FLUKE networks

TS®100 PRO
Cable Fault Finder

Users Guide

PN 3850759
October 2011, Rev. 3 5/2015

LIMITED WARRANTY AND LIMITATION OF LIABILITY

Each Fluke Networks product is warranted to be free from defects in material and workmanship under normal use and service unless stated otherwise herein. The warranty period for the mainframe is 18 months and begins on the date of purchase. Parts, accessories, product repairs and services are warranted for 90 days, unless otherwise stated. Ni-Cad, Ni-MH and Li-Ion batteries, cables or other peripherals are all considered parts or accessories. The warranty extends only to the original buyer or end user customer of a Fluke Networks authorized reseller, and does not apply to any product which, in Fluke Networks' opinion, has been misused, abused, altered, neglected, contaminated, or damaged by accident or abnormal conditions of operation or handling. Fluke Networks warrants that software will operate substantially in accordance with its functional specifications for 90 days and that it has been properly recorded on non-defective media. Fluke Networks does not warrant that software will be error free or operate without interruption.

Fluke Networks authorized resellers shall extend this warranty on new and unused products to end-user customers only but have no authority to extend a greater or different warranty on behalf of Fluke Networks. Warranty support is available only if product is purchased through a Fluke Networks authorized sales outlet or Buyer has paid the applicable international price. To the extent permitted by law, Fluke Networks reserves the right to invoice Buyer for repair/replacement when a product purchased in one country is submitted for repair in another country.

For a list of authorized resellers, visit **www.flukenetworks.com/wheretobuy**.

Fluke Networks warranty obligation is limited, at Fluke Networks option, to refund of the purchase price, free of charge repair, or replacement of a defective product which is returned to a Fluke Networks authorized service center within the warranty period.

To obtain warranty service, contact your nearest Fluke Networks authorized service center to obtain return authorization information, then send the product to that service center, with a description of the difficulty, postage and insurance prepaid (FOB destination). Fluke Networks assumes no risk for damage in transit. Following warranty repair, the product will be returned to Buyer, transportation prepaid (FOB destination). If Fluke Networks determines that failure was caused by neglect, misuse, contamination, alteration, accident or abnormal condition of operation or handling, or normal wear and tear of mechanical components, Fluke Networks will provide an estimate of repair costs and obtain authorization before commencing the work. Following repair, the product will be returned to the Buyer transportation prepaid and the Buyer will be billed for the repair and return transportation charges (FOB Shipping point).

THIS WARRANTY IS BUYER'S SOLE AND EXCLUSIVE REMEDY AND IS IN LIEU OF ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, INCLUDING BUT NOT LIMITED TO ANY IMPLIED WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE. FLUKE NETWORKS SHALL NOT BE LIABLE FOR ANY SPECIAL, INDIRECT, INCIDENTAL OR CONSEQUENTIAL DAMAGES OR LOSSES, INCLUDING LOSS OF DATA, ARISING FROM ANY CAUSE OR THEORY.

Since some countries or states do not allow limitation of the term of an implied warranty, or exclusion or limitation of incidental or consequential damages, the limitations and exclusions of this warranty may not apply to every buyer. If any provision of this Warranty is held invalid or unenforceable by a court or other decision-maker of competent jurisdiction, such holding will not affect the validity or enforceability of any other provision.

4/15-18

Fluke Networks
PO Box 777
Everett, WA 98206-0777
USA

Contents

Title Page

TS®100 PRO Cable Fault Finder

Overview of Functions

The TS100 PRO Cable Fault Finder with PowerBT™ bridge tap detection is a portable, handheld TDR device used by installers, repair technicians and other authorized personnel for detecting bridge taps, locating problems on installed cable pairs, and managing cable inventory. This enhanced version of the TS100 Cable Fault Finder has improved technology that lets technicians qualify, troubleshoot, and repair copper facilities that support high-speed VDSL services.

The TS100 PRO Cable Fault Finder includes the following features and functions:

- Easy to use
- Tests all common cable pairs
- Provides low cost protection against lost time due to cable and connector problems
- Accurate to ±2 feet (±0.6 meters) for cables less than 30 feet (9 meters)
- Accurate to ±5 feet (±2 meters) for cables longer than 10 feet (3 meters) and shorter than 200 feet (60 meters)
- Accurate to ±3%, ±5 feet (±2 meters) for cables longer than 200 feet (60 meters)
- Bright 0.4 inch (1.016 centimeters) LED display
- Up to 4 readings per second
- Audible indication of shorted wires and external voltage greater than 90 volts AC or 100 volts DC
- Automatic adjustments
- Tone injection with the SmartTone™ positive identification system
- The input is protected up to 250 volts for accidental connections to a power source
- Components protected against damage from moisture
- Fifty hour battery life, intelligent power-down
- Low battery indicator
- Uses 4 AA batteries (included)
- High strength plastic (ABS) housing

Registration

Registering your product with Fluke Networks gives you access to valuable information on product updates, troubleshooting tips, and other support services. To register, fill out the online registration form on the Fluke Networks website at **www.flukenetworks.com/registration**.

Contacting Fluke Networks

www.flukenetworks.com

support@flukenetworks.com

+1-425-446-5500 or 1-800-283-5853

- Australia: 61 (2) 8850-3333 or 61 (3) 9329 0244
- Beijing: 86 (10) 6512-3435
- Brazil: 11 3759 7600
- Canada: 1-800-363-5853
- Europe: +31-(0) 40 2675 600
- Hong Kong: 852 2721-3228
- Japan: 03-6714-3117
- Korea: 82 2 539-6311
- Singapore: +65-6799-5566
- Taiwan: (886) 2-227-83199
- USA: 1-800-283-5853

Visit our website for a complete list of phone numbers.

Safety Information

The following IEC symbols are used either on the tester or in the manual:

	Warning: Risk of personal injury. See the manual for details. Caution: Risk of damage or destruction to equipment or software. See the manual for details.
	Warning: Risk of electric shock.
	Risk of damage to equipment from static discharge.
	Earth ground
CE	Conformité Européenne. Conforms to relevant European Union directives.
C SP US	Meets safety requirements of North America
	Do not put products containing circuit boards into the garbage. Dispose of circuits boards in accordance with local regulations.

