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Tap Detector Manual

TDR III

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WARRANTY

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INTRODUCTION

BACKGROUND

As the price of electricity has increased, energy theft has become more lucrative. The incidence of pilfering, as well as major theft, increased dramatically in the 1980's. It is estimated that utilities are losing between 3% and 6% of their generated power to theft.

Theft of electricity can be accomplished by tampering with the meter itself, using a substitute stolen meter for a portion of the billing period, or by tapping the service drop ahead of the meter so that the stolen electricity never goes through the meter at all. The Tap Detector is designed to detect and locate illegal taps on the service drop ahead of the meter.

Thieves go to great lengths to prevent the utility from finding their illegal taps. A method commonly used is to tap onto the service and run the tap coinciding with the service drop so that it cannot be detected with a metal detector.

One method for detecting illegal taps is to pull the meter and confirm that all power is indeed cut off. If a light is still on, or the air conditioner continues to run, it is obvious that a tap exists. To circumvent discovery, the thief connects a breaker to the tap that is automatically tripped when the meter is removed from the socket. When the meter is removed, the breaker disconnects the load connected to the tap. It appears that pulling the meter disconnected all of the service. The breakers have manual resets to further confound detection of the tap.

Most taps are found because the thief brags to the wrong person, the thief falls out of good graces of someone who knows about the tap, or an innocent disclosure by someone unaware of the theft; i.e., the wife having coffee with a neighbor mentions that their electric bill is only $50.00 per month and the neighbor in a similar size and equipped home with a bill of $200.00 per month calls the power company to have the discrepancy investigated.

WHAT IS A TAP DETECTOR?

The Tap Detector (TDR III) is an easy to use precision instrument for sensing the presence and location of a tap between the utility distribution transformer and the meter. These illegal taps are installed to power large loads, such as air conditioners, electric heat and swimming pool heaters, without paying for the power consumed.

The TDR III is a two module system: an interface adaptor and the measurement and analysis instrument that plugs into the interface adaptor. The technology is Time Domain Reflectometery that has been customized for analyzing utility lines. The TDR III inserts a signal and sequentially measures the voltage response reflection based on the impedance every .8 feet along a 183 foot cable. This record is then analyzed by some unique thresholds which permit determining the exact location of any discontinuity on the cable.

The TDR III can identify the presence and location of an illegal tap if the tap is an open

circuit or drawing power. The TDR III works equally well while other customers are connected to the secondary side of the distribution transformer, and whether or not they are drawing power during the test.

The TDR III can identify the tap location to within 1 foot of the socket or out to the transformer.

The TDR III consists of two modules, the measurement and analysis instrument and the interface adaptor. In addition to these two field devices, a computer running Windows Software and a printer are required. The computer and printer are standard, the same ones you use for other projects.

Interface Adaptors

The interface adaptor is the interface between the power line and the measuring instrument. The terminals connected to the power line are electrically isolated from the instrument by 600V capacitors. The capacitors block the AC voltage from the banana jack plugs on the interface adaptor.

There are 5 different interface adaptors available. These are for 3 wire singlephase, 3 wire delta or network, 4 wire Y or Delta and a universal 2 terminal device with alligator clips or E-Z Macro Hook for use on non-socketed services.
A detailed description of the interface adaptors is supplied in section 4 of this manual.

Cable Analyzer TDR III

The TDR III is housed in a 4 X - 7 1/2 X 1 1/2" plastic enclosure that weighs less than 2 pounds. There is a removable battery access panel to facilitate changing batteries. An 8 foot coaxial cable extends from the front edge with a banana plug for connecting to any of the interface adaptors. An on/off power switch and DB9 terminal; are located on the right side of the instrument.

There is a two line 16 character LCD on the face of the TDR III. This displays the selections of each process; measure, analyze, administrative and setup. A detailed discussion of the TDR III operation is in section 5.

The TDR III has only four control "buttons". These "buttons" are surface mounted tactal switches on the face of the TDR III. The controls are up, down, menu and go. The up and down keys move the cursor on the LCD up or down. Go initiates a process. Menu is essentially an abort key to return the system to the main menu screen.

Computer

The computer is your standard personal computer with a Windows based operating system. The computer is used to set up the TDR III and later to retrieve, analyze and store records.

The computer is used to set administrative data in the TDR III such as the time and date,

operator initials and to calibrate the TDR III for cables and soil conditions. Custom thresholds can be developed and downloaded to the TDR, to detect any type of anomaly.

Later the computer is used to store, display, analyze and print plots of records taken in the field by the TDR III. Each record is identified by serial #, operator initials, time and date taken and record #. With the Host computer details of address, meter #, customer name, etc., can be quickly added to the file.

Records can be printed directly or exported to a spreadsheet for printing. Printed records can be captured in a word processor and added to a report to management, customer or the courts.

Printer

Records may be printed with your standard printer working with your windows program. No special printer or drivers are required. All of the analysis is accomplished in the TDR III or, optionally, in the computer.

THEORY OF OPERATION

The TDR is a Time Domain Reflectometer. It operates on basic transmission line theory. It will analyze any cable that exhibits the characteristics of a transmission line.

