Site Analyzer™

Test To Success

A proactive field testing program for antennas and feedlines, rather than limiting service to ooutright failures, is a key to maximizing wireless system performance.

Table 1. Problems with antennas and cable.

ANTENNAS

- Lightning, water and wind damage.
- Damage from ultraviolet radiation.
- Damage due to icing and long-term temperature cycling.
- Corrosion from airborne pollutants.
- Antenna radome dielectric changes due to environmental conditions, resulting in changes in antenna characteristics.

CABLES

- Installation damage, such as overtightening of grounding clamps, resulting in deformed outer conductors.
- Water penetration of cable dielectric.
- Corrosion of outer conductor caused by damaged insulation.

CONNECTORS

- Corrosion caused by improperly installed weather seals.
- Improper termination of cable center or outer conductors.
- Improper tightening at installation, or loosening due to temperature cycling.

Technicians and engineers involved in the construction, performance verification and ongoing maintenance of communication systems need all the help they can get. Communication networks of all types are experiencing unparalleled growth, while competition between various services and providers has intensified. Field technical personnel are thus under increasing pressure to work as efficiently as possible on an increasing number of communication sites. Keeping networks tuned for maximum performance while holding total maintenance costs down necessitates the use of the right tools and methodology for every maintenance or repair task.

The testing of antenna and feedline systems is an important element of site maintenance and repair. Typically, antennas and feedlines are tested during the construction and commissioning of new sites, and during ongoing maintenance and troubleshooting after a site is in operation. At that point, one might opt for a philosophy of limiting service to outright failures as a means of reducing maintenance labor and costs. However, a properly planned and executed program of proactive site management, including periodic testing and analysis of working systems, can actually reduce overall downtime while providing more-consistent,

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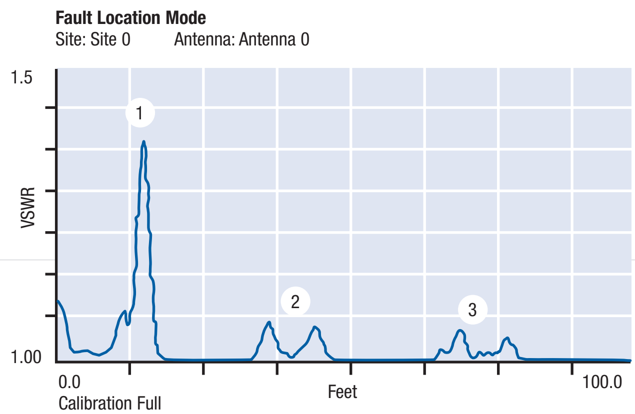
higherquality service and considerable savings of time and money.

The following overview covers two of the most common field measurements performed by site installation and maintenance personnel, along with some recommended practices and step-by-step procedures designed to streamline these site management activities.



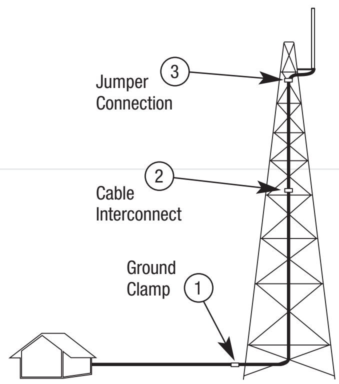


Figure 1. Correlating fault location measurements to physical antenna system problems.

Table 2. Fault location signature analysis planning.

- Develop procedures to incorporate fault location signature analysis for all new sites under construction, as well as those already In operation. Collect and archive fault location "reference data."
- Obtain good tools for conducting signature analysis. Some of the features to look for in these instruments are:
  - Instruments should be easy to use, minimizing technician training time.
  - Portability for convenient use in site conditions.
  - Good screen resolution for locating small faults. Screen should be viewable in all lighting conditions.
  - Ability to store many fault location signatures and organize and label stored information in a convenient manner for easy recall.
  - Ability to yield good fault location measurements in co-located environments, or those with significant ambient RF energy levels.
  - Ability to do on-screen comparisons of current fault location signatures at the site. Also, instruments should allow for uploading of archived fault location signatures from a large database of fault location signatures.
  - Convenient, versatile software tools for creating large fault location signature databases.
- Train personnel in the proper methods of collecting and interpreting fault location data.
- Perform fault location signature analysis as a part of regular site maintenance, rather than as a response to antenna system problems. Regular fault location analysis will identify many antenna system problems before they affect service.

Fault-location Measurements

Because of their exposure to severe outdoor environmental conditions, transmission lines, antennas and their associated hardware are the most common failure points in every wireless communication system, as shown in the photos. These components are prone to a variety of natural adversities, as well as vandalism and even damage from stray bullets.

Table 1 lists some common problems with antennas and feed lines.

In addition, there may be problems unique to a particular area, such as increased corrosion caused by airborne pollutants in areas of heavy industry, or special problems such as high winds or icing caused by local weather conditions. Correction of many of these problems extracts a premium because it may require climbing a tower for troubleshooting and remedy.