Warning

To avoid possible fire, electric shock or personal injury:

- **Before you use the tester, carefully read all of the safety information and instructions in this manual.**
- **Do not connect this equipment directly to a mains electrical supply. This equipment conforms to the safety measurement standard for equipment without a rated measurement category.**
- **Do not connect the tester to power sources. If the VOLTAGE LED is on, immediately disconnect the tester from the cable.**
- **Do not use the tester to test cables that may have hazardous voltages present. When the tester indicates the presence of high AC or DC voltages, carefully disconnect immediately to prevent any personal injury. Be careful when you make connections to cables.**
- **Do not touch voltages > 30 volts AC RMS, 42 volts AC peak, or 60 volts DC.**
- **Do not connect the tester to voltages higher than the maximum specified by the measurement category (CAT) rating of the lowest-rated individual component of the tester, the test leads, or any accessory.**
- **Do not use the tester around explosive gas or vapor or in damp or wet environments.**

- **Do not use the tester if it is damaged. Before you use the tester, inspect the case. Look for cracks or missing plastic. Pay particular attention to the insulation surrounding the connector. If the tester is damaged, remove the battery and make sure that no one uses the tester.**
- **Do not use the tester with the case opened.**
- **Do not use the tester if it operates incorrectly.**
- **Before you use the tester, make sure that the supplied test leads are tightly attached to the BNC connector.**
- **Always handle the clip leads and the cables by their insulation, never directly by the exposed metal of the test clips. Use only the insulated clips provided to connect to any wire or cable.**
- **To prevent unreliable test results, use only the test leads supplied with the tester or supplied by Fluke Networks as accessories for the tester. See Table 4 on page 20.**
- **Do not use test leads if they are damaged. Examine the test leads for exposed metal and damage to the insulation. Make sure the wear indicator on the cords does not show. The wear indicator is white for the two cords that come out of the test clips and black for the single cord that comes out of the Y-shaped splitter. Verify the continuity of the test leads.**
- **To prevent unreliable test results, replace the battery as soon as LO BATT shows on the display.**
- **Before you remove the battery door, disconnect the test leads from the tester.**
- **Use only four AA batteries, correctly installed, to supply power to the tester.**
- **Do not use the tester without the battery door installed.**
- **If this product is used in a manner not specified by the manufacturer, the protection provided by the product may be impaired.**
- **Use the TS100 PRO only on dry (non working) circuits. If you connect the TS100 PRO to an operating ADSL or hi-cap circuit, it can cause the service to be dropped.**

⚠Caution

To prevent damage to the tester from static discharge, keep the test leads connected to the BNC connector at all times. Do not touch the BNC connector with your hand.

When testing telephone cables, connect the tester only to non-working circuits. If accidentally connected to a working XDSL or T1 circuit, the tester can cause a service outage.

Legal requirements may exist regarding permission to connect equipment to a Telecom network operated by a public network operator.

Physical Characteristics

See Figure 1.

① Power key, which turns the tester on and off.

② Four-digit LED display shows test results.

③ The **BT FILTER** LED is on when the bridge tap filter is on. The filter causes the tester to ignore the first reflection so it can find a second bridge tap.

④ The **VOLTAGE** LED is on when the tester detects DC voltage, and flashes when the tester detects AC voltage.

⑤ Connector for the test leads (female BNC).

⚠Caution

To prevent damage to the tester from static discharge, keep the test leads connected to the BNC connector at all times. Do not touch the BNC connector with your hand.

⑥ The **BRIDGE TAP** LED is on when the tester detects a bridge tap. The four-digit LED display shows the distance to the bridge tap or the length of the bridge tap.

⑦ The **BT LENGTH** LED is on when the four-digit LED display shows the length of the bridge tap.

⑧ The battery compartment is on the back of the tester (the label on the battery cover shows common values of VOP).

⑨ ▲ ▼: Up/down keys let you scroll through results and configure the tester.

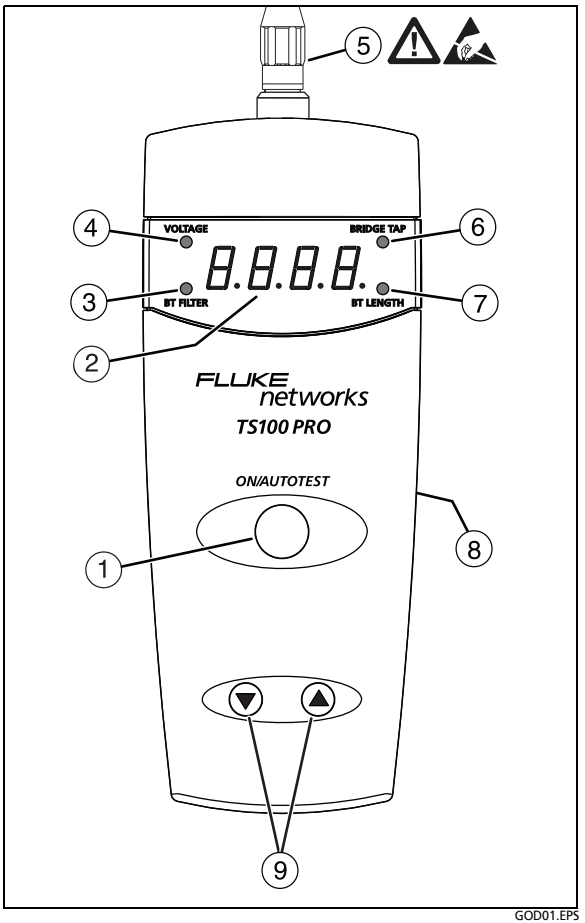


Figure 1. Physical Characteristics

Test Leads and Accessories

Use only test leads approved by Fluke Networks for use with the TS100 PRO tester. See Table 4 on page 20. Other test leads may cause incorrect measurements. For information on accessories, contact your local Fluke Networks authorized distributor.

Operation

Installing Batteries

⚠Warning⚠

To avoid possible fire, electric shock or personal injury:

- **To prevent unreliable test results, replace the battery as soon as LO bATt shows on the display.**
- **Before you remove the battery door, disconnect the test leads from the cable or circuit.**
- **Use only four AA batteries, correctly installed, to supply power to the tester.**
- **Do not use the tester without the battery door installed.**
- **Use caution when handling batteries. Do not let the terminals short together. Dispose of batteries properly to ensure terminals cannot short. Disposal may be restricted by local laws.**

Note

To extend battery life, remove the batteries if you will not use the tester for a long period.

To install the batteries:

See Figure 2.

1 Use a number 2 Phillips screwdriver to loosen the screw on the battery door.

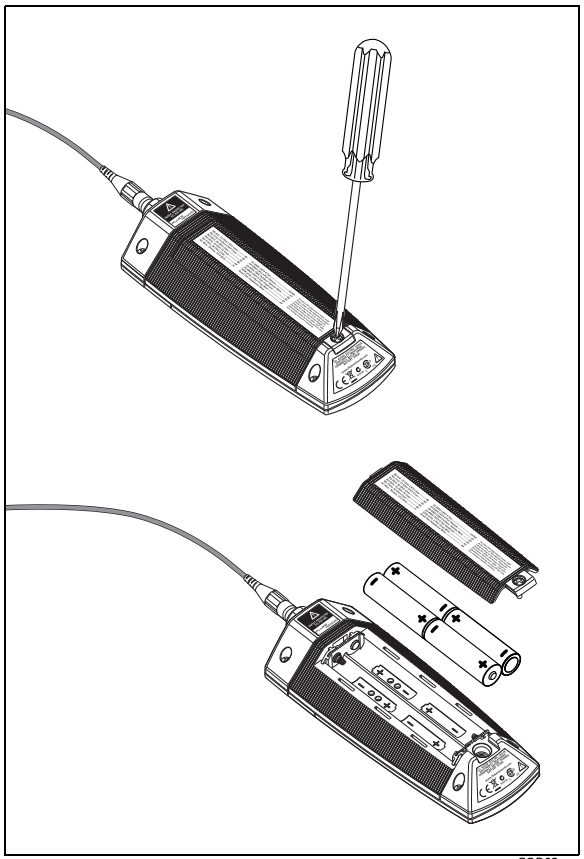
Note

The screw does not come out of the battery door.