If you insert a signal (Ping) into a transmission line with an impedance of 93 ohms (the characteristic impedance of a power line cable) with no discontinuities along the line and terminated in a 93 ohm impedance, there will be no reflected signal because all of the transmitted Ping is absorbed in the perfectly balanced 93 ohms at the end of the cable. The TDR in this example would see no reflection.

If the end of the cable above is open, the reflected signal from the end of the line will be the Ping inserted but attenuated by the length of the cable. The longer the cable, the greater the attenuation. This is the response of a clean cable (no taps, spreads or splices) open at the end.

If the end of the cable above is shorted, all of the energy of the Ping will be returned but inverted, a negative pulse, which is the transmitted Ping inverted and attenuated by the cable length. This is the response of a clean cable (no taps, spreads or splices) shorted or connected to a transformer at the far end. At the frequency of the Ping used in the TDR, the transformer (inductor) at the far end looks electrically like a short.

If there is a tap, spread, splice or other discontinuity on the cable, some of the energy of the Ping is reflected back to the TDR. A tap looks like a short (negative signal) and a splice or spread look like an open (positive signal). This is the method the TDR III uses for locating and identifying discontinuities on the cable.

A similie is a long canal with perfectly even sides and depth. If a single wave were initiated at one end of the canal and the canal were infinitely long, all of the energy would be dissipated- and there would be no reflection. If the end of the canal was at a distance an exact multiple of the wave length of the inserted wave, the reflected wave would return to the starting point exactly like it was inserted. If the canal were 1/2 wave length longer, the reflection would return to the start 180 degrees out of phase with the transmitted wave.

Continuing with the similie, we have a canal 200 feet long and 10 feet wide with an abutment protruding one foot from each side at 50 feet. If a wave is started from one end of the canal, there will be a reflection from the abutment. Timing the return wave will determine that the abutment is at 50 feet.

This is analogous to a change in impedance caused by a spread or tap on a cable. The TDR III inserts a narrow pulse (like the wave in the similie) into one end of the cable. The TDR then measures the reflection of the Ping which is a positive or negative voltage based on the impedance of the point. being measured. The TDR actually measures the level of the signal every .8 feet along the line. The TDR takes 240 measurements and, therefore, measures the voltage based on the impedance at 240 points along the cable. The measurements are taken at .8, 1.6, 2.4, 3.2 . . . 183 feet. The overall length of the cable that can be measured depends on the propagation velocity of the signal in that cable

but is basically between 150 and 200 feet.
The TDR captures all of these 240 measurements and plots an exact representation of the cable's 240 points. Once the cable has been measured (5.4 seconds), the analysis is accomplished with positive and negative thresholds above and below the center line. If the wave crosses the negative threshold for a determined amount of time, the TDR III identifies that as the location of a tap. That location is displayed on the TDR III LCD. The TDR III has a linear and exponential threshold and the user can add their own custom threshold based on experience in the field. The threshold only effects the way the wave form is automatically analyzed by the TDR III or computer. With the wave form displayed on a computer screen, the brain can do its own analysis by experience.

The only other concept in understanding how the TDR operates is propagation velocity. The Ping travels at different speeds based primarily on the dielectric constant of the insulator around the conductor. Dielectric constants of insulation around electric cable are similar but could have minor differences. The propagation velocity determines how fast the Ping travels in a given cable.

Provisions have been made to cover any possible propagation velocity that can be encountered. The propagation velocity can be set from 2.000 to 9.999. This is the method used to calibrate the TDR III.

Propagation velocities are different in overhead and buried cable and can vary depending on the soil conditions. The TDR has two propagation constants in its memory, normally one for overhead and one for buried cables. Alternatively these could both be for underground cables; one for dry conditions and one for wet conditions, etc.
These can be calibrated from the computer and downloaded to the TDR III.

This section started by stating that the TDR worked based on transmission line theory. The two wires of the cable are a transmission line. The furthur the two wires are spread, the less the cable looks like a transmission line, until eventually it is not a transmission line and the reflections seen by the TDR are random and meaningless.

This is analogous to a multi-faceted puddle. If you insert a wave at one facet, there will be reflections from every irregularity and, therefore, can not be meaningfully analyzed.

This is why no time domain reflectometer can analyze random layed wire. Random layed wire is not a transmission line.

INTERFACE ADAPTORS

There are 5 interface adaptors available for the TDR III. The TDR III is supplied with a singlephase adaptor that works with the Utilities services. Others may be purchased for a nominal charge.

All adaptors have a .01 of 600V capacitor between the banana jack on the face of the adaptor and the connection to the line side of the power cable. In the singlephase adaptor there are two, one on each leg. The polyphase socket adaptors have multiple capacitors to insulate the TDR III and operator from each of the line voltages.

Singlephase Socket Adaptor

The singlephase adaptors are depicted in the figure below. The socket adaptor is designed for utilities that have the 4 terminal singlephase sockets. The adaptors with the clips are for accessing bottom connected and buss bar meters. The clips can be supplied as alligator or E-Z hooks.

OPERATION OF TDR III

The TDR III was designed to be easy to use by all skill levels with minimal training. The TDR III can be used as a data gatherer and the analysis performed later in the office, or the operator can use the automatic data analyzer in the TDR III on site to establish conditions.

