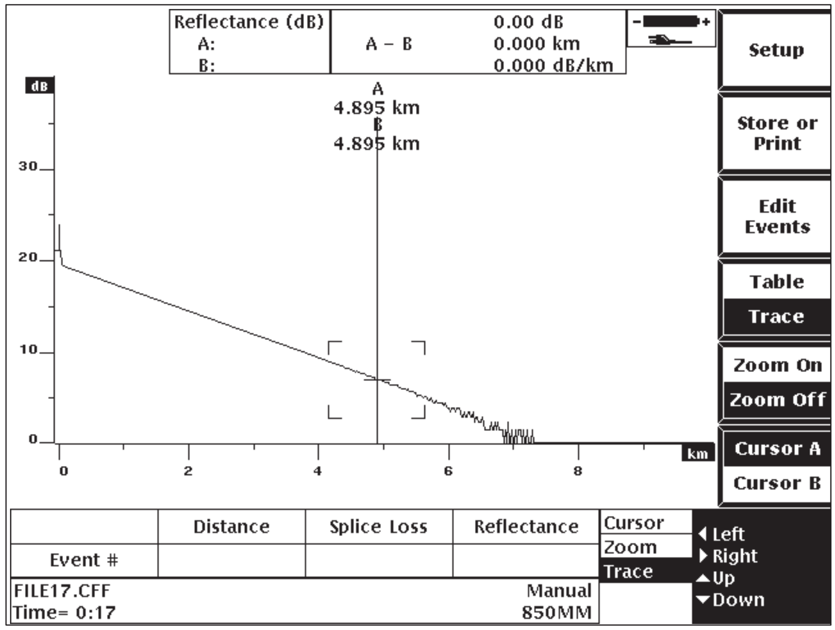


Figure 4–28: Multimode Range Test Fixture Trace, 1-m Pulse Width

9. Press the Zoom On softkey to zoom in on the front section of the pulse.

10. Extrapolate the zero-meter backscatter intercept by drawing a straight line on the backscatter across the incident pulse to the zero-meter point. See figure 4–29. Note where this line intersects the loss axis.

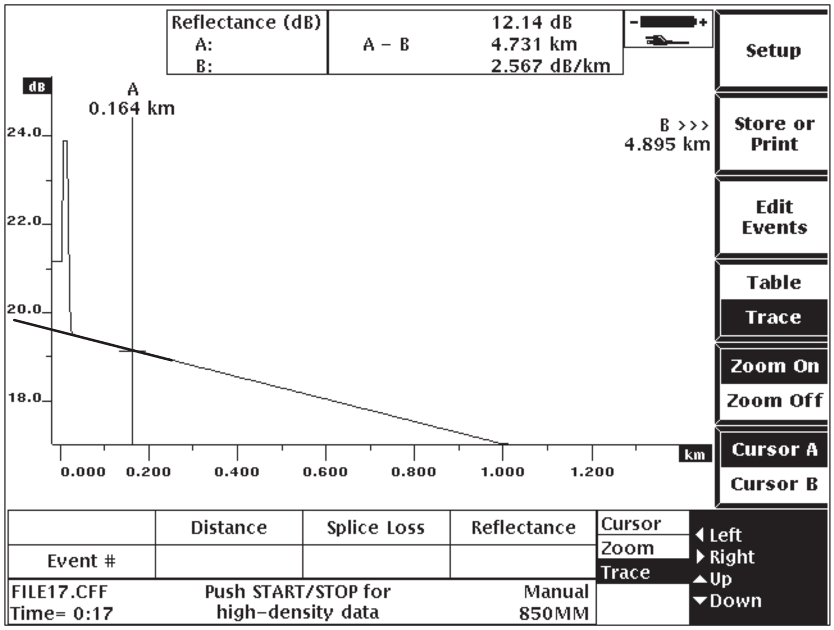


Figure 4–29: Multimode Dynamic-Range Check Zero Intercept, 1-m Pulse Width

11. Press Zoom Off to turn off zoom. Press SELECT to highlight the cursor function, then use the arrow keys to move cursor A to 9.6 km.

12. Press and hold the Cursor A/Cursor B softkey to join the two cursors.

13. Move cursor B to 9.9 km.

14. Press Zoom On. Press SELECT to highlight the zoom function, then use the arrow keys to adjust the zoom so that 400 m of the noise is on the screen.

***NOTE**. Half of all acquisitions for this test will not display noise past the end of the waveform.*

---

15. Identify the seven highest points and draw a line parallel with the distance axis so the seven highest points fall above the line. If the trace has no noise, the 98% noise level is zero. See figure 4–30.

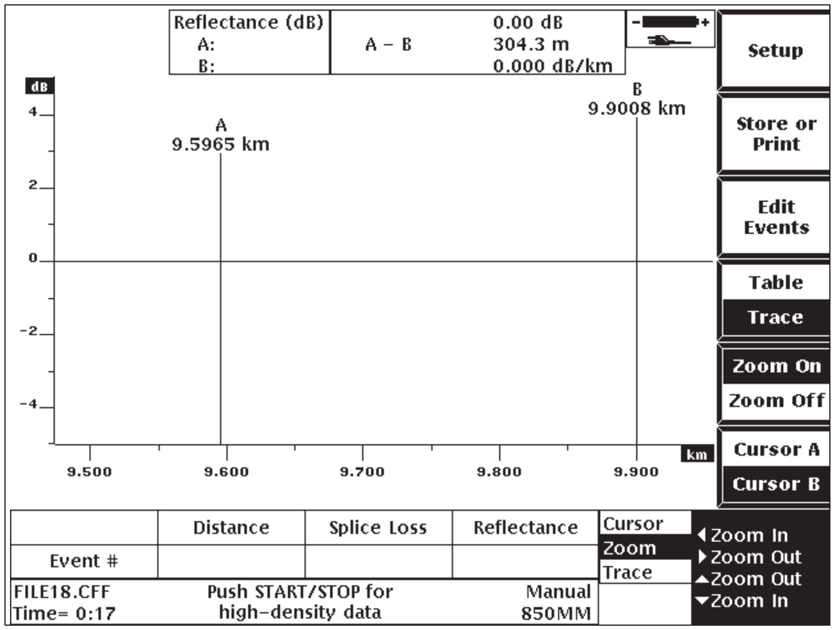


Figure 4–30: Multimode Dynamic-Range Check 98% Noise Level, 1-m Pulse Width

16. Note where this line intersects the loss axis. This is the 98% noise level.

17. Subtract 1.5 dB from the number noted in the previous step to calculate the SNR=1 noise level.

The SNR=1 noise level cannot be less than zero. If the 98% noise level is 1.5 dB or less, the SNR=1 noise level is zero.

18. To calculate the SNR=1 dynamic range level, subtract the SNR=1 noise level from the zero-meter level obtained in step 10. In the example shown here, the SNR=1 dynamic range is 19.6 - 0 = 19.6 dB.

19. Verify that the measured dynamic range is equal to or greater than the specification for the wavelength and pulse width being tested.

20. Repeat steps 3 through 19 at 850 nm if the unit is an option 03.

Multimode Event-Detection Check

NOTE. *If the instrument has two wavelengths, this check must be done on both wavelengths.*

1. Clean the connector on the TFS3031 and the TFS3031 multimode event-detection/dead zone test fixture.
2. Connect the TFS3031 to the event-detection test fixture and turn on power to the instrument.
3. Check that loss at the front-panel connection is minimized (0.75 dB or less).
   - **a.** Press the Setup softkey to display the Test Setup menu, and set the range to 1 km and the pulse width to 5 m. Select 1300 wavelength, or 850 if option 01. Press Exit.
   - **b.** Press and hold the START/STOP button to start a real-time acquisition.
   - **c.** If front-panel loss is greater than 0.75 dB, clean the fiber connector and the laser output port.
4. Press the Setup softkey, then press SELECT if necessary to display the Test Setup menu.
5. Select 1300nm wavelength, or 850 nm if option 01.
6. Set Fiber Scan to IntelliTrace.
7. Press the Exit softkey.
8. Press the START/STOP button.

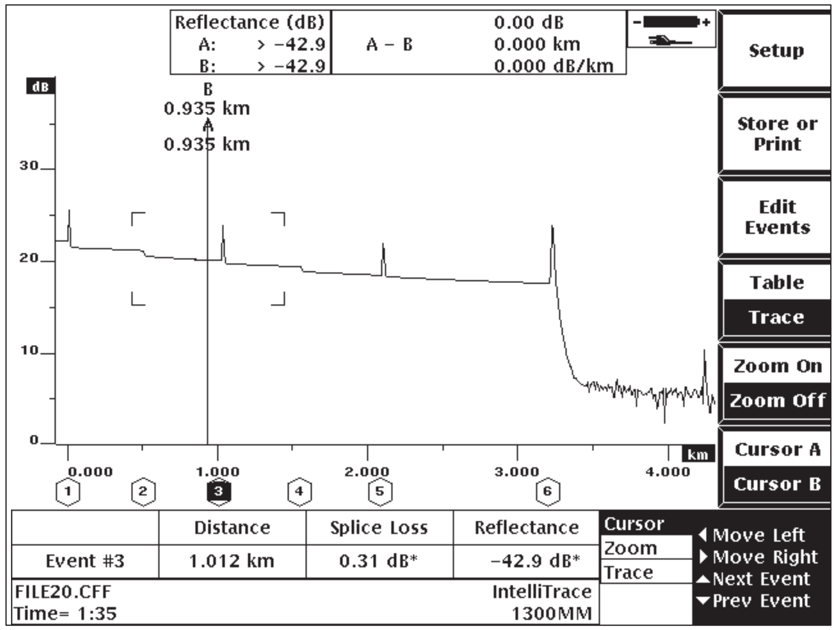


Figure 4–31: Multimode Event-Detection Test Fixture Trace

9. When the test is complete, press the Table/Trace softkey to display the event table.

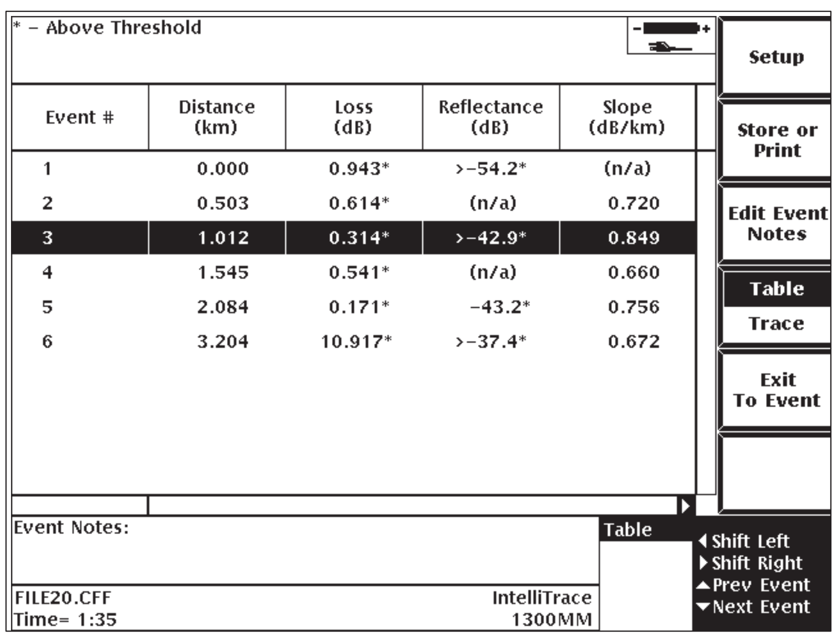


Figure 4–32: Multimode Event-Detection Test Fixture Event Table

10. Verify that all events were detected and distance and loss measurements are correct and within tolerance.

If an event is not detected the first time, repeat the test several times to determine that the missing event is detected and reported accurately in 95% of the tests.

11. Repeat steps 3 through 10 at 850 nm if the unit is an option 03.

Multimode Dead-Zone Check

***NOTE**. If the instrument has two wavelengths, this check must be done on both wavelengths.*

1. Clean the connector on the TFS3031 and the TFS3031 multimode event-detection/dead-zone test fixture.
2. Connect the TFS3031 to the event-detection/dead-zone test fixture and turn on power to the instrument.
3. Check that loss at the front-panel connection is minimized (0.75 dB or less).
   a. Press the Setup softkey to display the Test Setup menu, and set the range to 1 km and the pulse width to 5 m. Select 1300 wavelength, or 850 if option 01. Press Exit.
   b. Press and hold the START/STOP button to start a real-time acquisition.
   c. If front-panel loss is greater than 0.75 dB, clean the fiber connector and the laser output port.
4. Press the Setup softkey, then press SELECT if necessary to display the Test Setup menu.
5. Select 1300nm wavelength, or 850 nm if option 01.
6. Select the following test setups on the TFS3031:

   Fiber Scan: Manual
   Test Range: 4 km
   Pulse Width: 10 m
   Averages: 4096
7. Press the Exit softkey.
8. Press the START/STOP button.
9. When the test is complete, press the SELECT button highlight the cursor option. Move cursor A to a single event on the fiber.
10. Press the Zoom On softkey to magnify the event.
11. Position cursor A on the backscatter 40 to 45 m following the event.
12. Press and hold the Cursor A/Cursor B softkey to join cursors.
13. Press the Cursor A/Cursor B softkey to select cursor B.

14. Move cursor B until the Cursor A–B difference shown at the top of the screen is 0.5 dB or less.

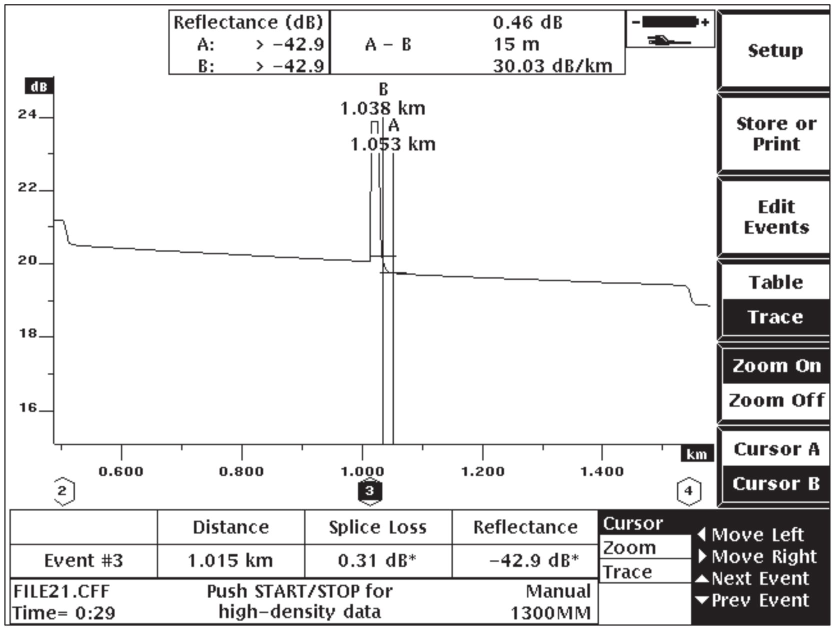


Figure 4–33: Multimode Dead-Zone Check, Establishing the Backscatter Level

15. Press the Cursor A/Cursor B softkey again to select cursor A as the active cursor.

16. Position the active cursor on the rising edge of the pulse of the magnified event.

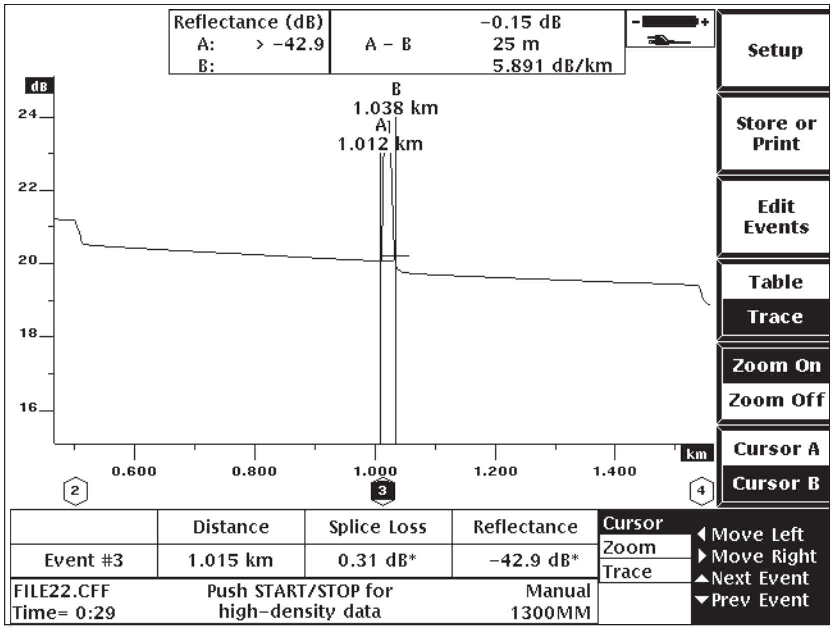


Figure 4–34: Multimode Attenuation Dead Zone

17. The Cursor A–B reading at the top of the screen is the attenuation dead zone.

18. Verify that the attenuation dead-zone measurement is equal to or less than the specifications for the wavelength and pulse width being tested.