2 Remove the battery door.

3 Install the batteries. Make sure the polarity is correct, as shown at the bottom of the battery compartment.

4 Install the battery door and tighten the screw.



GOD02.eps

Figure 2. Installing the Batteries

Turning on the Tester

Turn the tester on by pressing the **ON/AUTOTEST** key. The tester performs a self test each time it is turned on. During the self test, the tester displays **8888**.

Automatic Power-Down

To save battery power, the tester automatically turns off after five minutes if it is not connected to anything, or one hour after you connect to a cable. Also, if the **ON/AUTOTEST** key is held down for more than 20 seconds, the tester turns off. This prevents battery drain if an object accidentally presses the key.

Testing Cables

⚠Caution

When testing telephone cables, connect the tester only to non-working circuits. If accidentally connected to a working XDSL or T1 circuit, the tester can cause a service outage.

To test a cable, attach the test lead clips to a pair of wires at one end of the cable you are testing.

The tester shows the distance to the nearest fault it finds. Table 1 describes the tester's display and beeper indications.

Note

Length measurements do not include the length of the test leads.

Table 1. LED Display and Beeper Indications

Test Condition	Status LEDs That Are On	Display	Beeper
Incorrect test leads are attached		The display shows a non-zero measurement	Off
No test leads are attached		no tESt LEAd	Off
Test leads are open		0	Off
Cable is open*		Distance to the open	Off
Cable is shorted		Distance to the short	Continuous
Bridge tap detected	**BRIDGE TAP**	Distance to the bridge tap	Off
Bridge tap detected, and you pressed ▲	**BT LENGTH**	Length of bridge tap	Off
Bridge tap detected, and you pressed ▲ again		Total length of the cable, including the bridge tap	Off
Bridge tap filter is on	**BT FILTER** (others can also be on)	Any of the length or distance measurements shown above	Off
Cable is too long to measure		-Err	Off

Table 1. LED Display and Beeper Indications (continued)

Test Condition	Status LEDs That Are On	Display	Beeper
Deadzone mode is on		d 50 (when in feet mode) d 15 (when in meters mode)	Off
DC load (light bulb, TV, etc.) is detected		-Err	Off
AC voltage >4 V AC and <60 V AC is detected	**VOLTAGE**	Alternates between the AC voltage measurement and AC	Off
DC voltage >6 V DC and < ±60 V DC is detected	**VOLTAGE**	Shows the DC voltage measurement once, then shows the TDR results	Off
Hazardous voltage or ringing voltage is detected (≥90 V AC, 20 Hz to 450 Hz; ≥±100 V dc)	**VOLTAGE**	Alternates between the measured voltage and HI AC or HI dC	Staggered if ≥90 V AC or ≥100 V DC
Low battery (Battery voltage is < 4.5 V DC)		LO alternates with bAtt 4 times, then the display shows a measurement as usual. This sequence occurs every 2 minutes.	Off
The self-test failed		8888	Off
The tester cannot measure the cable because of excessive noise, crosstalk, terminations, or anomalies on the cable		-Err	Off

* An open can be the end of a pair, a break in a one wire, or separation between the wires in the pair. If one wire in the pair separates from the other wire for more than 1 ft (30 cm), the tester indicates an open at the separation.

SmartTone™ Positive Identification System

See Figure 3.

The tester injects a tone onto the connected pair concurrently with fault locating signals. This tone is compatible with most tone probes. When you are using a tone probe to identify a wire pair, the tone volume from nearby wires may be indistinguishable from the tone from the target pair. The SmartTone Positive Identification System lets you positively identify the wire pair. The tone has 5 frequency and cadence options.

To use the SmartTone System:

1 Connect the tester to a wire pair; then turn on the tester.

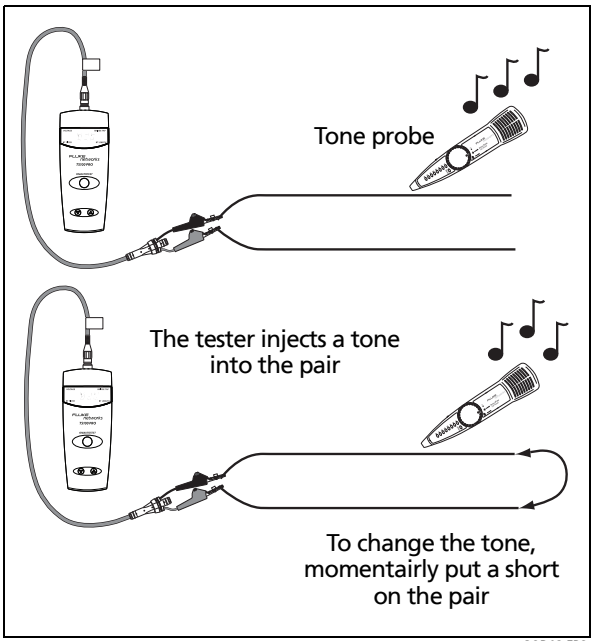
2 At the other end of the cable, use your tone probe to find the wire pair by probing for the pair with the loudest tone.

3 Short the wire pair together, then release the short.

- If the tones do not change, then you have not found the correct pair.
- If the tones change, then you have found the correct pair.

Note

The tone is not audible on the tester's beeper.



GOD03.EPS

Figure 3. SmartTone Positive Identification System

How to Select the Modes of Operation

The TS100 PRO has the following modes of operation:

- Normal mode
- Deadzone Test mode: ignores the first 50 feet (15 meters) of cabling
- Bridge tap filter test mode: skips first bridge tap to locate the second bridge tap
- VOP mode: shows the VOP during a test
- Setup mode: lets you configure FT/M or return to factory default

Normal Test Mode

When you turn on the tester, it is in normal mode:

- The display, LEDs, and beeper operate as described in Table 1 and the unit has a deadzone of zero.
- To turn on the 50-foot deadzone test mode (50 feet or 15 meters from tester), press ▼.
- To turn the bridge tap filter (**BT FILTER**), press ▼ again once the tester is in deadzone test mode.
- Press ▼ again to return to normal test mode.

Deadzone Test Mode

Deadzone test mode ignores the first 50 feet of cabling when testing a cable. The purpose of this mode is to allow you to skip events in the first 50 feet (15 meters) from a terminal or crossbox - events such as splices or other expected or visually apparent events on the cable.