The TDR III analyzes lines for determining the presence and location of a tap. It performs this task by determining where the signal measured crosses an arbitrary threshold. A clean cable has a response curve that approximates the zero X axis on the graph from start to end. Minor perturbations cause the signal to deviate up and down from the zero axis. This could be caused by a wet spot in the soil, spreads in the cable, passing adjacent or perpendicular to another cable, bends in the cable, etc. The reflections from these anomalies are typically small as compared to the reflection from a tap.

If the thresholds were straight lines just above and below the zero line, the TDR III would identify each of these minor negative transitions as a tap. The TDR III would identify "taps" on 70% of the lines measured.

To circumvent this problem, the TDR III has three thresholds that can be used depending on conditions at the time of making a cable measurement. Refer to page 3-3, 7-3 and 8-2 for a discussion of thresholds and how they work in the TDR III. The measurement of the cable is independent of the threshold used. The thresholds are only used to automatically analyze the cable response. After taking a record, it can be auto-analyzed with each of the three thresholds in the TDR III. They can be used like a strainer, coarse to fine.

Only by examining 100's of records taken with the TDR III in your soil, under your specific conditions and your evaluation of how many "taps" you want to "see" or "miss", can a threshold be optimized for your location.

Only by analysis with the Host program can you positively identify the presence and exact location of a tap. The human brain can do far more analysis in a few seconds than the TDR III can do in a month. For this reason, the TDR III should be used as a data gathering and indicating device and the Host program used for analysis. When you want to analyze a record in the field, take a laptop computer with the Host program with you. Analyze your records in your vehicle with the Host prior to going for a search warrant. A reading of a line can be accomplished in less than 6 seconds, making the TDR III the ideal instrument for "sweeping" the system prior to installing AMR.

The TDR III is shown in the figure above. Note the LCD display, the four control pads, power switch and the cable for connecting to the interface adaptor. The TDR III is designed to work with all interface adaptors. Therefore, one TDR III can measure any service connection.

Operating the TDR II can be divided into five sections: controls, LCD display, selecting the analysis threshold, measuring and analyzing a line and analyzing any record in the TDR III.

The battery access door is on the rear of the enclosure and slides open without any tools. Each TDR III is supplied with an emergency 9 volt battery connector. The normal battery is a 2.5 Amphour lithium battery that will take approximately 500 measurements. If the battery fails, use a 9 volt alkaline battery to continue working. The 9 volt battery will last about one day. All records are stored in non-volatile memory so that no information will be lost if the battery expires. The date and time are maintained with a separate internal battery with a 10 year life.

Display

The display is a two line 16 character/line LCD display. The display will provide

selections for measuring a line, analyzing a line, admin data and setup. The functions of each of these routines will be discussed in the appropriate section below in this section of the manual.

TDR III Controls

There are only four control pads on the TDR III and an on/off power switch on the right side. The controls are Menu, Up, Down and Go.

To turn the TDR III on, slide the power switch down as indicated on the cover decal. When the unit is energized, the copyright screen is displayed, followed by a screen which displays the date of the imbedded software, the unit serial # and the current operator's initials. The operator's initials can only be changed from the Host program described in section 7 of the manual. The serial number is programmed at the factory and can not be modified by the user.

Following the serial # screen, the LCD will display four choices for the operator: Measure, Analyze, Admin and
Set Up. This is the Menu screen. The up and down arrow keys move the cursor around the menu so the operator can select which routine they want to perform.

The Menu key will recall the serial # screen and then
return to the main menu. Pressing the menu key at any time will abort a process and return to the main menu.

The Go key initiates the selected process, i.e., measure a line, analyze a record, Admin data or Set Up.

Selecting Thresholds

The TDR III can utilize one of three thresholds to analyze a record. These are each named with the file name assigned in the Host program. The Host program is shipped with several thresholds that can be downloaded to the TDR or the user can create their own custom threshold. The stock thresholds shipped from the factory are horizontal 100, 200, 300, 400, linear 400 and 600, and exponential 500 and 1000. Thresholds are discussed in section 7 of the manual.

Selecting a threshold is accomplished by using the Up/Down cursor to select Set Up and pressing the Go key. The name of the current threshold will be displayed- Press Menu to continue using that threshold or press GO to enable the arrow keys to select a different threshold. Use the arrow keys to select different thresholds. When the desired threshold is displayed, press GO. The selected threshold will be used until changed by repeating this procedure.

One application for multiple thresholds is to use them like a strainer. Start with the narrow threshold, a horizontal line at +200 and -200. If it doesn't identify any taps, you can be 99% sure there are no taps. If the TDR identifies several "taps", change the threshold to Hor 300 or Hor 400 and reanalyze the record. If the taps all disappear there

probably isn't a tap. Use the Host analysis program to increase your skill level in determining what is and isn't a tap with the TDR III.

Measuring a line

To measure a line, connect the interface adaptor to the line to be measured and plug the banana plug connector into the interface adaptor. Slide the power switch on. When the Main Menu is displayed, the cursor will be pointing to Measure. Press the Go key.

