

Site Master

Distance-To-Fault

Application Note



*Antenna and Cable Installation and Maintenance Tool.
Reduce Maintenance Costs and Improve Quality
Using Frequency Domain Reflectometry.*

Introduction

Distance-To-Fault (DTF) is a performance verification and failure analysis tool for antenna and transmission line service. It uses Frequency Domain Reflectometry (FDR). FDR is a transmission line fault isolation technique which precisely identifies signal path degradation for transmission lines. FDR technology is different from traditional time domain reflectometry (TDR) techniques. The FDR technique uses RF frequencies instead of TDR type DC pulses. FDR can locate RF faults, not just DC open or short circuit conditions. This dual role of predicting future failure conditions and isolating existing problems makes DTF an important part of service/maintenance planning.

DTF displays RF return loss or SWR data versus distance. The effects of poor connections, damaged cables, or faulty antennas are quickly identified. Since DTF automatically accounts for attenuation versus distance, the display accurately indicates the return loss of the antenna - allowing technicians to perform fault isolation from ground level.

Reduce Maintenance Expense

For the majority of tower mounted transmission lines and antennas, the absence of DTF capability renders preventative maintenance procedures impractical. RF failure conditions at the top of the tower frequently aren't measurable with traditional tools such as TDR and spectrum analyzer/tracking generators. TDR's cannot detect small performance changes at RF frequencies. Thus, it is not possible to monitor performance degradation between maintenance intervals with traditional methods. Without FDR techniques, the "Fix after Failure" philosophy becomes the only alternative.

Many components can cause problems. Transmission lines are typically the most common failure point in a communication system. Tower mounted transmission lines are exposed to weather, and will degrade over time. Lightning can sever a portion of the antenna or damage the in-line lightning arrestor. Sunlight exposure can change the dielectric properties of the antenna's housing, causing the antenna bandwidth to drift. Common problems are listed in Table 1. Each causes unwanted signal reflections. Poorly tightened connectors and poor environmental seals are exacerbated by acid rain corrosion. Eventually these problems cause intermittent outage and failures at exactly the times they are least welcome - such as during thunder storms or during extreme periods of cold.

CABLE PROBLEMS

*Cable Discontinuities
Damaged/Dented Ground Shield
Moisture and Corrosion
Fasteners Pinch Cables*

Connector Problems

*Corroded Connectors
Low Quality Connectors
Poor Center Pin Contact*

Antenna Problems

*Out of Specification
Storm/Shipping Damage
Damaged Lightning Arrestor*

Table 1

As transmission lines age, the number of service calls increases rapidly. With DTF available, the root causes of RF problems can be identified. For example, connector corrosion can be detected early and weather seals replaced before moisture destroys expensive cables. DTF finds these problems because the FDR technique can accurately detect very small performance changes within the transmission line.

Tower mounted transmission lines and cables are replaced frequently, perhaps every five to ten years, in some cases. Usually, all the site's cables are replaced - based upon the assumption that maintenance calls are imminent on other feeds in addition to the problem cable. This practice may be precipitated by the cable installer; who would likely make the same mistakes on each cable connection. Replacing all the cables frequently is an expensive proposition. It is much less expensive to monitor individual transmission lines for slight degradation and fix the problem early, before serious damage occurs.

Preventative maintenance has another set of benefits even more important than cost. Quality is improved. Uptime is maximized by preventing failures. Transmitter performance is optimized by eliminating poorly performing components. Cell coverage is more consistent. Hand-off anomalies are reduced by eliminating ping-ponging between weak/strong base stations. Overall quality is improved giving greater customer satisfaction. These quality improvements are particularly important to digital cellular and PCS systems. Return loss specifications are more stringent than analog cellular to avoid intermod and adjacent channel interference. Digital TDMA and CDMA transmission systems are more prone to disconnect when coverage area is reduced because a fixed minimum signal-to-noise ratio is required.

Immunity to RF Interference

Site Master's design is highly resistant to interference from incoming and ambient signals. RF suppression capabilities are realized with frequency-selective, narrow-band receiver technology and a proprietary phase tracking synthesizer technique. RF modulation is transparent to the Site Master making it useful in any cellular modulation environment. High immunity is necessary at cellular basestations because:

1. Competitors co-locate sites to improve quality.
2. Competitors sometimes share sites to reduce costs.
3. Technicians prefer daylight work hours, when basestation transmitters must remain on-line.

Site Master can perform accurate return loss, SWR, and DTF measurements even in the presence of interfering signals.

FDR Measurement Theory

The FDR measurement technique requires a swept frequency input to the transmission line/antenna. An inverse FFT (Fast Fourier Transform) is performed on the reflected signals transforming this information into the time domain. The distance is then calculated from this information knowing the velocity. The relative propagation velocity of the transmission line is required for the calculation. The attenuation/ft for the cable is also required in order to compensate for the attenuation versus distance. Thus, the actual return loss versus distance is shown (Figure 1).

TEST TIP

Cable manufacturers specify the propagation velocity (V_p) of cables. If this specification is not available, it can easily be determined by measuring a known length of cable. The cable's average insertion loss can be verified at the same time. See page 9 for a detailed procedure.

