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Ask Dr. SETI ®

Chapter 6: Technology

Impedance Matching for Antenna Feeds

Dear Dr. SETI:

In putting my radio telescope on the air, I've gotten a lot of great advice from my fellow SETI League members. Thank you all.

One thing I do not know how to accomplish is measuring the impedance of a helix feed. I've gotten good suggestions on how to construct matching devices that transform the 140 ohms of the feedpoint to 50 ohms of the coax and receiver input, but they are all approximate. I won't know how close the match is, or how much to tweak it, without measuring it.

This is an area I've always been kind of weak on, so it would be good to learn. When transmitting, I always went with the idea that if SWR is a good ratio then at least my finals won't bake. I get the feeling that's not good enough here in this application (not to mention I'm not transmitting, but rather, receiving).

Dave (Project Argus participant)

The Doctor Responds:

The first principle here, Dave, is that antennas are completely reciprocal devices. That is, they perform the same in receive as they do in transmit. The VSWR between a 50-ohm output transmitter and an antenna is exactly the same as the VSWR between that same antenna and a 50-ohm input receiver.

Consider an antenna as primarily an impedance matching device. It matches the characteristic impedance of your feedline (in this case, 50 ohms) to that of free space (120 pi ohms, or 377 ohms -- derivable from the characteristic permittivity and the characteristic permeability of free space. See my Chapter 5 of the ARRL UHF-Microwave Experimenter's Manual for the derivation.)

When you adjust an antenna's match, you are making sure that all the transmit energy actually goes out into free space, and none is wasted in reflections. In receive service, the opposite will be the case: all the energy incident upon the antenna from free space will be coupled to the receiver, with none wasted in reflections.

Now, the way to measure VSWR is to pump a small amount of energy into the antenna (from, say, a signal generator), and to use instrumentation (say, a directional coupler, impedance bridge, slotted line, etc.) to measure how much energy reflects. We tweak antennas so as to minimize that reflection. You use various pieces of test equipment for this measurement and tweaking. When this is done, the performance of the antenna is optimized for transmit **and** receive.

So, if you have a signal generator of the proper frequency, and a device for measuring reflections (there are several types), just tweak away for minimum reflections. But what if you don't have any microwave test equipment -- are you out of luck? Not necessarily. If you are using a receiver that has a signal strength indicator (S-meter or equivalent), and you have either a weak signal source or an actual signal to receive, you can achieve a reasonable match by monitoring signal strength at the receiver, and tweaking the feed to maximize it. Maybe you won't be able to quantify your VSWR using the "tune for maximum smoke" technique, but you will be able to minimize reflections, and that's what antenna matching is all about.

On the other hand, achieving low reflections (that is, being an efficient impedance-matching device) is not the *only* function of an antenna. It also has to radiate -- and ideally, in the desired direction. (Or, as a receiver, it has to scoop up photons -- also, ideally, from a particular direction). That is why I can show you a device that has a perfect VSWR, with no reflections whatever, and it will make a lousy antenna! (That device is a dummy load...) So a good match is a necessary, but not a sufficient, condition for good antenna performance, in transmit or receive service.

Class dismissed.