19. Position cursor A at the peak of the reflection.

20. Press Cursor A/Cursor B to select cursor B, and move it to a point on the falling edge of the reflection at least 0.3 dB down from cursor A.

21. Press Cursor A/Cursor B to select cursor A, and move it to the rising edge of the pulse.

22. The Cursor A–B reading at the top of the screen is the event dead zone.

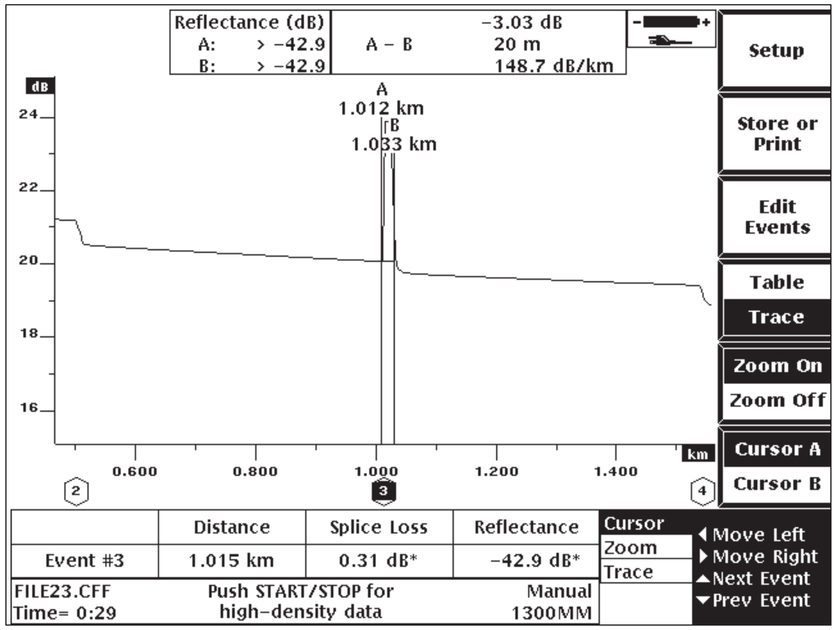


Figure 4–35: Multimode Event Dead Zone

23. Verify that the event dead-zone measurement is equal to or less than the specifications for the wavelength and pulse width being tested.

24. Repeat steps 1 through 23 using a pulse width of 1 m.

25. Repeat steps 1 through 24 for 850 nm if the unit is an option 03.

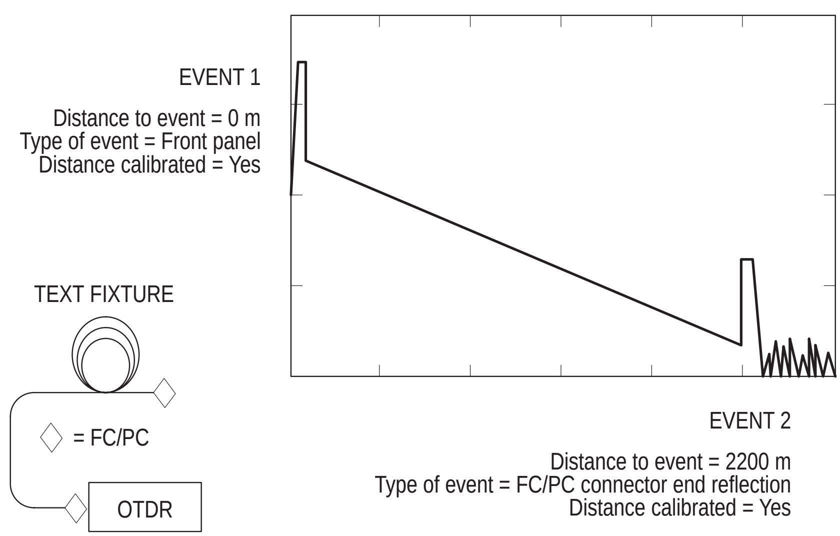
Multimode Distance Accuracy Check

The multimode distance accuracy check is a test using a test fixture made up of a 2.2 km length of multimode fiber with known length (time of flight).

1. Connect the multimode fiber of known length to the instrument multimode port.
2. Make the following selections in the Setup menu:
   - Wavelength: *850 nm or 1300 nm* (based on instrument options)
   - Fiber Scan: *IntelliTrace*
   - IR: *1.4776 at 850 nm and 1.4719 at 1300 nm*
3. Exit the Setup menu.
4. Push the START/STOP button to start an IntelliTrace acquisition.
5. When the acquisition is complete, compare the distance to event number two in the TFS3031 event table to the known distance to the end of the multimode fiber. This distance should be within the distance tolerance in the specifications.

The following configuration illustrates the test fixture. There is one roll of fiber 2.2 km (± 200 m) in length. The length of the fiber is measured by the standard time-of-flight method. This gives a propagation delay which can be mathematically translated into a known length at a given (assumed) group index.

This simulated waveform shows the location and description of the multimode events captured on the OTDR.



—— This concludes the performance check ——

Maintenance

Cleaning

The following procedures describe the proper cleaning of the laser output port, the connector adapter, and the fiber connector.

CAUTION. *Clean the optical connections before testing a fiber.*

Do not touch the exposed end of the laser output port or fiber connector with anything but a lint-free swab or paper wipe dampened with electronics-grade alcohol.

Turn off the instrument and disconnect the power/charger adapter before beginning any cleaning procedure.

Do not use index matching fluid or gel on the laser output port or fiber connector. It may cause contamination and a fatal error message. If index matching material is inadvertently used, clean the laser output port and fiber connector thoroughly.

Do not use acetone on optical connectors.

WARNING. *INVISIBLE LASER RADIATION. To eliminate hazardous radiation exposure do not use controls or adjustments, or perform procedures, other than those specified in this manual.*

Cleaning Materials

- Dust-free canned air
- Lint-free swabs or paper wipes
- Lint-free pipe cleaners 0.35 cm (0.15 inch) diameter
- Electronics-grade alcohol

NOTE. *Tektronix Optical Cleaner, PN 006-8134-00, includes lint-free isopropyl alcohol wipes and an application note on cleaning optical-fiber connectors. This kit comes standard with Tektronix OTDRs, and can be ordered by calling 1-800-TEK-WIDE or contacting your local Tektronix representative.*

Exposing the Laser Output Port for Cleaning

Remove the connector adapter by unscrewing it *counterclockwise* and pulling it off the laser output port.

When the connector adapter is removed the laser output port is accessible for cleaning.

***NOTE**. The connector adapter and laser output port are keyed for proper mating during reinstallation.*

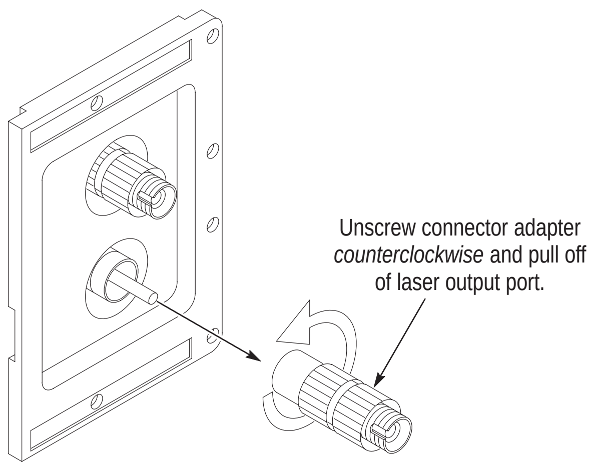


Figure 5–1: Exposing the Laser Output Port for Cleaning

Cleaning the Laser Output Port

Dampen a lint-free swab or paper wipe with electronics-grade alcohol, and gently wipe across and around the port a couple of times.

Dry with a dry swap or dry part of the paper wipe.

If the port is extremely dirty repeat the procedure with a second lint-free swab or paper wipe.

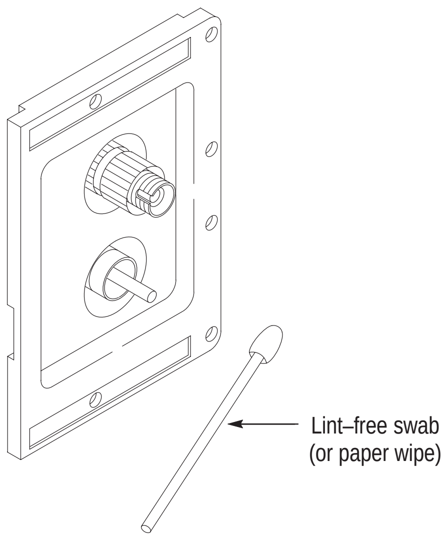


Figure 5–2: Cleaning the Laser Output Port

Cleaning the Connector Adapter

1. Blow through each end of the connector adapter barrel with dust-free canned air (see figure 5–3).

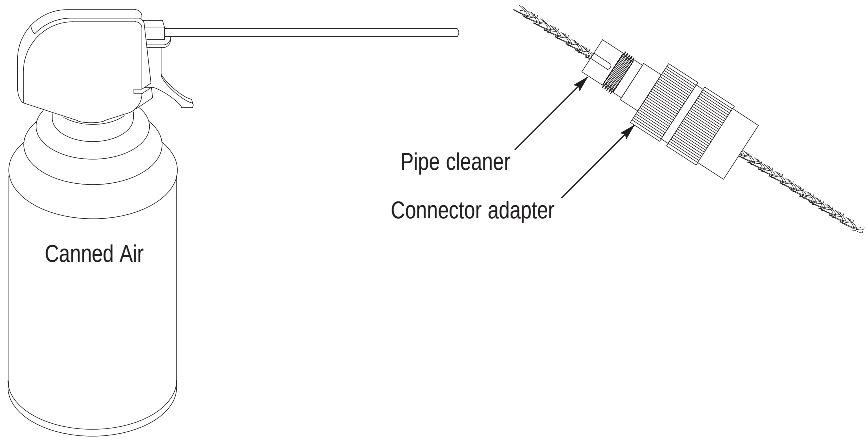


Figure 5–3: Cleaning the Connector Adapter

2. Dampen a lint-free pipe cleaner with electronics-grade alcohol. The pipe cleaner absorbent should be about 0.35 cm (0.15 inch) in diameter, and the wire part of the pipe cleaner should be less than 0.1 cm (0.04 inch) in diameter.
3. Gently insert the dampened pipe cleaner into the barrel of the connector adapter. Be careful not to scratch the barrel with the wire while inserting it.
4. Pull the pipe cleaner completely through the barrel.
5. Blow the barrel completely dry with dust-free canned air.

If the connector adapter is extremely dirty repeat the procedure with a second pipe cleaner.

Cleaning the Fiber Connector

Dampen a lint-free swab or paper wipe with electronics-grade alcohol, and gently wipe across and around the connector a couple of times.

Dry with a dry swap or dry part of the paper wipe.

If the connector is extremely dirty repeat the procedure with a second lint-free swab or paper wipe.

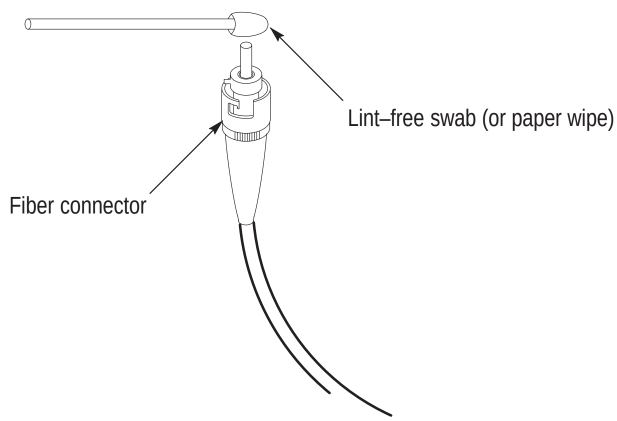


Figure 5–4: Cleaning the Fiber Connector

Disassembly

This section explains how to disassemble the TFS3031 to module level. Disassemble the TFS3031 in the sequence described on the following pages.

Reassembly is the reverse of disassembly, paying close attention to replacing all cable connectors, and miscellaneous hardware such as mounting posts, screws, nuts and washers that are not referred to specifically in the disassembly procedure.

CAUTION. *Many components in the TFS3031 are static sensitive. During disassembly work only in a static-free environment and practice anti-static handling precautions.*

The DC/AC Converter board contains high voltages. Before disassembly make sure that the TFS3031 power is powered off and disconnected from any external power source.