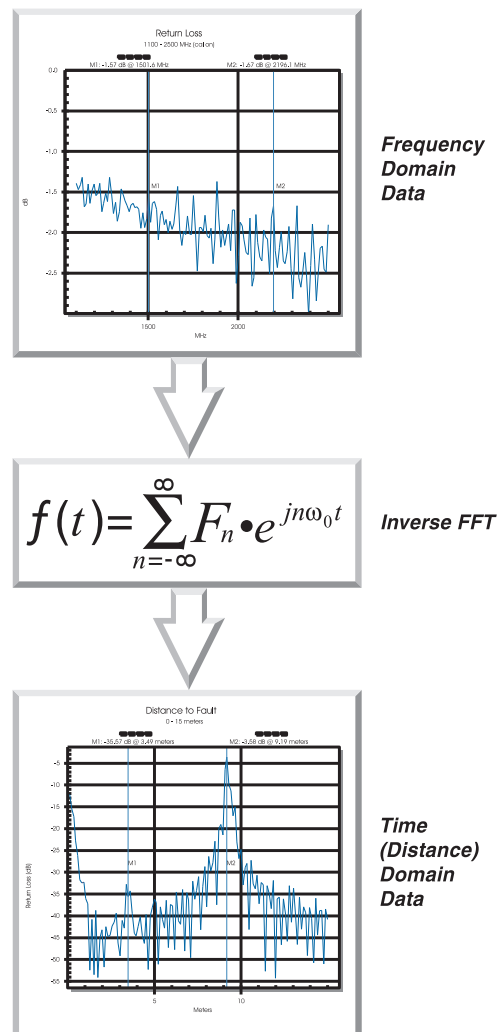
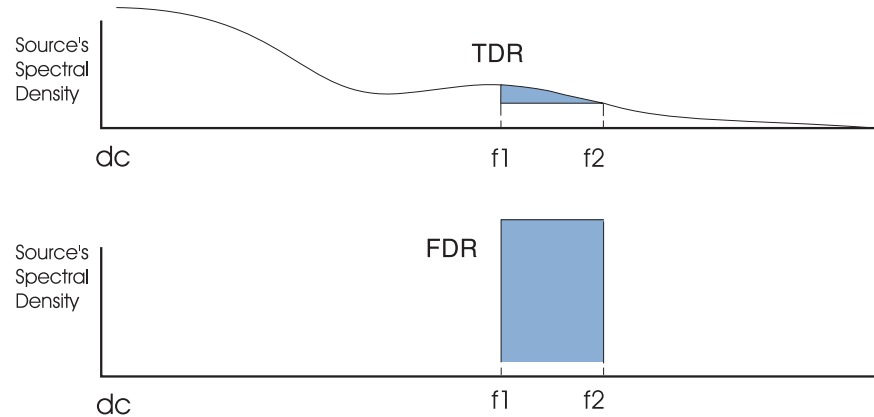


Figure 1

FDR Versus TDR

FDR and TDR (Time Domain Reflectometry) are used for similar purposes but are very different in their technical implementation. TDRs send pulsed DC signals into a copper pair and then digitize the return response of reflected pulses. The FDR technique requires a swept frequency RF signal. The Frequency Domain Reflectometry (FDR) principle involves vector addition of the source's output signal with reflected signals from faults and other reflective characteristics within the transmission line. Historically TDRs have been less expensive than FDR based analyzers. While the price discrepancy is no longer true today, the technical differences remain.



TDRs, for all practical purposes, do not measure RF performance, but rather identify opens or shorts in the conductors. Neither cables nor antennas can be tested to their RF specifications. In Cellular and PCS applications, TDRs are limited because a corroded junction might easily pass a DC signal, but cause large reflections of RF power. Despite commercial claims of high equivalent bandwidth, pulse TDRs do not provide sufficient effective directivity for accurate RF frequency tests such as return loss. Sensitivity is not adequate to identify small changes in return loss characteristics. Further, TDRs frequently fail to measure in the presence of RF interference from nearby transmitters. Thus, TDR measurements support only catastrophic open and short circuit failure conditions.

DTF Test Process

Distance-To-Fault accurately verifies the transmission line and antenna system performance. The Site Master is used in the Site Commissioning process and for maintenance service. It plays an integral role in the overall system maintenance/service plan. Both DTF (Frequency Domain Reflectometry) and return loss measurements are based upon the same basic, signal reflection principles shown in Figure 2. No transmission line component is a perfect impedance match, each will reflect some of the signal energy. The reflections are detected and analyzed using DTF.

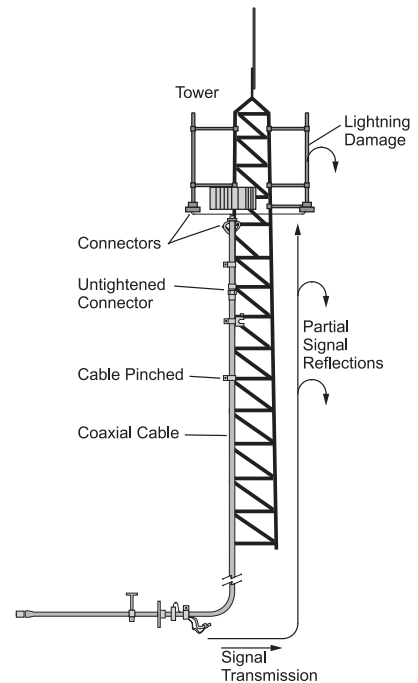


Figure 2

Site Commissioning

In the Site Commissioning process, a return loss measurement is done to verify the system meets specification (with some margin). A baseline DTF measurement is taken. The return loss of the antenna can be verified with the DTF measurement. The location of any connectors, jumper cables and the antenna are noted and confirmed. This becomes the baseline DTF “signature” to which all subsequent measurements are compared.

1. Set up the instrument, calibrate and perform the return loss measurement.
2. Store the display and the setup in internal memory for future use. (Print hard copy if required)
3. Set up the instrument, calibrate and perform a DTF measurement.
4. Store the display and the setup in internal memory for future use. (Print hard copy if required)
5. Download stored displays to a PC (using Site Master Software Tools) for database updating and future analysis.

Maintenance Service

The presence of a problem is easily detected by comparing a DTF measurement to previous “DTF Signature” data.

