Model 3300

Twisted Pair
Metallic Time Domain Reflectometer

Operator's Manual

Radiodetection
Riser Bond

Thank you for purchasing Riser-Bond Instruments' Model 3300 Metallic Time Domain Reflectometer. Our goal is to provide you with a high quality troubleshooting tool which is both powerful and easy to use. We all share a commitment to quality and excellence and will do our best to continue to provide you with test equipment to meet your needs. Please read the operator's manual thoroughly to ensure the best results from your TDR. As always, Riser-Bond Instruments welcomes your comments and suggestions.

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SECTION 1: GENERAL INFORMATION

1.1 Safety Information

Symbols:

⚠	Caution: Refer to accompanying documents
Warning	Any ***Warning*** sign identifies a procedure or process, which if not correctly followed, may result in personal injury.
Caution	Any ***Caution*** sign identifies a procedure or process, which if not correctly followed, may result in equipment damage or loss of data.

Warnings

Before using, review all safety precautions. Note and observe all warning and caution statements on the equipment and in the documentation.

Do not operate this instrument near flammable gases or fumes.

Do not modify any part or accessory of this instrument. If the unit is damaged, do not use. Make sure the product is secured from use by others.

To avoid electric shock, do not remove covers or any parts of the enclosure.

If the instrument or any associated accessory is used in any manner not detailed by the accompanying documentation, the safety of the operator may be compromised.

Caution: As with most electronic equipment, care should be taken not to expose the equipment to extreme temperatures. To ensure that your Model 3300 will be ready to use, store the instrument indoors during extreme hot or cold temperatures. If the instrument is stored overnight in a service vehicle, be certain the instrument is brought to specified operating temperatures before use.

1.2 Introduction

The Model 3300 is a multipurpose metallic time domain reflectometer, cable fault locator. Model 3300 is designed to quickly and easily locate cable faults in metallic cables, primarily on non-loaded twisted pair cable in the telecommunications industry.

Using time domain reflectometry, or cable radar, the Model 3300 transmits a signal down the cable. Impedance discontinuities along the length of the cable reflect some or all of the signal energy back to the instrument. These reflections are measured and displayed as both a waveform and a numeric distance to the fault.

The Model 3300 will test all types of metallic paired cables for open, shorts, impedance discontinuities and many other cabling problems common to the telecommunications industry.

1.3 General Features

Locates cable and connector faults in all types of twisted pair telephone cables.

Compact, lightweight, portable.

Rugged packaging for testing in all types of weather conditions.

Pre-set Ranges for quick testing.

Exclusive SUPER-STORE waveform storage.

RS-232 Port.

Automatic and manual cursor placement functions.

Intermittent Fault Detection Capabilities.

SECTION 2: OPERATING PROCEDURES

2.1 Theory of Operation

A Time Domain Reflectometer (TDR) works on the same basic principle as radar. Pulses of energy are transmitted down the cable under test. If the cable has a constant impedance and is properly terminated, all of the energy will be absorbed.

If the pulse reaches an impedance discontinuity, part or all of the pulse energy is reflected back to the instrument. If the cable is an open circuit, the reflected pulse will be in-phase (upward reflection) with the output pulse. If the cable is a short circuit, the reflected pulse will be out-of-phase (downward reflection) with the output pulse.

In either case, a substantial amount of energy will be reflected. If it were possible to have a cable with no loss, all of the signal energy would be reflected. The incident and the reflected signals would look identical.

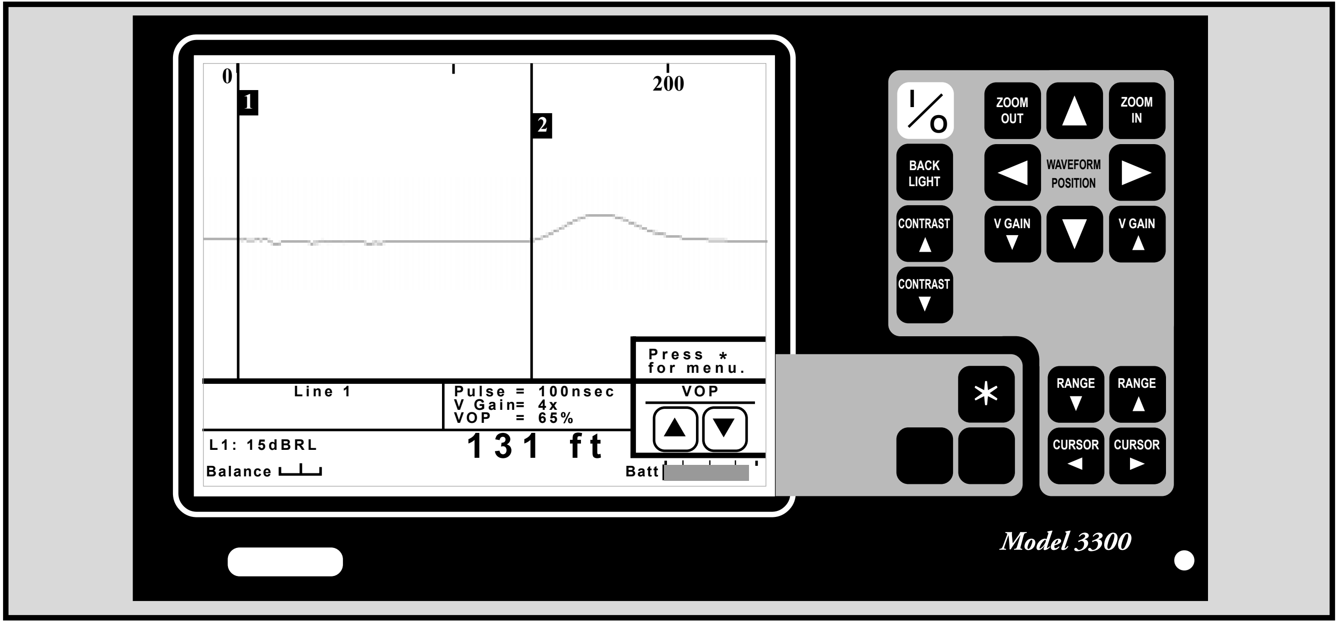
Reflections from an impedance higher than the characteristic impedance of the cable are in-phase, or upward. Reflections from an impedance lower than the characteristic impedance of the cable are out-of-phase, or downward.

Inductive faults cause the TDR to display an impedance higher than the characteristic impedance of the cable being tested. Capacitive faults cause the TDR to display an impedance lower than the characteristic impedance of the cable.

The Model 3300 displays the cable under test as a digitized waveform and a numeric distance readout on the Liquid Crystal Display.

The digitized waveform enables the operator to view the signature of the cable in great detail. An impedance mismatch (opens, shorts or faults of less severity) can be identified and the distance to the fault determined.

2.2 Front Panel Description



Keypad

I/O Use the I/O key to turn the instrument on and off.

Backlight Use the backlight key to turn the electroluminescent backlight on or off.

Contrast Use the two arrow keys to change the contrast of the LCD.

Zoom In, Zoom Out Use the two zoom keys to “zoom” in or out on an area of interest on the waveform display.

Waveform Position Use the four arrow keys to move the position of the waveform(s) left, right, up and down.

V Gain Use the two arrow keys to decrease and increase the vertical waveform amplitude or gain.

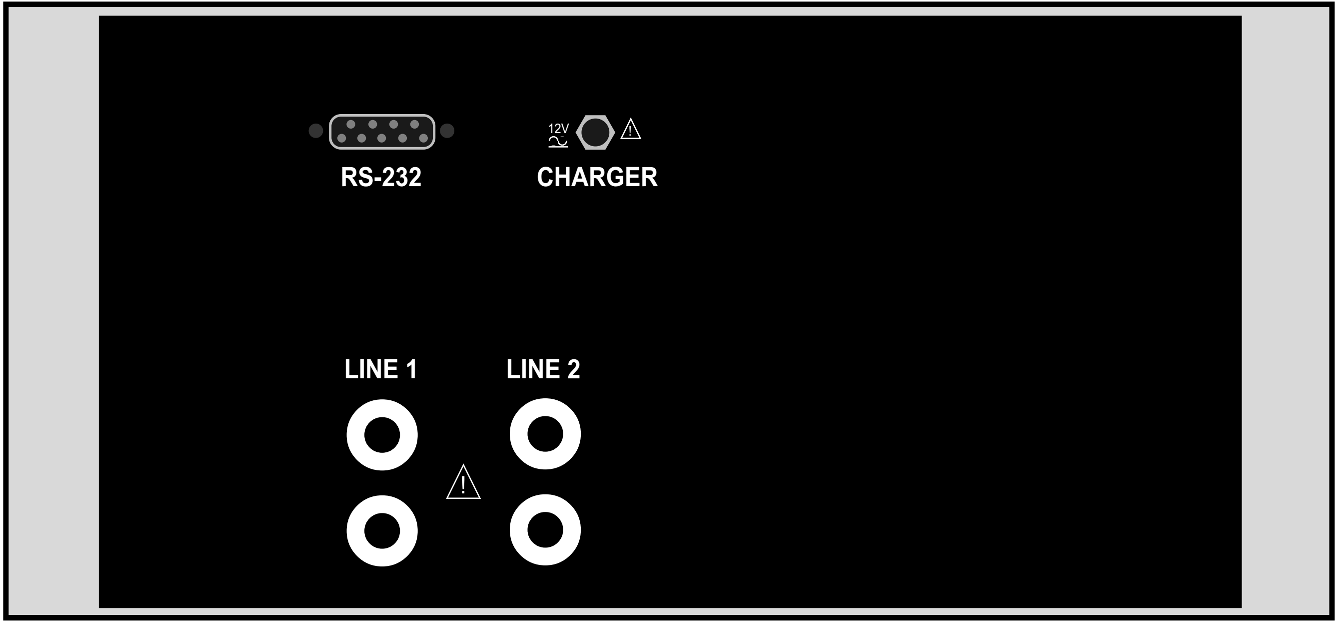
Range Use the two range keys to increase and decrease the cable distance displayed on screen. Pulse width and vertical gain are automatically adjusted for each range.