NOTE. *This disassembly procedure assumes that two optical modules (one singlemode and one multimode module), and the optional floppy disk drive are installed in the instrument. Not all instrument are configured with all options installed. Therefore, skip any references to modules that are not installed in your instrument.*

Equipment Required

Table 5–1: Equipment Required for Disassembly

Equipment	Application
Static-free workstation	Static damage protection
1 point Pozidrive torque screwdriver	Remove case-half screws
11 mm D-nut wrench (RIFOCS 1CT–SW11)	Remove Laser Output port from bulkhead
14 mm open end wrench	Remove Laser Output port from bulkhead
$^1/_4$ inch torque nut driver	Remove Display module from Front Panel assembly
$^3/_{16}$ inch torque nut driver	Remove Display module mounting plate

Equipment	Application
$^1/_8$ inch torque nut driver	Remove RS232C and parallel ports from side panel
Torx T10 screw driver	Remove screws from side panel
Locktite #242	Securing screws and nuts during reassembly
Locktite #414	Securing channel grommets to circuit board holders
Soldering/desoldering equipment	Only if remounting the DC/DC converter (see page 5–20)

Electrical Modules

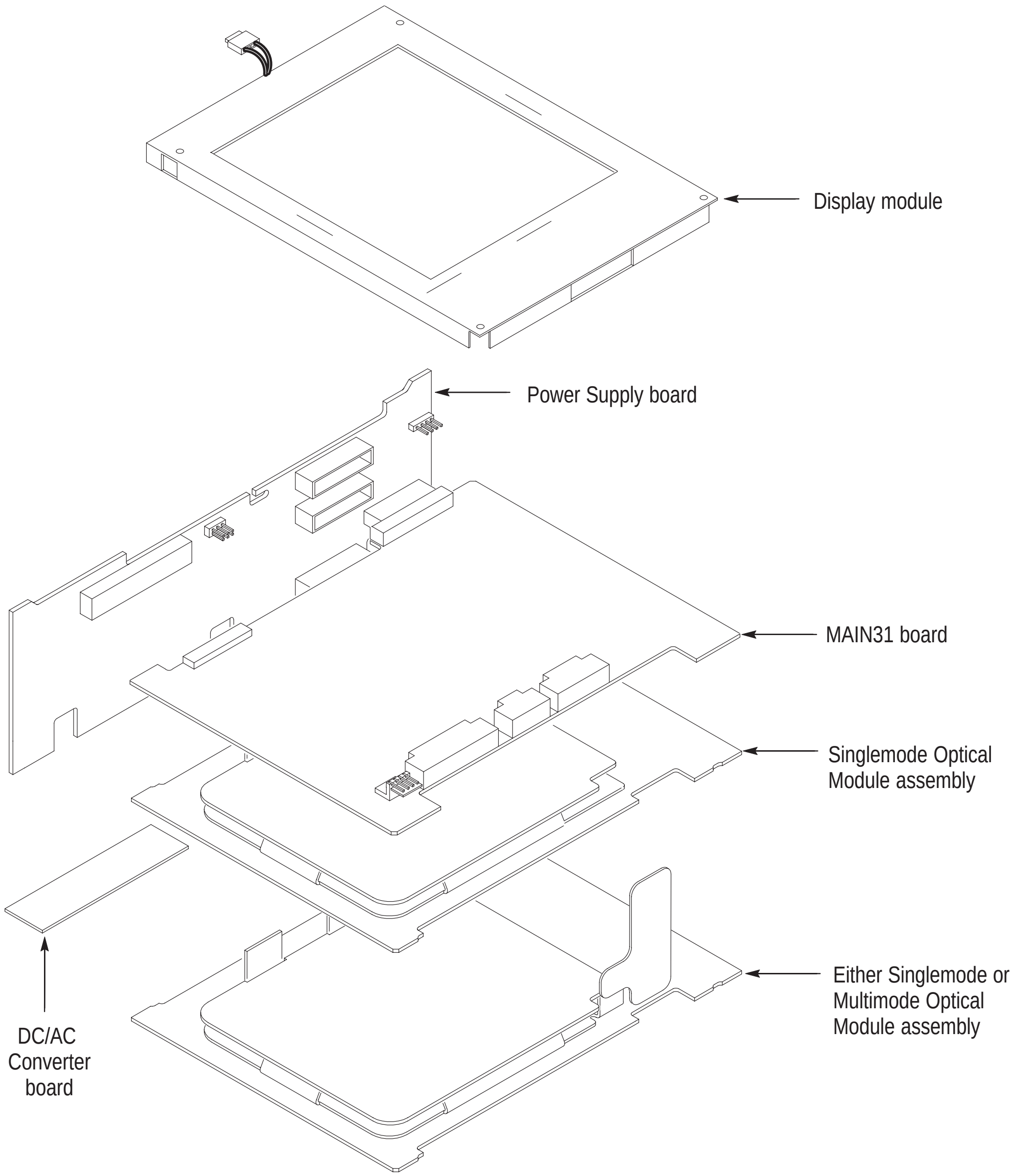


Figure 5–5: Electrical Module Locator

Mechanical Parts

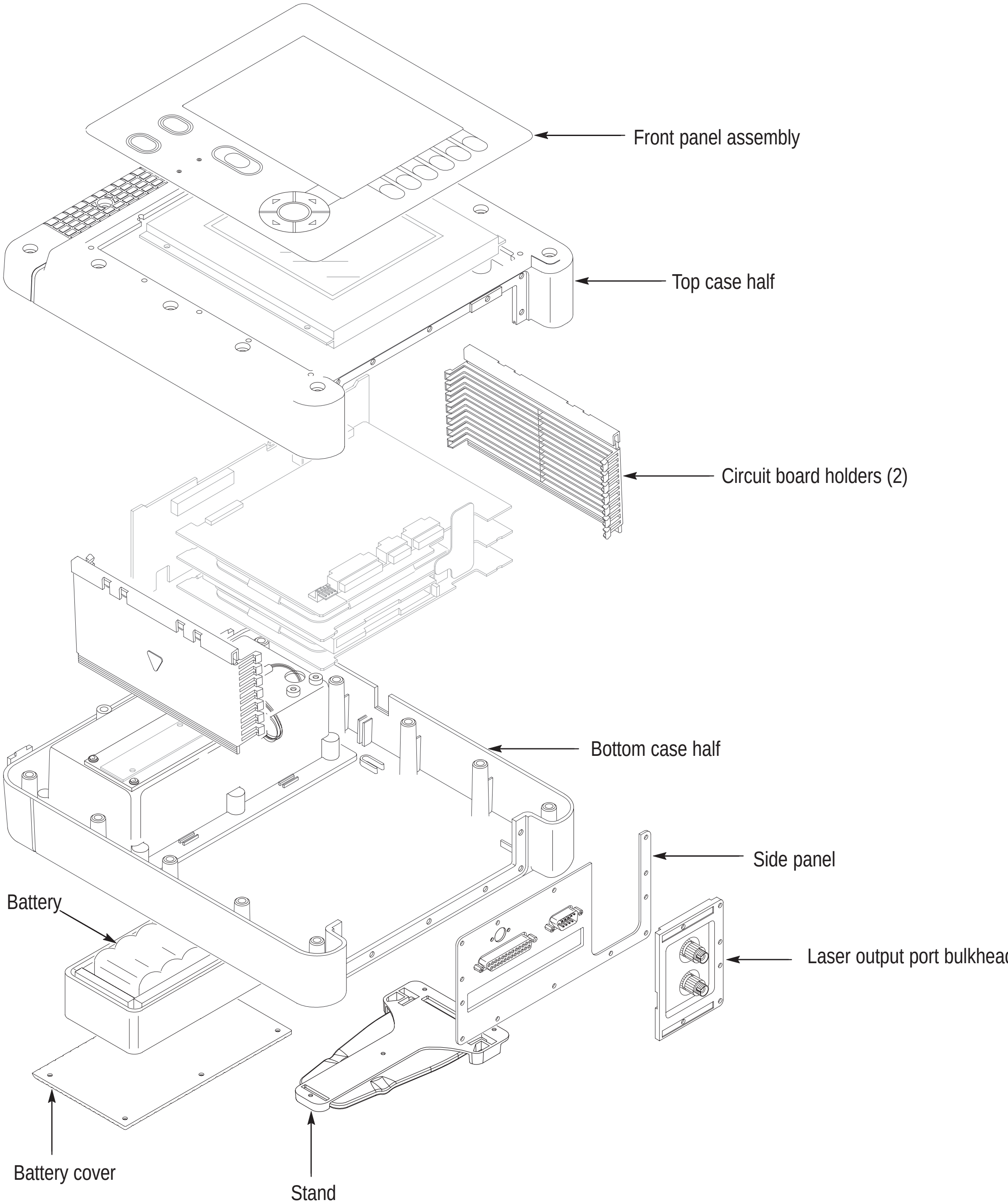
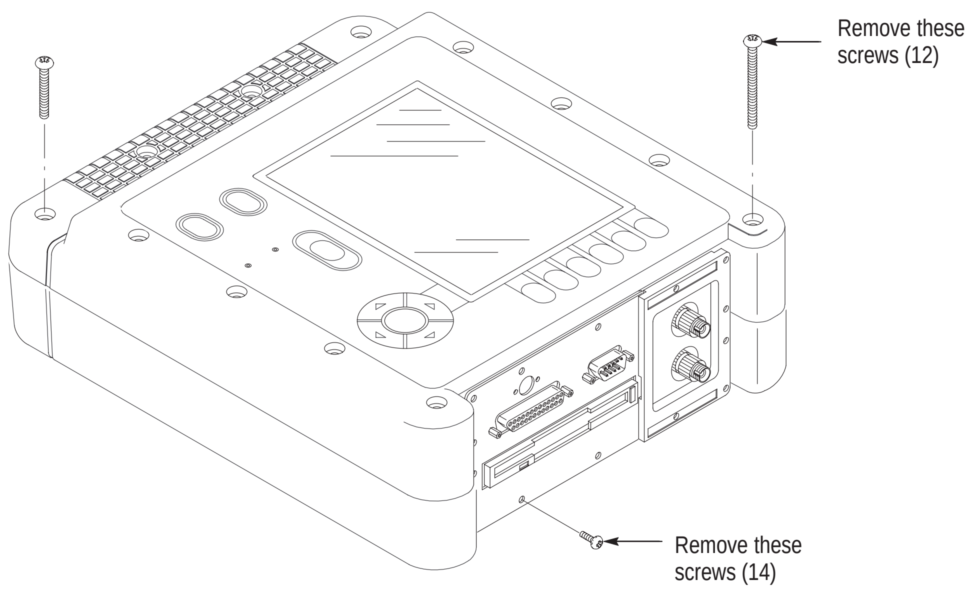


Figure 5–6: Mechanical Parts Locator (Electrical Modules are Dimmed and Included for Reference Only)

Disassembly Procedure

1. Turn off the TFS3031 and disconnect the power/charger adapter. Leave the battery in its compartment. *The battery is not removed during disassembly.*
2. Use the Torx T10 screwdriver to remove 14 screws that hold the side panel (including Laser Output port bulkhead) to the top and bottom case halves.

   Do not separate the side panel and Laser Output port bulkhead from the case halves at this time. Remove the screws only.
3. Use the 1-point Pozidrive screwdriver to remove 12 screws that attach the top case half to the bottom case half.



Reassembly Notes

During reassembly, torque the 12 Pozidrive screws to 7 inch-pounds. *Do not* add Locktite.

Note the locations of the four 1-inch screws and eight 2-inch screws that attach the case halves. Do not mix the different size screws.

Add Loctite 242 to the Allen or torque screws on the side panel and torque to 2.5 inch-pounds.

4. To separate the top and bottom case halves, do the following in sequence:

   a. Carefully lift the top case half just enough to disconnect the cable that connects the Display module to the MAIN31 board.

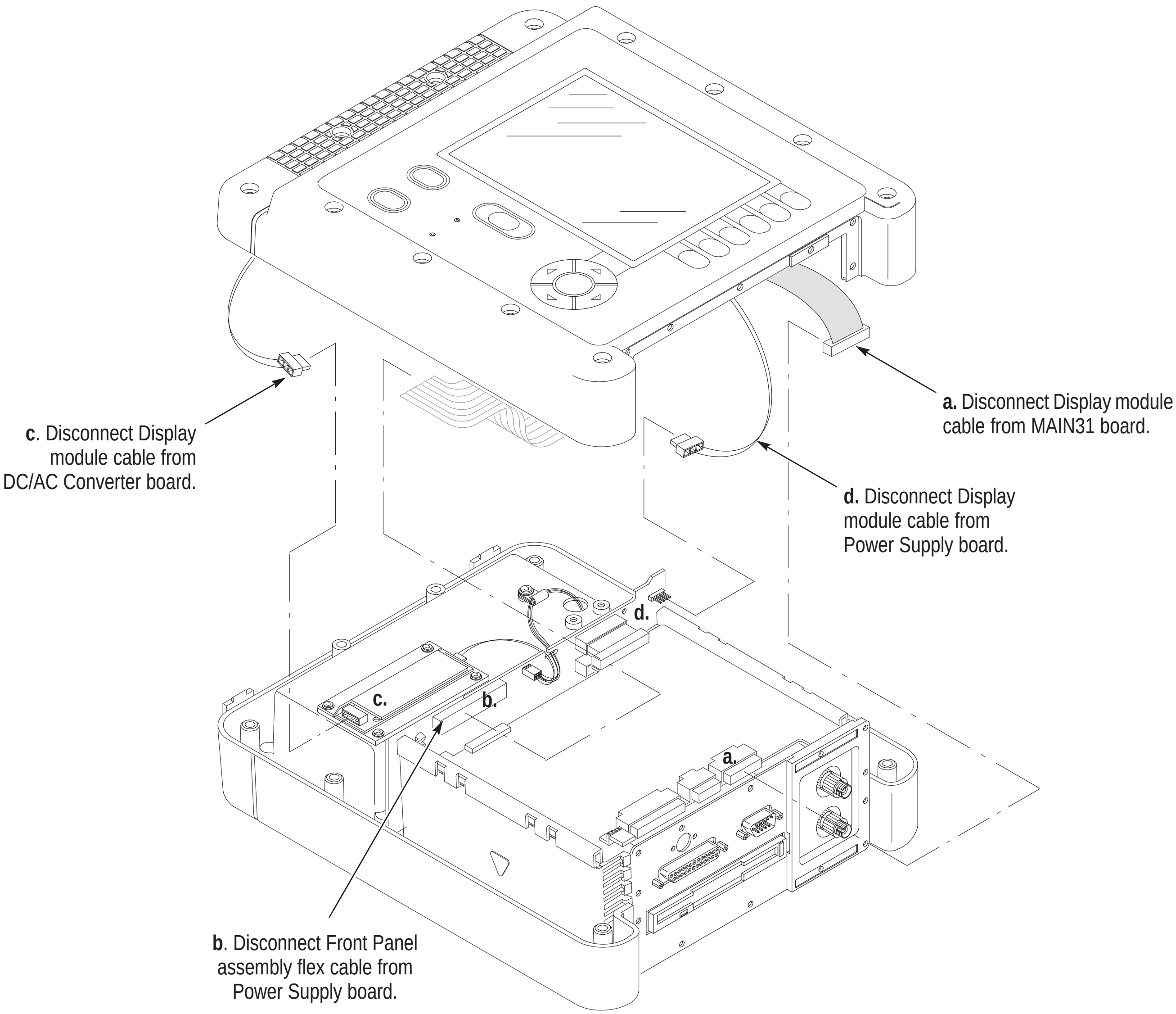
   b. Continue to lift the top case half and disconnect the Front Panel assembly flex cable from the Power Supply board by using your thumb and forefinger to pull out on the connector on the Power Supply board.

      Note for reassembly that this connector has two, small alignment/locking pins that fit the alignment holes in the flex cable.

   c. Disconnect the cables that connect the Display module to the DC/AC Converter board.

   d. Disconnect the power-supply temperature-sensor cable from the back of the display (not seen in this view).

   e. Lift the top case half clear of the unit and set it aside for now.


a. Disconnect Display module cable from MAIN31 board.
c. Disconnect Display module cable from DC/AC Converter board.
d. Disconnect Display module cable from Power Supply board.
d.
c.
b.
a.
b. Disconnect Front Panel assembly flex cable from Power Supply board.