Performance monitoring consists of several specific steps.

1. Recall the DTF instrument setup used at Site Commissioning. Calibrate the test setup and perform a DTF measurement.
2. Store the measurement in internal memory. Download to notebook PC (using Site Master Software Tools). (Print hard copy if required).
3. Retrieve “Baseline” DTF measurement data on notebook (stored on hard drive or floppy).
4. Compare the measurement to the stored data. (Use overlay function in Site Master Software Tools)
5. Investigate any transmission line section showing a discrepancy from the base line data.
6. Repair any problems, then repeat the measurement and store the data for future analysis.
7. Recall the Return Loss instrument setup used at Site Commissioning. Calibrate the test setup and perform a return loss measurement to verify the system meets specification.
8. Store the measurement in internal memory. Download to notebook PC (using Site Master Software Tools). (Print hard copy if required).

Each cable/antenna tends to have a unique Distance-To-Fault (DTF) “Signature” because differing cable electrical lengths, cable types, dielectric thickness variations, and the position of components (connectors, adapters, and lightning arrestors) will cause different reflections at differing positions in the transmission line. Reflections from the transmission line’s various components are vector signals which will add or subtract vectorially depending upon their relative phases. The relative phases are dependent upon 1) the individual characteristics of each device and 2) their relative physical position in the transmission line.

When measuring at the end of a transmission line, addition and subtraction of the various reflections create a nearly random pattern of ripples on the return loss display. The result is that each individual cable will have its own unique “signature” or “finger print”. Variations in the “signature” between maintenance intervals offer a good indication of damage or damage causing conditions. A large change indicates a problem. Small changes may indicate aging, ultra-violet exposure, or dimensional changes due to seasonal temperature conditions.

Return Loss is the vector sum of all the reflections on the transmission line. Slight changes in the reflected signal from one component may not be apparent in a return loss measurement as illustrated in figure 3. The return loss has degraded slightly at several frequencies but it is still meeting the -17 dB specification. In the DTF mode the reflections from each component along the transmission line are isolated. Changes in the performance of the transmission line or the components over time can be easily seen, as shown in figure 4. The two DTF graphs are the same except for the return loss value at marker 1. The return loss at that point has degraded by approximately 5 dB. While return loss analysis can be an ambiguous quality indicator, Distance-To-Fault (DTF) analysis highlights the problem clearly.

In this case the problem was a loose connector. When it was tightened the DTF display again appeared as the plot on the left (the baseline data). If the connector remained untightened, invasive moisture would eventually destroy the expensive antenna cables.

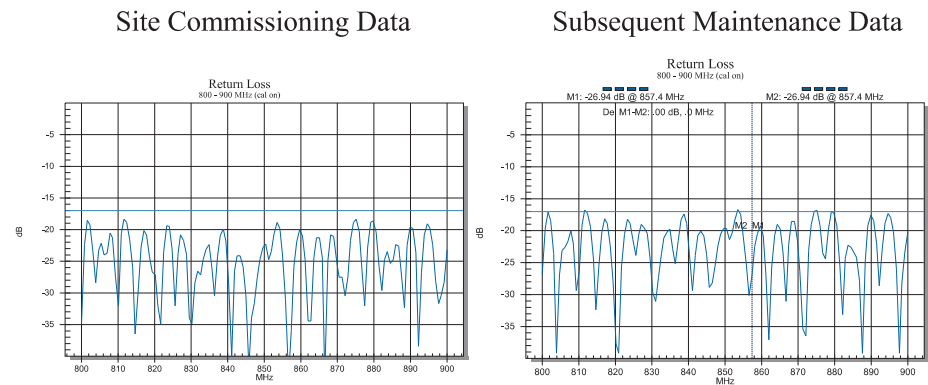


Figure 3

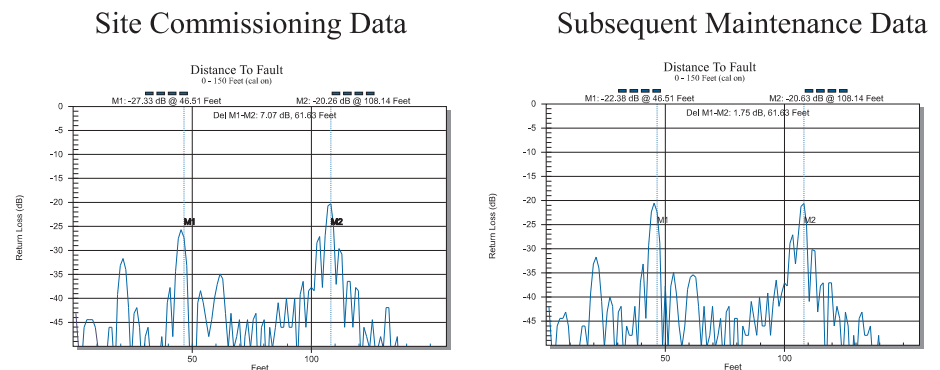


Figure 4

DTF Measurement Procedure

Distance domain measurements—commonly known as Distance-To-Fault (DTF)—are made over a selectable distance range. The maximum distance range is dependent upon the frequency range. See “Optimizing Frequency Range” for further explanation.

Recalling a Setup

To use a previously stored setup:

- Step 1. Press the **RECALL SETUP** key.
Enter the desired numerical value using the keyboard (1 to 9) or the Up/Down Arrow key.
Press **ENTER** when data entry is complete.

Skip to Performing a Calibration.

OR

Selecting a Frequency Range

- Step 1. Press the **FREQ** soft key, from the Main Menu.
- Step 2. Press the **F1** soft key from the ensuing soft key menu.
Enter the desired numerical value using the keypad or the Up/Down Arrow key.
Press **ENTER** key when data entry is complete.
- Step 3. Press the **F2** soft key from the ensuing soft key menu.
Enter the desired numerical value using the keypad or the Up/Down Arrow key.
Press **ENTER** key when data entry is complete.