Cursor Use the two arrow keys to move the cursor left and right.

***** A menu will pop-up when the asterisk key is pressed. The unlabeled icon keys control a selection cursor for choosing the desired instrument control. Once the control is selected, pressing the asterisk key will close the pop-up menu and activate the control.

When a control is activated, the icon keys will control the function and on-screen icons will graphically represent how the keys affect the control. The icons will change depending on the type of action in the particular control.

Back panel description



The Model 3300 has three connectors on the back panel.

RS-232 Serial I/O Port enables the operator to transfer waveforms to a printer.

The Model 3300's battery pack is charged by plugging the external battery charger into the charging socket and AC power. The Model 3300 may be operated while the batteries are charging as long as the charge level is above the minimum level.

Twisted pair cables are connected to the Model 3300 by way of the telco test leads. Test leads connect to the Line 1 and Line 2 banana jack connectors.

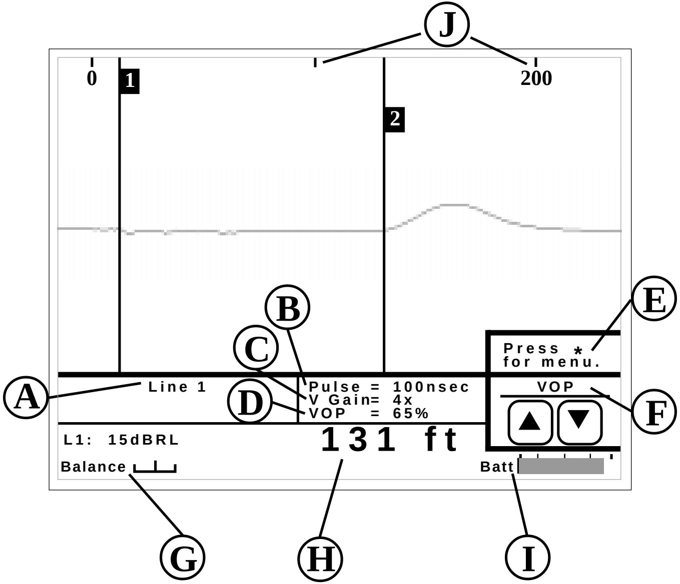
Display

The display is a 320 x 240 dot-matrix, high contrast, SUPERTWIST Liquid Crystal Display (LCD) with electroluminescent back lighting. The top two thirds of the display contains the waveform and cursors. Instrument settings and measurements are located on the bottom of the display.

Information areas on the Liquid Crystal Display (LCD) are:

A. MESSAGE CENTER. The message center displays various information about the status of the instrument and waveform display modes. Additional messages are displayed when utilizing the standard and optional waveform storage functions.

B. PULSE WIDTH. Model 3300 has selectable pulse widths for testing various lengths of cable.



C. VERTICAL GAIN. Displays the level of vertical amplitude or gain applied to the waveform.

D. VOP or V/2. The programmed velocity of propagation is displayed as a percentage of the speed of light from 30% to 99%.

E. MENU. Pop-up menu for selecting instrument controls.

F. SELECTED MENU ITEM. Displays the currently active menu selection, which is controlled by the icon keys. The on-screen icons graphically represent how the keys effect the control.

G. BALANCE displays the current position of the CABLE BALANCE control on a "slider" type indicator.

H. DISTANCE BETWEEN CURSORS. Model 3300 automatically calculates and displays the distance between the 1st and 2nd cursors or between a cursor and the zero distance reference, depending on the setup configuration. (See Setup Options Menu in Section 2.3) Each time the cursor placement is changed or the VOP is adjusted, the DISTANCE BETWEEN CURSORS reading will automatically update.

I. BATTERY LEVEL INDICATOR. A horizontal bar graph indicates the battery level. When the battery level reaches the one-quarter full scale mark, the low battery message is activated.

J. DISTANCE MARKERS. These tick marks are displayed along the top of the screen and can be in feet or meters format. These distance markers enable the operator to view the distance along the cable being tested.

Pop-up menu

Pulse Use the two icon keys to decrease and increase the pulse width.

VOP or **V/2** (depending on the velocity format setting chosen in the setup menu) Use the two icon keys to decrease and increase the velocity of propagation.

Balance Use the two icon keys to adjust the output balance circuit.

Filter Use the two icon key to cycle through the available software filters.

Setup Use the ***** key to display the setup options menu.

Store Use the ***** key to store a waveform to an available storage location.

Recall Use the ***** key to recall a stored waveform from memory and display the list of the stored waveforms.

Overlay Use the two icon keys to adjust the trace separation in dual waveform display modes. This control is only available when two waveforms are displayed.

Mode Use the two icon keys to cycle through the available display modes for single, dual, or difference waveform display modes.

Print Use the ***** key to print the on-screen waveform to a serial printer for documentation.

Search Use the ***** key to preform an auto-search of the cable to find major faultsor the end of the cable.

Cable Use the two icon keys to scroll through a menu of cable types in order to obtain the correct VOP of the cable being tested.

Press * to select.

Pulse	Overlay
VOP	Mode
Balance	Print
Filter	Search
Setup	Cable
Store	
Recall	

2.3 Instrument Operation

Proper operation and precise distance readings will be ensured if you remember the following procedures and choose the mode of operation to best suit your cable testing conditions:

1. Establish a quality cable connection.
2. Adjust the Balance Control to match the proper impedance of the cable.
3. Enter the correct VOP of the cable under test.
4. Start the test in the shortest pulse width.

2.3.1 Range Control

RANGE operation will step through and display a preset distance of cable. A range consists of a specific pulse width, gain setting, and distance of cable. The transmitted pulse is on the left side of the screen and the cable span is shown to the right. The exact length of cable on the screen for each range will be relative to the VOP being used. When using Range, you still have complete manual control and can change the pulse width, zoom-level and other key functions as needed.

With the distance format set in feet mode and a 65% VOP, the ranges are 20, 50, 100, 200, 500, 1,000, 2,000, and 5,000 feet.

With the distance format set in meters mode and a 65% VOP, the ranges are 10, 20, 50, 100, 200, 500, 1,000, and 2,000 meters.

Characteristics of RANGE operation:

1. To switch to the next range, press the RANGE up or down arrows. The distance graduations will change as the range is changed.
2. The cursor can be moved while in the RANGE

mode. As the ranges are changed, the cursor will remain at the same position as the previous range.

3. If the instrument is setup in the dual cursor mode, cursor 1 can also be adjusted; however, it will be placed back at the "0" distance marker whenever a new range is selected.

2.3.2 Distance Between Cursors

Distance readout format may be selected in the setup menu as either single distance cursor or dual distance cursor.

Single Cursor Operation

Single cursor operation uses a single distance cursor to display the distance to fault. All measurements are referenced from the zero distance marker and the front panel cursor keys control cursor movement. Remember that the distance measurement is from the transmitted pulse, to the cursor. Accuracy of the distance reading is dependent on the placement of the cursor and an accurate VOP.

Dual Cursor Operation

When a test is initiated, the independent cursors are used to measure the distance to a fault or to the end of the cable. The cursors are interchangeable; but, to reduce confusion, use the 1st cursor to mark the point you are measuring from and the 2nd cursor to mark the point you are measuring to. The cursors will retain their accuracy and resolution regardless of distance or horizontal zoom settings.

Model 3300's unique dual independent cursors allows you to place cursors at, and measure to (or between) ANY TWO POINTS on the waveform. The distance displayed will automatically adjust with the movement of the cursors. The front panel cursor keys control Cursor 2 and a menu selection controls Cursor 1.

DISTANCE BETWEEN CURSORS is automatically calculated and displayed. Distance is determined from the cursor placement on the waveform. Therefore, the accuracy of the cursor placement is crucial for accurate readings. For greatest accuracy, place Cursor 1 at the "0" distance marker and Cursor 2 at the leading edge of the reflected pulse.

To set the cursors manually, zoom in on the first cursor using HORIZONTAL ZOOM. Set the first cursor by using the 1st cursor left and right arrows to the “0” distance marker on the waveform. To set the second cursor, zoom in on the point of interest and use the 2nd cursor left and right arrows to move the second cursor to the leading edge of the reflection. For the most accurate distance reading, always zoom in on the reflected pulse and adjust cursor placement manually.

The distance between the cursors is displayed on the LCD. Remember that the distance measurement is not from the transmitted pulse, but from the first cursor to the second cursor. Accuracy of the distance reading is dependent on the placement of the cursors and an accurate VOP.

2.3.3 Display Modes

There are a number of different display modes to choose from. Using the pop-up menu, scroll to “Mode” and use the icon keys to cycle to the desired display mode.

Display Mode	Explanation
Line 1	Live waveform from Line 1 input
Line 2	Live waveform from Line 2 input
Line 1 & Line 2	Two live waveforms simultaneously
Line 1 - Line 2	Difference between Line 1 and 2
Crosstalk	Crosstalk mode (Line 1 transmits, Line 2 receives)
IFD	Intermittent Fault Detection mode
Live & Stored	Live and stored (recall) waveform

Live - Stored	Difference between live and stored
Stored	Stored (recall) waveform

Display Mode Loops

Line 1 ———————————		Recall
Line 2 ———	Recall	Line 1 & Stored
Line 1 & Line 2	Line 2 & Stored	Line 1 - Stored
Line 1 - Line 2	Line 2 - Stored	Stored
Crosstalk	Stored	Line 1
IFD	Line 2	

2.3.4 Intermittent Fault Detection (IFD) Mode

IFD detects and displays intermittent faults, whether they are opens or shorts. Some TDRs have a similar feature; however, if the waveform is repositioned, the intermittent fault function is interrupted and the process must be started over. The Model 3300's IFD retains the waveform trace. The waveform can be adjusted, repositioned, zoomed in and out, and the cursors moved, without affecting the IFD function. The Model 3300 will monitor the cable, waiting for an intermittent fault to occur.

