AN217
Measuring Feedline on a Tower

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Abstract

Transmission tower feedline measurements using a TDR determine the feedline's overall condition, and the distance to any faults. A pseudo feedline may also be built (using the TDR) for testing attached antennas with a network analyzer. This application note discusses these types of tests.

General

The tower feedline suffers more adverse conditions than most other types of coaxial installation. The weather exposes the feedline to temperature extremes, wind, rain, lighting, and snow. But Mother Nature is not its only enemy. Hunters have a penchant for shooting at the aircraft warning lights on towers and the feedline frequently experiences the ill effects of their lousy marksmanship. Locating and evaluating the damage on a feedline has is an excellent job for a TDR. Since feedline coax uses the highest quality cable, testing requires the highest quality tools. The "Step TDR" is the best tool for evaluating how close the cable's condition is to factory specifications.

Documenting Installations

To give maintenance personnel a baseline condition to compare all future readings, document the feedline at the time of installation. When documenting a high quality installation like a feedline, AEA Technology recommends using the 20/20 TDR's "Detailed Save" feature which greatly increases the resolution of the plot for future reference. When expanded on a PC screen a Detailed Save provides up to 2000 data points as opposed to the ~250 data points from a "Screen Save". If a feedline was not documented at its installation, it is still not too late, document its condition after completing maintenance on the tower or feedline. As part of the documentation, include notes on the number and type of adapters and leads used to connect the TDR to the feedline. Also take note if the adapters and leads were in the plot or calibrated out of the plot. This becomes important later when looking at the cable's distance measurements. The 20/20 TDR will automatically save the velocity (VF), which is crucial to comparing measurements at a later date. Also saved are the Impedance (Z_0), Noise, Averaging, and Video filters settings. The Video filter is saved for reference, but only applies to the 20/20 TDR's LCD picture, not the PC presentation. See the Operators Manual, Section 2 for the best filter application.

What the 20/20 TDR Will Show

As mentioned before, feedline uses very high quality coaxial cable with a very low resistance on the center conductor and shield. This yields a very flat horizontal trace over the length of a good cable (very little dribble up). If the antenna is connected at the time of the installation the end of the trace will show an open or a short depending on antenna design. If a condition opposite to the expected were to appear, it would mean either a short or open respectively at or near the antenna's connector or in the antenna itself. For this reason AEA Technology recommends pre-qualifying the antenna before installation on the tower and connection to the cable. See AN110 and AN112. If the antenna and cable are already installed the antenna can still be analyzed with AEA's Network Analyzer using a "Pseudo Feedline" (PFL) to subtract the cable. See application note AN114 "Tower Site Tips" for instructions on measuring with a pseudo cable.

Wet Cable

Water is a cable's worst enemy. Once inside the cable it moves via capillary action and gravity to the lowest points in the cable and remains there causing irreparable damage. The water permits electrical conduction across any two points with a difference in electrical charge. This leads to the matriculation of metal molecules from the negative conductor to the positive conductor through the dielectric, seriously reducing its insulating value. Since the water usually displaces air in the cable, the capacitance increases and the impedance of the wet cable section is reduced. Additionally, the speed or Velocity Factor of that cable section slows by some random value which invalidates any distance measurements in and beyond the wet section.

Recognizing Water's Signature

Water inside a cable leaves a recognizable signature of erratic reductions in impedance as depicted in Figure 1.

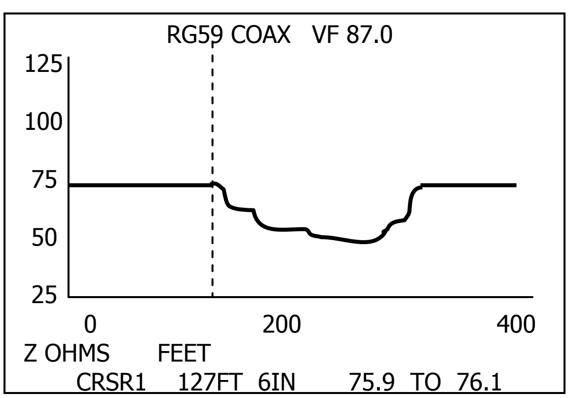

Figure 1

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For more information on measuring the length of a slug of water in a cable see AN213.

Crimps or Bends

Most feedlines are well secured to the tower with their mounting brackets. However, the opportunity for crimping or bending damage exists during installation when the cable is being handled. It can also occur if one or more securing brackets break loose and the cable is permitted to move too freely in the wind. The result is one or more spots in the cable where the shield is now closer to the center conductor causing low impedance (Z) zone. Step TDRs are particularly good at indicating this type of reflective event. AEA Technology's 20/20 TDR offers an automatic fault find that permits the user to set maximum deviation limits in impedance and will jump the cursor to an out-of-limit event.

Center Conductor to Shield Short

If a crimp becomes too severe and the center conductor makes even the slightest contact with the shield, that point will become the electrical end of the cable. All energy will be reflected back to the transmitter at the point of contact. Another source of shorts is bullets. They can lodge between the center conductor and the shield or pass on through leaving strands of shield touching the center conductor. The 20/20 TDR can find the distance to shorts with pin-point accuracy. Additionally, these shorts are often intermittent. The 20/20 TDR has an "Intermittent Grabber" feature that can be invaluable in locating even the slightest point of contact.

Open Center Conductor or Shield

The most likely location for corrosion to cause an open in a feedline is at the connectors. Once wet, verdigris builds between any copper connections. The growth is fueled by contaminates in the water and stimulated by the RF energy traveling through the connection. Once all the direct copper connection is gone the verdigris becomes a high resistance junction between the connection points. This type of open occurs on the center conductor or the shield's connection at the connector. It normally cannot be detected until the damage is severe enough to open the connection point completely. Another cause for an open would be a serious amount of flexing should the feedline loose one or more supports. Wind continuously flexing a cable eventually causes the center conductor to snap in two. This generally occurs right at one of the last holding support before the cable's loose section. And lastly, the infamous bullet making a clean hole through the center of the feedline can cause an open as it severs the center conductor.

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Conclusion

To avoid unnecessary trips up the tower, use the 20/20 TDR to examine the condition of the feedline both before and after antenna installation. Save that documentation on a PC using TDR PC Vision software. If trouble is suspected later, the documented traces and the current measurements can be compared in TDR PC Vision to either locate the fault or eliminate the cable as the cause of the problem.

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