To enter the 50-foot deadzone test mode from normal test mode, press ▼. If you are in feet mode, the display will show d 50 and then the TDR results. If you are in meters mode, the display will show d 15 and then the TDR results.

If the cable you are testing measures less than 50 feet (15 meters), the tester is unable to report any events and will display -Err since it is unable to see the end of the cable. To measure a cable length shorter than 50 feet or to locate events in the first 50 feet (15 meters), return to Normal Mode by pressing the ▼ twice.

Bridge Tap Filter Test Mode

Bridge tap filter test mode skips the first bridge tap on a cable to locate the second bridge tap on the cable. The first bridge tap could be located anywhere on the cable. To "see" past the first bridge tap, activate the bridge tap filter.

To enter the bridge tap filter test mode from normal test mode, press ▼ twice. The red BT FILTER LED will be lit.

To exit bridge tap filter test mode, press the ▼ button once. The red BT FILTER LED will go off.

VOP Mode

In VOP mode you can quickly change and monitor the VOP value that the tester uses. This mode is useful when you change from one cable type to another, or when you initially characterize a cable.

To enter the VOP mode:

Turn off the tester, then hold down ▲ or ▼ while you press and release the **ON/AUTOTEST** key.

In VOP mode:

- The display alternates between the measured length and the VOP setting.
- To change the VOP, press ▼ to increase, or ▲ to decrease the VOP value shown. The VOP value shows two digits or three digits. See "VOP" below.
- The bridge tap detection, bridge tap filter, and auto-shutoff features are disabled in this mode.

To exit the VOP mode:

Turn off the tester, then turn it on again.

Setup Mode

This mode lets you select units of measurement (feet or meters), and reset all parameters to factory defaults.

To enter setup mode:

Turn off the tester, then hold down both arrow buttons for 3 seconds while you press and release the **ON/AUTOTEST** key. To select the setting you want (feet or meters), press the ▲ button.

To exit the setup mode:

Turn off the tester, then turn it on again.

To reset all parameters to factory default values:

Turn off the tester, hold down both ▲ and ▼ buttons, turn on the tester, then wait at least 10 seconds before you release ▲ and ▼ buttons.

Turn the tester off, then turn it on again.

Velocity of Propagation (VOP)

VOP is a cable specification that specifies the speed at which a signal travels down the cable. A VOP of 66 means the signal travels at 66 % of the speed of light. The tester uses VOP to calculate cable length. See "Time Domain Reflectometry (TDR) Technology" on page 14 for details.

Here are some important points about VOP:

- Different cables have different VOP values.
- The tester's default VOP setting of 66 is suitable for most applications.
- Using the VOP specified for a cable ensures the most accuracy in fault location, length measurements, and inventory management. Table 2 and Table 3 show VOP values for common cables. Some common VOP values are also listed on the tester's battery door.

You can set the tester's VOP to a known value (see "Setup Mode" on page 9), or you can use the tester to determine the VOP for a known length of cable.

To set the VOP to a known value:

1 Turn the tester on while holding down ▲ or ▼. In this mode, the display shows the VOP setting, then it shows the calculated cable length if a cable is connected.

2 When the VOP setting shows, press ▲ or ▼ to change setting. The tester automatically saves the setting.

3 To exit the VOP adjustment mode, turn off the tester.

To determine the VOP of a known length of cable:

1 Connect a known length of cable to the tester. The cable must be 200 feet (60 meters) or longer (such as an unopened box of cable).

2 Turn the tester on while holding down ▲ or ▼. In this mode, the display alternately shows the VOP setting and the measured length of the cable.

3 While the length measurement shows, press ▲ or ▼ to adjust the length to the known length of the cable.

4 To exit the VOP adjustment mode, turn off the tester.

Notes

While the tester is in VOP adjustment mode, tone is not injected into the cable.

The tester keeps the VOP setting in flash memory when you change the batteries

Applications

See Figure 4.

The tester locates opens, short circuits, and crosses in any two metallic conductors (twisted, untwisted, coax, copper, aluminum, and steel). It also detects bridge taps on copper twisted pairs and shows the location and length of the tap.