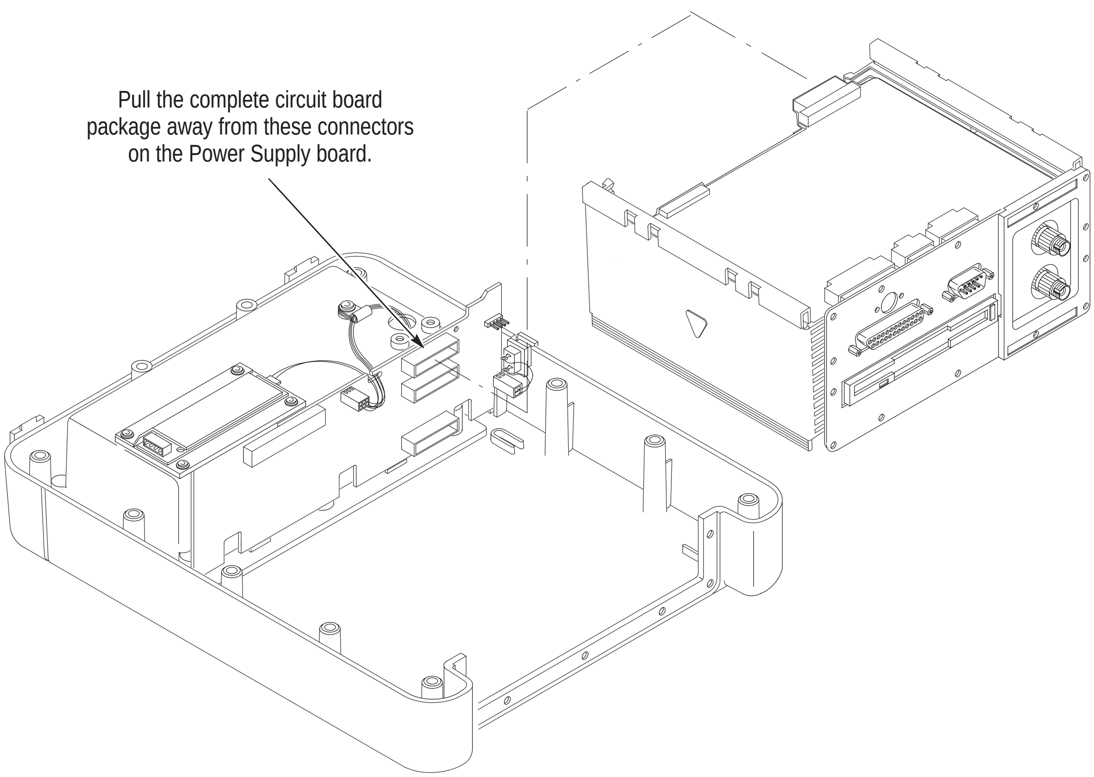
5. All electrical modules are now fully exposed as a unit.

As a unit, lift the Multimode Optical Module assembly, Singlemode Optical Module assembly, MAIN31 board, and side panel (containing the Optical Output ports) out of the bottom case half by carefully pulling the complete unit out and away from their connectors on the Power Supply board.

***NOTE**. If there are two optical module assemblies installed, the multimode assembly will be in the lower port position and singlemode assembly in the upper port position (under the MAIN31 board which is in topmost position).*

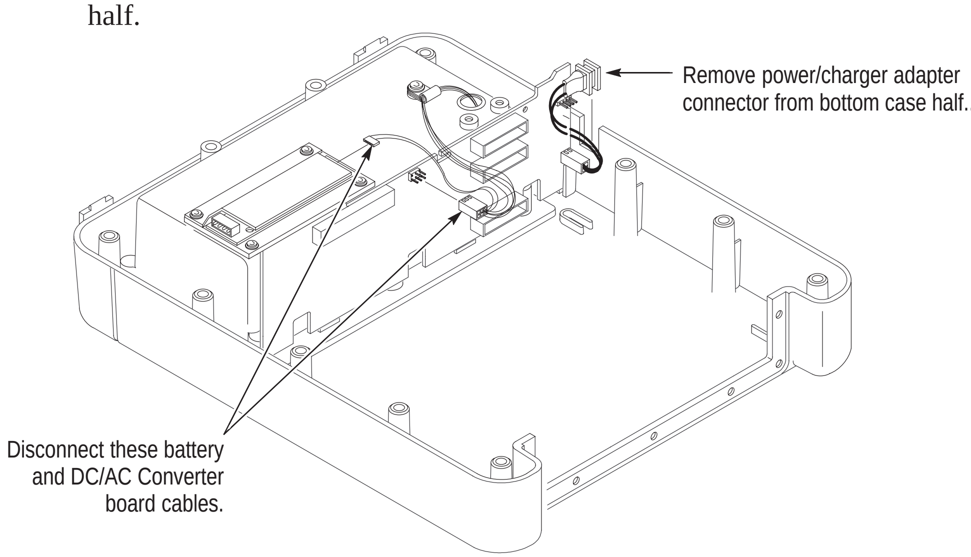
If only one optical module assembly is installed, it will always be in the lower port position whether it is singlemode or multimode.

The floppy disk drive is always mounted on the optical module assembly in lower port position.



6. Slide the power/charger adapter connector out from its groove in the bottom case half.

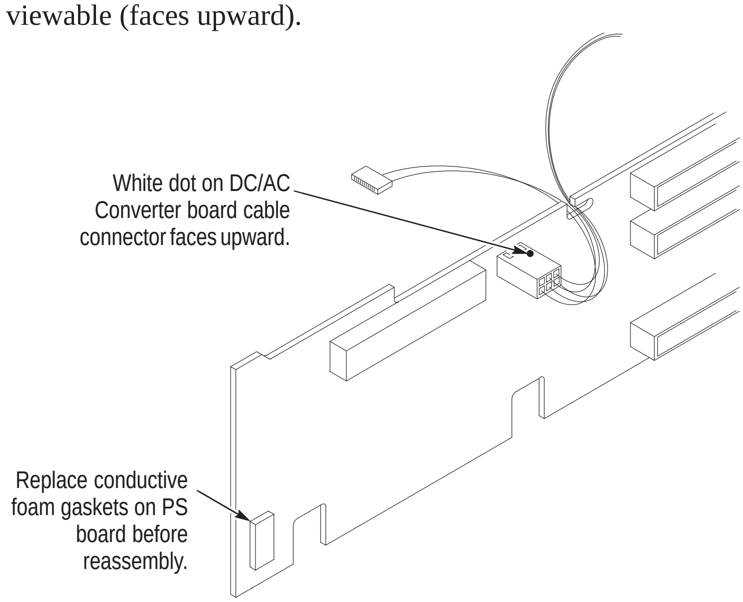
   Disconnect the cables that connect the Power Supply board to the battery and DC/AC Converter board. Lift the Power Supply board out of the bottom case half.



Reassembly Notes

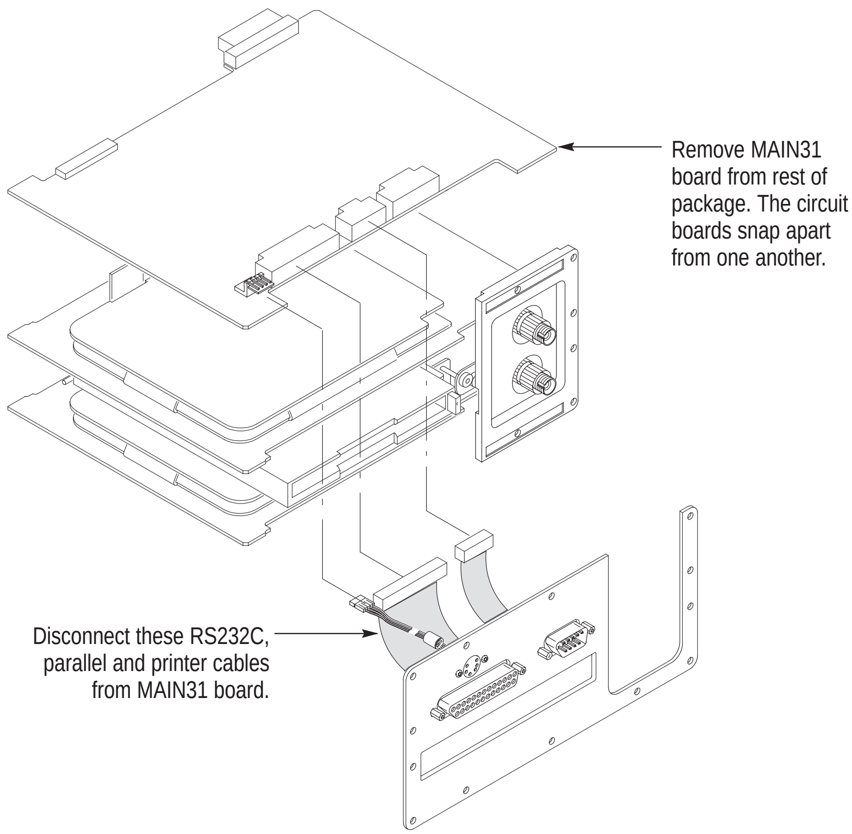
During reassembly, make sure that the O–ring is in place on the power/charger adapter connector. The O–ring seals against dust and moisture.

Make sure the DC/AC Converter board cable connector that attaches to the Power Supply board is oriented in its socket so that the white dot under pin #1 is viewable (faces upward).



7. Carefully separate the side panel from the Laser Output port bulkhead and the other circuit boards by disconnecting the RS232C serial and parallel printer cables from their connectors on the MAIN31 board.

Remove the MAIN31 board.

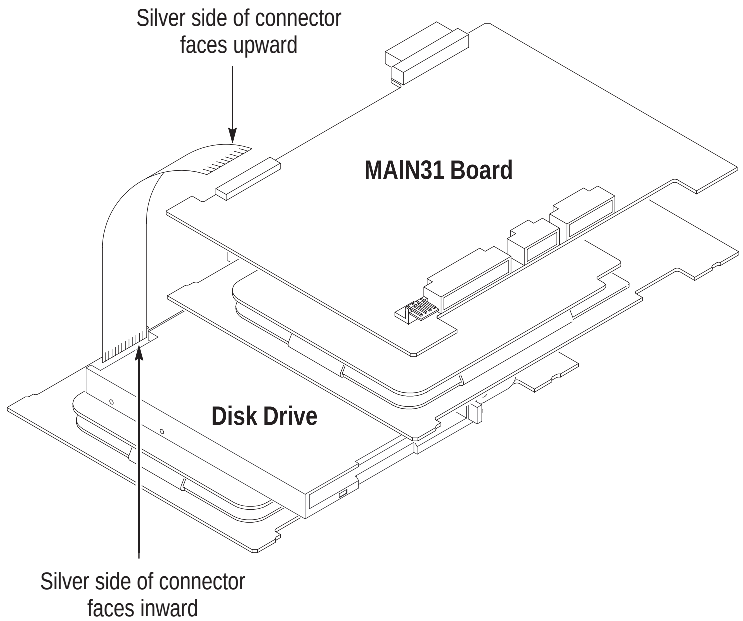


Reassembly Notes

It is not normally necessary to remove the nuts that attach the RS232C serial and parallel cables to the side panel. However, if this is done, use a $^{1}/_{8}$ inch nut driver. During reassembly, torque these nuts to 5 pounds and add Locktite #242.

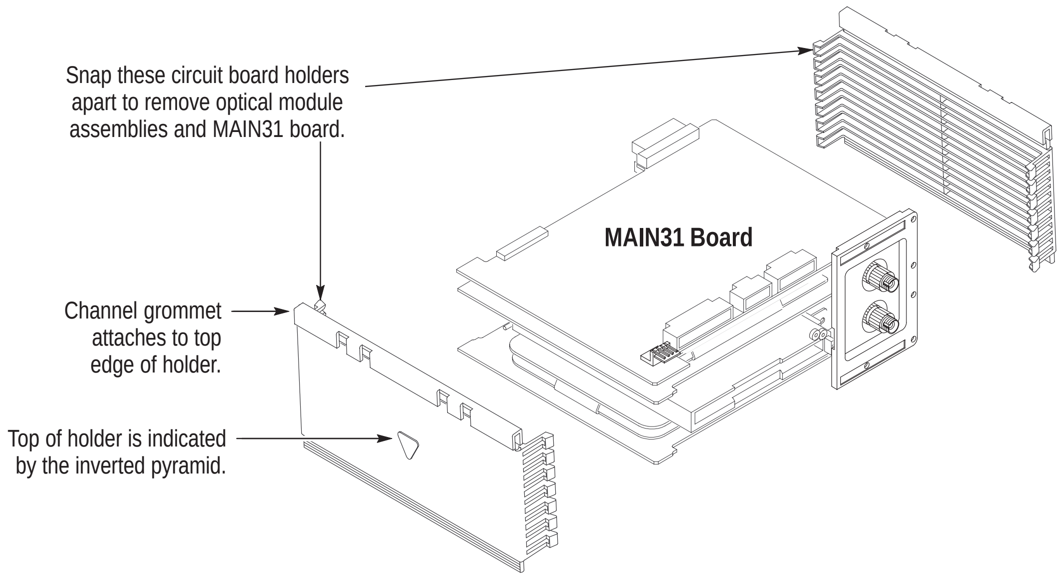
Also, clean the backs of the connectors with alcohol before re–sticking the EMI pads attached to the cables back in place on the connectors.

If the cable that connects the MAIN31 board to the floppy disk drive is removed, note for reassembly that the ‘‘silver’’ side of the connectors are oriented in their sockets as shown in this illustration:



8. Snap the circuit board holders apart to access the the optical module assemblies and MAIN31 board.

CAUTION. *The fiber organizers are mounted on top of the optical module assemblies. Do not attempt to remove the fiber organizers. Severe damage can result which will void the warranty.*



Reassembly Notes

If the channel grommets are removed from the circuit board holders during disassembly, at reassembly glue the channel grommets back in place with Loctite #414.

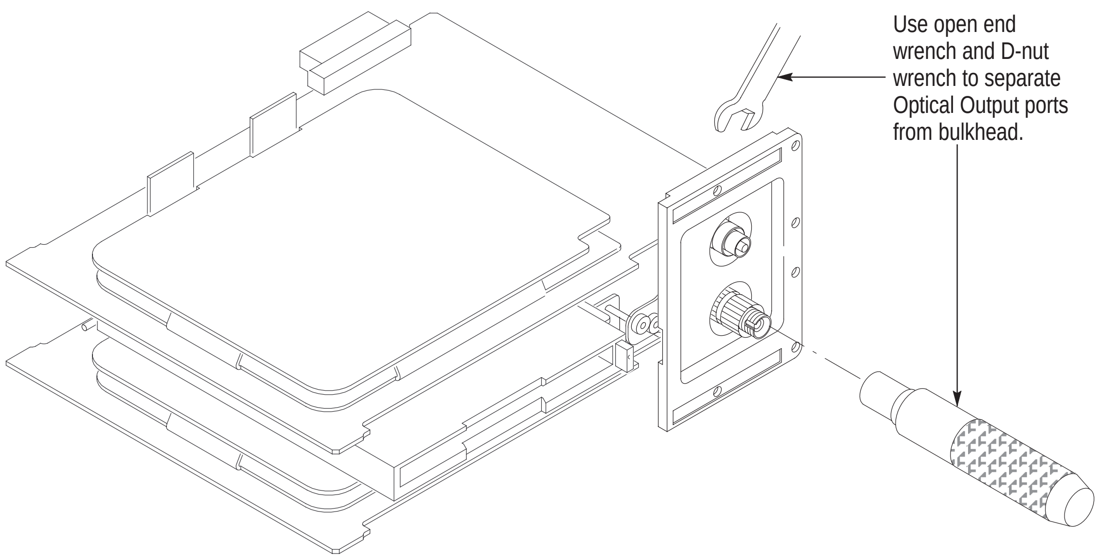
Note for reassembly the orientation of the circuit board holders. The channel grommet are on top. The top edge is indicated by an inverted pyramid (∇) embossed on the outside of the holder.

