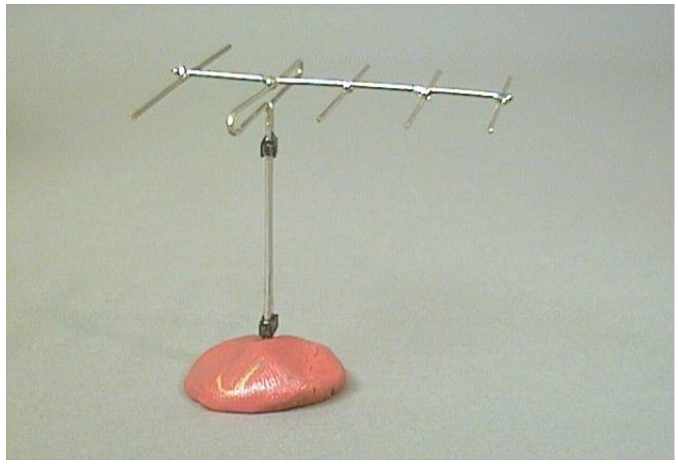
Tech-Talks

A Quick Look at Understanding Antennas

Almost all Hams have played around with antennas to some extent. It could be stringing wire for a Dipole or soldering copper pipe to make a 2 meter J-Pole. Even store bought antennas need to be installed and tuned-up.

Antennas are an enigma, how could a simple collection of wire and tubing be such a difficult thing to design and evaluate? The more you study about how an antenna operates, the greater the mystery becomes. The key is to keep it simple. We will look at a few simple antennas during the demonstration and just maybe shed a little light on the subject and help you understand antennas a bit more.



A five element Yagi antenna for 3GHz

Antennas are transducers. In the same manner that a speaker converts electrical signals from an audio amplifier into sound waves that travel through the air, an antenna converts RF energy from the coax into electromagnetic waves that travel through space. Audio enthusiasts will confirm that there are many types of speakers, each having their own quirks, each type suited for a different application. Antennas also must be carefully chosen to fit the job at hand.

Antennas conform to the reciprocity rule; that is, an antenna transmits the same as it receives. Although the desired characteristics of receive may be different from the transmit side. This is why many Hams use two antennas, one for receive, another for transmit.

It is important to understand a couple of terms that are used to describe the type and performance of an antenna. Some terms may not be familiar; if you have questions please feel free to give me a call.

Element – This is a part of an antenna that has a direct electrical influence on the performance of the antenna. This could be a wire or a piece or tubing.

Driven Element – This is an element that is directly driven with RF energy from the transmitter.

Parasitic Element – This is an element that is not directly driven but provides for the shaping of the antenna's beam pattern. Much like the baffles and ports in a speaker.

Dipole – This is a simple two element antenna. It is usually ½ wave in length. The feed is a balanced feed in the center of the antenna. Dipoles have an impedance of 73 ohms when resonate.

Monopole – As the name implies, this is a single element antenna. A ground plane or radials are used to drive the antenna against. Feed is single ended with the shield of the coax tied to ground or the radials. A ¼ wave dipole generally has an impedance of 37 ohms, or about half that of a Dipole.

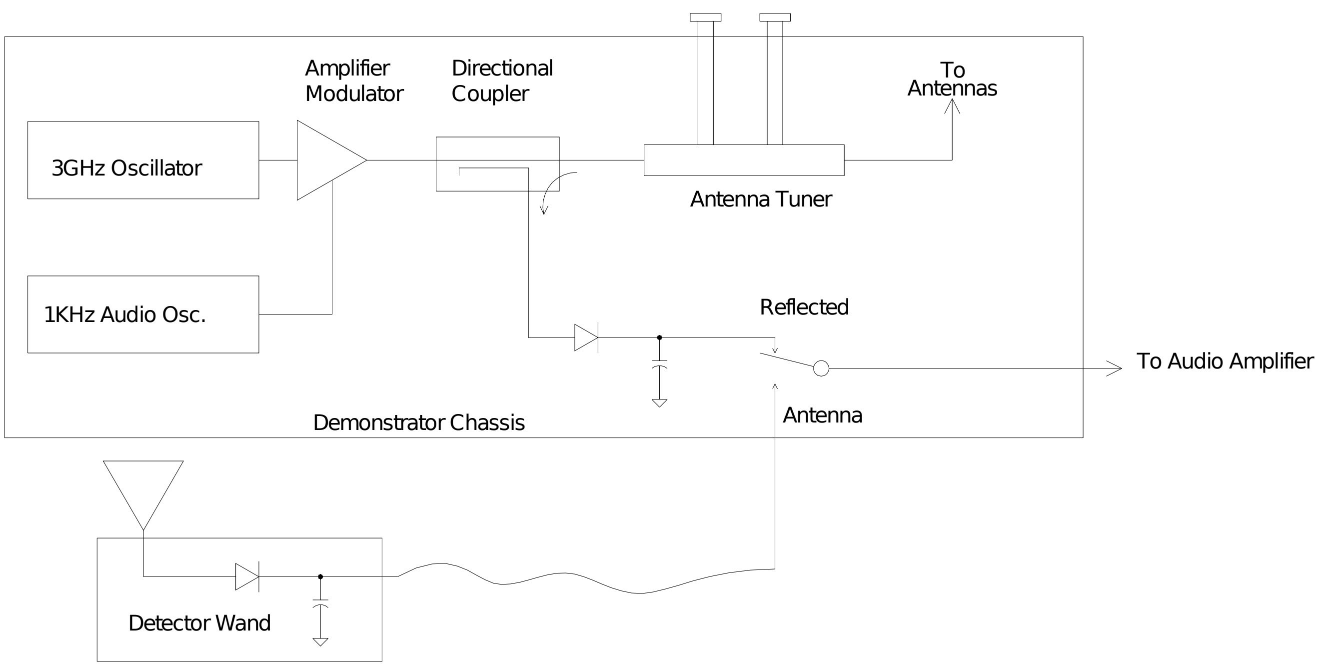
Yagi – This is the most popular antenna, of the multi-element type, for use at HF through UHF frequencies. The Yagi is a grouping of one set driven elements and one or more parasitic elements. The Yagi antenna can be designed to be very directional and have the effect of multiplying the transmitter's power many times.