An important and powerful tool for site management is distance-to-fault (DTF) measurement. DTF measurement provides information about the return loss or VSWR vs. distance for a transmission-line system. DTF measurements can reveal various types of problems including bad connectors, distorted transmission cables and generally poor performance from complete antenna systems. An added value of DTF measurement is that these problems, including their severity and relative positions along the transmission line, can readily be identified from the end of the cable at the base of the antenna tower. (See Figure 1 at left.)

Fault location analysis is useful as an element of maintenance planning and can track conditions not easily identified with spectrum analyzers or tracking generators.

Perhaps even more valuable is that field personnel equipped for DTF measurements can not only identify bona fide equipment failures, but they can also monitor more subtle degradations of antenna system performance. Fault-location analysis is useful as an element of maintenance planning and can track conditions not easily identified with traditional tools, such as spectrum analyzers or tracking generators.

The regular comparison of fault-location "signatures" is a cornerstone of effective communication system maintenance and site management. All of the various components in a particular trans mission system cause reflections to occur in transmission lines. Each transmission system has its own unique pattern of VSWR or return loss aberrations and relative positions. If these signatures are regularly monitored, changes in them will reveal problems that frequently can be corrected before they impair service.

Figure 1 shows a typical transmission system and its associated fault location signature. Note that each of the system components, including the antenna, jumper cables, interconnects and any abnormalities caused by improper installation, result in some reflected energy. These reflections are revealed as "bumps," or areas of higher VSWR in the fault location signature. Problem areas may be identified by comparing fault location signatures of each transmission system to the signature obtained at site commissioning and to those obtained during subsequent maintenance sweeps.

In many cases, analysis of fault-location signatures will pinpoint problems with specific system components, thereby permitting service personnel to avoid a "shotgun" approach to system maintenance. For example, fault-location analysis may reveal that a suspected antenna problem is, in fact, caused by a poor-quality connector and not by the antenna itself. The value of such knowledge is obvious in view of the expense and downtime required to blindly replace an antenna or sort through several hundred feet of transmission line.

Table 2 outlines several steps for developing an effective site management program based on fault-location signature analysis, The steps in Table 3 outline a method for system assessment using fault analysis data.

Cable Loss Measurements

In many cases, site installers and tower erectors are required to perform cable-loss measurements as a part of antenna site commissioning. As in the case of any other measurement situation, some methods yield better, more accurate results than others.

When measuring the insertion loss of a length of cable, the most accurate method involves having access to both ends of the cable and using a precision two-port measurement instrument to determine the loss in the cable. While this is the ideal, it is impractical because, in most cases, one end of the cable is at the top of a tower and is thus inaccessible. In addition, most precision two-port instruments for the measurement of insertion loss are laboratory instruments not suitable for field use.

The most widely accepted method for making field cable-loss measurements, in situations where one end of the cable is remote, is to use a single-port instrument to measure the return loss of the antenna system. A typical procedure for making these measurements is to:

1. Measure the return loss of the cable with the remote end either open or shorted. The trace will resemble Figure 2. Read the return loss at a trace maximum and at a trace minimum.
2. Read the return loss at a trace maximum and a trace minimum.
3. Take the average of these two values and divide by two to arrive at the one-way cable-loss value.

   While this method yields an insertion loss measurement for a length of cable, the value obtained may not be less accurate than values obtained by other means.

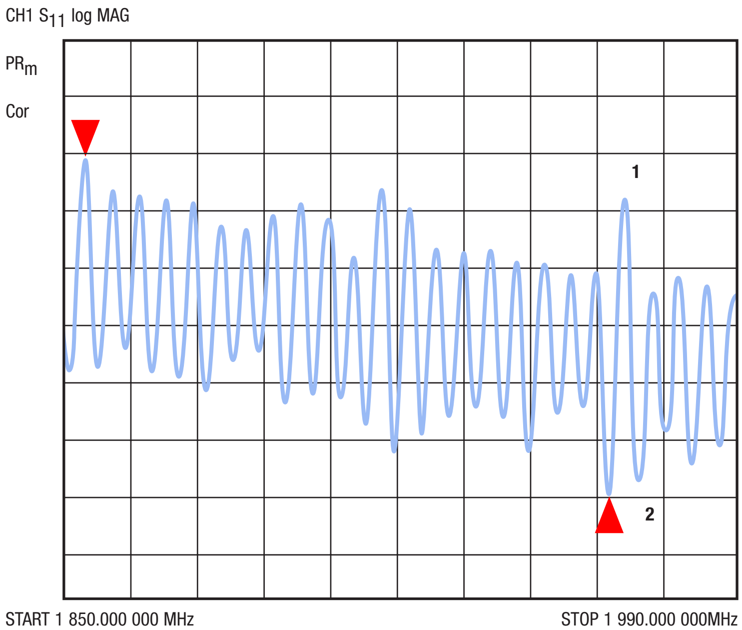


Figure 2. Single-port return-loss measurement.