The screen will prompt for the cable length. Use the cursor to advance the cable length from 50 to 200 feet. The selection of the cable length determines the distance that the Analysis function will analyze the cable. Set this distance so that the entire cable is included, i.e., if the cable is 60 feet long select 75 feet, if it is 100 feet select 150 feet, etc. This selection does not have to be exact and is only used to eliminate reflections beyond the end of the cable being reported as taps. When the cable length has been selected, press GO to proceed.

The screen will then prompt for the interfaced adaptor to soil line distance. If the service is an overhead, press Go to skip this step. If the service is an underground, use the cursor to select the distance from the interface adaptor to where the cable enters the soil. When the soil line distance is selected, the TDR III automatically uses the propagation velocity for an underground cable. When the cable response is plotted in the Host program on a computer, a vertical line can be displayed on the graph at this point to remind the operator that this is where the cable enters the soil. Refer to Theory of Operation in section 3 of this manual for more information on this subject. The point the cable transitions from air to earth causes a discontinuity which could be analyzed as a tap.

If the operator does not select a distance for interface adaptor to soil line, the TDR III uses its propogation velocity for an overhead cable. If an interface adaptor to soil distance is selected, the TDR III uses the undergound propogation velocity. The propogation velocities are set during calibration of the TDR III and are downloaded from the Host. The operator can only select overhead or underground which determines the propogation velocity used by the TDR III, not change the propogation velocity in the TDR III. Refer to section 7 for a discussion on propogation velocity and calibration. Press Go to continue.

The LCD now displays the next record number that will be measured and the current date and time. The TDR III automatically increments the record counter each time a measurement is taken to prevent accidentally overwriting a stored record. The TDR III holds 94 records and must be uploaded to the Host computer prior to taking more measurements. Press GO to initiate the measurement. This will take about 5 seconds.

Following the measurement, the TDR III automatically analyzes the record with the threshold selected. It will display No TAPS, tap @ 16 feet, open at 50 feet, etc. The TDR III may also display open at 000 feet, depending on the type of interface adaptor you are using. This report of open at 000 feet should be ignored if it appears. It will scroll through all of the anomalies seen in the record and the Main Menu will be re-displayed.

If the LCD displays "EE Error!!", the response from the TDR did not get properly stored. Turn power off for 5 seconds, re-power unit and retake record.

Analyzing any record in the TDR III

From the Main Menu, use the cursor to select Admin. Press Go to initiate. The screen is requesting record # to analyze. The first screen permits changing the record # by 10's. If you want to analyze record 83, press the down arrow key two times and the display will display 80. Press Go again to change the record # by ones.. If you want to .analyze record 83, press the up arrow key three times and 83 will be displayed. Press GO again, and the Main Menu will be displayed.

Use the Cursor to select Analyze and press GO. The record # selected, i.e., 83, and the current date and time will be displayed. Press GO to analyze that record. It will scroll through the anomalies it sees and return to the Main Menu. To repeat the analysis of the chosen record, select Analyze and Go.
The TDR III uses an algorithm to 'positively identify a tap. The wave form must be below the negative threshold for 6 samples, between the two thresholds for less than 6 samples and then above the positive threshold for 6 samples to definitely identify an anomaly as a tap.

If the wave form crosses the negative threshold and not the positive threshold, it will be noted as an anomaly but not positively identified as a tap. If the wave form crosses either threshold for less than 5 samples it will be ignored by the analysis but will obviously be displayed on the Host screen.

If the wave form crosses the lower threshold for less than 6 points or not at all but does cross the positive threshold for more than 6 points, it will detect an open or splice. This can also be displayed at 0 or 1 foot depending on the interface adaptor being used.

OPERATION OF TDR III

Log Sheet

It is imperative that the field investigator maintain a log of all records taken. This is the chain of evidence to tie the customer identity to the recorded response. 100 log cards are supplied with each TDR III. Additional packages of 100 may be purchased from UPC for a nominal charge or you can develop your own.

The log sheet identifies the serial # of the TDR III, operator initials, the date span the records were recorded and an identifier for each response # to positively link the recorded response to a customer location. With this information, it is easy to locate the desired record in the Host computer and transfer the identifying information to that file.

Each response recorded contains the date, time, serial # of the TDR III, operator intials, length and type of cable (underground/overhead) and the propogation velocity used in the header of the file in the computer, to provide a positive chain of evidence for that record.

Metric/Feet

The TDR III unit and Host program are designed to display the cable analysis in feet or meters. The selection of feet or meters is made from the configuration screen in the Host computer. Records can be taken in one mode and then later switched to the opposite mode. When the TDR and Host are in metric, the screens will display meters and the analysis will be in meters. If the TDR and Host are in feet, the screen will display feet and the analysis will be in feet.

COMPUTER

System Requirements- The TDR III Software is a windows-based, proprietary software used only for TDR III analysis.

-The TDR3 Host software will run on virtually any computer certified for use with Microsoft Windows 3.1 or higher.

-A color or grayscale VGA or better monitor. If your computer displays VGA colors in grayscales, use Windows .Setup to choose the appropriate color driver.