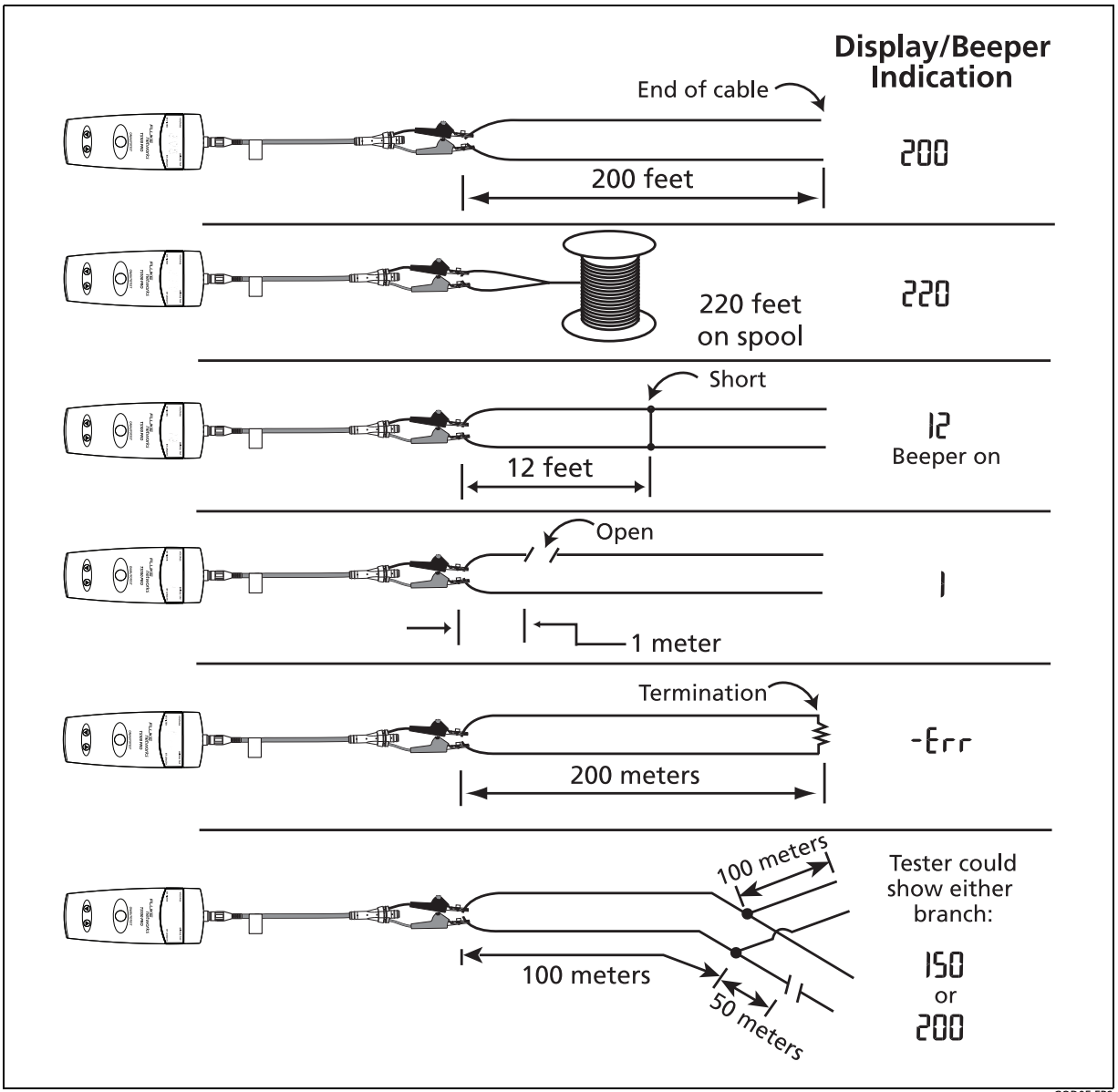


Figure 4. Testing for Lengths, Shorts, Opens, and Terminations

If you have an optional, inductive probe (Not included. See Figure 3), you can use the SmartTone feature to identify multiple pairs. When using an inductive probe to ID the wire pair together, then release the short. If the cadence changes, positive identification is confirmed. Because the tester beeps when it detects a short circuit, it also serves as a circuit (for example, continuity) tester.

Multi-Wire Environment

When testing wires in a multi-wire environment, such as 4 wire telephone cable, 8 wire CAT-5 cable, 12-2 with ground AC wire, or several THHN wires inside a conduit, a short could exist between any number of the conductors, including a shield or the conduit. To detect the short, you must connect the tester to the wires that are shorted. This means that to fully test a multi-wire cable, you must check every wire against every other wire including the shields and conduits.

Although a quick way to test many conductors against conduit or the shield is to connect all the conductors to one clip lead and the shield to the other lead, this will reduce the impedance of the cable, and measurements may fall below the tester's range. It is more reliable to test the wires individually.

Conduit

When you test wire in a conduit. you can test a pair of wires or a single wire.

Testing a Wire Pair in a Conduit

To test a wire pair, connect the two test leads to the pair. If one wire separates from the other for 1 foot (30 cm) or more, the tester indicates an open at the separation. For example, if the wires separate after exiting the conduit, the tester indicates an open at the end of the conduit.

Testing a Single Wire in a Conduit

You can test a single wire by clipping one test lead to the wire and the other to the conduit. The tester shows the length up to a fault or to the point where the wire separates from the conduit by at least 1 foot (30 cm). For example, if there is a 2 foot (30 cm) service loop outside the conduit, the tester shows the length up to the service loop. This is true even if the two sections of conduit are electrically connected.

Inventory Management

The tester is an inventory management tool. It measures lengths of wire or cable still on the spools.

The ability to measure the length of multi-conductor cable remaining on its spool is valuable for both job-site and warehouse personnel. With the TS100 PRO, you can measure the length from just one end of a pair of wires, allowing you to take inventory without unspooling the cable, or even moving the spools.

At the job-site, you can determine if the cable remaining on your spool or in your box will be sufficient for the job at hand. This will save you an unnecessary trip to the warehouse for more cable, and help you avoid running out of cable in the middle of an installation.

There are two points to remember when measuring the length of wire on a spool:

- The wire length must be within the range of the TS100 PRO (see Table 2 on page 13).
- The accuracy of the measurement will be optimum if the VOP is set correctly for the type of wire being measured. See Table 2 on page 13 for a list of specifically identified cables and Table 3 on page 14 for a list of VOP values for other cable types.

In the warehouse, you can quickly measure the cable remaining on all your spools, allowing you to select the right spool for each job. Additionally, by keeping a record of the prior inventory, you can determine how much wire was used on the current job.

Note

The TS100 PRO works on two conductors. You cannot use the tester to measure single-conductor cable.

Table 2. VOP Values and Maximum Length for Specifically Identified Cables

VOP	Maximum Length	Cable
64	2000 ft (610 m)	Lucent 1024 006ABE 6/24 W1000, 6 pair CAT3 (Blue-White)
63	1500 ft (460 m)	BICC General Aerial Service Wire (ASW) 2/22, 2 Pair Drop Wire
61	2000 ft (610 m)	Superior Essex, 4 pair CAT3 Plenum (not pair dependent)
60	1500 ft (460 m)	BICC General, 24 AWG CMX Outdoor CMR Station Wire
58	1000 ft (300 m)	BICC General cross-connect 24 AWG twisted pair on original spool
66	2500 ft (770 m)	Berk-Tek, CAT5 (Orange-White)
68	2500 ft (770 m)	Superior-Essex Cobra CAT5 CMR (Orange-White)

Table 2. VOP Values and Maximum Length for Specifically Identified Cables (continued)

VOP	Maximum Length	Cable
72	2500 ft (770 m)	Superior-Essex Cobra CAT5 CMP (Orange-White)
82	1000 ft (300 m)	CommScope 5726, RG6 CATV Coax
81	1000 ft (300 m)	CommScope 2275V, RG6 CATV Coax
79	1000 ft (300 m)	CommScope 5571, RG59, TV Coax
67	500 ft (150 m)	Belden 88760 2 wire shielded 18 AWG, Red-Black
68	500 ft (150 m)	Belden 88760 2 wire shielded 18 AWG, Red/ Black-Shield
64	500 ft (150 m)	Carol C1156 RG-174/U
57	500 ft (150 m)	BICC General, E22025, Red-Black
73	1000 ft (300 m)	Channel Master Polyclad Model 9354 300 Ohm Foam Antenna Wire
71	2000 ft (610 m)	Triangle Wire and Cable, type NM-B 12/2 W/G, Black-Ground
67	2000 ft (610 m)	Triangle Wire and Cable, type NM-B 12/2W/G, Black-White

Table 3. VOP Values for Other Cables

VOP	Cable Type
78	Belden Drop Foam
82	CommScope Drop
87	CommScope Trunk
63	RG58/U 50 Ohm Network Coax
80	RG59 TV Coax
64	Service Wire
83	Times Fiber Drop
87	Times Fiber Trunk
93	Trilogy Trunk
68	Twisted Pair, Gel Filled 19 AWG
64	Twisted Pair, Gel Filled 22 AWG
62	Twisted Pair, Gel Filled 24 AWG
60	Twisted Pair, Gel Filled 26 AWG
68	Twisted Pair, Paper 22 AWG
66	Twisted Pair, Paper 24 AWG
65	Twisted Pair, Paper 26 AWG
72	Twisted Pair, PIC 19 AWG
67	Twisted Pair, PIC 22 AWG
66	Twisted Pair, PIC 24 AWG
64	Twisted Pair, PIC 26 AWG

Time Domain Reflectometry (TDR) Technology

Note

This section goes deeper into the theory of operation. You can skip this section and still use the tester effectively by reading the other parts of this guide. However, it is worth reading this section if you want more insight into how the tester works.