Check that the FREQ (MHz) scale in the display area indicates the new frequency start and stop values.

Performing a Calibration

CAUTION: The measurement system **MUST** be calibrated at the ambient temperature prior to making a measurement. If the temperature drifts outside a specified range an indicator appears ($\updownarrow^{\circ}\text{C}$). A recalibration at the current temperature is recommended. Any time the frequency range is changed the appropriate calibration must be recalled or a new one performed. The instrument can store up to two calibrations. The calibration is not stored with a setup. When you recall a stored setup, perform a new calibration or recall a stored calibration.

NOTE

Calibration data is not stored with a saved setup. Therefore a calibration must be recalled or a new one performed.

- Step 1. Press the **START CAL** key. Use the Up/Down Arrow key and **ENTER** key to select the location to store the calibration (A or B).
Follow the ensuing instructions. “Connect OPEN, Press **ENTER**,”
“Connect SHORT, Press **ENTER**,” and “Connect LOAD, Press **ENTER**”

[Connect the respective Open, Short, and Load component to the end of the Test Port Extension Cable if used]

After each selection, one of the messages “Measuring OPEN,” “Measuring SHORT,” “Measuring LOAD” appears while the measurement is in progress.

OR

Recalling a Calibration

- Step 1. Press **CAL** key. Use Up/Down Arrow key and **ENTER** key to select a stored calibration (A or B), the frequency range for the stored calibration is shown.

* If, during a calibration, you wish to repeat a measurement or change the order in which the Open, Short, and Load are connected, press Up/Down Arrow key.

OPTIMIZING FREQUENCY RANGE

Selecting the appropriate frequency range is not as obvious as it may seem. For return loss measurements at site commissioning, the specification usually calls out the frequency range over which the data is to be taken – Usually the operating frequency range of the system. For Distance-To-Fault analysis, the resolution and maximum distance range are dependent upon the frequency sweep range, the number of frequency data points and the relative propagation velocity of the cable being tested. Therefore, the frequency range must be chosen carefully.

When checking the return loss of the antenna in DTF mode, the operating frequency range of the antenna should be used.

For checking transmission lines, a large frequency span is desirable to highlight potential faults or areas of performance degradation. There is a constraint that limits the frequency range. The maximum distance is inversely related to the frequency range.

$$\text{maximum distance(meters)} = \frac{150 \times \text{relative propagation velocity} \times 129}{(F2 - F1)}$$

(F1 and F2 in MHz, 129 is the number of frequency data points used by Site Master)

The wider the frequency range, the smaller the maximum distance that can be measured. Graphs illustrating this relationship are shown in figure 5.

There is also a relationship between resolution and frequency range. The wider the frequency range, the smaller the resolution. So wider frequency sweeps improve the resolution of DTF measurements.

$$\text{resolution(meters)} = \frac{150 \times \text{relative propagation velocity}}{(F2 - F1)}$$

(F1 and F2 in MHz)

With adequate frequency sweep range, 0.3 meters can be resolved. Distance range can exceed 100 kilometers using narrow frequency sweeps.

NOTE

For best calibration results — compensation for all measurement system uncertainties — ensure that the Open/Short/Load is at the end of the test port or optional extension cable; that is, at the same point that you will connect the antenna or device to be tested. If you require a Test Port Extension cable, use a phase stable cable. If you use a typical laboratory cable to extend the test port to the device-under-test, cable bending subsequent to the Open/ Short/Load calibration will cause uncompensated phase reflections inside the cable. Thus, cables which are NOT phase stable cause unacceptable measurement errors that are more pronounced as the test frequency increases. For optimum calibration, Anritsu recommends using precision calibration components.

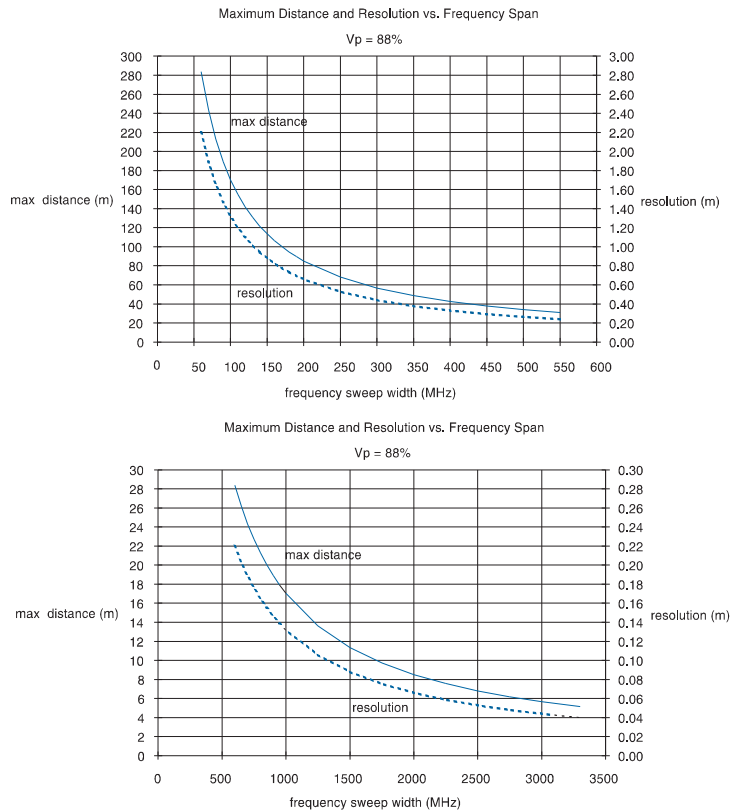


Figure 5

Performing a DTF Measurement

Verify that CAL A or CAL B appears in the upper left corner of the screen.