Table 3. Fault location analysis procedure.

1. The process begins with reference fault-location data from the site to be tested. This Information must be recalled either from the Instrument trace memory, or from archives maintained on a computer. If the Instrument Is so equipped, upload the archived data to the instrument to be used so that onsite comparisons may be made.
2. Perform the fault-location measurement at the site, using the same test procedure used Initially. Some fault-location test instruments allow for the storage of several test setups to simplify this process. Be sure to properly calibrate the instrument before performing the test.
3. Compare the test results to the stored fault-location trace.
4. Note any differences in the fault-location signatures; investigate and repair if necessary.
5. After performing any repairs, fun the fault-location test again to provide a now fault-location reference signature for the antenna system. Be sure to store and label this new data.

The secondary cycling of the return-loss trace caused by the VSWR of the cable assembly and the source match of the test instrument can reduce accuracy. Because of this secondary cycling, the maximum and minimum chosen for the return-loss values are critical. The wrong choices can result in large errors.

A better method for using a single-port instrument for these types of measurements is to obtain readings of the cable's return loss alternatively using an open and a short at the remote end of the cable. (See Figure 3.)

Because this causes a 180˚ change in the phase of the reflection coefficient, the trace shifts 180˚ (what was a maximum now becomes a minimum). These two return-loss values are measured at the same frequency and may now be averaged and divided by two for the one-way, cable-loss (insertion loss) value. Performing the

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Figure 4. Bird Site Analyzer.

measurement in this sequence ensures that any inaccuracies caused by secondary cycling of the return-loss trace are avoided, and the best cable loss measurement can be obtained.

To summarize the best procedure for cable loss measurements:

1. Measure the return loss of the cable assembly with the remote end of the cable open. Position a marker at the frequency of interest but at a peak on the trace.
2. Repeat the return-loss measurement with the remote end shorted. You will notice that the marker was positioned at the peak of the trace is now at the adjacent valley.
3. Average these two values, and divide by two. This value is the one-way cable loss. Table 4 illustrates typical results using the above technique for making the return-loss measurements with a single-port field antenna analyzer (Bird Site Analyzer, Figure 4) as compared to a laboratory instrument. (HP8753D Network Analyzer). The measurements were made using 100 feet of 1/2" corrugated copper cable. (RFS FLC12- 50J). The above method produces results with the portable analyzer that closely correlate to readings obtained with an instrument commonly found in laboratory settings.

Table 4. Insertion-loss comparison

INSTRUMENT	INSERTION LOSS
Hewlett Packard 8753D	3.66 dB
Bird Site Analyzer	3-53 dB

Electronic Corporation
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30303 Aurora Road, Cleveland, OH 44139-2794
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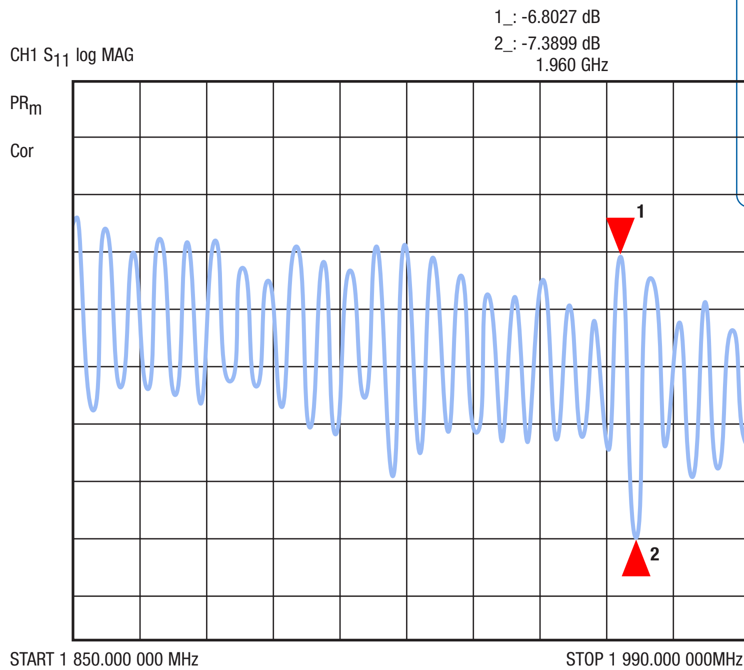

Figure 3. Improved single-port return-loss measurement.

Conclusion

The procedures and measurement techniques described in this article can be used as core elements of a site management program that can help minimize system downtime, increase the efficiency of field maintenance personnel and reduce total system operating costs. The keys to making these practices work are fairly simple:

- Select test equipment that adequately addresses your specific needs.
- Develop a simple, workable program to monitor system performance.
- Train service personnel to implement the program.
- Regularly apply the program, including signature measurement and subsequent comparisons, to determine short-term and long-term system trends.
- Take corrective action before identified potential problems significantly affect system performance.

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