Upon entering the intermittent fault mode:

> The LCD's waveform area displays and saves the maximum and minimum reflections of the waveform trace. The auto-off 10 minute timer is disabled so the instrument does not turn off in the middle of the test.

The IFD waveform area stores waveform changes. If an open or short occurs, the instrument will keep the fault trace displayed against the live waveform. This function allows the user to find intermittent problems.

The operator can adjust the waveform with the horizontal position controls, increase or decrease the vertical gain, zoom in or out, and move the cursors. When zooming during the IFD mode, the instrument may need to pause slightly to fill in additional waveform data.

During the IFD mode, do not change the pulse width. If the pulse width is changed, the IFD routine will reset and start collecting data at the new pulse width.

The intermittent fault waveforms are stored in memory. This is an important difference between the Model 3300 and other TDRs. While the waveform is in memory, there are three important things to note;

1. The waveform can be adjusted as if it were a live waveform.
2. Make sure the Model 3300 battery is fully charged. In the IFD mode, if the instrument battery level goes below a minimum safe level, the instrument will turn itself off to prevent possible battery damage.
3. Waveforms can be stored and taken back to the office for downloading to a serial printer for archiving.

Storing an IFD Waveform

To store an IFD waveform, select Store from the pop-up menu while in the IFD mode. The instrument will save the intermittent waveforms in a dedicated IFD memory location. If a waveform has been stored in the IFD memory, the next time you enter the IFD mode, a prompt will appear to confirm you wish to overwrite the old waveform.

2.3.5 Zoom Control

The Horizontal Zoom control expands and contracts the waveform around center screen. This control can be used to closely examine a feature found using preset RANGE operation or can be adjusted manually for complete control of the waveform display distance.

2.3.6 Balance Control

The Balance Control matches the instrument to the impedance of the cable under test and cancels the output pulse out of the waveform display. Connect the instrument to the cable, adjust the balance control so the pulse out area is as flat as possible.

If a fault is contained in the pulse area, the balance control will not be able to balance the reflection out of the waveform so the fault will be visible.

2.3.7 Vertical Gain

The Vertical Gain increases or decreases the vertical amplitude or gain of the waveform display. Increasing the vertical gain of the waveform display allows the user to see smaller reflections or minor faults on the cable signature.

2.3.8 Setup Options Menu

Before using the Model 3300, there are several setup options you can choose from. The options chosen will remain selected, even when the instrument is turned off.

<u>Options available</u>

Distance format: *Distance graduation markers are the same format as the distance reading display.*	FEET or METERS
Velocity format:	VOP % or V/2
Backlight ON or OFF at start-up	ON or OFF
Single or dual cursor option:	SINGLE / DUAL
Cancel test lead length in distance reading	YES or NO
Horizontal Reference	ON or OFF

The distance format option allows the operator to select the distance between cursor and waveform distance markers to either feet or meters.

The backlight at start-up option is used to select whether the LCD backlight is on or off at start-up.

The velocity format option selects whether the velocity of propagation control is displayed as a percentage of the speed of light (VOP) or as meters or feet per microsecond velocity divided by 2 (V/2).

The cancel test lead length option allows the user to automatically subtract the length associated with the test leads from the distance between cursor readout. The instrument will place the first cursor and the zero reference at the end of the test leads.

> Note: Always use the test leads provided. Using test leads of a different length will result in erroneous distance measurements.

The serial printer option is used to select the type of serial printer for RS-232 printing. The options available are Seiko DPU 411 thermal printer and the Citizen PN60 plain paper printer.

2.3.9 Waveform Storage and Recall

Model 3300's SUPER-STORE waveform storage capability allows the operator to store a waveform for later comparison and analysis. SUPER-STORE stores the entire cable under test, not just the section of cable displayed on screen at the time of storage. This feature is helpful if: the incorrect section of cable was on screen at the time of storage; in comparing two separate waveforms (cables); or for comparing the same waveform (cable) before and after repairing the cable.

The Model 3300 comes standard with four SUPER-STORE waveform memory locations. The Extended memory option is available to increase the stored waveform capacity to 16 waveforms. The waveform(s) will remain in storage, even after the instrument is switched off.

Caution: Replacing the batteries, or running down the batteries to a totally discharged state will cause the waveform storage data to be lost.

To store a waveform, scroll through the menu items until STORE is highlighted. SUPER-STORE will prompt the operator to select a memory location or overwrite a used location.

Choose a previously stored waveform to be displayed by scrolling through the menu until RECALL is highlighted. A memory selection list will appear allowing the user to select the desired memory location.

If any waveforms are currently stored in memory, the operator may choose the stored waveform by scrolling to the desired number. When the desired location number is highlighted, press ***** to select the stored waveform to be displayed with the live waveform. All instrument functions will operate normally.

2.3.10 Overlay Control

The overlay control allows adjustment of the waveform trace separation of two simultaneously displayed waveforms, such as Line 1 and Stored. The primary purpose is to enhance the ability to see differences in waveforms when performing comparison tests by positioning the two waveform traces directly on top of each other.

2.3.11 Charging the Batteries

The Model 3300 is powered by a rechargeable battery pack contained within the instrument. The Model 3300 is shipped from the factory with a full charge and will operate approximately 10 hours between charges.

When the battery supply has been depleted and the batteries need to be recharged, plug the external battery charger into the charger socket and into any common AC outlet. The front panel green LED will light to indicate the batteries are being charged. The LED indicator will stay illuminated while the charger is plugged in.

The Model 3300 has a built-in, current-limiting circuit which limits battery charge current. As the batteries approach maximum charge, the charging rate is decreased. Do not leave the batteries charging for long periods of time; their useful life will be shortened. The Model 3300 can be charged with either an AC or DC power source with correct voltage and current specifications.

The Model 3300 will operate while charging as long as the battery level indicator is above a quarter charge. Allow at least 16 hours charging time for the batteries to cycle from a completely discharged state to a fully charged state.

> Note: The Model 3300 may also be charged using an optional 12 volt cigarette lighter adapter.

2.3.12 RS-232 Interface

Model 3300 includes an RS-232 Interface Connector for serial printing. The default serial print device is a Citizen PN60 using the Epson LQ860 emulation format.

SECTION 3: TDR FUNDAMENTALS

3.1 First Time Start-up

Before using your Model 3300, there are several setup options to choose from. Select the Setup menu control and select the desired default settings for the instrument. The options chosen will remain selected, even when the instrument is turned off. See Section 2.3 for setup options.

3.2 Cable Connection

It is important to establish a quality connection to the cable under test. The TDR sends a high frequency signal that is not efficiently transmitted through poor connections or inadequate test leads.

Cables are connected to the Model 3300 by way of banana jack connectors. A banana jack connector provides the versatility to test in, and adapt to, various kinds of environments and industries.

3.3 Cable Check

Do a quick check of the cable. Get as close to the suspected fault as possible. Use common sense when examining the area near the suspected fault. For example, if there is a new fence or sign post, that is probably where the problem is located.

One method for verifying that a cable is free from major damage (or at least has continuity), is to have someone alternately open and short one end of the cable while you test from the other end. If the waveform reflection changes between positive and negative, the cable is good, or not damaged severely enough for the Model 3300 to detect. If the reflection holds one position, the cable is damaged and the Model 3300 will show that a fault exists in the cable.

When testing a section of cable where different types of cable are spliced together, use the independent cursors and the correct VOP for each section of cable to yield the most accurate readings.

3.4 Cable Impedance

Any time two metallic conductors are placed close together, they form a transmission line which has a characteristic impedance. A TDR tests for a change in impedance which can be caused by cable damage, water ingress, change in cable type, improper installation, taps and “tees”, and even manufacturing flaws.

The insulating material that keeps the conductors separated is called the cable dielectric. The impedance of the cable is determined by the conductor diameter, the spacing of the conductors from one another, and the type of dielectric or insulation used.

The Model 3300 uses an output pulse balance circuit that cancels the output pulse out of the waveform display and matches the instrument to the cable under test. Model 3300 still displays fault reflections which occur in this region.

3.5 Velocity of Propagation (VOP)

<u>Determining the VOP</u>

Knowing the correct velocity of propagation is one of the most important factors in successfully finding the distance to a fault. A quick reference VOP card is included with each instrument.

The VOP of a cable not listed on the VOP card can be obtained from the manufacturers’ catalog specifications or by contacting the manufacturer. If you cannot obtain the VOP of a particular type of cable, the VOP can be determined by the following method:

Measure a length of cable identical to the type to be tested. The longer the cable length, the more accurate the result. Connect the cable under test to the Model 3300 and set the cursors to the zero distance marker and the leading edge of the reflected pulse. Change the VOP setting until the distance reading matches the known cable length. The VOP has now been determined. If you are testing buried cable, be certain to allow for cable snaking and depth.

Reducing VOP error

NOTE: Procedures 1 and 2 will work on faulted cables only. When measuring undamaged cable (as on a reel) follow the procedure outlined above. Proceduce 1 and 2 simply test (measure) the cable from one end only. Testing from each end of an undamaged cable will obtain the same reading from either end.

PROCEDURE 1. *Procedure 1 assumes only one fault per cable length. If there are extreme changes in the VOP setting, multiple faults may be present or the cable route may be incorrect.* Testing a cable from both ends is the most common and most accurate method of eliminating VOP error. Using a cable locator and measuring wheel, determine the length and path of the cable being tested.