Step 1. Press the **DIST** soft key from the Main Menu.

Step 2. Press the **D1** soft key from the ensuing soft key menu.
Enter the desired numerical value using the keypad or the Up/Down Arrow key.
Press **ENTER** when data entry is complete.

Step 3. Repeat the above step for **D2**.

Step 4. Press the **MORE** soft key to go to the Distance Sub-Menu.

Step 5. Press the **CABLE** soft key to select a coaxial cable from the menu or press the **LOSS** and **PROP V** soft keys to enter cable loss and relative propagation velocity parameters manually.
Enter the desired numerical values using the keypad or the Up/Down Arrow key.
Press **ENTER** when each data entry is complete.

Step 6. Press the **MAIN** soft key to return to the Main Menu.

NOTE

Press the **B5** soft key from the Option Sub-Menu to toggle between feet and meters. Values entered in either will freely convert to the other. Loss and relative propagation velocity values for many common cable types are listed in Table 2.

CABLE CHARACTERISTICS

The loss of a cable varies with frequency. The higher the frequency the greater the loss of a cable. Most cable manufacturers specify the loss of their cables at one or more specific frequencies. If the loss is not specified for your particular frequency or the loss of the cable is unknown, the Site Master can be used to find the loss.

Using a small piece of the type of cable to be tested, connect it to Site Master with the other end open (not connected to anything). Perform a DTF measurement over the frequency range of operation. A spike in return loss should be visible where the open is located (at the end of the cable). An open circuit should have 0 dB return loss (full reflection) so you adjust the loss parameter until the open at the end of the cable measures 0 dB return loss.

The relative propagation velocity of a cable is equal to $1/\text{SQRT}(\text{relative dielectric constant})$. The dielectric constant is determined by several factors including the dielectric type of the transmission line and the diameter thickness of that dielectric. It is specified by the manufacturer of the cable. Flexible cables may have more than +/- 10% variation in dielectric constant along the cable's length due to manufacturing tolerances. Dielectric constant does not vary with frequency. If the correct relative propagation velocity is not used the distance calculation will be incorrect. If the relative propagation velocity is unknown it can be found using Site Master.

A known length of cable (the type being tested) can be used to determine the propagation velocity. Connect it to Site Master with the other end open (not connected to anything). Perform a DTF measurement. A spike in return loss should be visible where the open is located (at the end of the cable). An open circuit should have 0 dB return loss (full reflection). Adjust the relative propagation velocity parameter until the open at the end of the cable indicates the correct cable length.

Using DTF AID Table

Step 1. Press **DIST** soft key, from the Main Menu.

Step 2. Press **DTF AID** soft key, from the Main Menu.

Selecting the Maximum Distance

Enter the maximum desired distance numerical value using the keypad or the Up/Down Arrow key.

Press **ENTER** key when data entry is complete.

Selecting the Center Frequency

Enter the operating Center frequency numerical value using the keypad or the Up/Down Arrow key.

[F 1 and F2 will be automatically optimized to have a maximum DTF resolution]

Press **ENTER** key when data entry is complete.

DTF AID Table Parameters

Step 3. Use the Up/Down Arrow key and the **ENTER** key to select the desired coaxial cable from the coaxial cable list table.

Alternatively, use the Up/Down Arrow key and the **ENTER** key to select **PROP VEL** and **LOSS** and enter the relative propagation velocity and cable loss parameters numerical value manually.

Change any **DTF** parameters in the **DTF AID** table display area by using the Up/Down Arrow key and the **ENTER** key.

[Note: Maximum distance, D2, is displaying 10% more than the numerical value originally entered in step 2]

Performing a Calibration

CAUTION: The measurement system **MUST** be calibrated at the ambient temperature prior to making a measurement. If the temperature drifts outside a specified range an indicator appears ($\updownarrow^{\circ}\text{C}$). A recalibration at the current temperature is recommended. Any time the frequency range is changed, the appropriate calibration must be recalled or a new one is performed. The instrument can store up to two calibrations. The calibration is not stored with a setup. When you recall a stored setup, perform a new calibration or recall a stored calibration.

Step 4. Press **OK - START CAL** to perform calibration

Step 5. Use the Up/Down Arrow key to select the location to store the calibration (A or B). Follow the ensuing instructions. “Connect OPEN, Press **ENTER**,” “Connect SHORT, Press **ENTER**,” and “Connect LOAD, Press **ENTER**”

[Connect the respective Open, Short, and Load component to the end of the Test Port Extension Cable if used]

Performing A DTF Measurement

Verify the CAL A or CAL B appears in the upper left corner of the screen.

Adjusting Markers

- Step 1. Press the **MARKER** key to call up the Marker Menu.
- Step 2. If M1 needs to be turned OFF, press the **M1** soft key on the Markers Menu. If M1 needs to be turned ON, press the **M1** soft key again. Press **EDIT** soft key to open the **M1** parameter for entry. If needed, enter the desired numerical value using the keypad or the Up/Down Arrow key. Press **ENTER** when the data entry is complete.
- Step 3. If M2 needs to be turned OFF, press the **M2** soft key on the Markers Menu. If M2 needs to be turned ON, press the **M2** soft key again. Press **EDIT** soft key to open the M2 parameter for entry. If needed, enter the desired numerical value using the keypad or the Up/Down Arrow key. Press **ENTER** when the data entry is complete.
- Step 4. Press the **MAIN** soft key to return to the Main Menu.

After calculations are complete (approximately 8 seconds), observe that the message area displays the return loss data at the two marker points. (The message area displays are visible only if markers are on.)