9. Use the 11 mm D-nut wrench and 14 mm open-end wrench to separate the Singlemode Optical Module Laser Output port from its bulkhead. Then separate the module from the rest of the circuit board package.

Repeat this procedure to remove the Multimode Optical Module Laser Output port from its bulkhead.

***NOTE**. If a connector adapter is installed on the Optical Output port, remove the connector adapter before using the D–nut wrench.*

***CAUTION.** Do not put unnecessary stress on the optical fibers or bulkhead. Rough handling can damage the fibers.*



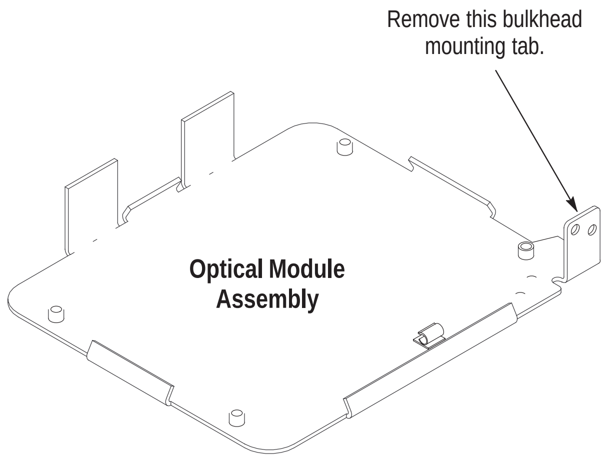
Reassembly Notes

New Optical Module Assembly in Upper Port Position

When replacing the optical module assembly located in the *upper* port position with a new assembly, the bulkhead mounting tab on the new assembly must be removed to allow mounting room.

If the bulkhead mounting tab is a part of the optical module assembly casting, use pliers (or your fingers) to bend the bulkhead mounting tab back and forth to break it off.

If the bulkhead mounting tab is attached to the optical module assembly with two screws, remove the screws.



Reassembly Notes

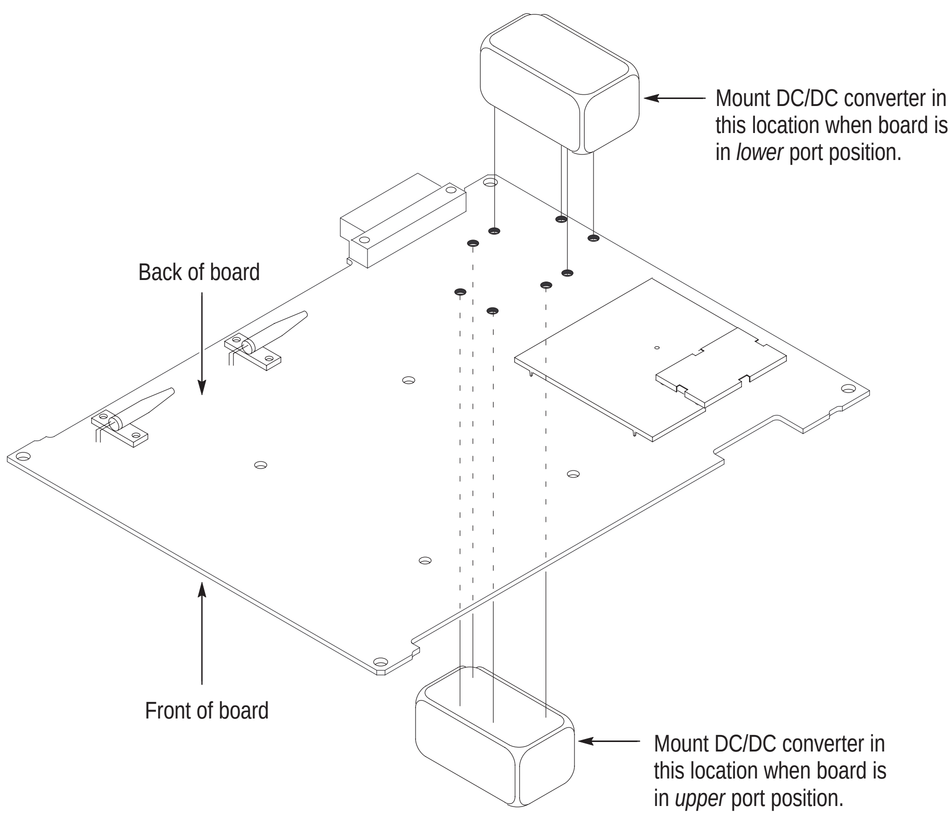
DC/DC Converter Mounting

If the optical module assembly is located in the *lower* port position, the DC/DC converter is mounted on the *back* of the board (facing upward). This applies to all multimode assemblies and single-port singlemode assemblies.

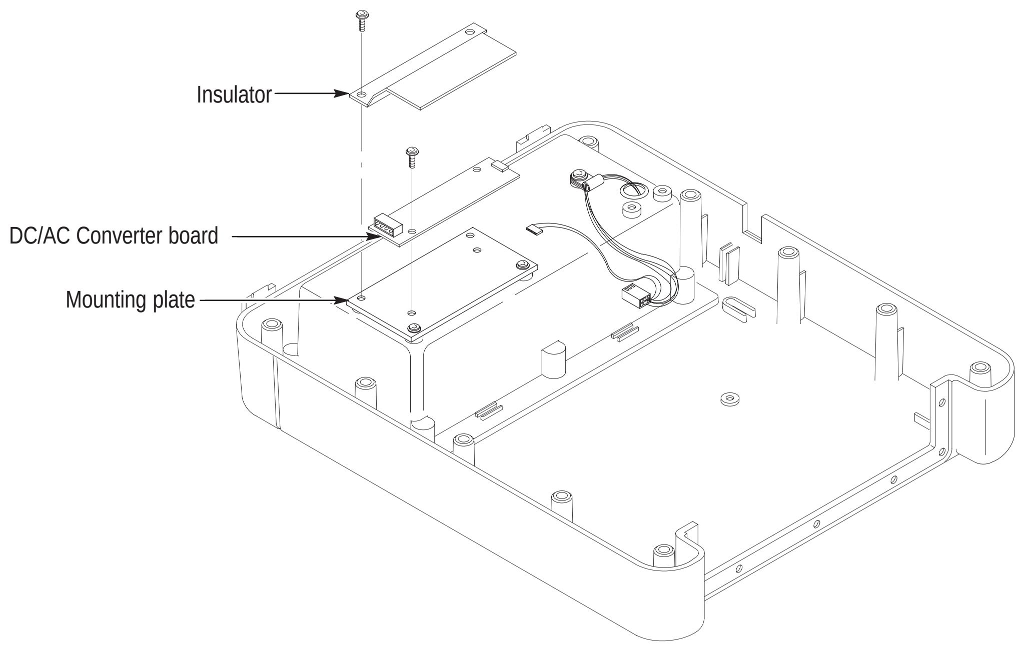
If the optical module assembly is located in the *upper* port position, the DC/DC converter is mounted on the *front* of the board (facing downward). This applies to all dual-port singlemode assemblies.

Use soldering/desoldering equipment to remount the DC/DC converter.

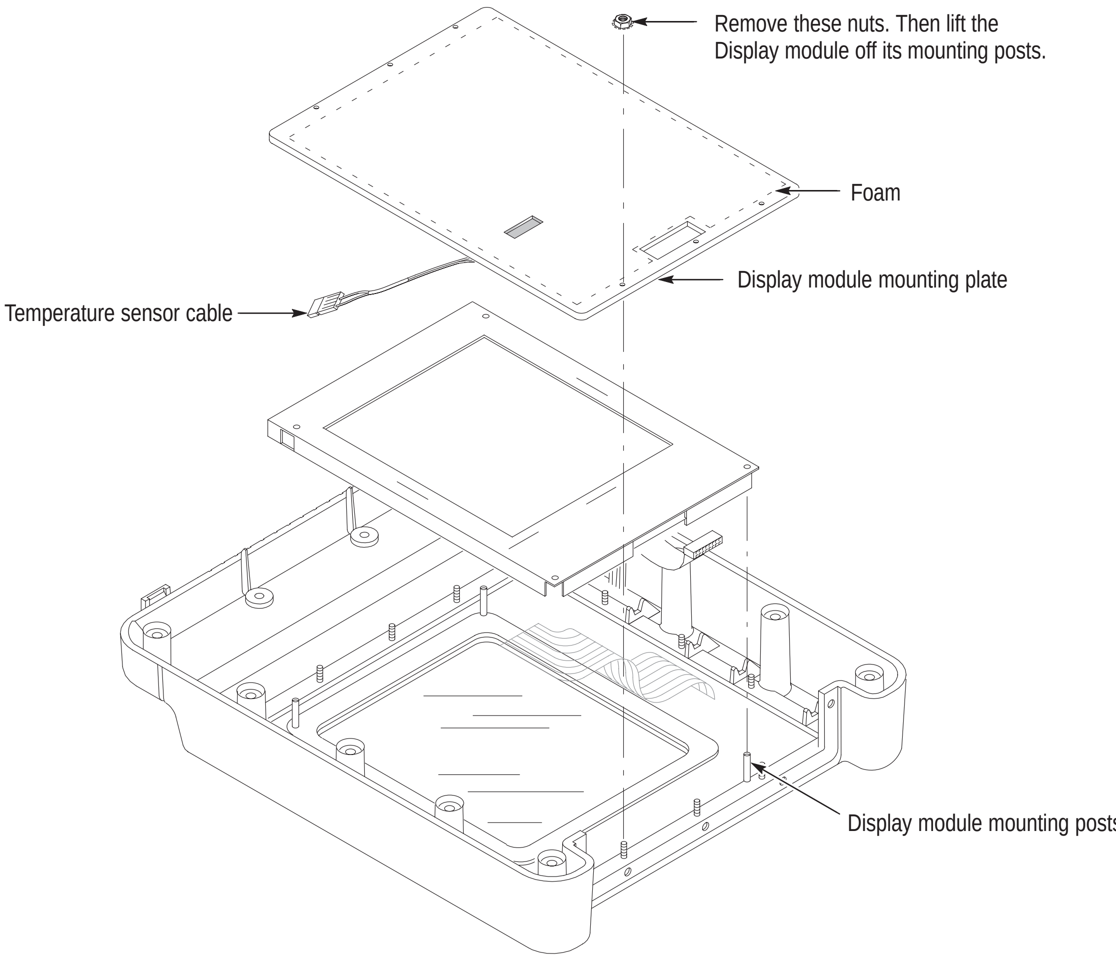
***NOTE**. The back-board and front-board mounting holes for the DC/DC converter are in a different location on the board.*



10. To remove the DC/AC Converter board from the bottom case half, remove two screws that hold the insulator to its mounting plate on the bottom case half. Then remove two screws that attach the DC/AC Converter board.

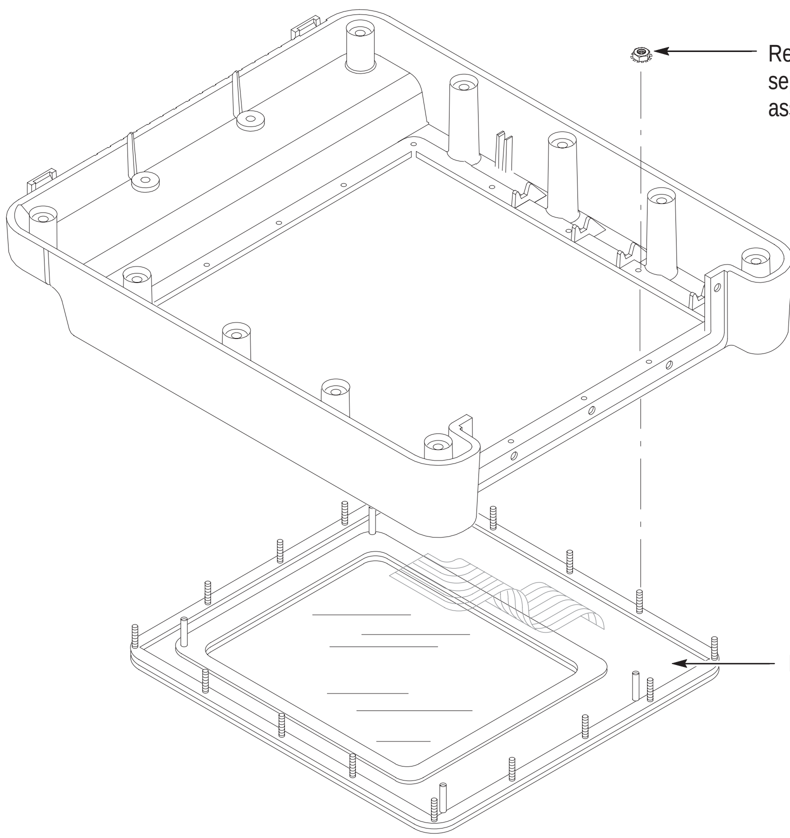


11. To separate the Display module from the Front Panel assembly, use the $^3/_{16}$ inch nut driver to remove 6 nuts that hold the Display module mounting plate. Then lift the Display module off its mounting posts.



Reassembly Notes During reassembly, torque these nuts to 3 pounds and add Locktite #242.

12. To separate the Front Panel assembly from the top case half, use the $^{1}/_{4}$ inch nut driver to remove 10 nuts that hold them together.