-A mouse

-Microsoft Windows 3.1 or higher

-Dos-Version 5.0 or higher

-1 megabytes (MB) of random access memory (RAM)

-5 MB of available disk space. Each record stored requires 2K of memory. Every 500 records will require 1 MB of memory.

Installing Software

Before you can use the TDR III with the computer, you must first use the install program to transfer the program files to your hard disk.

1. Insert the installation CD in drive A or D.
2A. In Windows 3.1 select File Run and type A:\SETUP, or D:\SETUP
2B. In Windows 95 select Start Run and type A:\SETUP, or D:\SETUP
2C. If the Software Disc is not recognized and does not appear on your computer screen, go to My Computer and select the disc in your CD drive.
3. Select OK.
4. Follow the instructions on the screen. The latest version software will automatically update and install all files.

As enhancements are made to the Host Software, you will receive a CD with upgrades to the TDR3Host file only. You will be able to upgrade your software by copying the new TDR3Host over the existing TDR3Host.

What is the Host Program?

The Host program is used to download administrative data to the TDR III, to read, analyze, graph and file records from the TDR, calibrate the TDR, create thresholds, set the time and date in the TDR, print records from TDR, transmit TDR records via Email or standard modem link, and mass storage for all TDR records.

Starting the Host program

To start the Host program, either double click the Icon in Windows 3.1 or click on the program button in Windows 95. The Host screen will be displayed.

In the bottom center of the screen is the ComPort selector. Select the Com port used to connect your TDR III to the Host computer by left clicking on the Com #.

Control Panel

The control panel is located across the top of the screen. Selections include File, Update, Analyze and Help. These can be accessed via the ALT command or by left clicking with the mouse.

The File pulldown screen permits loading stored thresholds to the screen, saving thresholds to file (.thr), loading stored cable responses from files, saving a single record from a TDR to a file (.rsp), creating files to export to a spreadsheet (.txt) and exiting the program.

The Update Configuration command permits changing the operator ID code, calibration by changing the propagation velocities for both underground and overhead, bulk uploading all .rsp files from the TDR 111, resetting the record counter in the TDR III and

to send Admin data to the TDR III via the Get Admin and Set Admin Data Buttons. The Configuration screen can also be accessed by clicking the Display Config screen button on the main screen.
The number of records in the TDR window displays the number of records in the TDR when a bulk upload is performed.

The Update Graph Threshold command causes a new threshold created by changing the numbers displayed in the threshold windows below the graph to be graphed. Refer to page 7-3 for detailed instructions for creating a threshold.

The Analyze control will cause the Host program to analyze the record displayed for the distance displayed in the end of cable window below the graph and provide a plain English display of its analysis. The analyzed distance can be changed by double clicking on the end of cable window and typing in a new distance. This analysis can also be initiated by left clicking on the Taps button below the graph.

Any record can be retrieved from a TDR by selecting the record # and left clicking the Get Record button below the graph. Select the record by double left clicking in the record number window and typing in the record to be recalled. The serial # of the TDR and the date and time the record was taken will be displayed in the lower right corner of the screen.

Graph Display

When a record is retrieved from the TDR or Host computer files, a graph is displayed in the graph section of the Host screen. The cable response displayed is from 0 to the length of cable selected when the record was taken. This distance, is also displayed in the "end of cable- window below the graph. To display more or less of the cable response, double click on the "end of cable" window and type the distance desired. By placing the cursor at any point on the graph and left clicking, the location of the cursor will be displayed below the right corner of the graph using the propagation velocity in the TDR when the response was recorded. The X axis also displays the distance in feet or meters at 10 locations across the graph.

If the cable response displayed is a record of an underground cable, a vertical line from plus 1200 to minus 1200 will be drawn on the graph at the point that was selected for the cable entering the soil when the cable response was measured. There will be a negative going response at that point on the graph. The point the cable transitions from air to earth causes a discontinuity which could be analyzed as a tap_

The XX Distance YY below the graph on the right side is the position of the cursor when left clicked on the graph. The XX is the number of data points from the beginning of the data and the YY is the number of feet represented by the XX based on the propogation velocity used.

The serial # of the TDR that took the record and the date and time of the record are displayed on the lower right corner of the screen. The record # is also displayed in the record # window.

Record File System

When the Bulk Upload button on the configuration screen is clicked, all of the .rsp files in the TDR III will be retrieved. The response records are, however, maintained in the TDR III until they are overwritten by taking more records in the field.
When uploaded, the response records will be filed in TDR3Host\serial#\980219\XX:YYrc##.rsp. The serial # is the serial # of the TDR, the 980219 is the year, month and day, i.e. February 19, 1998, XX is the hour and YY is the minutes, i.e. 13:02 would be 1:02PM and the ## is the sequential # of the record in the TDR.

If records were taken on four different days with one tap detector, they would be filed in the directory of the serial # with a four sub directories for each of the four days and then the individaual response files by time and record #.

If, for example, a TDR III is used to take 10 records in the morning and you bulk upload it without resetting the record counter and continue to take more records in the afternoon and then bulk upload again, the program is smart enough to know which records it has and it will append them to the existing files.

If for example, a TDR III is used to take 10 records and is then bulk uploaded and the record counter is reset to zero and then more records are taken the same day and are bulk uploaded, the program will append them to the same directory for the date but there will be more than one record with record ID # 01 but they will have their unique time stamp.