Scaling the Display

The display can be scaled using either of the following methods:

Automatically scale the display using the **AUTO SCALE** key.

Manually scale the display using the **SCALE** soft key-from the Main Menu-and the **TOP** and **BOTTOM** soft keys from the ensuing soft key menu.

Optional

Adjusting a Limit

Press the **LIMIT** key to call up the Scale Menu.

If the Limit needs to be turned OFF, press the **LIMIT** soft key on the Scale Menu. If the Limit needs to be turned ON, press the **LIMIT** soft key again. This will open the Limit parameter for entry. If needed, enter the desired numerical value using the keypad or the Up/Down Arrow key. Press **ENTER** when the data entry is complete.

If you wish to have an audible beep when the trace is above the limit line, press the **OPT** soft key from the Main Menu.

Press the **B2** soft key from the Option Menu to toggle the limit beep indicator on.

Saving a Setup

Press the **SAVE SETUP** key.

Enter the desired numerical value using the keypad (1 to 9) or the Up/Down Arrow key. Press **ENTER** when data entry is complete.

Storing a Trace

Press the **SAVE DISPLAY** key.

Enter the desired numerical value using the keypad (1 to 40) or the Up/Down Arrow key. Press **ENTER** when data entry is complete.

Downloading to a PC

Connect Site Master's serial interface port to the PC's serial port.

Into a Database

Open Site Master Software Tools application on the PC. Click "**Capture**" and "**Capture to Database**" from the drop-down menu.

Be sure the proper COM port has been selected by using the "Settings" from the drop-down menu.

Follow the database instructions to download the plot(s) to either a new database or an existing database.

Enter the number(s) of the stored-display memory location(s) (1-40) from which the Database is to store and click "OK."

OR

Into Screen Display

Connect the Site Master serial interface port to the PC's serial port.

Open Site Master Software Tools application on the PC. Click on **“Capture Multiple Traces”** icon or click on “Capture” and “Capture multiple traces,” from the drop-down menu.

Be sure the proper COM port has been selected by using the “Settings” from the drop-down menu.

Enter the number(s) of the stored-display memory location(s) (1-40) from which Site Master Software Tools is to display and click **“OK.”**

Printing a Screen

Connect the printer to the serial port.

Obtain a SWR, RL, or Distance-To-Fault measurement display.

Press the **PRINT** key.

Be sure the proper printer is selected. To view or select printer, press **OPT, MORE** and **B7** soft key.

DTF Performance

“DTF Instrumentation Accuracy” is less than 0.1% but the more practical concern is “Measurement Accuracy”. Return loss measurement accuracy is influenced by many factors; the quality of the calibration (including the calibration components and calibration method), the accuracy of the information entered by the user, and the quality of the cables being tested. Precision calibration components allow greater measurement accuracy. For accurate calibration results, all measurement system uncertainties need to be compensated for by ensuring that the OPEN/SHORT/LOAD are connected to the same point that will be connected to the device being tested (at the end of any extension cables or adapters being used).

Distance calculations are based on the assumption of a specific propagation velocity value for the cable or transmission line. If the propagation velocity is deliberately set incorrectly, the Site Master will identify the fault's location at the wrong distance.

Relative propagation velocity is calculated as $1/[\text{SQRT}(\text{relative dielectric constant})]$. The dielectric constant is determined by several factors including the dielectric type of the transmission line and the diameter thickness of that dielectric. Cable manufacturers routinely have dielectric constant variations. The variation may be $\pm 10\%$ or more along the cable's length. Low cost cables generally have even greater variation in dielectric constant.

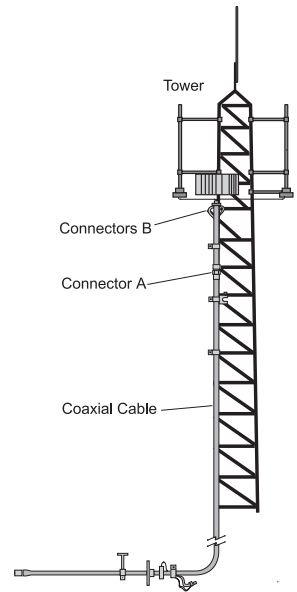
Further practical impediments to absolute distance accuracy include the various filters, diplexers, adapters, and differing cable types that are typical of most RF transmission lines. Despite the fact that the instrument itself is extremely accurate, the characteristics of the device under test confound attempts to specify absolute distance accuracy requirements for practical, in-service measurements. The net effect is that each transmission line will have its own “signature” or “finger print” on a DTF display. The ability to store DTF displays, download them to a computer and overlay traces makes analysis of these unique signatures simple. When historical data is compared to recent data, large changes in the “signature “ indicates a serious problem. Small changes may indicate aging or dimensional changes due to seasonal temperature conditions.

The real question is “How critical is DTF measurement accuracy?” to the maintenance process. Probably not very. The accuracy is adequate as long as it provides repeatable DTF measurements.

Typical absolute measurement accuracy for tower mounted transmission lines is within 1 foot, slightly better than a technician's ability to measure physical length on a tower mounted cable. Further, most service problems are either physical damage or connector problems. Physical characteristics such as connectors, adapters and bends show up clearly on the DTF display. Thus, identifying a problematic transmission line section is straightforward. As compared to return loss measurements where test accuracy is critical because small performance changes may indicate big problems. Comparison of DTF “before” and “after” plots isolates problems quickly and easily.