Reassembly Notes *During reassembly, torque these nuts to 5 pounds. Do not add Locktite.*

13. To remove the floppy disk drive:

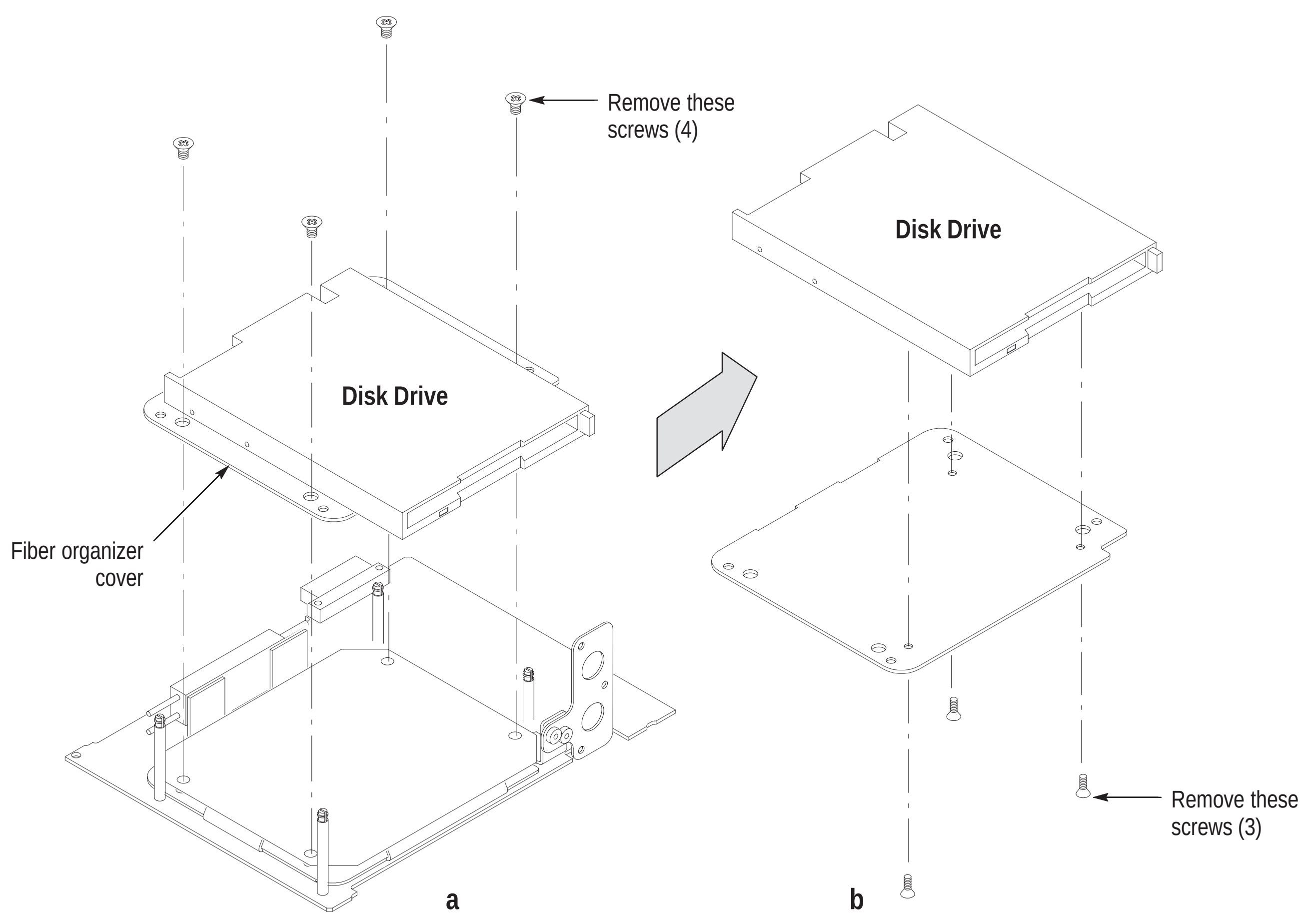
a. The disk drive is mounted on top of the fiber organizer cover. Use the 1-point Posidrive screwdriver to remove 4 screws that hold the fiber organizer cover.

CAUTION. *When the fiber organizer cover is removed, be extremely careful not to touch the fiber or clear plastic sheeting that covers the fiber. Severe damage can result which will void the warranty*

b. Remove 3 screws that hold the disk drive to the fiber organizer cover.

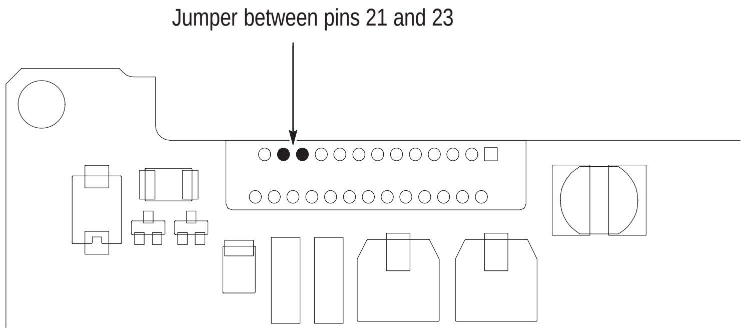
To protect the fiber, put the fiber organizer cover back on the fiber organizer if the fiber will remain exposed for any length of time.

The disk drive is replaceable only and cannot be repaired.



Reassembly Notes

The Panasonic disk drive requires a solder jumper between pins 21 and 23 of the Main31 board disk-drive connector. The TEAC disk drives do not require this jumper. If you are installing a Panasonic disk drive, locate the disk-drive connector on the MAIN31 board. Make there is a solder jumper between pins 21 and 23. If not, place one between pins 21 and 23 as shown below.



Main31 circuit board front view

Troubleshooting

This section explains how to resolve problem messages that may be displayed by the TFS3031.

Static-Sensitive Components

CAUTION. *All modules in the TFS3031 contain components that are sensitive to electrostatic discharge (ESD)*

When servicing the TFS3031, work only at a static-free work station, and practice standard anti-static handling procedures.

No Power-On

If the TFS3031 will not power on properly, the most likely cause is a discharged battery, faulty battery, or faulty Power Supply or DC/AC Converter board.

Typical indications of a power problem are:

- Low-battery warning message on screen.
- Random, horizontal lines across a black screen.
- Low backlight.
- Blank or dim display.

To solve a power problem, first try to recharge the battery or power the TFS3031 with the power/charger adapter alone. If the power problem persists, replace in order the:

1. Battery
2. Power/charger adapter
3. Power Supply board
4. DC/AC Converter board

If the TFS3031 will not power on when the battery is fully charged, disconnect the battery cable. Then wait for 1 minute, reconnect the battery cable, and power-on the instrument.

Error Message Resolution

Front Panel Connection Status

If a message involving the status of the front panel connection appears on the screen after pushing the START/STOP button, follow directions in the message.

Self Test Error Messages

If any of the following error messages occur during power on, try powering the TFS3031 off and on again before proceeding with possible solutions.

Error Message	Description	Possible Solutions
Real Time Clock Communication Error	Unable to establish communication with real-time clock.	Replace the MAIN31 board.
Nonvolatile Memory Was Reinitialized	Checksum error on nonvolatile memory. Nonvolatile parameters are reset to factory defaults.	Power TFS3031 off then on again. If the failure repeats replace the MAIN31 board.
Video Ram Access Error	Error during initial video RAM access. Unable to guarantee LCD image.	Replace the MAIN31 board.
LCD Controller Error	Error during LCD controller initialization/setup. Unable to guarantee LCD operation.	Replace the MAIN31 board.
Power Supply Processor Error	Unable to establish communication link with power supply processor. Unable to guarantee keyboard operation.	Replace the Power Supply board. If the failure repeats replace the MAIN31 board.
Upper/Lower Optics Module Communication Error	Unable to establish communication link with upper or lower port processor.	Replace the upper or lower optical module assembly.[1]
No Optics Module Installed	No optical module assembly installed in the instrument.[1]	If an optical module assembly is installed, power the TFS30301 off and on again. If the failure repeats, replace the MAIN31 board.
Storage FLASH file System 0 Error	Error in FLASH memory file system internals.	Reformat internal storage by powering the TFS3031 off and on again. If the failure repeats replace the MAIN31 board.
Upper/Lower Optics Module Unknown Option Type	Optical module assembly reported unknown option type to MAIN 31 board.[1]	If the correct optical module assembly is installed, power the TFS30301 off and on again. Verify option jumpers on optical module are set correctly. If the failure repeats replace the MAIN31 board.
Cannot Read Calibration File	Could not read the calibration file.	Power the TFS3031 off and on again. If the failure repeats replace the MAIN31 board.

Error Message	Description	Possible Solutions
Keyboard Processor Error	Unable to establish communication with keyboard processor.	Disconnect keyboard if attached. Power the TFS3031 off and on again. If the failure repeats replace the MAIN31 board.
Keyboard uses excessive current. Keyboard is disabled.	External keyboard is drawing more than 500 mA. Power to the keyboard has been disabled.	Disconnect keyboard if attached. Power the TFS3031 off and on again. If the failure repeats replace the MAIN31 board.
Warning – Using Default Calibration File	The factory internal calibration procedure has not been done, or there is a FLASH memory problem.	Perform “CALS” on the TFS3031, then power the TFS3031 off and on again. If the failure repeats replace the MAIN31 board.
Storage FLASH File System 011 Error	Unable to format FLASH memory as a floppy disk.	Power the TFS3031 off and on again. If the failure repeats replace the MAIN31 board.

[1] Optical Module assembly includes the multimode (MMDAS) or singlemode (SMDAS) board and its optical module.

Miscellaneous Problems

Problem	Possible Solutions
TFS3031 will not power off.	Reseat Front Panel assembly to Power Supply board. If the failure repeats, disconnect battery for one minute, then reconnect. If the failure repeats, replace the Power Supply board. If failure repeats, replace the Front Panel assembly.
TFS3031 will not power on when the battery is fully charged.	Reseat Front Panel assembly to Power Supply board. If the failure repeats, disconnect the battery cable for one minute, then reconnect the cable. If the failure repeats, replace the Power Supply board.
LCD is on but the backlight is off.	Check that cables are plugged in and not pinched. Make sure the backlight parameter is *not* set to OFF. If the failure repeats, replace the backlight inverter module.
LCD has missing pixels, or some pixels stay lit continuously.	Reseat LCD module to main cable. If the failure repeats, replace the LCD module. If the failure repeats, replace the MAIN31 board.
Battery not fully charged after five hours of recharging at room temperature with the TFS3031 powered off.	Replace the battery. If the failure repeats replace the Power Supply board.
TFS3031 does not respond to button or key pushes.	Reseat Front Panel assembly to Power Supply board. If the failure repeats, disconnect the battery for one minute, then reconnect. Verify that the keypad cable is properly connected to the Power Supply board. If the failure repeats, replace the Front Panel assembly. If failure repeats replace Power Supply board.

TFS3031 reports repeated timeout errors while communicating with the optical module assembly during testing.[1]	Reseat the board interconnects. If the failure repeats replace the optical module assembly. If the failure repeats again replace the Power Supply board. If the failure repeats again, replace the MAIN31 board.
TFS3031 reports a low measurement range.	Clean the fiber connection. If the failure repeats replace the optical module assembly.[1]

[1] Optical Module assembly includes the multimode (MMDAS) or singlemode (SMDAS) board and its optical module.

Battery Charge Current Check

Equipment Required

- Oscilloscope with current probe and amplifier that has a >1 amp range and ±10% accuracy. Example is a Tektronix AM503S current probe.

Current Check Procedure

1. Disconnect the TFS3031 from the power/charger adapter.
2. Discharge the battery by operating the TFS3031 exclusively on battery power until it stops operating. The instrument automatically turns off when the battery is fully discharged.
3. Remove the battery from the battery compartment. *Do not disconnect the battery cable or connectors*.

   If necessary, see page 1–15 for battery removal instructions.
4. Attach the current probe to battery wire #2.
5. Set the current probe to measure 1 amp current, 200 mA range, full bandwidth, and DC coupled.
6. Set the oscilloscope for 10 mv/div, 50 ohms, DC coupled.
7. Plug the power/charger adapter into the TFS3031. *Do not power on the TFS3031.*
8. On the oscilloscope, verify that the charging current is about 960 mA.
9. Power on the TFS3031 and allow it to initialize and stabilize.
10. Verity that the charging current is about 660 mA.

***NOTE**. Charging currents of 100 ma and 330 mA may be observed assuming a good battery and Power Supply board, and depending on battery charge condition and ambient temperature.*

11. Power off the TFS3031, remove the fiber test fixture, and reinstall the battery in its compartment.

Replaceable Parts

This section contains a list of the replaceable modules for the TFS3031. 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 instruments are sometimes made to accommodate improved components as they become available and to give you the benefit of the latest circuit improvements. Therefore, when ordering parts, it is important to include the following information in your order.

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

If 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.

Module Servicing

Modules can be serviced by selecting one of the following three 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.

Module Repair and Return. You may ship your module to us for repair, after which we will return it to you.

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 TFS3031. Use this list to identify and order replacement parts. The following table describes each column in the parts list.

Parts List Column Descriptions

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.
7	Mfr. Code	This indicates the code of the actual manufacturer of the part.
8	Mfr. Part Number	This indicates the actual manufacturer's or vendor's part number.

Abbreviations

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

Mfr. Code to Manufacturer Cross Index

The table titled Manufacturers Cross Index shows codes, names, and addresses of manufacturers or vendors of components listed in the parts list.

Manufacturers Cross Index

Mfr. Code	Manufacturer	Address	City, State, Zip Code
TK2174	TETON MACHINE CO	1600 VALLEY RD	PAYETTE ID 83661
TK2383	PANASONIC INDUSTRIAL CO	1600 MC CANDLASS DR	MILPATAS, CA 95035
TK2453	TOKO AMERICA, INC	2480 NORTH 1ST STREET,SUITE 260	SAN JOSE, CA 95131–1014
TK2491	RIFOCS CORPORATION	833 FLYN ROAD	CAMARILLO, CA 93010
TK2531	BROOKWAY CORP	PO BOX 650	WILSONVILLE OR 97070
TK2539	ROYAL CASE CO INC	315 SOUTH MONTGOMERY PO BOX 2231	SHERMAN TX 75091–2231
TK2545	ORNELAS ENTERPRISES INC	2900 SW 219TH AVE SUITE 443	HILLSBORO OR 97123
0B0A9	DALLAS SEMICONDUCTOR CORP	4350 BELTWOOD PKWY SOUTH	DALLAS, TX 75244
0DWW6	MICRO POWER ELECTRONICS	7973 SW CIRRUS DRIVE BLDG. #22	BEAVERTON OR 97005
0J4Z2	PRECISION PRINTERS	964 GOLDEN GATE TERRACE	GRAND VALLEY, CA 95945
0J7N9	MCX INC	30608 SAN ANTONIA ST	HAYWARD CA 94544
0J9P4	DELTA ENGINEERING	19500 SW TETON	TUALATIN OR 97062
0JRZ5	GASKET TECHNOLOGY	23605 NE HALSEY SUITE A	TROUTDALE OR 97060
0KB01	STAUFFER SUPPLY	810 SE SHERMAN	PORTLAND OR 97214
0KB05	NORTH STAR NAMEPLATE	5750 NE MOORE COURT	HILLSBORO OR 97124–6474
0KBZ5	MORELLIS Q & D PLASTICS	1812 16TH AVE	FOREST GROVE OR 97116
00779	AMP INC	2800 FULLING MILL PO BOX 3608	HARRISBURG PA 17105
06915	RICHCO PLASTIC CO	5825 N TRIPP AVE	CHICAGO IL 60646–6013
2K262	BOYD CORP	6136 NE 87TH AVE PO BOX 20038	PORTLAND OR 97220
3M099	PORTLAND SCREW CO	6520 N BASIN ST	PORTLAND OR 97217–3920
5H194	AIR–OIL PRODUCTS CORP (DIST)	2400 E BURNSIDE	PORTLAND OR 97214–1752
50356	TEAC AMERICA INC	7733 TELEGRAPH ROAD PO BOX 750	MONTEBELLO CA 90640–6537
53387	3M COMPANY ELECTRONIC PRODUCTS DIV	3M AUSTIN CENTER	AUSTIN TX 78769–2963
53421	TYTON CORPORATION	7930 N FAULKNER ROAD PO BOX 23005	MILWAUKEE WI 53223
55335	JKL COMPONENTS CORP	13343 PAXTON STREET	PACOIMA CA 91331
7X318	KASO PLASTICS INC	11015 A NE 39TH	VANCOUVER WA 98662
70485	ATLANTIC INDIA RUBBER WORKS INC	571 W POLK ST	CHICAGO IL 60607
77824	SCHLEGEL CORP	1555 JEFFERSON RD PO BOX 23197	ROCHESTER, NY 14692–3113
79136	WALDES KOHINOOR INC	47–16 AUSTEL PLACE	LONG ISLAND CITY NY 11101–4402
80009	TEKTRONIX INC	14150 SW KARL BRAUN DR PO BOX 500	BEAVERTON OR 97077–0001
85471	BOYD CORP	13885 RAMOMA AVE	CHINO CA 91710