This file system permits an investigator with minimal computer skills and his log sheet to identify the exact record needed for his or her investigation.

It is recommended that a tape or diskette record archive system be developed for all of your records. Frequency of backing up and removal of records from the Host directory should reflect the number of TDR III's and the number of records retrieved to insure that the computer operating file system is not violated or pushed to its limits.

A low level Data Base can be developed with any spreadsheet program using the' data on the Log Sheet and the record number on the .rsp file recorded by the TDR III.

DOWNLOAD TO TDR III

This section of the manual explains how to create and download parameters to the TDR III. Data to be downloaded include administative, calibration and thresholds.

Communicating with the TDR III

The first step to communicating between the TDR III and computer is to setup the "communication link," also called the "ComPort." Each device that is plugged into a computer must have a ComPort associated with its connection or the devices will not communicate between each other. The simplest way to setup the link is to open the TDR software and click on one of the ComPorts available (ComPort 1-4). In some cases, your computer may assign a ComPort to a device at the time the device is initially plugged into the computer. In this case, you must manually assign a ComPort to the device.

Follow the below steps for manually assigning a ComPort to the TDRIII.
1. Plug in the TDR III and turn ON the unit
2. Go to Control Panel>System>Hardware
   It will ask if you have already connected. Click YES
3. Go to Device Manager Tab>Ports>ComPorts
4. Find ComPort you wish to assign to the TDR III (ComPort 1-4)
5. Right Click on Properties and go into Port Settings>Advanced
6. Choose ComPort 1-4 from dropdown list and Click OK. The device should be connected through the ComPort you have selected. Go to the TDR III graph screen and select the ComPort 1-4 that you selected. Try downloading graphs.

Calibrating the TDR III

Calibration of the TDR III is accomplished by changing the propogation velocity from the Host program. The propogation velocity is the speed in nanoseconds/foot that the Ping signal travels down the cable. To calibrate the TDR III on a particular type of cable, it is necessary to measure the response of a known situation on that type of cable. This is very easy to do and can be accomplished in a few minutes.

Connect a 50 foot length of cable to a termination (terminal block or socket), lay the cable on a wooden floor or someplace off the ground and short the opposite end. Connect a TDR III to the interface adaptor. Measure the line with the TDR (refer to page 5-5). Note the record # in the TDR.

Connect the null modem cable to the serial port of a computer with the Host program. Use the Get Record command (refer to page 6-3) to display the record on the Host screen. The short at 50 feet is depicted by a negative going pulse on the display. Move the cursor to the point where the reflection from the short crosses the negative threshold, and left click the mouse. The distance displayed at the lower right of the screen should read 50 feet.

If the distance reads greater or less than 50, i.e., 45 or
55 feet, the propogation velocity must be adjusted for that cable to accurately locate a tap.

Click Update on the Menu bar and select Configuration from the pull down menu or click the Config screen button on the main screen. On the right side of the edit configuration properties display is a box labeled 1/propogation velocity (overhead). Double click on the window displaying the number. If you measured 55 feet above, increase the number displayed by .06/foot the measurement was wrong. In our example you would add 5 X .06 = .30. If the setting was 3.4, change it to 3.7. If you measured 45 feet above, decrease the number by 5 X .06 = .30, i.e. 3.4 to 3.1

Click OK and the Host graph will be redisplayed. Click on the same location used for the initial test and the distance should now display 50 feet. If the reading is slightly off, repeat the process and increase or decrease the constant appropriately until 50 feet is displayed.

Once overhead is calibrated repeat the process for underground. Use the same cable, but now bury it at the typical depth your company buries cable. Repeat the calibration process for the underground propogation velocity.

When the overhead and underground propogation velocities have been determined, click the set admin button on the configuration screen. This stores the constants in the TDR. To verify, take another record with the TDR and recall it to 'the screen. The distances will now be correct.

Thresholds

Referring to section 3 of this manual, it was established that the TDR uses positive and negative thresholds for determining where and what type of discontinuity the TDR "sees". The cable is Pinged, and the signal level is
measured 240 points along the cable. These points are then graphed. When the graph goes negative there is a short or tap, and when it goes positive it is an open or a spread. The TDR III uses a positive and negative threshold to determine what it "sees". When the reflected signal crosses the negative threshold, the TDR identifies that as the
location of a tap, and when it crosses the positive threshold the TDR identifies that as the location of a spread cable.

The TDR III is shipped with thresholds HOR – 100, HOR.300 and EXP.500 in memory. These and other thresholds can be displayed on the Host screen. Refer to page 8-1 for procedures to retrieve the thresholds to the Host screen. Review the thresholds on the Host screen. The closer the threshold is to the zero axis, the more times the cable response may cross the threshold, possibly giving a false indication of a tap when it was only a small anomaly. The further the thresholds are from the zero axis, the more likely to miss a tap.

If the cable response you are retrieving either crosses the threshold. too often or not often enough, other thresholds can be downloaded or you can create your own custom threshold to increase or decrease the TDR III sensitivity.