Cable Insertion Loss

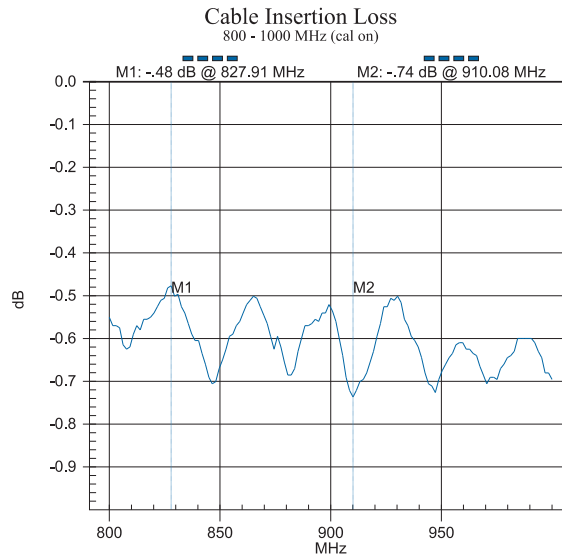
Site Master performs cable insertion loss measurements. Cable insertion loss is determined by measuring return loss at one end of the cable with the other end open circuited (disconnected from any antennas or devices). The open circuit return loss is measured and divided by two to calculate cable insertion loss. This method is excellent for trouble shooting or verifying previously installed cables, but lacks the accuracy to verify transmission line cable to manufacturers specifications. Repeatability is excellent when proper measurement technique is used. For best results the cable's insertion loss should be < 4 dB. When comparing measurements to historical data remember that Site Master is sensitive to phase length changes, so it is best to always disconnect the cable (open circuit) at the same position. For example, if the original measurement was performed with Connector A open then all subsequent measurements should be performed in the same manner. If a subsequent measurement is taken with Connector B open the results will be different and cannot be directly compared.



TEST TIP

To avoid climbing the antenna tower to disconnect the cable, experienced technicians can consider using a frequency sweep that is substantially outside of the antenna's specified bandwidth. Most antennas behave like an open circuit when tested out of band.

In many cases the cable insertion loss display will have a ripple pattern as shown. In these cases the cable insertion loss value used should be the sum of the highest and lowest value divided by two (the average value).

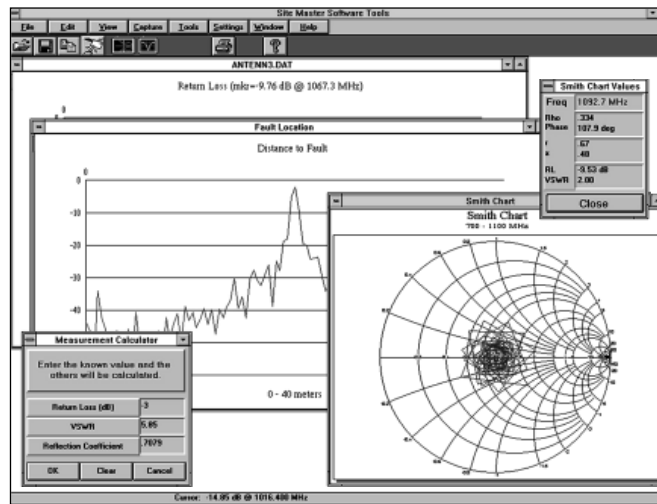


Return Loss Accuracy

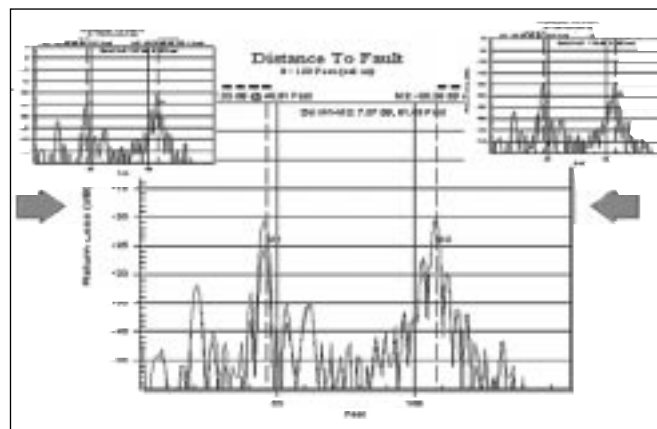
Site Master can achieve the accuracy of benchtop VNA's with proper calibration. Precision open/short and load calibration components reduce measurement uncertainty improving accuracy. Vector error-correction techniques are used to provide excellent return loss measurement accuracy.

Powerful Software Tools

Site Master Software Tools is a Windows based utility program. Return Loss, SWR and DTF data is down loaded to a PC via RS-232. Site Master Software Tools calculates DTF and Smith Chart information from return loss or SWR data. Any stored trace may be downloaded and displayed using the software tools. With its “Drag” and “Drop” feature, displayed traces may be overlaid. This allows quick comparison of “before” and “after” DTF measurements. Recent data can be compared to a historical PC database record which is usually recorded during site installation/commissioning. Software Tools has four adjustable markers, allowing monitoring of antenna bandwidth changes. A built-in look-up table for cable loss and dielectric constant can be customized by the user making DTF set up simple. Output is available in ASCII or graphic format making analysis and report generation easy. Multiple displays can be downloaded from a Site Master unit using the software tools. The displays can then be named and saved as ASCII files creating a database of measurement data. Saving files as Windows Metafiles (a graphics file) allows them to be imported into other software packages for report generation and presentations. Site Master Software Tools is a free software program provided with every Site Master unit.



Use the Smith Chart for antenna impedance matching and transmission line quality checks.



Historical performance changes are evaluated by overlaying stored data traces on a personal computer.

