TENNA TIP #2

VOR ANTENNAS FOR COMPOSITE AIRCRAFT

by Bob Archer of Sportcraft Antennas

In the first installment I talked mainly about COM antennas so in this one we will discuss internally mounted VOR antennas and their installation problems in composite aircraft. The use of VOR receivers is decreasing with the advent of LORAN and GPS but they are still useful and I believe that, as with fuel pumps, you can't have too many backups. Also if you fly IFR you still need the Localizer and glide slope.

Navigation antennas being horizontally polarized require that they be mounted in an area that has a large enough horizontal area that a half wave dipole can be installed. If the elements are swept the dipole can be reduced to about 40 inches. The logical locations are the wings, horizontal stabilizer and the top and bottom of the fuselage. There are always gotchas though and wings with large conductive horizontal structures such as graphite wing spar caps, push rods, cables etc. are not ideal locations. If the antennas in such wings can be positioned so that they are about 0.2 wave lengths (about 20 inches) ahead of the spars or such they would have more gain from the front but would reduce signals from the rear. If mounted behind the spar or other conductive device the reverse would be true and the signal would be stronger from the rear.

If the horizontal tail is constructed of graphite of course it is not suitable for antenna installations. Other than that it is a pretty good location except in the case where the signal is coming from directly in front and has to pass through the engine and cabin area to arrive at the antenna. If the aircraft is a canard of course the reverse is true. In this condition the signal will be weakened and the CDI needle could possibly wander. This also happens in the case of a metal aircraft with the VOR antenna on the top of the vertical stabilizer. When the airframe gets between the transmit and receive antennas as you approach the VOR station there is usually a bit of needle wagging going on.

In the case of aircraft with almost all graphite construction and graphite being conductive the only location for internally mounted VOR antennas would be in the fiber glass wing tips. Because of the wing tip lights, wires and strobes normal types of antennas work very poorly in this location. The light wires have a very low impedance to ground and being so close to the antenna tend to short the RF energy to ground. To solve this problem I have developed a series of wing tip VOR antennas that are shorted to ground DC wise and are very good antennas RF wise. These antennas are grounded monopoles fed with a modified gamma match and the parameters are such that the VSRW matches well across the VOR frequency band. The wing tip lights and wires on these antennas become part of the antenna and therefore have no effect on the antenna performance. Antennas of these types have been flown for years on various types of aircraft with excellent results. If your installation has two VOR antennas do not connect them together using any means unless you really, really know what you are doing. Being as far apart as the wing tips are will cause a phasing problem between the antennas that causes multiple lobes to be formed, the number of lobes being determined by the distance apart. Using one antenna for each receiver will result in the increase in range of about 25% over one antenna with a two set coupler into two receivers. Try to keep at least a 2" radius on all RG58/U cable installations. The same things apply to VOR antennas that I mentioned last time such as little black ferrite transformer boxes and ferrite beads. I don't believe that ferrite devices have any place in antennas because they do absorb RF energy.

Just a few words on dipole antennas for clarification. There are two types of dipoles, the two element type that is fed in the center, and is the type that is common and everyone is familiar with. There is also a continuous conductor type that is a continuous conductor from tip to tip for a full half wavelength. Each of these types require a different type of feed device. A center fed dipole dipole really should have a balun installed for proper operation. Without a balun on a center fed dipole fed with coaxial cable the antenna has uneven currents on the elements because half the currents on the braid side travel down the outside of the cable, the impedance is poor because the nominal impedance of this type of dipole is 150 ohms and is being fed with 50 ohm cable and the radiation pattern is bad because the radiation off the outside of the outer conductor interferes with the radiation off the elements. So a good balun does three things:

1. Balances the currents on the elements.
2. Matches the impedance of the cable to the elements.
3. Chokes off the currents that would otherwise travel on the outside of the cable.

For those that would rather do it themselves I have enclosed a rather rough sketch of a modified type two balun, I believe it is, that very neatly solves these problems. I recommend using RG142/U cable if available for its resistance to melting during soldering. By the way those ferrite beads that so many composite builders are using are totally useless. The beads do absolutely nothing at these frequencies that I could determine. And the ones with the ferrite transformers in the center are very lossy. Up to 12 dB depending on the type they are using. I strongly recommend using a real balun.

The continuous conductor dipole is interesting in that the center point has an impedance of zero ohms and the tips have an impedance of infinity, or there abouts, so somewhere between zero and infinity there is bound to be an impedance point that we could use. If we were to split the conductors apart on a 300 ohm twin lead cable and attach a conductor to the 150 ohm point on each side of the neutral center we would have a very good 300 ohm antenna. To feed with a 50 ohm cable though is a bit more of a problem. What we need to do here is to connect the braid of the cable to the neutral center point and the center conductor to the 50 ohm point on one side. A problem arises in that in connecting the center conductor to the antenna element we introduce an inductive loop which needs to be balanced out with a series capacitance. When all the parameters are correct this also becomes a very good antenna. This antenna design allows control of the length, feed point impedance and capacitance/inductance relationships so can be tuned to a high level of performance. Specialized antenna measuring equipment must be used for tuning this type of antenna. Most of my antennas are designed in this manner.

Bob Archer
Sportcraft Antennas
21818 Ocean Ave.
Torrance, Cal., 90503
Tel. 310-316-8796
“E” mail.<bobsantennas@earthlink.net>

Below are frequently asked questions about antennas with their answers.

Active Elements? The part of the antenna that actually does the radiating or the receiving of the RF energy.

Aperture? The capture area of the antenna. On a dipole or monopole it is the overall dimension of the active elements, on dish antennas it is the diameter of the dish.

Feed point? Generally the point at which the coaxial cable attaches to the antenna but could be where the feed device attaches to the active elements

VSWR? Voltage Standing Wave Ratio. The measurement of the ratio of incident to reflected RF energy. An indication of the quality of energy transference. The lower the number the better. 1:1 is perfect. 2:1 is good ,3:1 is OK, 4:1 and up is poor to terrible.

Radiation Pattern? A pattern showing the relative signal level around an antenna. Signal strength can be severely reduced in particular directions by other antennas, vertical stabilizers, landing gears etc.

Balun? A device that converts a balanced transmission line (such as TV lead in) to a coaxial line which is an unbalanced line. Provides balanced currents on dipole antennas while matching the 50 ohm line to the nominally 150 ohm antenna.

Polarization? The plane in which RF energy is radiated. Normally either vertical, such as COM, or horizontal, such as VOR, or any angle in between, such as bent COM antennas. There is also circular polarization, which we will discuss along with GPS antennas.