AN112
Tuning an Antenna

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Abstract:

This paper describes how to use an AEA Technology network analyzer to tune an antenna. This paper discusses tuning issues at a general level; no specific model of antenna is addressed here.

Introduction:

For best link efficiency, you must properly tune the antenna to resonance. Additionally, if the antenna has two or more adjustments available, you should also tune the antenna for the optimum match.

Resonance occurs when the reactive portion of the antenna impedance is zero. This causes the voltage to be in phase with the current, and allows the transmitter to generate its maximum power. SWR or return loss readings do not provide enough information to determine resonance. You must use a vector impedance reading to see resonance.

The transmission lines used to feed the antenna can add a layer of confusion to the measurements. If practical, tune the antenna by itself first, then add in the feedline for more measurements.

Discussion:

Read the manufacturer's instructions to find out about available tuning adjustments. Some common forms of adjustment include length (height) adjustment, feed element tap, variable caps or coils, or some balun adjustment. The mounting height combined with the mast and tower affect the tuning, so try to make the measurement under conditions that represent the actual installation. Always use the simplest set of adaptors required to make a measurement. If you are operating at high frequencies or at a very narrow bandwidth, you should cable null the analyzer (and adapters). See AN101 for info about cable nulling.

1. Tune the antenna to resonance. Set one of the plots on the network analyzer to impedance angle (or reactance). Tune for zero reactance or impedance angle. If the combinations of adjustments are unable to do this, a tuning stub may be required. See AN110 for more information on stub tuning.
2. Tune the antenna for best match, while maintaining resonance. Set the other plot of the network analyzer to Total Z. The best match occurs when the total Z approaches the characteristic impedance (Z0) of the system, usually 50 ohms. Multiple adjustments often interact, so a little patience goes a long way.

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3. Once you have achieved both resonance and match, save the reading to memory for saving to the PC later on. Many people want to see reports with the scalar values, i.e. SWR or return loss. You may extract this data from the vector data (Z and Z angle or Resistance and Reactance).
4. Add the feed line to the antenna. Measure the input of the feedline; it should be close to a good match and near resonance. When the Z0 of the feedline does not match the antenna Z, the resonance information will be masked by the feedline length. This situation should be addressed with baluns or other matching networks. Ideally, you want the transmitter Z = feedline Z0 = Antenna Z.

Conclusion:

Use an AEA Technology network analyzer to tune your antenna for resonance and match. When you achieve both resonance and match, you have your best efficiency. SWR/return loss meters do not give resonance information.

References:

AN101 When to Use Cable Null, AEA Technology
AN110 Coaxial Stub Tuning, AEA Technology

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