Gain – This is an often misunderstood term. Although an antenna does not have the capability of amplifying a signal, it does have the ability to concentrate the transmitter's energy into a narrow beam. If a Ham had two antennas, one with 3dB more gain than the other. A receiving station, in the beam of the antenna, could not tell whether the Ham had switched to the higher gain antenna or doubled his output power. The bonus is that antennas also have receive gain. The signal to noise ratio of the distant station would be increased by 3dB if the higher gain antenna was used. A coach cups his hands over his mouth to yell at his players. Cupping your hand around your ear enhances the receive.

Isotropic Gain – Gain of an antenna in usually expressed as the increase in gain over an isotropic radiator, or dBi for short. An isotropic radiator is one, which radiates in all directions at the same time with uniform energy. Think of a very small light bulb suspended at the center of a translucent globe. The globe would be evenly illuminated without shadows or hot spots. There is, of course, no such thing as a true isotropic radiator, but the concept makes it easy to calculate effective radiated power, field strengths, and link budgets. Some people prefer dBd, which is gain over a dipole. A dipole in free-space has a gain of 2.1dBi, so an antenna that is rated 12dBi could also be rated 9.9dBd. Since it is unlikely that anyone could build an HF dipole in true free-space, the dBd is not generally considered useful by professional communications engineers.

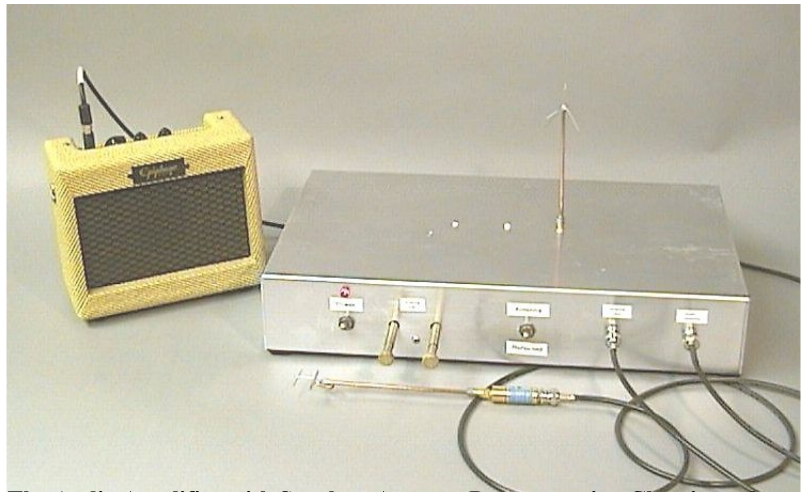
Polarization – Radio waves travel through space as two components. The "E" wave is the electrical component. The "H" wave is the magnetic component. Think of the H wave as current. The two components travel in two planes that are orthogonal (90 degrees apart) to one another. Polarization refers to the plane in which the E wave is traveling. A vertically polarized signal has an E wave in a vertical plane, and the H wave in a horizontal plane. Horizontally polarized signals are the opposite. If you were to try to receive a horizontally polarized signal, line of sight, using a vertical whip, things would not work out to well. The tall vertical element would look very short to the horizontally traveling E wave. No voltage would be induced, no signal received. Once the transmitted signal bounces off something such as a building or the ionosphere, all bets are off. The signals polarization becomes garbled and all vertical or horizontal characteristics tend to disappear.

Now for the demonstration!



The block diagram below shows how the experiment is set-up.
An oscillator operating at 3GHz is amplitude modulated by a 1KHz tone. This is a very common practice in the measurement of microwave signals. A diode detector easily demodulates the 1KHz and the strength of the tone is directly related to the strength of the microwave signal. No fancy equipment needed. The wavelength of this signal is 10cm or about 4 inches. So we can make our antennas very small and simple.

The signal is feed through a directional coupler that allows us to look at the reflected signal. The reflected output of the coupler is detected with a diode and connected through a switch to the audio amplifier.
A home-made double-stub antenna tuner allows us to match to load and reduce the reflected power. With the switch in reflected, the tuner is adjusted for minimum audio.
The output of the tuner can be connected to one of three different outputs. An SMA connector, a balanced output, and a single-ended output.
A wand consisting of a two element Yagi and a diode detector is used to sample the energy transmitted by the antenna under test.



The Audio Amplifier with Speaker, Antenna Demonstration Chassis, and the Receiver Wand. Notice the small ground plane antenna.

To operate the unit, connect the tuner to the desired output. Connect the antenna to be tested to the appropriate connector on the top of the unit. Turn on the oscillator power and the audio amplifier. Put the selector switch in “REFLECTED” and adjust the tuner stubs for minimum audio. Switch to “ANTENNA” and use the wand to explore the fields produced by the antenna. It’ just that simple.

I hope this helps you understand and be a bit more at ease with antennas. Do some reading, and build a few. Remember: your SWR meter says nothing about how well your antenna is working, signal reports are the proof of the pudding here!

Home-brew is good; long live the soldering iron.

73,
George Carlson KC5RCC

A collection of test antennas for 3GHz.
The PL-259 is for size comparison