One of the keys to understanding how the TS100 PRO works is to first understand that a pair of wires has a fixed impedance as long as the wires of the pair are kept in the same geometrical relationship to each other. A pair of wires (either standalone or within a multi-wire cable) is designed to have a constant wire-to-wire impedance. If the physical relationship of the wires in the pair is altered during the wire run, then there will be a change in impedance at the point where the physical relationship changes. For example, if one or both wires of the pair are broken (open), or they are shorted to each other, or they become sufficiently separated from each other, their impedance will change. The TS100 PRO looks for these changes in impedance. If the impedance change is large enough, (such as that caused by a break in one of the wires of the pair), the TS100 PRO will detect the impedance change and will display the length of the wire up to the impedance change.

So, the TS100 PRO can measure the length of a pair of un-terminated wires, because, the open circuit at the far end causes a very large impedance change.

The TS100 PRO Cable Fault finder uses Time Domain Reflectometry (TDR) to determine the length of the target cable. A TDR, much like RADAR, sends a pulse down the pair of wires. Part of that pulse reflects off any impedance variations in the pair of wires. All of the reflections, together with the original pulse, combine

to make an electrical signal (TDR waveform) that has various flat and bumpy sections that represent the start, the impedance changes, and the end of the cable. The size and shape of the flat and bumpy sections depend on the distance to the impedance changes and the magnitude of the impedance changes.

For example, the start and end of a bridge tap cause a negative and a positive reflection, as shown at the top of Figure 5. The tester uses the time taken to receive the first reflection to calculate the distance to the bridge tap. Then it uses the time between the two reflections to calculate the length of the bridge tap.

A connection causes a small, S-shaped reflection, as shown at the bottom of Figure 5. The tester ignores small reflections because they do not usually indicate a problem on the cable.

If there is more than one problem on the cable, the TS100 PRO shows only the first problem. If that problem is a bridge tap, you can turn on the BT Filter to ignore the first bridge tap and find a second bridge tap. The TS100 PRO can always see past the bridge tap to measure the cable length.

The actual result of the measurement is the time to the fault. The software in the tester converts the measured time to a length by multiplying the time by the speed of the electrical signal in that particular cable. That speed is represented as a percentage of the speed of light and is called the Velocity of Propagation (VOP).

The actual formula used is as follows:

$$\text{Length} = \frac{\text{Time in billionths of a second}}{2} \times \frac{\text{VOP}}{0.9835}$$

The time is divided by two because the signal traveled the length of the cable twice. Once when it left the tester and went to the failure point, and again when it reflected back to the tester to be detected. The speed of light expressed in billionths of a second per foot is 0.9835 (about a billion feet per second) (0.2998 [about 300 million meters per second]).

VOP Variations

This characteristic speed of the signal for a particular cable is not normally a tightly controlled part of the cable manufacturing process and can vary widely from one manufacturer to another as well as from one box of cable to the next. As with all TDR-based cable measurement tools, the TS100 PRO measures time within specified tolerances, but the displayed length is the result of a calculation with the user-selected VOP, and is only as accurate as the selected VOP.

For most uses, a length reading with an incorrectly set VOP is sufficiently accurate to locate the fault in the cable. After all, an installed cable is hardly ever run in a straight line. It can be stapled along the 2x4, laid diagonally in the ceiling, and coiled behind the junction box, all of which is not visible.

Also, common sense should prevail. For example, if the tester reports an open at 80 feet (25 meters), and you can see a junction box at about 70 feet (20 meters), your first step should be to check at the junction box.

However, for some uses such as measuring the remaining cable in a box, it is important to set the VOP correctly in order to achieve the accuracy desired. Depending on the cable construction (shielded, twisted, etc.), insulating material (foam, air, fiber, etc.), and conductors tested (wire-to-wire, wire-to-shield), coiling the cable on a spool or in a box may alter its VOP.

Additionally, other conductors in close proximity to the conductors being tested can affect the VOP. For example, a solitary 12 gauge THHN in a metal conduit has a VOP of 82, while that same wire in a smaller conduit filled with other wires has a VOP of 72.

Note

The actual VOP of any particular cable is dependent on the conductor spacing and the material between the conductors and could vary by as much as ±5 feet (±2 meters) from the value listed in Table 2.