Replaceable Parts List

Assy Number	Tektronix Part Number	Serial No. Effective	Serial No. Discont'd	Qty	Name & Description	Mfr. Code	Mfr. Part Number
					TFS3031 ELECTRICAL ASSEMBLIES		
A1	119–4821–00	B010100	B029999		DISPLAY, MODULE: LCD	TK2453	119–4821–00
	119–5435–00	B030000			DISPLAY, MODULE: LCD	TK2569	LM64K103
A2					**OPTICAL MODULE ASSYS: MULTIMODE**		
	119–4951–00	B010100	B039999		OPTICAL MODULE W/CIRCUIT BOARD: **OPTION 01**	80009	119–4951–00
	119–4951–01	B040000	B052351		OPTICAL MODULE W/CIRCUIT BOARD: **OPTION 01**	80009	119–4951–01
	119–4951–02	B052351	B055064		OPTICAL MODULE W/CIRCUIT BOARD: **OPTION 01**	80009	119–4951–02
	119–4951–03	B055065	B055496		OPTICAL MODULE W/CIRCUIT BOARD: **OPTION 01**	80009	119–4951–03
	119–4951–04	B055497			OPTICAL MODULE W/CIRCUIT BOARD: **OPTION 01**	80009	119–4951–04
	119–4950–00	B010100	B039999		OPTICAL MODULE W/CIRCUIT BOARD: **OPTION 03**	80009	119–4950–00
	119–4950–01	B040000	B052351		OPTICAL MODULE W/CIRCUIT BOARD: **OPTION 03**	80009	119–4950–01
	119–4950–02	B052352	B054913		OPTICAL MODULE W/CIRCUIT BOARD: **OPTION 03**	80009	119–4950–02
	119–4950–03	B054914			OPTICAL MODULE W/CIRCUIT BOARD: **OPTION 03**	80009	119–4950–03
	119–4945–00	B010100	B020570		OPTICAL MODULE W/CIRCUIT BOARD: **OPTION 09**	80009	119–4945–00
	119–4945–01	B020571	B020708		OPTICAL MODULE W/CIRCUIT BOARD: **OPTION 09**	80009	119–4945–01
	119–4945–02	B020709	B039999		OPTICAL MODULE W/CIRCUIT BOARD: **OPTION 09**	80009	119–4945–02
	119–4945–03	B040000	B042151		OPTICAL MODULE W/CIRCUIT BOARD: **OPTION 09**	80009	119–4945–03
	119–4945–04	B042152			OPTICAL MODULE W/CIRCUIT BOARD: **OPTION 09**	80009	119–4945–04
A3					**OPTICAL MODULE ASSYS: SINGLEMODE**		
	119–4949–00	B010100	B020570		OPTICAL MODULE W/CIRCUIT BOARD: **OPTION 04**	80009	119–4949–00
	119–4949–01	B020571	B020708		OPTICAL MODULE W/CIRCUIT BOARD: **OPTION 04**	80009	119–4949–01
	119–4949–02	B020709	B039999		OPTICAL MODULE W/CIRCUIT BOARD: **OPTION 04**	80009	119–4949–02
	119–4949–03	B040000	B042151		OPTICAL MODULE W/CIRCUIT BOARD: **OPTION 04**	80009	119–4949–03
	119–4949–04	B042152	B052557		OPTICAL MODULE W/CIRCUIT BOARD: **OPTION 04**	80009	119–4949–04
	119–4949–05	B052558	B053496		OPTICAL MODULE W/CIRCUIT BOARD: **OPTION 04**	80009	119–4949–05
	119–4949–06	B053497			OPTICAL MODULE W/CIRCUIT BOARD: **OPTION 04**	80009	119–4949–06
	119–4947–00	B010100	B020570		OPTICAL MODULE W/CIRCUIT BOARD: **OPTION 06**	80009	119–4947–00
	119–4947–01	B020571	B020708		OPTICAL MODULE W/CIRCUIT BOARD: **OPTION 06**	80009	119–4947–01
	119–4947–02	B020709	B039999		OPTICAL MODULE W/CIRCUIT BOARD: **OPTION 06**	80009	119–4947–02
	119–4947–03	B040000	B042151		OPTICAL MODULE W/CIRCUIT BOARD: **OPTION 06**	80009	119–4947–03
	119–4947–04	B042152	B052557		OPTICAL MODULE W/CIRCUIT BOARD: **OPTION 06**	80009	119–4947–04
	119–4947–05	B052558	B053496		OPTICAL MODULE W/CIRCUIT BOARD: **OPTION 06**	80009	119–4947–05
	119–4947–06	B053497			OPTICAL MODULE W/CIRCUIT BOARD: **OPTION 06**	80009	119–4947–06
	119–4946–00	B010100	B020570		OPTICAL MODULE W/CIRCUIT BOARD: **OPTION 08**	80009	119–4946–00
	119–4946–01	B020571	B020708		OPTICAL MODULE W/CIRCUIT BOARD: **OPTION 08**	80009	119–4946–01
	119–4946–02	B020709	B039999		OPTICAL MODULE W/CIRCUIT BOARD: **OPTION 08**	80009	119–4946–02
	119–4946–03	B040000	B042151		OPTICAL MODULE W/CIRCUIT BOARD: **OPTION 08**	80009	119–4946–03
	119–4946–04	B042152	B049999		OPTICAL MODULE W/CIRCUIT BOARD: **OPTION 08**	80009	119–4946–04

Replaceable Parts List (Cont.)

Assy Number	Tektronix Part Number	Serial No. Effective	Serial No. Discont'd	Qty	Name & Description	Mfr. Code	Mfr. Part Number
	119–5509–00	B050000	B052557		OPTICAL MODULE W/CIRCUIT BOARD: **OPTION 10**	80009	119–5509–00
	119–5509–01	B052558	B053496		OPTICAL MODULE W/CIRCUIT BOARD: **OPTION 10**	80009	119–5509–01
	119–5509–02	B053497			OPTICAL MODULE W/CIRCUIT BOARD: **OPTION 10**	80009	119–5509–02
					TFS3031 ELECTRICAL ASSEMBLIES (con't)		
A3	119–6214–00				MODULE,OPTO;1625NM SM;TFS3031: **OPTION 12**	80009	119–6214–00
A4	671–3293–01	B010100	B020639		CIRCUIT BOARD ASSEMBLY: MAIN31	80009	671–3293–01
	671–3293–02	B020640	B021251		CIRCUIT BOARD ASSEMBLY: MAIN31	80009	671–3293–02
	671–3293–03	B021252	B029999		CIRCUIT BOARD ASSEMBLY: MAIN31	80009	671–3293–03
	671–3886–00	B030000	B042017		CIRCUIT BOARD ASSEMBLY: MAIN31	80009	671–3886–00
	671–3886–01	B042018	B052579		CIRCUIT BOARD ASSEMBLY: MAIN31	80009	671–3886–01
	671–3886–02	B052580	B052902		CIRCUIT BOARD ASSEMBLY: MAIN31	80009	671–3886–02
	671–4100–00	B052903			CIRCUIT BOARD ASSEMBLY: MAIN31	80009	671–4100–00
A5	671–3300–01	B010100	B019999		CIRCUIT BOARD ASSEMBLY: POWER SUPPLY	80009	671–3300–01
	671–3300–02	B020100	B020630		CIRCUIT BOARD ASSEMBLY: POWER SUPPLY	80009	671–3300–02
	671–3300–04	B020631	B029999		CIRCUIT BOARD ASSEMBLY: POWER SUPPLY	80009	671–3300–04
	671–3887–00	B030000	B031710		CIRCUIT BOARD ASSEMBLY: POWER SUPPLY	80009	671–3887–00
	671–3887–01	B031711	B049999		CIRCUIT BOARD ASSEMBLY: POWER SUPPLY	80009	671–3887–01
	671–3887–02	B050000			CIRCUIT BOARD ASSEMBLY: POWER SUPPLY	80009	671–3887–02
A6	119–5411–00				POWER SUPPLY: 2.2W,DC–AC CONVERTER	55335	BXA–12563

Replaceable Parts List (Cont.)

Fig. & Index Number	Tektronix Part Number	Serial No. Effective	Serial No. Discont'd	Qty	Name & Description	Mfr. Code	Mfr. Part Number
FIG 6–1					**CASE AND CONNECTOR PANEL ASSEMBLIES**		
–1	390–1135–01	B010100	B029999	1	CASE HALF, TOP:TFS3031	7X318	390–1135–01
	390–1135–02	B030000		1	CASE HALF, TOP:TFS3031	7X318	390–1135–02
–2	211–0882–00			4	MACHINE SCREW:6–32 X 1,TRUSS,BLK OXIDE	0KB01	211–0882–00
–3	333–4160–00	B010100	B029999	1	FRONT PANEL ASSY:TFS3031	0J4Z2	333–4160–00
	333–4160–01	B030000	B049999	1	FRONT PANEL ASSY:TFS3031	0J4Z2	333–4160–01
	333–4160–02	B050000	B053573	1	FRONT PANEL ASSY:TFS3031	0J4Z2	333–4160–02
	333–4160–03	B053574		1	FRONT PANEL ASSY:TFS3031	0J4Z2	333–4160–03
–4	211–0881–00			8	MACHINE SCREW:6–32 X 2,TRUSS HEAD,SS,BLK OXIDE	0KB01	211–0881–00
–5	348–1443–00			1	GASKET:BULKHEAD STRIP,1.7 X 0.32 X 0.031 W/PRESSURE	2K262	348–1443–00
–6	386–6892–00	B010100	B029999	1	PLATE,CMPNT,MTG:LCD MOUNTING,20 GAUGE SS	0J9P4	386–6892–00
	386–6892–01	B030000		1	PLATE,CMPNT,MTG:LCD MOUNTING,20 GAUGE SS	0J9P4	386–6892–01
–7	253–0437–00	B030000		.375'	TAPE,PRESS,SENS:0.080 THK,0.500 WIDE ACRYLIC FOAM	53387	253–0437–00
–8	361–1699–00	B010100	B029999	6	SPACER,SLEEVE:0.190 +/– 0.005,AL ALLOY	TK2174	361–1699–00
	361–1699–01	B030000		6	SPACER,SLEEVE:0.190 +/– 0.005,AL ALLOY	TK2174	361–1699–01
–9	386–6833–00	B010100	B029999	1	PANEL W/DISK DRIVE OPTION	0J9P4	386–6833–00
	650–3716–00	B030000		1	SIDE PANEL ASSY: W/DISK DRIVE OPTION, CABLES	0J7N9	650–3716–00
	386–6834–00	B010100	B029999	1	PANEL WITHOUT DISK DRIVE OPTION	0J9P4	386–6834–00
	650–3719–00	B030000		1	SIDE PANEL ASSY: WITH CABLES	0J7N9	650–3719–00
–10	211–0908–00			14	. CAP SCREW:4–40 X 0.375,BUTTON HD,HEX,SS,BLK	0KB01	211–0908–00
–11	253–0437–00			2	. TAPE,PRESSURE:0.080 IN THK,0.055 IN W,ACRYLIC FOAM	53387	253–0437–00
–12	200–4125–00			1	. CAP,DUST:PLASTIC ASSY	TK2545	200–4125–00
–13	200–4234–00			1	. CAP,DUST:ASSEMBLY (25 PIN CONN)	TK2545	200–4234–00
–14	131–0890–01			4	. CONN,HARDWARE:DSUB,JACK SCR,4–40 X 0.312 L HEX	00779	205818–2
	650–3739–00			1	BOTTOM CASE ASSEMBLY	7X318	650–3739–00
–15	342–1011–00			1	. INSULATOR,COVER:A6 BD,PHENOLIC IMPREG FELT	2K262	342–1011–00
–16	343–1502–00			1	. CLAMP,CABLE:0.188 ID X 0.25 W,0.141 MT HOLE,BLK	53421	NX1
–17	348–0005–00			1	. GROMMET,RUBBER:BLACK,ROUND,0.375 ID	70485	230X–36017
–18	386–6817–00			1	. PLATE,INTVERT:0.06 THK FR4 ECB MAT W/PRESSMT	0J9P4	386–6817–00
–19	348–1343–00			1	. PAD,CUSHIONING:BATT COVER,0.155 POLYURETHANE	2K262	348–1343–00
–20	354–0576–00			4	. PACKING,PREFMD:0.437 ID X 0.562 OD XSECT	5H194	2–013 P642 70
–21	348–0062–00			4	. FOOT,CABINET:NATURAL POLYURETHANE	0KBZ5	ORD BY DESCR
–22	211–0701–00			4	. SCREW,CAP:6–32 X 0.662,HEX SKT,SST	3M099	ORD BY DESCR
–23	211–0917–00			4	. SCREW,MACH:4–40 X 0.25,STL,PNH,TORX DR,BLK OXIDE	0KB01	211–0917–00

Replaceable Parts List (Cont.)

Fig. & Index Number	Tektronix Part Number	Serial No. Effective	Serial No. Discont'd	Qty	Name & Description	Mfr. Code	Mfr. Part Number
FIG 6–1					**CASE AND CONNECTOR PANEL ASSEMBLIES (con't)**		
–24	386–0082–00			1	. KICKSTAND,PLATE:LEXAN, GE 920A,GRAY	7X318	386–0082–00
–25	361–1639–00			1	. SPACER,BATTERY:POLYURETHANE,BLK W/PSA	2K262	361–1639–00
–26	348–1320–00			1	. GASKET,BTRY DOOR:0.062 PORON,7.38 X 3.98	2K262	348–1320–00
–27	650–3675–01			1	COVER, ASSEMBLY:BATTERY DOOR (INCLUDES THE ATTACHING HARDWARE)	7X318	650–3675–01
–28	211–0889–00			6	. THUMBSCREW:6–32 X 0.656,MACH,OXIDESLOTTED HD	0KB01	211–0889–00
–29	354–0759–00			6	. O–RING,RETAINING:#004	7X318	354–0759–00
–30	146–0112–00			1	BATTERY PACK;14.4,NICAD,2.8AH,2X6 ARRAY	0DWW6	101–595–1
–31	346–0272–00			1	STRAP,HANDLE:HAND/CARRY GRIP ASSY	TK2539	346–0272–00
–32	334–8893–02			1	MARKER,IDENT:LEXAN W/SPA	0KB05	334–8893–02
–33	334–5435–00			1	MARKER,IDENT:MKD CAUTION	0KB05	334–5435–00
–34	348–1340–00			2	PAD,CUSHIONING:PWR SUPP BD,POLYURETHANE W/SPA	2K262	348–1340–00
–35	354–0728–00			1	O–RING:0.062 +/– 0.005 DIA,BLK ETHYLENE PROPYLENE	0JRZ5	354–0728–00
–36	343–1593–00			1	CLAMP,CABLE:FLAT,ROUTING3.0 L X 0.5 W,ADHESIVE BACK	06915	FCC–16–3–RT