Test the cable from both ends and record the distance readings. If the two readings do not equal the measured length of the cable under test, change the VOP setting and retest. For each VOP setting, test the cable from both ends. When the sum of the two readings equals the known cable length, the VOP error has been minimized and the exact location of the fault has been determined.

PROCEDURE 2. The same result can also be determined mathematically when testing cables from both ends: Take the actual cable length and divide it by the sum of the two (tests from each end) TDR readings. This gives you an adjustment factor. Next, multiply each of the TDR readings by the adjustment factor. The result will be the corrected length readings.

PROCEDURE 3. If you are unable to test both ends of a cable you suspect is damaged, measure an undamaged cable of identical type to that which you wish to test.
When testing a section of cable where different types of cable are spliced together, use the independent cursors and the correct VOP for each section of cable to yield the most accurate readings.

3.6 Pulse Widths

Many TDRs have selectable pulse width settings. The pulse width allows the TDR signal to travel down a cable at different levels of energy and distances. The wider the pulse width, the more energy is transmitted, and therefore, the further the signal will travel down the cable.

NOTE: Always start the fault finding procedure in the shortest pulse width available, the fault may be only a short distance away. Use the zoom and gain controls. If the fault is not located, switch to the next larger pulse width and retest. Keep switching to larger pulse widths until the fault is located.

Cable Loss

Cable has loss. A signal attenuates as it travels down a cable. Some cables have greater loss or signal attenuation than others. Because the pulse amplitude is reduced by the loss in the cable, major faults at long distances will appear to be of the same amplitude as minor faults close to the instrument.

Attenuation affects the maximum length of cable that can be tested. The greater the cable attenuation, the more energy must be sent down the cable to test longer lengths. To increase the amount of energy transmitted into the cable, increase the pulse width. Model 3300 has multiple pulse widths which the operator can select to best accommodate the cable length being tested. However, since the location of a fault is unknown, it is best to start the testing procedure in the shortest pulse and increase the pulse widths as you increase the distance being tested.

3.7 Noise Filter / Powered Cable

Testing cable with power or a signal present is possible, although for safety reasons, it is not recommended.

> WARNING: For safety reasons, it is recommended that the Model 3300 not be connected to cable that has a signal or power present. The Model 3300 is input protected and features a POWERED CABLE WARNING indicating power is present on the cable under test. The POWERED CABLE WARNING will appear in the message center.

If you must test a powered cable, the Model 3300 features NOISE FILTERS which allow the testing of cables with some signal or power present. If the Model 3300 is connected to a cable with power present, the microprocessor automatically filters the power signal and displays only the normal waveform of the cable under test. When the NOISE FILTER automatically engages, the message center will alternately display POWERED CABLE and AUTO FILTER.

If noise or power is present at levels not sufficient to automatically engage the noise filter, the filter can be switched on manually.

<u>Multifunction Waveform Filtering (Optional)</u>
This feature provides a unique system for filtering out various types of interference on the cable. The operator has the option to try many types and levels of filtering until the appropriate filter is located for each test. The AUTO FIL-

TER will automatically engage if power is present on a cable under test. Testing cable with power present may cause instrument damage. The auto-filter option may also be disengaged, when not required, to speed up the test process.

Riser-Bond Instruments' waveform TDRs offer the most filtering of any TDR. This is extremely beneficial when RF,or any other type of interference is introduced to a cable. If this occurs, the waveform may become noisy and difficult to interpret. The user would then engage the filters to remove the "noise" on the waveform. The waveform will become smoother and easier to interpret. Multilevel/ Multifuncion filtering allows the user to test antennas or cellular sites that may be receiving signals.

There are many different types of signals that can be present on the cable. They range from 50/60 Hz power to audio frequency, to data in the 1 to 100 MHz range, to RF. No single filter will eliminate all of these signals. Riser-Bond Instruments' waveform TDRs have multiple types and levels of filters which eliminate almost any type of problem. In a filtering application, it is necessary for the operator to step through various filters to see which filter works best.

The TDR noise filters are extremely useful when testing noisy cable, but experience will enhance success so practice with different noise sources using different filters.

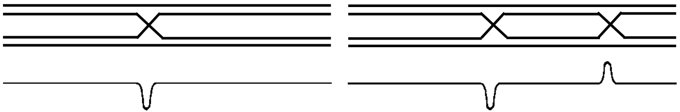
SECTION 4: APPLICATION NOTES

4.1 Locating Splits and Resplits

A split or resplit pair occurs when one conductor each of two different pairs are switched somewhere along the cable length. A TDR used in the traditional mode of simply looking for the impedance discontinuity can, many times, find this split. The problem with the tradi-

tional method is the discontinuity is relatively small and, therefore, the TDR's reflection will be small. If the split is close, it can be identified. If, on the other hand, the split is some distance away, the small reflection is attenuated by cable length and the split can be difficult to locate.
Using the Model 3300 in the Crosstalk mode greatly enhances the reflection and makes finding splits that are far away much easier.

Shown below is an example of a split, and split/resplit and their corresponding TDR waveforms using the crosstalk mode.



Connect one pair of the split pair to Line 1 and the other pair to Line 2. Set the Model 3300 to display Line 1 and adjust the 1st cursor to the "0" distance marker. Cycle the Model 3300 display mode to the Crosstalk mode. The Crosstalk mode transmits the TDR pulse on Line 1 and receives on Line 2. If any energy is coupled from pair 1 to pair 2 (split or resplit), it will return to the instrument and be displayed on the waveform trace. Use the Range horizontal zoom, waveform position, and vertical gain functions to find the discontinuity. Set the cursor to this point. Now you have found the locations of the split and resplit.

4.2 Locating Bridged Taps

A bridged tap is a component within a telephone system that can be one of the easiest to locate with a TDR, but it is also often mis-identified.

The definition of a bridged tap itself can often times cause confusion. Some people refer to a bridged tap as a lateral which extends off of a main cable. However, **the true definition of a bridged tap is the point on the cable where a lateral connects to the main cable. A bridged tap is *not* a section of cable.**

Therefore, we will refer to the **point of connection** of the lateral to the main cable as the *bridged tap*. The cable extending from the bridged tap to the subscriber will be referred to as the *lateral*.

Figure 1 is a common waveform which results from testing a section of cable containing a bridged tap from which a lateral extends to the subscriber.

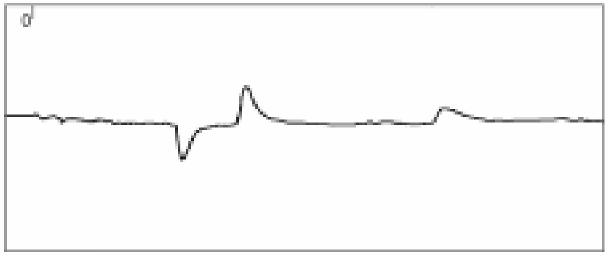
Referring to Figure 1, you *might* assume the following.

Point A: the TDR's point of connection to the cable

Point B: (downward reflection) the point of a bridged tap on the main cable

Point C: the end of the lateral

Point D: the end of the main cable circuit



A B C D

Figure 1

The waveform shown in Figure 1 and the conclusions were correct. However, Figure 1 could also be the result of a somewhat different cable layout as explained below.

A common mistake when testing through bridged taps is to mis-identify the end of the lateral for the end of the main cable circuit. As shown below, Figures 1a and 1b show two different cable plant layouts. However, the resulting waveforms are ***identical***.

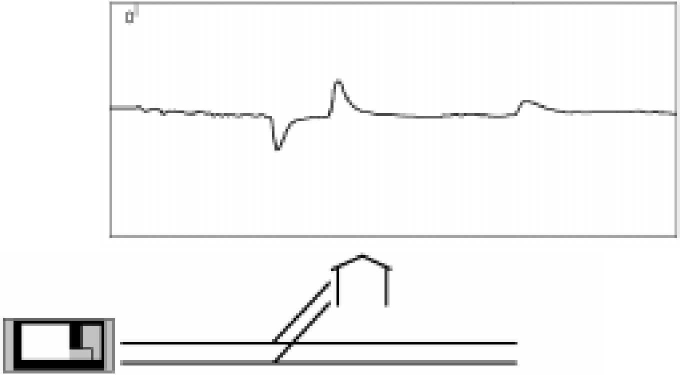


Figure 1a

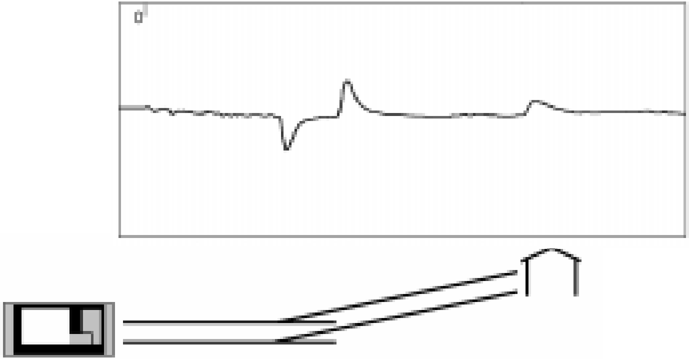


Figure 1b

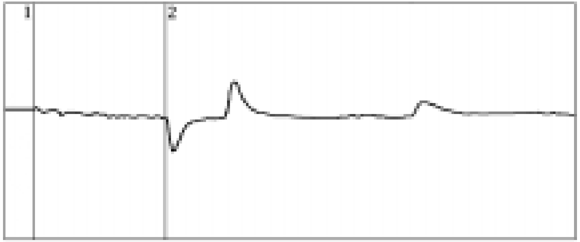
In Figure 1a, the length of the lateral is shorter than the end of the main cable circuit. In Figure 1b, the length of the lateral is longer than the main cable circuit.

LESSON: Do not assume the first upward reflection after a bridged tap is always the end of the lateral; it may be the end of the cable, depending on the layout of the network.