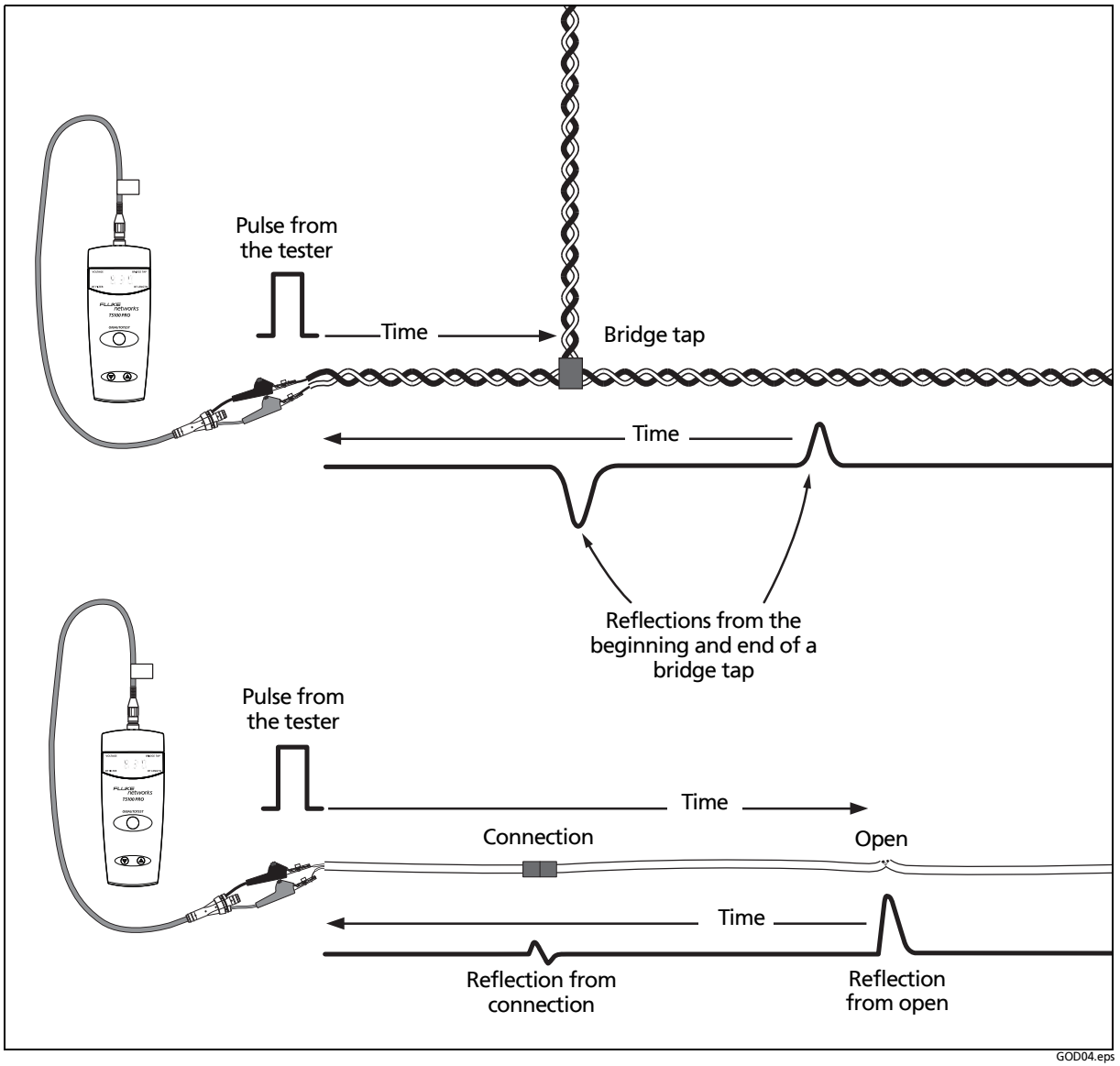


Figure 5. TDR Waveforms

To set the VOP for more accurate length measurements, see "Velocity of Propagation (VOP)" on page 10. See Table 2 and Table 3 for the VOP values for many cable types and conditions.

Maximum Length

The maximum length of cable that can correctly be measured by the TS100 PRO is determined by several factors. The most significant is the signal loss of the cable itself. When the signal loss in a particular cable is large enough, the tester cannot "hear" the TDR echo and cannot determine the length of that cable. In this situation, the tester displays -Err on the display. The amount of signal loss in a cable is determined by the characteristics of that cable and its length. The maximum length shown in Table 2 is the length above which the tester is not expected to be able to make a valid measurement. For lengths above those stated in Table 2, the tester's accuracy is not specified.

Frequently Asked Questions

Q: How do I calibrate or perform a self-test on the tester?

A: There are no adjustments inside the tester, and the internal coating protects the critical components from moisture and contaminants. There is nothing to calibrate. The tester does a self-test every time you turn it on.To do a self-test, turn the tester off then on again. The tester will not lose any settings because it saves settings in flash memory. The tester displays 8888 during the self-test.

Q: Does it matter which clip lead I connect to which wire in the cable under test?

A: Not for any of the testing functions. However, when you connect the tester to a cable, if you connect the red lead first, an invalid reading may be displayed until the full connection is made with both leads. The tester's TDR technology requires both leads be connected to the wire pair or cable in order to determine its length. While using only one of the leads is useful in tracing cable position with the injected tone, both leads are required to make valid length measurements.

Q: What does the low battery indicator really indicate?

A: The display shows LO and bAtt when the battery voltage falls below 4.5 VDC (see Table 1), indicating that you should replace the batteries. Although the tester will continue to operate for at least 1 hour below this voltage, some readings may be less accurate.

Q: I tested an orange outdoor 25 foot (8 meter) extension cord and the display read 19 feet (6 meters). Is the tester broken?

A: No. The accuracy of the reading is dependent on the setting of the VOP. While the nominal setting for general testing is **66**, the VOP for that kind of cable is **56**. To improve the accuracy of length measurements for that or any cable, change the VOP as shown in the instructions in the Velocity of Propagation section.

Q: Why does the length reading sometimes change a small amount when I open and short the far end of a test cable?

A: There are two causes. The first is that this is a characteristic of the measurement technique used in almost all low and medium cost cable length test tools.

In the case of the TS100 PRO Cable Fault Finder, the variance occurs in only a few cable types and both readings are within the specified accuracy of the instrument. The second cause occurs when an unshielded cable is coiled, as in a box or on a spool. The magnetic field caused by the TDR signal itself couples across to other parts of the cable and changes the characteristics of the reflections.

Q: Why, on some cables, does the number displayed jump between 2 or 3 different values?

A: As the TDR signal travels down a cable, it loses some of its strength. At some point, the noise on the cable has an amplitude similar to the reduced strength TDR signal and will influence the measurement results. The tester's software filters out many of the noise related variations in the displayed length, but some variations do get through.

Q: I accidentally cracked the plastic housing, does this affect the moisture protection of the components?

A: Not at all. The component protection is provided by a coating on the components and Printed Circuit Board (PCB).

However, if sufficient plastic is missing then a possible shock hazard exists. You should not use the tester until the plastic is repaired or replaced.

Q: Can this tester measure the length of single conductor wires like THHN?

A: No. All TS100 PRO measurements must be made on TWO conductors from the same end of a cable.

Q: If I touch the bare metal of the wires or clip leads, will the measurement be affected?

A: After BOTH clips are connected, measurement results will ordinarily not be affected if you accidentally touch the input connectors. If a large surface area of cable touches moist skin, some readings may be affected.

Q: On multi-conductor cables with a short between two of the conductors, I sometimes read an "open" at twice the known length of the cable.

A: If the cable has more than two conductors, and a short exists at the far end between one of the conductors you are connected to and a conductor you are not connected to, the displayed length will be the sum of the lengths of the conductors joined by the short. The TS100 PRO can only correctly test the two conductors that are connected to the tester. See "Applications" on page 10 for multi-conductor cables.

Q: When testing a set of wires that go into a conduit, I sometimes get a reading of 0 or 1. Why?

A: If there is more than a foot or so of wires that are physically separated before they enter the close confinement of the conduit, this will look to the tester like an open at the start of the cable. Remember that TS100 PRO reports the first failure that it finds. Try bringing the two wires of the pair closer together for the section from the tester to the entrance of the conduit.

Q: When connecting to a 6 foot (2 meter) piece of 50Ω Coax with the alligator clips, the tester reads 8 feet (3 meters). What's up?

A: When measuring a low impedance small cable (less than 15 feet [5 meters]), the clip leads can add up to 2 feet (1 meter) of length. For longer or high impedance cables, the clip leads have no effect.

Q: How does the tester react to a speaker or a transformer at the end of a cable?

A: A speaker or a transformer is actually a large coil of wire. This will usually cause the length reading to be larger than that of the cable alone. A moderate power speaker will add 500 feet (150 meters) to the length reading. Some combinations of speakers and transformers connected to the cable may prevent the tester from making a valid reading.

If Something Seems Wrong with the Tester

The display remains at 8888 after power on.

The self test has failed. The batteries may be weak or the tester has water inside. Try changing the batteries or drying the tester.

The tester reads less than 10 feet (3 meters) regardless of the length of the cable.

The connection to the cable is broken. Check your connection to the cable for dirt or insulation. Also, test the clip leads by shorting them and listening for the beeper. You can also visually check the center connection of the BNC for damage.

The tester does not respond to any key presses.