Summary

Site Master is a precision analysis tool which measures Distance-To-Fault (DTF), Return Loss and SWR on both analog and digital transmission lines. Site Master's DTF and Return Loss (SWR) measurements are accurate and repeatable, even in the presence of RF interference. As a trouble shooting tool, DTF analysis can pinpoint damage and impending failure conditions. Thus, small degradations to RF performance can be spotted before more serious damage occurs. For example, loose connectors and moisture intrusion can be detected before corrosion destroys the cable – saving thousands of dollars in material and re-installation costs. By contrast, previous TDR based fault location and spectrum analyzer based return loss measurements are error prone and susceptible to RF interference. TDR's can only find catastrophic faults. DTF finds potential problems quickly and reliably – allowing cellular service professionals to implement preventative maintenance plans and reduce cost-per-cell expenses. Since sixty to eighty percent of typical cellsite's problems are caused by problematic cables, connectors and antennas, Site Master pays for itself quickly. Site Master's rugged construction and wide temperature operating range provide trouble-free operation in the field.

Coaxial Cable Technical Data

Cable Type	Relative Propagation Velocity (V_f)	Nominal Attenuation dB/m @ 1000MHz
RG8, 8A, 10, 10A	0.659	0.262
RG9, 9A	0.659	0.289
RG17, 17A	0.659	0.180
RG55, 55A, 55B	0.659	0.541
RG58, 58B	0.659	1.574
RG58A, 58C	0.659	0.787
RG142	0.690	0.443
RG174	0.660	0.984
RG178B	0.690	1.509
RG187, 188	0.690	1.017
RG213/U	0.660	0.292
RG214	0.659	0.292
RG223	0.659	0.165
FSJ1-50A	0.840	0.197
FSJ250	0.830	0.134
FSJ4-50B	0.810	0.119
LDF4-50A	0.880	0.077
LDF5-50A	0.890	0.043
LDF6-50	0.890	0.032
LDF7-50A	0.880	0.027
LDF12-50	0.880	0.022
HJ4-50	0.914	0.087
HJ4.5-50	0.920	0.054
HJ5-50	0.916	0.042
HJ7-50A	0.921	0.023
LMR100	0.800	0.792
LMR200	0.830	0.344
LMR240	0.840	0.262
LMR400	0.850	0.135
LMR500	0.860	0.109
LMR600	0.870	0.087
LMR900	0.870	0.056
LMR1200	0.880	0.044
LMR1700	0.890	0.033
HCC 12-50J	0.915	0.092
HCC 78-50J	0.915	0.042
HCC 158-50J	0.950	0.023
HCC 300-50J	0.960	0.014
HCC 312-50J	0.960	0.013
HF 4-1/8" Cu2Y	0.970	0.010
HF 5" Cu2Y	0.960	0.007
HF 6-1/8"Cu2Y	0.970	0.006

Table 2

Complimentary Field Maintenance Equipment

Built to meet the stringent demands of field service, the MS2650A/60 Series spectrum analyzers are at home in R&D and manufacturing as well. Today's wireless communications equipment market requires increasingly sophisticated test equipment. These spectrum analyzers are capable of meeting these needs as well as those of the CATV equipment market. Covering frequencies ranging from 9 kHz to 3 GHz and weighing only 22 lbs., the MS2651B/61B series is ideal for field maintenance and installation of basestations. With coverage of up to 30 GHz, the MS2650/60 series can also be used for measurements of microwave equipment. When stringent measurements must be performed, such as adjacent channel leakage power and harmonic distortion, the MS2661A offers superior capability. MS2651A and MS2661A performance benefits include:

- Level accuracy of ± 1.1 dB.
- Low harmonic distortion levels.
- Optional RF preamplifier improves sensitivity by approximately 18 dB.
- Optional tracking generator.
- Time domain measurements and time gated spectrum analysis.
- Optional TV Monitor and speaker for CATV equipment maintenance.

Specific performance parameters of each unit are shown in the following table.

Model	MS2651B/61B	MS2653B/63B	MS2665C	MS2667C
Frequency Range	9 kHz to 3 GHz	9 kHz to 8 GHz	9 kHz to 21 GHz	9 kHz to 30 GHz
Sideband Noise	$\leq -100/-90$ dBc/Hz	$\leq -100/-90$ dBc/Hz	≤ -100 dBc/Hz	≤ -100 dBc/Hz
Average Noise Level	$\leq -115/-110$ dBm	$\leq -115/-110$ dBm	≤ -115 dBm	≤ -115 dBm
2 nd Harmonic Distortion	-75/-60 dBc	-75/-60 dBc	-70 dBc	-70 dBc
3 rd Harmonic Distortion	-80/-70 dBc	-80/-70 dBc	-80 dBc	-80 dBc
Maximum Dynamic Range	>110/105 dB	>110/105 dB	>110 dB	>110 dB

Table specifications are given for frequency at 1 GHz. Sideband noise at 10 kHz offset.

A bright, color LCD display and a full range of automated "one-button" measurement functions, such as adjacent channel power, occupied bandwidth, carrier-to-noise, noise power, frequency, and burst average power, make measurements easy. Definable user keys enable automatic measurement programs to be executed. Simply pressing the user-defined function key provides individual functions and menus. A built-in microcomputer function enables the spectrum analyzer to be used as a controller allowing for configuring of external equipment for automatic measurements.

The MS2650/60 are controlled easily by a laptop or notebook computer and come standard with an RS232C interface. GPIB or parallel interfaces are optional.



Certificate No. 6495

Sales Centers:

US (800) ANRITSU
 Canada (800) ANRITSU
 South America 55 (21) 286-9141

Anritsu

Microwave Measurements Division • 490 Jarvis Drive • Morgan Hill, CA 95037-2809
<http://www.global.anritsu.com> • FAX (408) 778-0239

Sales Centers:

Europe 44 (01582) 433200
 Japan 81 (03) 3446-1111
 Asia-Pacific 65-2822400