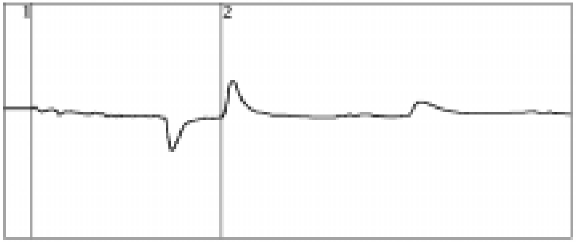
It is always a good idea to refer to plant maps whenever possible to help minimize confusion or errors, especially when testing through bridged taps.

Remember, a TDR will test through a bridged tap displaying a waveform of the cable under test, including any bridged taps and their corresponding laterals. A great deal of information is displayed in the waveform. Therefore, a thorough study of the waveform and correct cursor placement becomes very important.

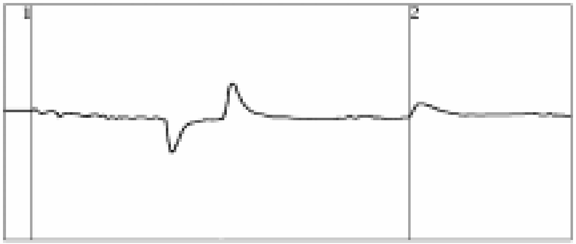
In the following examples, we will use the cable layout as shown in Figure 1a where the first downward reflection is the bridged tap, the next upward reflection is the end of the lateral, and the last upward reflection is the end of the main cable circuit.



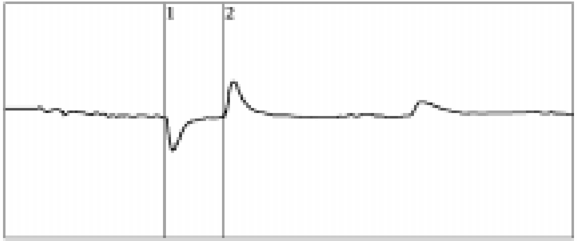
The distance between the two cursors is the distance from the TDR to the point of the bridged tap.



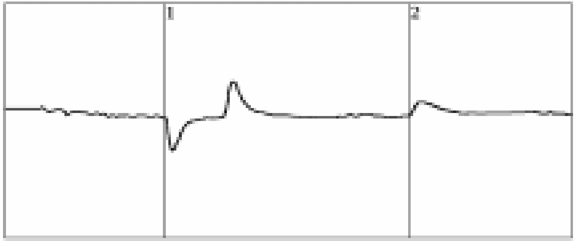
The distance between the two cursors is the distance from the TDR to the end of the lateral.



The distance between the two cursors is the distance from the TDR to the end of the main cable. There is no need to subtract the length of the lateral. This is an advantage of a TDR over an *open locator*.



The distance between the two cursors is the length of the lateral.



The distance between the two cursors is the distance from the bridged tap to the end of the main cable.

When testing through a bridged tap, it can be difficult to determine if the reflection caused by a fault is located in the lateral or in the main cable section *beyond* the bridged tap point, as illustrated in Figure 2. The fault could be in either the lateral or the main cable.

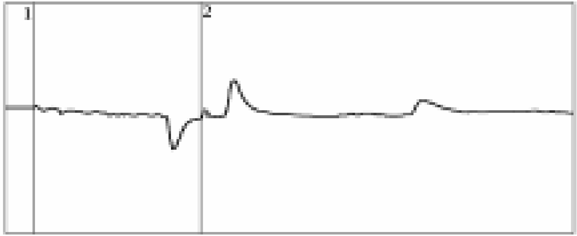


Figure 2

Figure 3 is a waveform from the cable plant layout in Figure 1a. The reflection caused by a fault is obviously located in the main cable beyond the point of the bridged tap and *not* the lateral. It is always a good idea to go to the bridged tap point and test both the lateral and the main cable beyond the point of bridged tap.

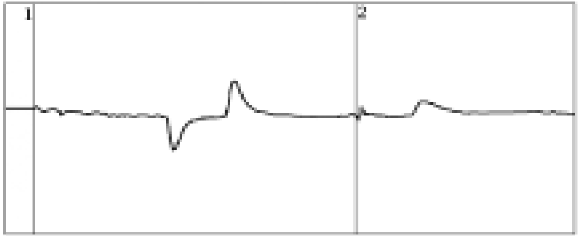


Figure 3

Another example of how bridged taps can be misinterpreted is shown below: In Figure 4, there appears to be a *short* at Point B on the waveform. However, the waveform shown in Figure 4 is actually the same waveform shown in Figure 5. The only difference is the operator has used the zoom function to show only a specific section of cable in Figure 4. The amount of cable shown on the display is not enough to see the end of the lateral or the end of the cable.

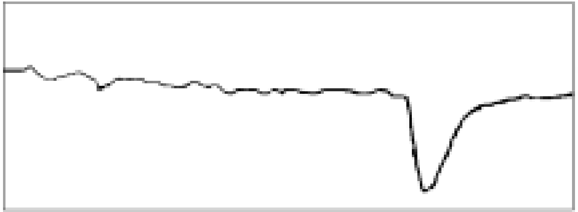


Figure 4

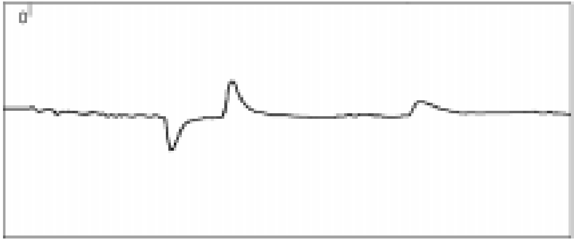


Figure 5

Remember, when testing with a TDR, always start the test in the shortest pulse width or range possible. Continue to increase the pulse width or range until the entire waveform has been viewed. This procedure will insure that no faults are accidentally missed and waveforms are not misinterpreted.

Ghost reflections can appear when testing through bridged taps. Referring to Figure 6a, it appears as though there is a partial open at Point E. This cannot be true as the cable physically ends at Point D. Referring to the cable plant layout in Figure 6b, the ghost is caused when the signal *returning* from Point D passes Point B. The signal splits, some energy returning straight to the TDR (Point D) and some energy traveling down the lateral, reflecting from the end and returning to the TDR (Point E) *after* the reflection of the end of the cable.

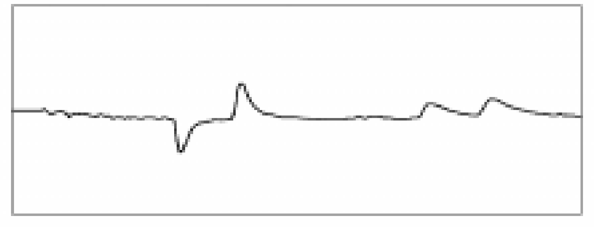


Figure 6a

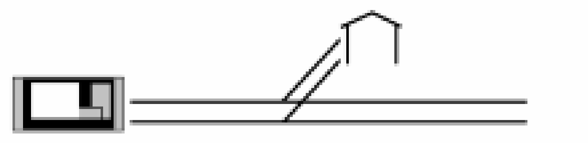


Figure 6b

A good clue that a reflection is actually a ghost from a bridged tap, is that the distance from the end of the cable to the ghost is the same length as the lateral itself (the distance from Points D to E in Figure 6a is the same as Points B to C in Figure 6a). A way to test whether or not Point E is a ghost is to have someone short the end of the cable. If Point D reflects downward along with Point E when the cable is shorted, then Point E is a ghost reflection of the bridged tap.

When testing through bridged taps, the signal strength is cut in half, because a lateral provides a second path for the signal. Point B in Figure 6b is where the signal splits, and because of this, the maximum distance readability is reduced from that point outward. If you can normally test 6,000 feet in a particular pulse width or range, you may only be able to see 3,000 feet beyond due to the bridged tap.

4.3 Moisture in twisted pair

A subscriber complained about a noisy telephone line. The noise was traced to the drop. The subscriber had a 2,800 foot two-pair drop to the home, along a country road ditch, through the yard, and into the house. The unused pair was found to be quieter so the customer was switched to the quieter pair. This seemed to solve the problem until a few months later, when the customer started complaining again.

Retesting the pairs found the original pair was now quieter. Noisy pairs going quiet and quiet pairs becoming noisy led the technicians to suspect water in the cable. Plant records showed the cable was not spliced so it was unknown how and where the water was getting into the cable.

The cable was tested with a TDR and an undocumented splice was found. Close examination of the splice showed it to be totally saturated with water. The cable was re-spliced and the lines were now quiet.

The greatest percentage of twisted pair problems fall in the moisture-in-the-cable category. How to locate the problem, why one pair may be affected but not another, and how much of the cable is affected are all problems which have to be addressed.

A TDR will find water in the cable. It shows up as a lowering of the cable impedance. Most times, though, it is difficult to accurately tell how much of the cable is affected. In filled cable, moisture cannot migrate inside the cable so it is typically a point problem in the cable or splice case. In air-core or pulp cable, moisture can migrate along the cable.

By testing the cable from both ends and recording the distance to fault in all pairs, it is possible to determine approximately how much cable is affected.

When testing through water, measurements up to the water are very accurate. After the water, distance readings may be erroneous due to a VOP change caused by the water. Although the moisture may be 20 or 30 feet wide, each pair usually becomes impregnated at different points. The range of these points will indicate the length of the problem.

Water can seep into the conductors through pin holes in the plastic insulator around the conductors. When testing each pair, the footage to the problem may read different for each pair. This is because the water has penetrated through the conductor insulation at different points and affects the conductors at different footages.

The location and how much cable is affected is now known. But it is still necessary to locate where the water actually entered the cable. A break in the sheath may not necessarily be within the span of where the water is and may not necessarily show up in testing. If the break in the sheath is not fixed, the problem will show up again in the future.