To create your own threshold, double click on the + and - threshold windows, one at a time, and type in the level desired at each point across the graph. This would be best accomplished by displaying an actual record of a cable with a tap that you had located on

the Host graph and customizing the threshold so that only the tap is identified.

After you have changed all the "windows", click Update on the Menu bar and click Graph threshold. Repeat this process until you have the threshold exactly where you want it. When the threshold is finished, click file on the menu bar and select save threshold to the file. Make Thresh the working directory by double clicking on Thresh . Double click on the file name window and type the name, xxxxrxxx.thr , and click OK:

Download Thresholds to TDR III

To download a threshold(s) to the TDR III, you must first cause the threshold to be displayed on the host screen. Refer to page 8-1 for procedures to retrieve a threshold to the Host screen. With the desired threshold displayed, click Set Threshold button on Host.

A window will be displayed identifying the current Host threshold. Click on one of the three storage locations and then click OK. The displayed threshold will now be stored in the TDR III in the location selected. Repeat the procedure to download other thresholds.

Modifying and Downloading to TDR III

With the TDR III connected to the host and powered, click the config screen button on the main screen. Click the Get Admin button and the current settings in the TDR III will be displayed.

To change the operator’s initials, double click on the initials window and input any three letters, numbers or combination of letter/number. If you want the system to operate in Metric, click the Metric box- If the metric box is checked and you want to display in feet, unclick the metric box. Verify that the propagation constants are as desired. If they are not, set them. (Refer to page 7-2)

Select if you want to reset the record counter by clicking on the appropriate box. Click the set admin button and the data will be downloaded. Click OK to exit the Configuration screen. The new operator initials, propogation velocities displayed on the screen, current time and date will be downloaded to the TDR. If you selected reset record counter, it will be reset to 00.

Other features of the Host Graph

The fixed offset is the number of counts of a record to bypass the transmitted Ping. If you locate the cursor on the beginning of the record on the graph and click, the distance displayed at the lower right side of the graph will be 0 distance 0. This is the beginning of the record returning from the cable being measured.

RUNNING HOST PROGRAM

Retrieving a record in Host to screen

To retrieve a record from a Host file, click on File on the Menu bar and select Load cable response from file. From the browse screen displayed, locate the record you want to display. Access is available to all drives and all files on your computer. Locate and select a directory, and record and click OK. The graph will be displayed on the Host screen. Note the serial # date and time of the record are displayed in the lower right corner. The record # is displayed in the record number window.

Retrieving a Threshold in Host to screen

To retrieve a threshold, click File on the Menu bar and select load threshold from file. Names of all thresholds in your Host will be displayed in the File Menu box. Double click on the one desired and the Host screen will be updated with the new threshold. Repeat the process for retrieving other thresholds.

Loading and saving a record from TDR III in Host

To load a specific record from a TDR III to the Host, connect the TDR III to the Host computer via the null modem cable and power on. When the TDR III LCD displays the main menu, double click on the window to the right of the Get Record button. Type the record # in the window and click the Get Record button. The record selected will be displayed on the Host screen.
To save the selected record from the TDR III in the Host program, click. File on the Menu and select save cable response to file. The next screen will prompt for the name of the file. Type a name for the file ending with .rsp and click OK. This record is now saved in the c:\TDR3Host\Data file with the name assigned.

Load a record to the Host screen using the procedures on page 8-1. The cable response displayed is from 0 feet (meters) to the cable length selected when the cable was pinged- To display more or less of the cable, double click on the "end of cable" window and type the distance desired. This is also the length that will be auto-analyzed.

If the record was an underground cable, a vertical line can be displayed at the point selected for the cable entering the earth at the time the record was taken. Click the Show Config screen button, click the show soil line box and press OK. A vertical line will be displayed at the soil line location from -1200 to +1200. To remove
the line, reverse the procedure.

Knowing that taps are negative going and splices are positive going, place the cursor on the point that the cable crosses the positive or negative threshold and left click. The distance to that anomaly will be displayed below the right corner of the graph. The distance is also displayed in metric or feet on the x axis.

To have the Host automatically analyze the record click the Taps button or select Analyze on the Menu Bar and select analyze the record.

The Host uses the same algorithm as the TDR III to identify anomalies. The wave form must be below the negative threshold for 6 samples, between the two thresholds for less than 6 samples and then above the positive threshold for 6 samples to definitely identify

an anomaly as a tap.

If the wave form crosses the negative threshold and not the positive threshold, it will be noted as an anomaly but not positively identified as a tap. If the wave form crosses either threshold for less than 5 samples it will be ignored by the analysis.

If the wave form crosses the lower threshold for less than 6 points or not at all but does cross the positive threshold for more than 6 points, it will detect an open or splice. This can also be displayed at 0 or I foot depending on the interface adaptor being used.

A window will be displayed of the Host computers analysis of the record. Use the scroll arrows if the record extends beyond the screen. Click OK when finished.

Exporting a record to a Spreadsheet file

Sometimes it is desirable to export a file to a spreadsheet file for printing and enhancing the graph display. To export a file to a spreadsheet, cause the file to be displayed on the Host graph, click File from Menu Bar and select export graph data to file.