The batteries could be dead or inserted incorrectly, or the contacts are dirty or broken. Please ensure that nothing is connected to the input connector before opening the battery door, and then check the battery installation. Remove the batteries and check the contacts for dirt or damage. Please observe correct polarity when inserting the batteries.

Maintenance

⚠Warning⚠

To avoid possible fire, electric shock or personal injury:

- **Do not open the case. You cannot repair or replace parts in the case. If you open the case, you can cause damage to the circuits in the tester.**
- **Use only service centers that are approved by Fluke Networks.**
- **Before you do any maintenance procedure, disconnect the test clips from the cable or circuit.**
- **Do not use the tester if it is wet. Do not apply heat to the tester to make it dry more quickly.**
- **Batteries contain hazardous chemicals that can explode or cause burns. If these chemicals touch you, immediately clean the area with water and get medical aid.**

⚠Caution

To prevent damage to the tester caused by battery leakage, remove the batteries if you will not use the tester for a long period.

Note

Opening the housing will void the warranty.

If the Tester Gets Wet

Moisture will not harm the tester. However, moisture can provide a leakage path that may conduct hazardous voltages to you.

If moisture gets inside the tester, let the tester dry at normal room temperature for 24 hours.

How to Clean the Tester

To clean the display, use lens cleaner and a soft, lint-free cloth. To clean the case, use a soft cloth that is moist with water or water and a weak soap. Do not use petroleum-based or chlorinated cleaning agents.

⚠Caution

Do not use CRC Cable Clean® or any similar chlorinated solvent on the test set. Doing so will damage the tester.

Accessories

Table 4 shows the accessories available for the TS100 PRO tester. For the latest list of accessories, visit the Fluke Networks website.

Table 4. Accessories

Description	Fluke Networks Model Number
Test leads, ABN with piercing-pin-clips	LEAD-ABNP-100
Test leads with alligator clips	LEAD-ALIG-100
Test leads with angled bed of nails	LEAD-ABN-100
TS100 PRO pouch with belt clip	CASE-TS-100

Specifications

Maximum Length	8,000 feet (2,438 meters) on certain cable types, 4,000 feet (1,220 meters) on most cable types, and 500 feet (152 meters) on cables with high loss. The tester shows -Err if the cable is too long to be correctly measured.
Representative Maximum Cable Length	8,000 feet (2,438 meters): CAT-3 Twisted Pair 8,000 feet (2,438 meters): CAT-5 Twisted Pair 6,000 feet (1,830 meters): 12/2 AC Wire 3,000 feet (900 meters): RG-6/U TV Coax 1,500 feet (457 meters): RG-174/U Coax
Minimum Length	No minimum length. Minimum non-zero reading is 2 feet or1 meter
Length Accuracy	±2 feet (±0.6 m) for cables less than 10 feet (3 m) ±5 feet (±2 m) for cables longer than 10 feet (3 m) and shorter than 200 feet (60 m) ±3%, ±5 feet (±2 m) for cables longer than 200 feet (60 m)
Distance to Bridge Tap	0 feet to 3,200 feet (975 meters)

Minimum Length of Bridge Tap	10% of the distance to the bridge tap, dependent on the cable characteristics
Measurement Rate	Maximum of 4 complete measurements per second, decreasing to 2 seconds per measurement based on cable size and uniformity.
VOP	Adjustable from 20 to 99, saved in flash memory
Test Technology	Time Domain Reflectometry (TDR) with 100 Ω drive impedance, 6 V maximum pulse height
Cable Type	Virtually all two or more conductor cables
Power	4 AA alkaline batteries
Reverse Battery Protection	No damage to the tester will occur if the batteries are installed backwards.
Battery Life	35 hours (typical)
Low Battery Indication	LED display alternates between LO and bAtt when the battery voltage falls below 4.5 V.
Maximum Isolation Voltage	250 volts RMS with < 1500 Vpk transient
Voltage Measurements	Range: 0 volts AC to 115 volts AC; 0 volts DC to ±150 volts DC Accuracy: AC: ±1%, ±2 volts AC (45 Hz to 65 Hz); DC: ±1%, ±2 volts DC
High Voltage Detection	AC voltage detected to 115 volts DC voltage detected to ±150 volts. AC voltage ≥90 volts or DC voltage ≥100 volts causes high voltage warnings to show on the display
Tone Injection	Approximately 1 kHz at an amplitude of 80 % of battery voltage. Variable frequency and cadence. Tone characteristics change as cable condition changes to "normal-open" from any other condition.
Impedance Range	35 Ω to 330 Ω with auto-compensation within this range. Cables with impedances outside this range will not be properly tested and may produce erratic or incorrect readings.
Temperature Range	Operating: 32 °F to 104 °F (0 °C to 40 °C) Storage: 32 °F to 131 °F (0 °C to 55 °C)
Humidity	Operating: 20% to 80% relative humidity Storage: 0% to 100% relative humidity
Operating Relative Humidity	80% maximum at 86 °F (30 °C) 50% maximum at 104 °F (40 °C)

Operating Altitude	9,843 ft max (3,000 m max)
Weight	1 lb (454 grams)
Dimensions	7.4 in x 2.7 in x 1.4 in (18.8 cm x 6.9 cm x 3.6 cm)
Safety	Meets 300 V CAT none, Pollution Degree 2
EMC	Meets IEC 61326-1: Portable. Meets FCC CFR Title 47, Part 15, Subpart B

User Application Notes:

Patents 6160405, 6285195, 6323654, and 6509740.

On certain types of cables with bridge taps, TS100 PRO reports bridge tap location and bridge tap length correctly, but reports cable length as -Err (cable too long). In certain circumstances, TS100 PRO may not always be able to determine length due to impacts of the tap on the TDR signal, such as excessive loss.

To detect bridge taps on 24 wire gauge cabling, bridge tap length must be at least 10% of distance to bridge tap. For example, if distance to bridge tap is 3,000 feet, then the minimum bridge tap must be at least 300 feet to be detected. Design is optimized for 24 wire gauge cabling. On larger wire gauges such as 19 awg, performance will increase and TS100 PRO will be able to find shorter-length bridge taps. On smaller wire gauges such as 26 awg, performance will decrease and bridge tap length should be greater than 10% of distance to bridge tap to be detected. Bridge tap detection may also vary based all specific cable characteristics.

When testing into a DSLAM or certain CPE (Customer Premise Equipment), the TS100 PRO may add 1,000 feet - 3,000 feet to the actual cable length. To maximize accuracy, it is recommended the user disconnect CPE prior to testing.

When testing at a crossbox or terminal and using crossbox test leads with a heavy gauge, TS100 PRO may identify the end of the heavy gauge as a BT due to the significant cable gauge change – for example, a BT at 7 feet (or 2 meters). To skip this event, turn on the BT Filter Test Mode by pressing the DOWN arrow button twice and the unit will display the end of cable.

When testing cables in the field, remember that what the TS100 PRO reports as a bridge tap may be another event with a similar reflectance pattern. If you are unsure, check these types of events against cable plans or visually inspect the cable.