If the break in the sheath happens to be at a high point in the cable, the water will enter through the hole then migrate to a lower point. If the water entry point is not found, it may be necessary to visually inspect the cable. Check the integrity of the sheath.

4.4 Locating Intermittent Faults

A major problem in troubleshooting outside plant is locating intermittent faults. The first indication of an intermittent fault is when a telephone customer complains of noisy static or no dial tone. The problem is usually a high resistance series fault or intermittent connectors.

Many times, the customer calls with a noisy telephone line. However, by the time the trouble crew is deployed, there is no trouble found. When there is no loop current, the fault heals itself. As soon as you leave the trouble, and the customer uses the line again, they report the same type of trouble.

Solid cases of trouble are very easy to locate with the help of a TDR. If the trouble is intermittent, the technician will have a difficult time seeing the problem on a TDRs waveform with just the naked eye. When this type of trouble is located very close to the subscriber end of the line, this may be a high resistance open (series resistance fault).

Below is a quick and easy guide on how to locate “noisy static” troubles with the Model 3300’s IFD Mode:

1. **Disconnect** at the lightning protector on the subscriber end.

2. **Confirm the trouble.** Connect a butt set, turn the speaker on and listen to the line. Confirm that the trouble you hear (if any) is what the customer reported.

3. **Turn the butt set to mute, and dial a silent termination.** This is done to prevent any noise picked up by the microphone of the butt set to be put on the line, as it may affect the TDR waveform.

4. **Connect the Model 3300.** Connect the test probe leads to the pair under test. Continue to keep the butt set connected to the pair with the silent termination.

5. **Switch on the TDR** by touching the I/O key.

6. **Initiate the IFD mode** by cycling through the various display modes.

7. **Wait for the fault to occur.** The Model 3300 will display a live waveform, while monitoring the line for any intermittent waveforms. If an intermittent fault occurs, the trace of the fault area will be superimposed on the live waveform. With the loop current on line, the trouble will normally appear within 5 to 10 minutes. Adjustment of the waveform on the screen both vertically and horizontally will not affect the test.

Note: Some intermittent faults are caused by the environment. For these situations it is not necessary to have access to a dial tone.

SECTION 5: WAVEFORM EXAMPLES

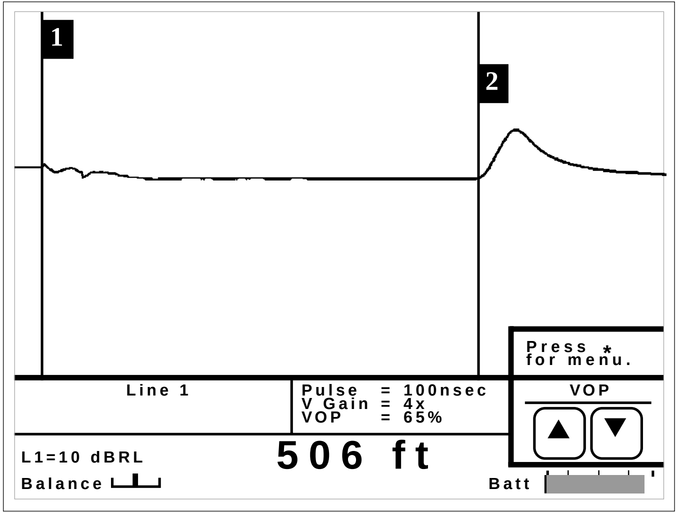
A great variety of waveforms may be encountered. This is due to the various applications and electrical and environmental characteristic differences found in the wide variety of cables that exist today.

Remember also: The reflection of a fault or component will look different on a short length of cable than it will on a long length of cable.

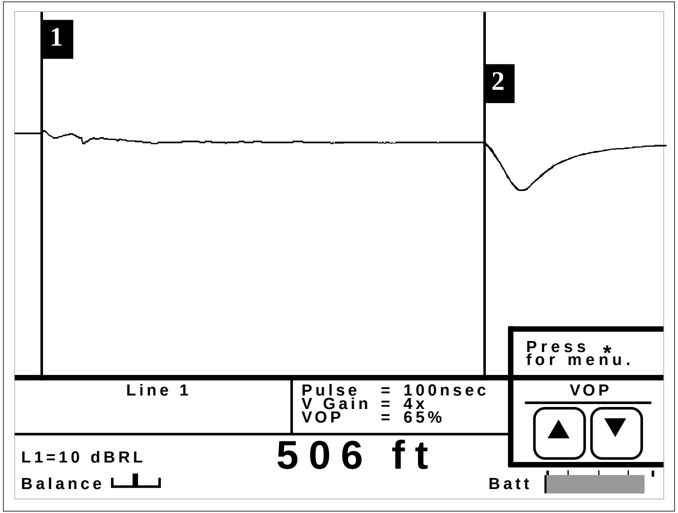
Various industries, cable types, and components produce many different waveforms. The TDR's pulse width, horizontal zoom, and vertical gain settings all affect how a waveform will appear.

Practice testing various known cable segments, with and without components. Become familiar with how each segments looks prior to any problems.

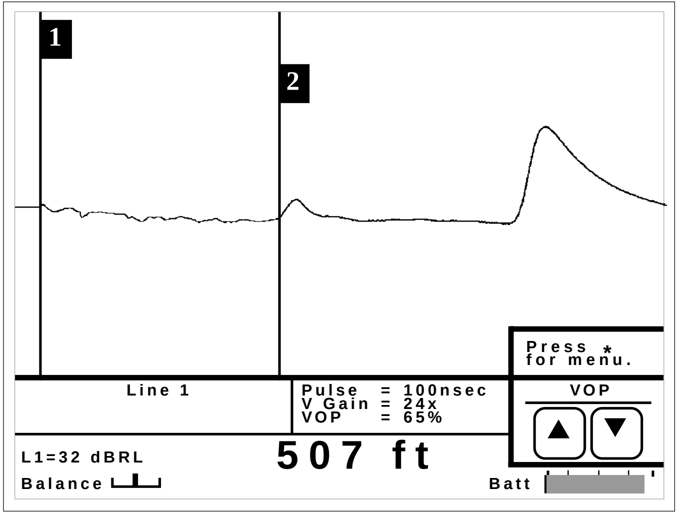
The following pages contain samples of waveforms you may encounter:



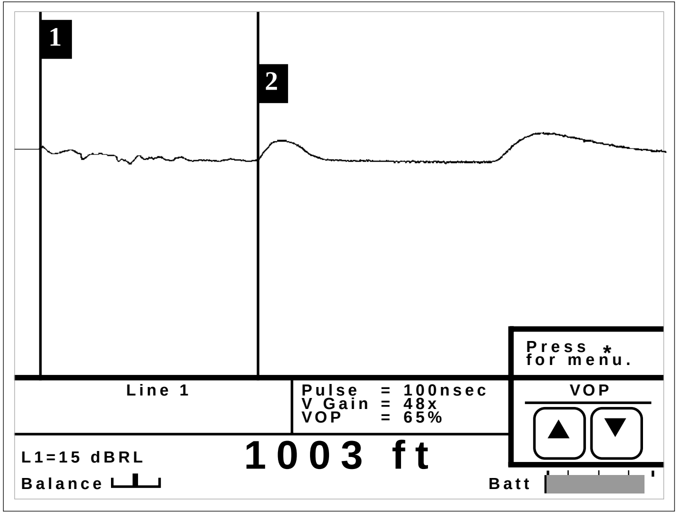
A reflection with upward polarity indicates a fault with OPEN (high impedance) tendencies. The reflection shown at the second cursor is a COMPLETE OPEN.



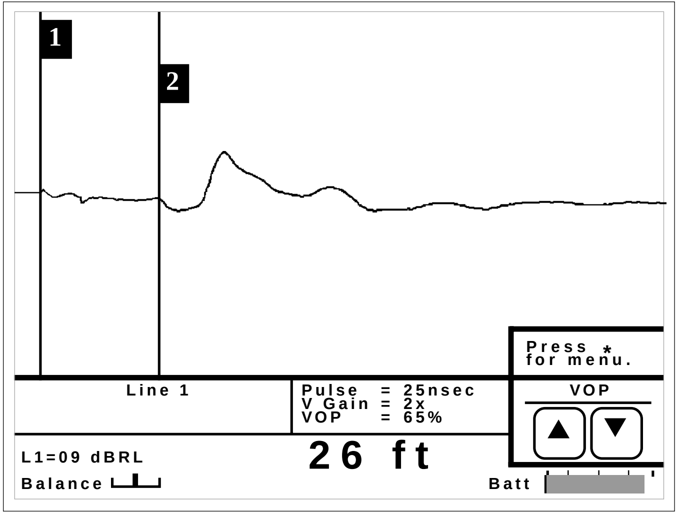
A reflection with downward polarity indicates a fault with SHORT (low impedance) tendencies. The reflection shown at the second cursor is a DEAD SHORT.



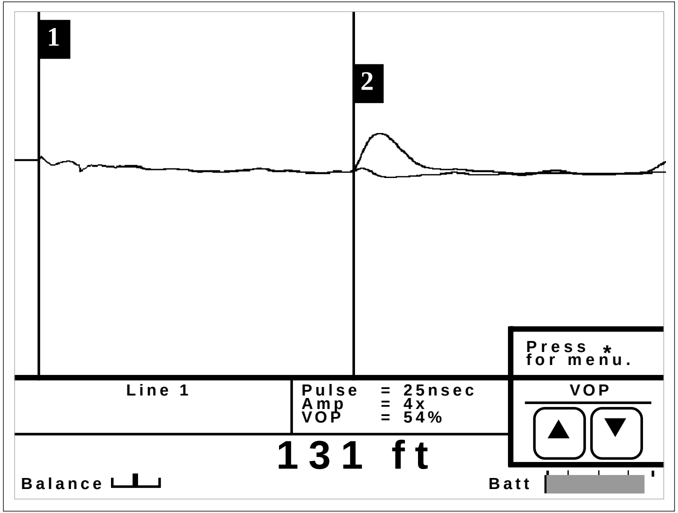
The middle reflection at the 2nd cursor is a ONE SIDE PARTIAL OPEN followed by a COMPLETE OPEN (end of the cable). The more severe the fault, the larger the reflection will be.



