AN114
Tower Site Tips

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Abstract:

This paper discusses tips for using the AEA Technology network analyzer at antenna sites. Adding an AEA 20/20 TDR20 TDR provides a powerful combination for testing the feedline and antenna.

Introduction:

Measuring the impedance of antennas located at the top of a tower presents one big problem: climbing the tower. Without climbing the tower, the best measurement you can make combines the feedline effects with the antenna impedance, which can make the readings confusing. Interfering signals from other towers can create a second problem. We discuss using a pseudo feedline (PFL) for improving impedance readings without climbing the tower. We also show how to use filters to remove interference.

Measure the Feedline:

Start with the 20/20 TDR to check the feedline. Towers typically have very high quality coaxial feedlines, so the TDR plot should look nearly perfect. Sometimes you will find water in the feedline caused by a bullet hole or other problem. Draining out the water and plugging holes usually requires a climb, but the TDR lets you know that the effort spent climbing the tower will result in a repaired feedline. Once the feedline has been verified, save the final reading, this reading helps create a “pseudo feedline” discussed in more detail below. Also take note to read about “Adapters” below. See the Appendix for a list of App Notes showing cable issues and their plots.

A good feedline will show a flat plot (usually 50 ohms) for the entire length of the line. Once the TDR signal reaches the antenna, the reading goes to an open or a short depending upon the antenna design. If the connector to the antenna has failed, you may not be able to distinguish the bad connector from a good antenna. The network analyzer takes care of this issue.

Take Impedance Reading:

Connect the network analyzer to the feedline, a low SWR reading (Z near 50 ohms) indicates that the connector and antenna both check OK. However, to get the maximum performance from the antenna, check the antenna for resonance in addition to SWR or Z magnitude. The feedline alters the resonant frequency reading from the actual value which masks the resonance information. To eliminate the feedline effects, perform a cable null on the network analyzer and feedline. Since this requires two people (the loser climbs the tower), lets find an alternate method.

Create a Pseudo Feedline:

We use the TDR reading to create a pseudo feedline (PFL) from an equivalent length of high quality coax. This PFL simulates the real feedline during the cable null operation. The PFL does not have to be the same cable or the same physical length as the real feedline; it only needs the same electrical length and have low loss. Follow the steps below to make the PFL:

1. Obtain a sufficiently long length of low loss coax that has the same Z0 as the feedline.
2. Install a coaxial connector (same type as on the network analyzer and TDR) to one end of the coax.
3. Connect the coax to the 20/20 TDR.
4. Turn on the TDR and recall the plot made from the real feedline.
5. Position the TDR cursor at the end of the feedline.
6. Press Exam/Plot to look at the coax line. It should measure longer than the feedline. Carefully shorten the coax, bit by bit, until it measures the same as the feedline. Note: Since we only care about matching the electrical length, we leave the VF unchanged for the coax, i.e. we use the same VF used during the feedline measurement.
7. Once the coax length matches the feedline, install a coaxial connector at the far end. This connector mates with the Short and Load used during cable null.

The commercially available BNC loads are only good for 120MHz or less, use the N short and load sets (AEA PN 6015-1301 or 6015-1302) if the frequency of the antenna exceeds 120MHz. It wouldn't hurt to use these high quality loads at lower frequencies too. It is critical that the short does not add electrical length (i.e. add extra adapters) to the coax. The open and the short must be the same length.

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Adaptors:

To properly match the pseudo feedline to the actual feedline we need to be careful about adaptors and the inconsistent lengths they produce when added in or taken out. If the network analyzer adapters are different in length than the TDR adaptors, the cable null will have some error. The easiest way to prevent this, use a 20/20 TDR model with the same connector as the network analyzer (usually N). Plan B: use an adapter that converts the TDR to the same connector as the network analyzer. Pretend this adaptor cannot be removed (i.e. make the TDR connector the same as the network analyzer connector). Use this TDR and adaptor from the very first site test. Doing this keeps the adaptor that converts the TDR or network analyzer to the feedline constant, so the cable null and PFL operate properly.

Measure the Antenna:

To measure the antenna:

1. Turn on network analyzer.
2. Set the network analyzer center frequency and sweep width to the desired values.
3. Set the plots to read Z and Z angle, or resistance and reactance.
4. Connect the S11 port to the PFL.
5. Perform the cable null using the PFL.
6. Remove the PFL.
7. Attach feedline to S11 port on network analyzer
8. Observe and save the impedance plots.

How to Interpret Impedance Data:

If the Z angle or the reactance is not near zero at the frequency(s) of interest, the antenna is not resonant. Study the antenna manufacturer's data sheet to see if adjustments are available. If not, the stub tuning may need to be done. If the antenna requires tuning, it must be done on the top of the tower. Use may use a matching circuit to get low SWR at the transmitter; however, this does not erase the lower power efficiency of the non resonant antenna. Let an antenna expert study the saved impedance data and devise a plan that tunes the antenna to resonance.

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Interference:

Interfering signals occur frequently at antenna sites. For best results, notch out the interfering signal. Build or buy a notch filter, and place it inline with the S11 port. Be sure to do a cable null after adding the notch filter.

Tips for notch filter construction:

1. Use a single series L-C trap from the signal line to ground.
2. Build the trap into a good connectorized enclosure (e.g. Pomona 2411), they are not cheap, but they are worth it.
3. For narrower notches, use large inductor and small capacitor.
4. For deepest notch the inductor must be low resistance. Inductor resistance always measures higher than the DC ohms due to the skin effect.

Batteries:

Be sure that you recharged or replaced your batteries recently. It wouldn't hurt to have backup set just in case they are needed. You do not want to run out of batteries when on the tower.

Conclusion:

Using a BPF, TDR, and PFL with the AEA Technology network analyzer improves the ability to diagnose faults and eliminate problems incurred at antenna test sites.

Appendix:

Refer to these other AEA Application notes for more information using the 20/20 TDR or AEA network analyzers

AN100	What SWR Doesn't Show You
AN101	When to Use Cable Null
AN102	Understanding Vector Network Analysis
AN103	Relationships of Impedance, Gamma, Return Loss, and SWR
AN110	Coaxial Stub Tuning
AN111	Find Characteristics of an Unknown Cable
AN112	Tuning an Antenna

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