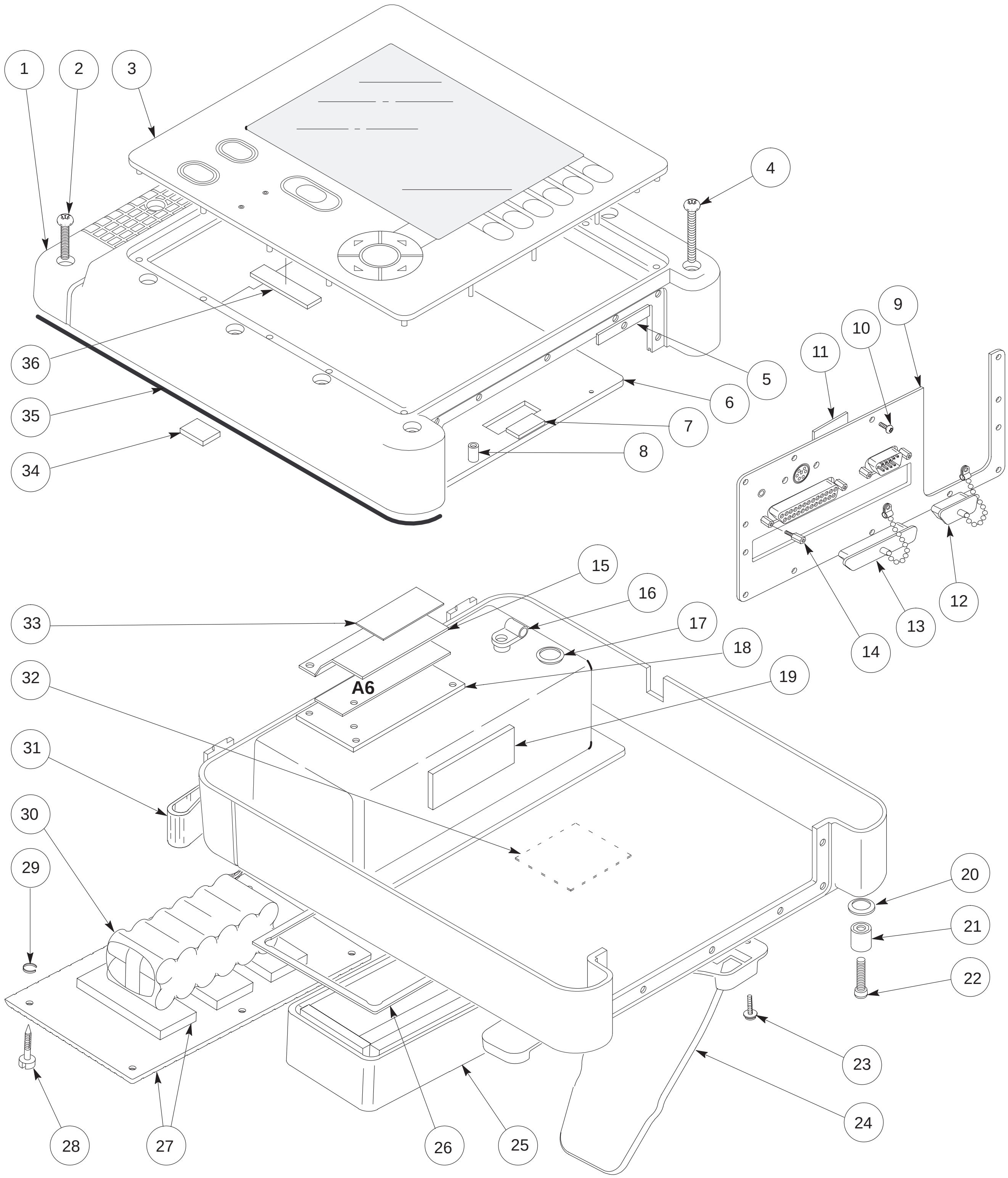


Figure 6–1: Case and Connector Panel Assemblies

Replaceable Mechanical Parts List

Fig. & Index Number	Tektronix Part Number	Serial No. Effective	Serial No. Discont'd	Qty	Name & Description	Mfr. Code	Mfr. Part Number
FIG 6–2					**OPTO-ELECTRICAL ASSEMBLIES: DUAL PORT**		
–1	––––– –––––			1	**A5** CIRCUIT BD ASSY:POWER SUPPLY (SEE ELECTRICAL ASSEMBLIES)		
–2	––––– –––––			1	**A6** POWER SUPPLY (SEE ELECTRICAL ASSEMBLIES)		
–3	––––– –––––			1	**A1** DISPLAY MODULE:LCD (SEE ELECTRICAL ASSEMBLIES)		
–4	––––– –––––			1	**A4** CIRCUIT BD ASSY:MAIN31 (SEE ELECTRICAL ASSEMBLIES)		
–5	361–1690–00			4	SPACER POST:SNAP–IN,SPACE 0.125,NYLON (DUAL PORT OPTIONS ONLY)	06915	MSP–2
–6	––––– –––––			1	**A3** OPTICAL MODULE ASSY:SINGLEMODE (SEE ELECTRICAL ASSEMBLIES)		
–7	361–1689–00			4	SPACER POST:SNAP–IN,SPACE 0.875,NYLON (DUAL PORT OPTIONS ONLY)	06915	MSP–2
–8	348–1439–00			1	O–RING:0.094 ID X 0.281 OD X 0.094 W,NITRIL (SINGLE PORT OPTIONS ONLY)	5H194	2–103N70
–9	200–4104–00			1	CAP,DUST:ELAY M75–M80 SHORE,BLACK MATT (SINGLE PORT ONLY)	TK2491	UT11–01
–10				—	**OPTION SPECIFIC BULKHEAD LABELS:**		
	334–8877–00			1	OPTION BLANK (SINGLE PORT OPTIONS ONLY)	0KB05	334–8877–00
	334–8881–00			1	850 MULTIMODE, OPT 01	0KB05	334–8881–00
	334–8878–00			1	850/1300 MULTIMODE, OPT 03	0KB05	334–8878–00
	334–8884–00			1	1310 SINGLEMODE, OPT 04	0KB05	334–8884–00
	334–8879–00			1	1310/1550 SINGLEMODE, OPT 06	0KB05	334–8879–00
	334–8882–00			1	1310/1550 SINGLEMODE EXTENDED, OPT 08, OPT 10	0KB05	334–8882–00
	334–8883–00			1	1550 SINGLEMODE EXTENDED, OPT 09	0KB05	334–8883–00
	335–0076–00			1	1625 SINGLEMODE, OPT 12	0KB05	335–0076–00
–11	––––– –––––			—	**OPTICAL BULKHEAD LABELS**		
	334–8875–00			1	DUAL PORT UNITS: MARKER,IDENT	0KB05	334–8875–00
	334–9366–00			1	DUAL PORT:MARKER,IDENT OPT 41 & 42 ONLY	0KB05	334–9366–00
	334–8876–00			1	SINGLE PORT UNITS: MARKER,IDENT	0KB05	334–8876–00
	334–9364–00			1	SINGLE PORT:MARKER,IDENT OPT 41 & 42 ONLY	0KB05	334–9364–00
–12	386–6846–00			1	HLDER,CONN:BULKHEAD, MOUNTED FOR OPTICAL CONN	7X318	386–6846–00
–13	386–6847–00			1	PLATE:CONN MOUNTING,AL	0J9P4	386–6847–00
–14	361–1698–00			2	SPACER,SHOULDER:0.375 L X 0.09 ID,NYLON 0.12 OD	06915	MNI#2–24
–15	211–0278–00			2	SCREW,CAP:2–56 X 0.500,SCH,SST,PASS,HEX	0KB01	ORD BY DESCR
–16	119–4547–01	B010100	B020586	1	DISK DRIVE:FLOPPY,3.5 IN;2MB,0.5 INCH,**OPT 11**	50356	FD–05HF–BLACK
	119–5250–01	B020587	B031683	1	DISK DRIVE:FLOPPY,3.5 IN,2M,,0.5 IN DSDD	80009	119–5250–01
	119–5528–01	B031684		1	DISK DRIVE:FLOPPY,3.5 IN,1.44MB,0.5 in,DSDD	TK2383	JU226AXX1F

Replaceable Mechanical Parts List (Cont.)

Fig. & Index Number	Tektronix Part Number	Serial No. Effective	Serial No. Discont'd	Qty	Name & Description	Mfr. Code	Mfr. Part Number
FIG 6–2					**OPTO-ELECTRICAL ASSEMBLIES: DUAL PORT (Con't))**		
–17	——— ———			1	**A2** OPTICAL MODULE ASSY:MULTIMODE (SEE ELECTRICAL ASSEMBLIES)		
–18	650–3659–00			2	CARD GUIDE ASSY:CKT BD HOLDER, CHANNEL GROMMET	7X318	650–3659–00
–19	361–1688–00			4	SPACER POST:SNAP–IN,SPACE 1.5,NYLON (SINGLEMODE PORT OPTIONS ONLY)	06915	MSP–24
–20	156–4357–00			1	BATTERY,CLOCK CALENDAR	0B0A9	DS1994L–F5
–21	348–0090–00	B010100	B020939	.5	PAD,CUSHIONING:2.03 X 0.69 X 0.312 SI RBR	85471	R–10470MED/PSA
–22	348–1547–00			2	SHIELD GASKET EMI:5 MM X 1 MM,URETHANE FOAM	77824	348–1547–00

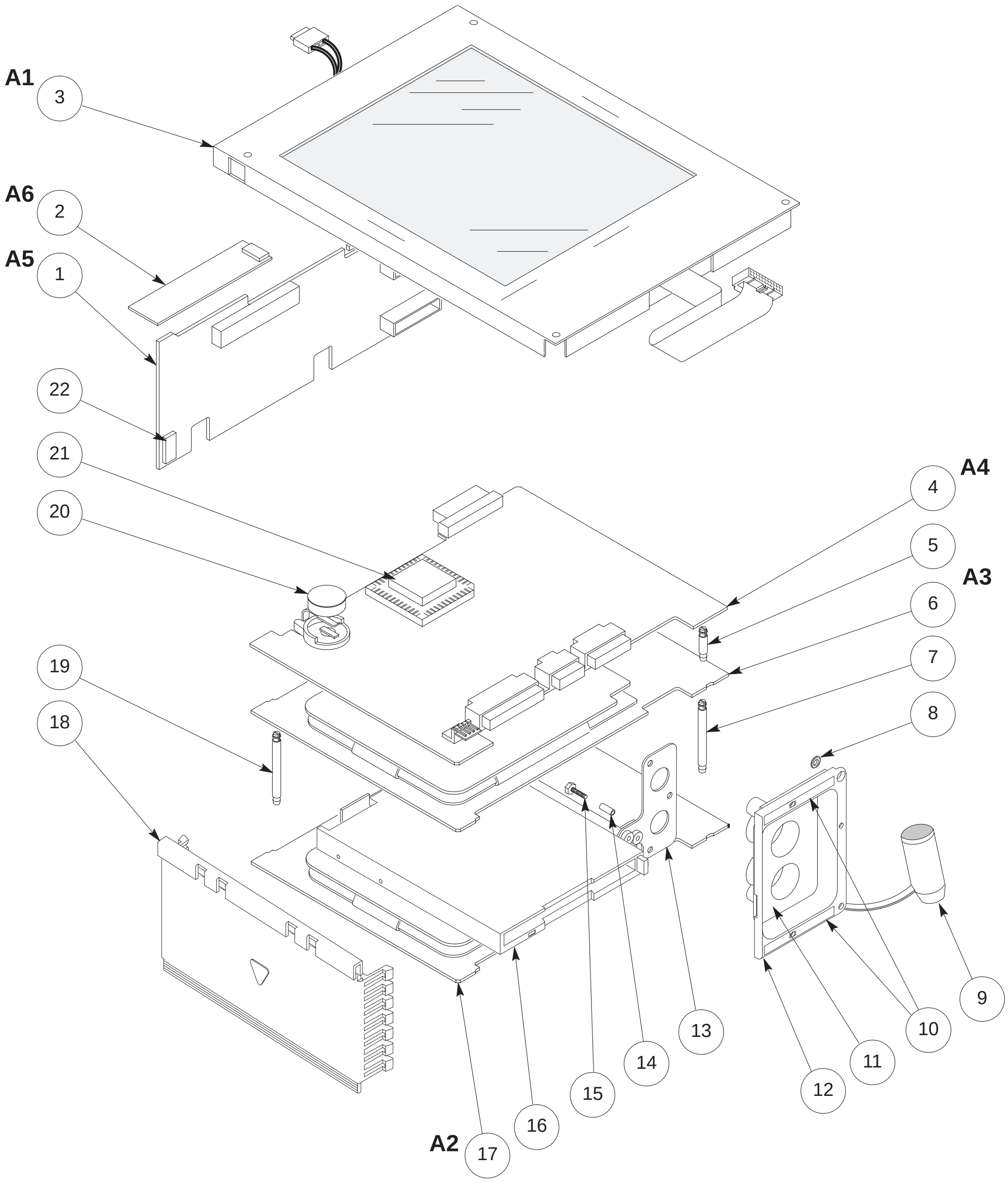


Figure 6–2: Opto–Electrical Assemblies: Dual Port

Wire and Cable Assemblies

NOTE. *Cable replacement vendor number is 0J7N9. Order by part number.*

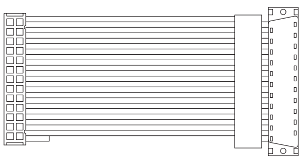
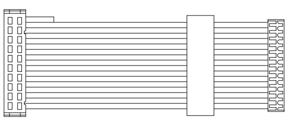
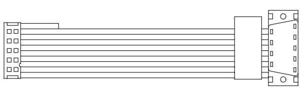
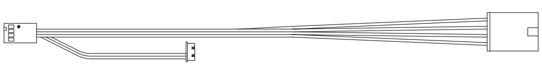
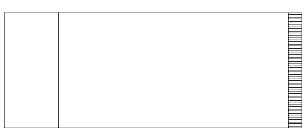
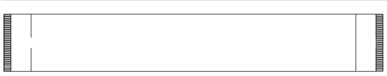
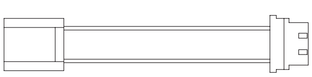
Illustration	Part Number	Location
	174–3425–00	PRINTER CABLE FROM SIDE PANEL TO A4 MAIN BOARD
	174–3426–01 B030000 174–3426–00 B010100 TO B029999	A1 LCD DISPLAY TO A4 MAIN BOARD
	174–3427–00	SERIAL CABLE FROM SIDE PANEL ASSY TO A4 MAIN BOARD
	174–3457–00	A6 DC–AC CONVERTER TO A5 POWER SUPPLY TO A4 MAIN BOARD
	174–3492–00 B010100 TO B020586	A4 MAIN BOARD TO OPTION 11 DISK DRIVE
	174–3590–00 B020587 AND BEYOND	A4 MAIN BOARD TO TOPTION 11 DISK DRIVE
	174–3632–00 B030000 AND BEYOND	A1 LCD DISPLAY MODULE TO BACKLIGHT INVERTER

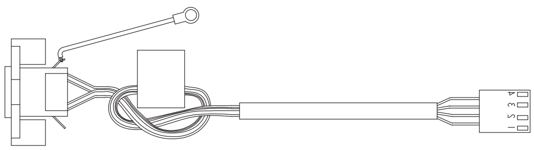
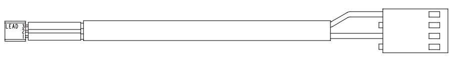
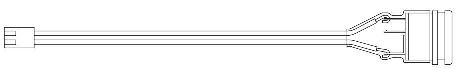
Illustration	Part Number	Location
	174–3635–00 B030000 AND BEYOND	KEYBOARD OPTION 19 TO A4 MAIN BOARD
	174–3639–01 B030000 AND BEYOND	A5 POWER SUPPLY TO A4 MAIN BOARD
	650–3660–00	A5 POWER SUPPLY TO DC OUTLET

Figure 6–3: Wire and Cable Assemblies

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