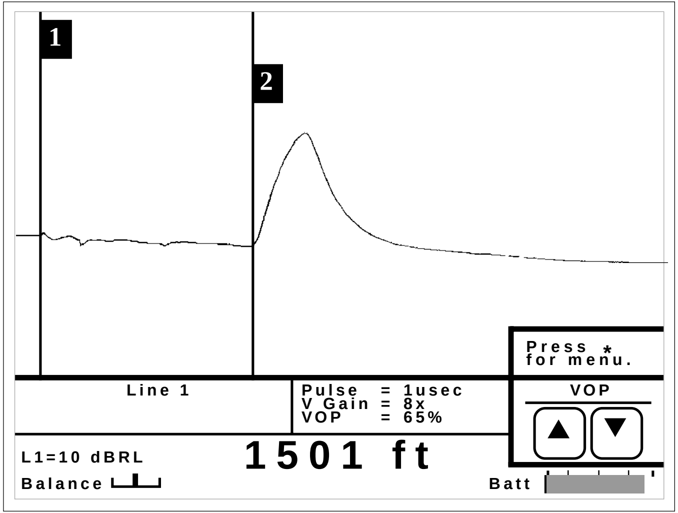
A 10 Ohm series resistance fault at the 2nd cursor (1000 feet) followed by a complete open at 2000 feet.



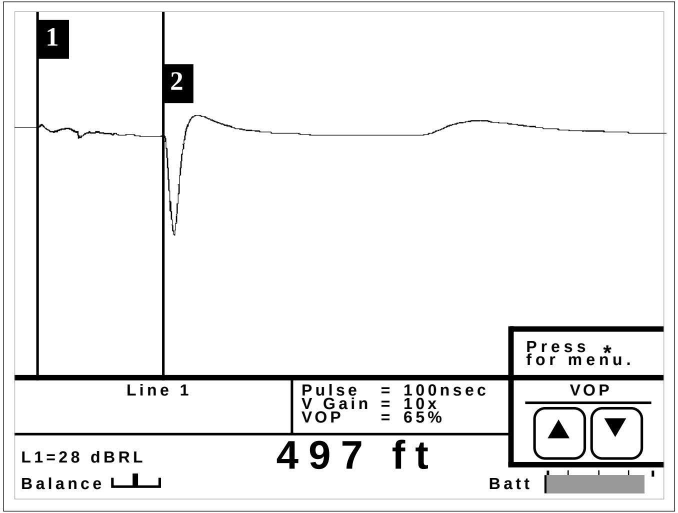
A wet splice at the 2nd cursor. This is the first splice out from the cross connect.



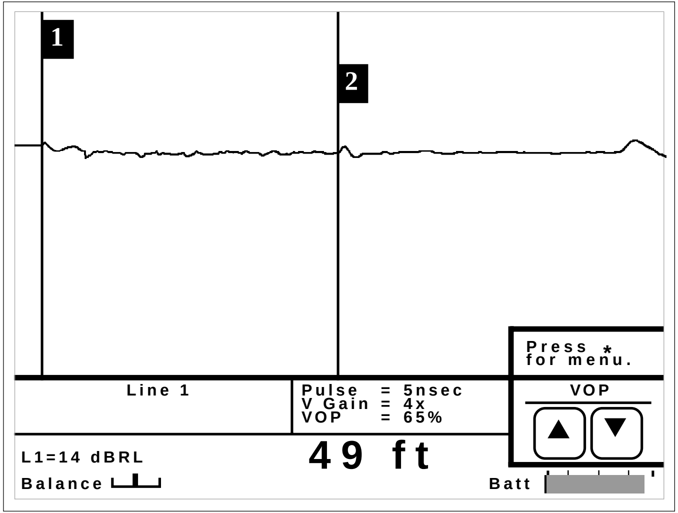
An intermittent open at the 2nd cursor is trapped by the Intermittent Fault Detection (IFD) Mode.



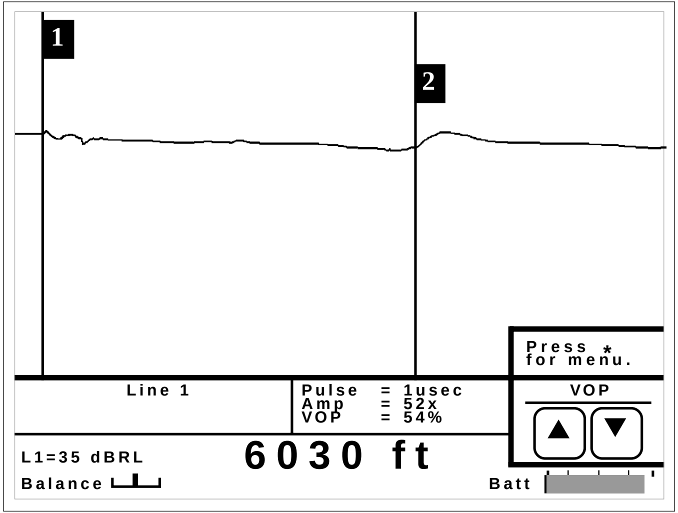
A telephone load coil will cause a high impedance UPWARD reflection (similar to a COMPLETE OPEN).



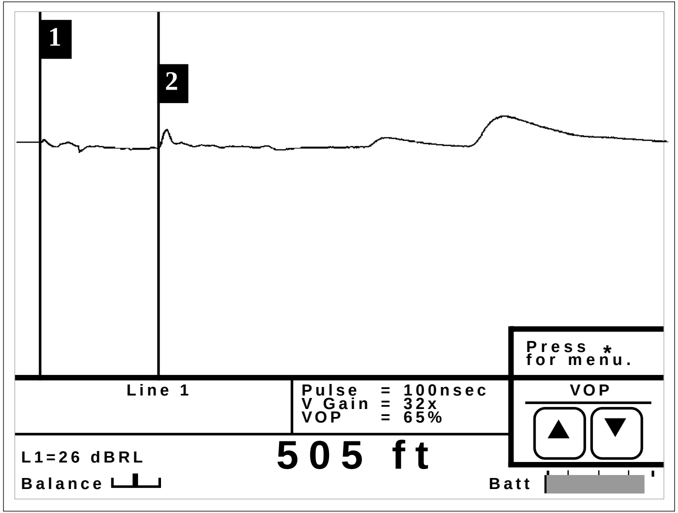
A telephone BUILD-OUT CAPACITOR causes a low impedance DOWNWARD reflection (similar to a SHORT) followed by a smaller positive reflection.



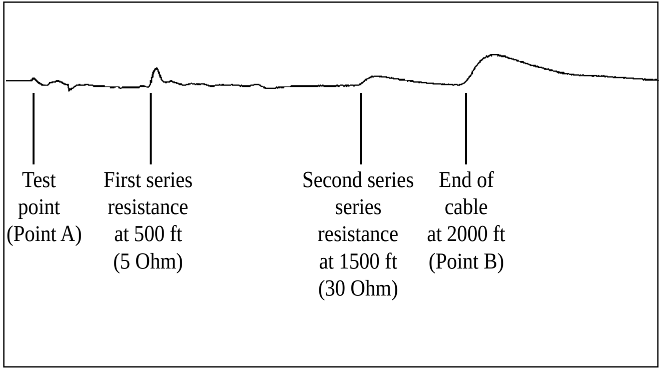
A joint or splice at the 2nd cursor. The visibility of a splice will depend on the type and quality of the splice, and the distance away.



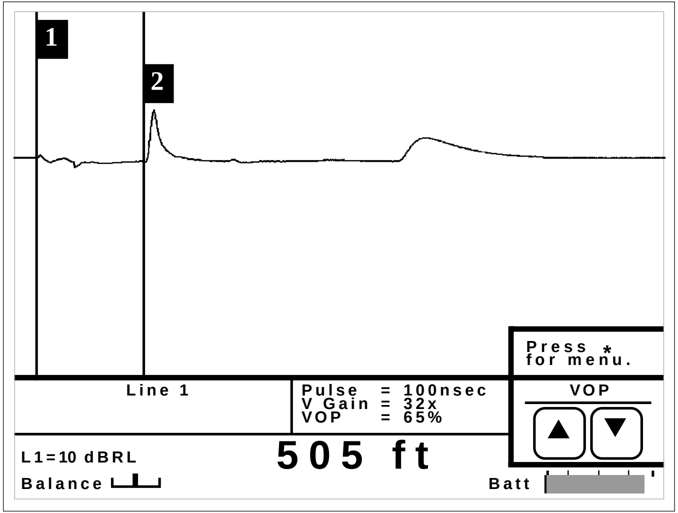
An open at 6000 feet on twisted pair cable. Increasing the pulse width and vertical gain is necessary to see a distant fault.



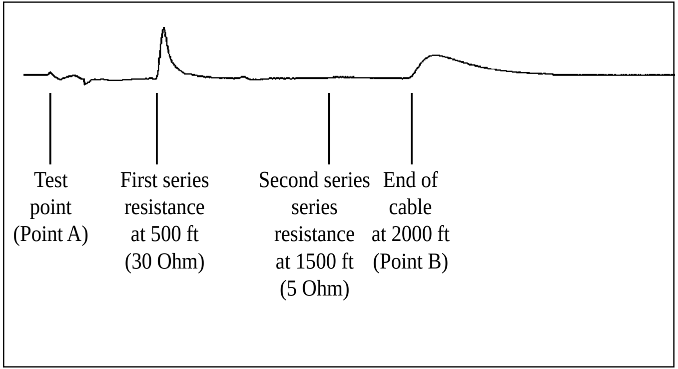
After the first major reflection, the second event could be a more severe fault. It appears smaller to due absorption of signal at the first fault. Always shoot the cable from both ends to eliminate this problem.