The browse menu will be displayed. Type the name of the file to be exported with a .txt extension. From the directories window, select the directory of the spreadsheet program where you want to transfer the file. Click OK, the graph will be stored as a .txt file in that directory.

Exit the Host program and call up the spreadsheet program. The graph file is stored as a .txt file. Select the directory and file. The data points are separated by semicolons. Use the features of your spreadsheet program to graph your record.

Printing from the Host Program

The program allows you to print any record directly from the Host screen. Use procedures discussed previously to cause the record you want to print to be displayed. Click the Print button on the main screen. A dialogue box will appear which allows you to enter up to 51 alphanumeric characters which will print across the top of the page. This could be name, address, meter# file #, etc.

When the dialogue is displayed as desired, click the OK button and the record will be printed. In addition to the graph with the distance printed on the X axis, the print out also includes the record #, Date and Time stamp, serial #, operator initials, propagation velocity used, cable type (overhead or underground), the auto analyzed length, and the temperature in Celsius, all of the data you would ever need in court.

Uploading all records from a TDR III

See bulk upload records in record file system on page 16.

Clearing Records from the TDR III

Please see the steps below for clearing the TDR records. All steps must be followed for clearing the TDR.

1. Connect TDR to host computer via Null Modem cable.
2. Power ON the TDR and wait for main menu to be displayed
3. Click the Show Config Screen Button to open the Administrative Data screen.
4. Click the Bulk Upload Button
5. The number of records to be retrieved will be displayed.
6. A Status window will indicate progress & the record #'s as they are uploaded
7. If the TDR memory is to be cleared following the bulk upload, click the clear TDR records box.
8. To complete the process of clearing records, click the Set Admin Data button. This double step prevents accidental erasure.
9. Click OK.
10. Press the GO button on the TDR three times and the LCD should indicate next record #01.

Help

At the time of printing, no online help screens had been developed. As we determine what is needed, you will receive free software upgrades with help screens.

Exiting the program

Click on File on the Menu Bar, and select Exit to exit the Host program. You can also exit and close the program with the normal Windows controls.

TRAINING

It has been said that experience is the best teacher. The best way to learn how to use the TDR III is to take some records on some known cables and analyze them with the TDR III and Host program.

H.J. Arnett Industries personnel are available to run a single-day training course with hands-on use of the TDR III and Host computer. To make the program cost-effective, at least 10 people must be trained per course. This can be, for example, two each from 5

utilities in an area. These experts will be certified as TDR trainers and can help to train other personnel.

Personnel only using the field instrument need only to be familiar with how the TDR III functions. They need familiarity with the following items:

Which interface adaptor to use
How to install the interface adapator
How to connect the TDR III to the interface adaptor Power on/off switch
Main Menu on the TDR III
How to set the length of the cable being measured How to set soil line distance
How to measure a line
How to identify the record # on a log sheet How to change batteries in the TDR III

If they are also going to analyze a record in the field, they also need to know:

How to call up a selected record for analysis
How to select thresholds
What analysis means using different thresholds

Personnel responsible for working with the Host program need familiarity with:
Running Windows software
Running Spreadsheets
Computer filing systems
Controls and functions of the Host program
Understand Theory of Operation
Calibration of the TDR III with Propogation velocity
Creating Thresholds
Uploading and downloading to and from the TDR III
Analyzing a record in the Host
Printing records
Email and data transmission

TRANSMITTING TDR RECORDS

It is possible to transmit the records from the TDR III using the Host program. Records can be sent via Email or via normal modem link.

Transmitting a record via Email

If you would like a second opinion on a record or just some help getting started, you can Email a record from your Host program to the Arnett Industries Computer. Type an Email addressed to us at chris.shipley@arnettindustries.com. Describe in the Email what you are looking for and a time to call or Email you a response. Send the xxxxxxxx.rsp file as an attachment using MIME encoding and select DO NOT put text attachments in body of message.

We will Email or call you back on the next business day or whenever you select. Be sure to include your name and phone number in the body of the message.

Transmitting a record via modem

A given record is only 2K bytes, so it is not necessary to zip a file to economize transmission time. The record file is a text file with an .rsp extension. Using any communication program, the file can be transmitted via modem to another computer in seconds.

MAINTENANCE

Low Battery – Batteries should remain above 6 volts for proper performance. When the batteries have insufficient power to reliably operate the TDR III, the copyright screen will be displayed and the keyboard is disabled.

Temperature effect on battery performance - Lithium battery performance is affected by ambient temperature. When approximately 1/2 of the battery energy has been consumed, the battery voltage when operated at less than 50 degrees F may fall below the operating threshold of the TDR III. Warming the TDR III to 60 degrees F will probably allow the unit to function again. There is no permanent damage to the TDR III or the batteries by temperatures down to 0 degrees F.

Replacing Batteries - To replace batteries, slide open the battery compartment door. The batteries are connected to a polarity limiting connector to prevent their being installed incorrectly. Replace the battery pack with a new one. Do not short circuit, dispose in fire or expose the battery packs to water. These are Lithium batteries and need to be disposed of properly. Consult your safety department for directions. Please Recycle!

In an emergency, a normal 9 volt alkaline battery can be used to run the TDR III. A 9 volt battery connector and connector to the TDR III are supplied.