Description of test setup, measuring from the **near** end.

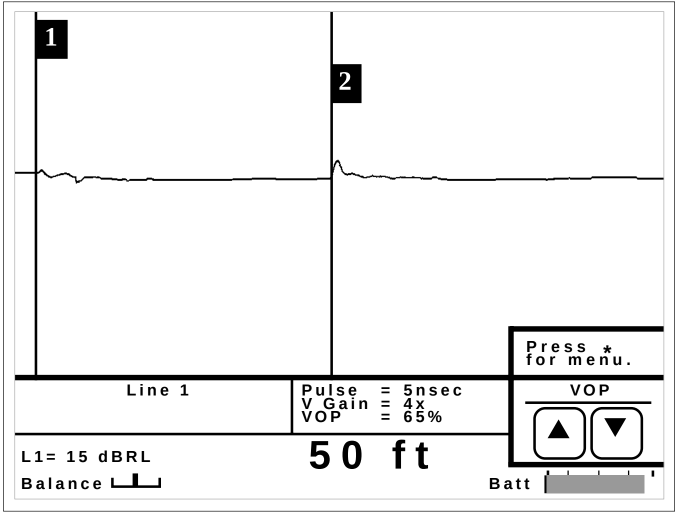


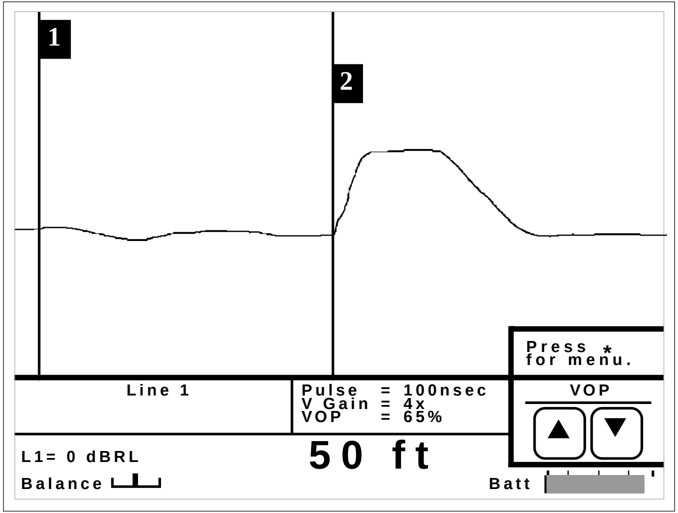
Measuring from the far end.



Description of test setup, measuring from the **far** end.

The next two waveforms illustrate how changing one setting can change the way a waveform appears. Both tests are of the same cable. Only the pulse width setting of the instrument has been changed.





SECTION 6: MAINTENANCE

Cleaning

Remove dust from the outside of the instrument and connectors with a lint free cloth or a small, soft brush.

Clean the case and instrument with a mild soap and water cleanser. Make sure the cloth is only *damp* to avoid getting water in the instrument.

Do not use harsh chemicals or abrasive cleaners. Damage to the front panel overlay may result.

Periodic Inspection

To maintain the TDR in peak operating condition, periodically inspect the instrument and accessories to make sure there is no damage, worn or missing parts or deformations in the enclosure.

If the unit is regularly operated in harsh, dusty or wet environments, inspect after every use.

The instrument should be inspected and cleaned periodically. Inspect the front panel connectors for dirt, broken or deformed insulation and contacts. Clean or replace as necessary.

Inspect cable accessories for damaged insulation, bent or broken clips. Replace as necessary.

Service

There are no user serviceable parts on or in this instrument. It is recommended that service of any type, to the instrument or any accessories, be referred to Riser-Bond Instruments or another authorized repair facility.

Warning: To avoid risk of electric shock, do not perform service of any type to the instrument or any accessory.

Instrument Disposal

This instrument is equipped with non user serviceable Nickle Metal Hydride batteries. Should this instrument need to be disposed of, please consult your local regulations as to the standard disposal procedures.

SECTION 7: SPECIFICATIONS
Specifications for Model 3300

Physical - Instrument Only

Height:	4.7 inches (120 mm)
Width:	9.5 inches (240 mm)
Depth:	2.4 inches (60 mm)
Weight:	2.75 pounds (1.2 kg)

Physical - Instrument with Carrying Case and Accessories

Height:	6 inches (152 mm)
Width:	11 inches (280 mm)
Depth:	4.5 inches (115 mm)
Weight:	4.75 pounds (2.15 kg)

Environmental:

Operating Temperature: 0^0 C to 50^0 C (32^0 F to 122^0 F)
Storage Temperature: -20^0 C to 60^0 C (-4^0 F to 140^0 F)
Humidity: 95% maximum relative, non-condensing

Distance Accuracy: +/- 0.5 ft (0.15 m) plus +/- 0.01% of reading

Safety:

EN61010-1:1993 inc AMD A2:1995

Display:

320 x 240 dot-matrix liquid crystal display with electroluminescent backlighting

Power:

Battery: Internal, rechargeable, 7.2V Nickel Metal Hydride
Charging Source: External 12 VAC transformer, 1.3 A
Operating Time: greater than 10 hours, continuous without backlight

Output Signal: Pulse widths of 5, 25, 100, 1000 nsec

Output Balance: Variable

Horizontal Resolution:

1 foot (0.1 m) at any VOP

Vertical Resolution:
14 bits with 170 dots displayed

Vertical Sensitivity:
Greater than 56dB

Maximum Range:
63,700 ft (19.4 km) at 99% VOP
38,600 ft (11.7 km) at 60% VOP
Range varies with VOP. Maximum testable cable lengths varies with pulse width and cable type.

Waveform Storage: (6144 samples/waveform)
Standard: 4 SUPER-STORE waveforms
Optional: 16 SUPER-STORE waveforms

Software Noise Filters:
Standard: 8x, 50/60 Hz, Auto
Optional: 4x, 16x, 32x, 64x, 128x Averaging

Input Protection:
400 V (AC+DC) from DC to 400 Hz, decreasing to 10 V at 1 MHz

Velocity of Propagation: *Two user-selectable display formats*
VOP (%) with 2 digit precision ranging from 30% to 99%
V/2 with 3 digit precision (feet or meters per microsecond) ranging from 45 to 148 in meters mode or from 148 to 487 in feet mode

Standard Accessories:
Operator’s manual, 12 VAC charger, padded carrying case, Two banana jack test leads

Optional Accessories:
Extended waveform storage
Extended noise filters
Extended warranty

APPENDIX A
Serial I/O Printer Port Connection

Epson LQ-860 Emulation
The Riser-Bond Instruments Model 3300 will print to an Epson LQ-860 type printer through the Epson LQ-860 command set. Serial communication parameters: no parity, two-stop bits, and 9,600 baud.

Citizen PN60 Pocket Printer
Riser-Bond Instruments Model 3300 will print to the Citizen PN60 Pocket Printer through the Epson LQ-860 command set. The printer setup parameters are as follows:

Language:	English
Font:	Roman
Font Lock:	Off
Line Spacing:	6 LPI
Character Set:	Italics
Code Page:	USA
Space Skip:	Enable
Stylewriter:	Auto
Protocol:	DTR
Emulation:	Epson
Pitch:	10 CPI
Compress:	Off
Form Length:	11 letters
Slash Zero:	On
Int’l Char Set:	USA
Auto LF:	Off
Power Off:	3 minutes
Baud Rate:	9,600

This printer may be connected to the Model 3300 with a DB-9 female to AMO178234-4 cable. This cable must be wired in a Null modem fashion (transmit to receive, receive to transmit). The serial printer cable connections are as follows:

9-Pin 3300	26-Pin Printer
2	15 Rx
4	18 DTR
5	1, 2 GND
7	20 RTS

RS-232 pin connections for the Serial I/O printer port.

APPENDIX B

VOP Table - Twisted Pair

CABLE	AWG	MM	VOP
PIC	19	.912	.72
	22	.643	.67
	24	.511	.66
	26	.404	.64
JELLY	19	.912	.68
FILLED	22	.643	.62
	24	.511	.60
	26	.404	.58
PULP	22	.643	.67
	24	.511	.68
	26	.404	.66

WARRANTY

Riser-Bond Instruments warranties the Model 3300 for a period of ONE YEAR from the date of shipment from Riser-Bond Instruments' factory or its designated distributor, that the Time Domain Reflectometer Model 3300 shall be free from defects in material and workmanship that develop under normal use in accordance with Riser-Bond Instruments operating instructions.

Items returned for repair or replacement shall be shipped with a copy of the dated invoice, freight charges prepaid, to:

Radiodetection

154 Portland Road, Bridgton, ME 04009 USA

Tel: (207) 647 9495   Toll Free: (877) 247 3797   Fax: (207) 647 9496   E-mail: bridgton@radiodetection.spx.com

This warranty will be void if products manufactured by Riser-Bond Instruments are modified by the purchaser during the period of warranty without Riser-Bond Instruments written consent. This warranty is expressly made in lieu of all other warranties expressed or implied, including merchantability, whether arising by law, custom or conduct. The rights or remedies provided herein are exclusive in lieu of any other rights or remedies unless specifically stated in the purchase order for this equipment. This warranty covers repair or replacement of the purchased item only and does not cover any subsidiary damages to associated customer equipment. If the extended warranty is purchased, it does not apply to the battery pack.

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Riser Bond

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