The HTML version of this article is available at "**http://www.qsl.net/wa1ion/dipole/short_dipole.htm**".

Electrically-Short Dipole Antennas

Mark Connelly, WA1ION - 8 APR 2001

A dipole antenna normally is cut for approximately one half of a wavelength. The customary formula is (468 / F) feet or (142.65 / F) meters where F is the frequency in MHz. This works out to about 0.48 wavelength. The dipole antenna has seen little use at medium wave because of its impractically large dimensions: about 883 feet / 269 m at the low end of the broadcast band (530 kHz). Furthermore, for the antenna to perform well, it has to be a minimum of a quarter-wave above the ground if mounted horizontally. If set up vertically, its top end is a half wave (or greater) above ground and if sloped at 45 degrees, the top end is at least 0.35 wavelength high.

In a quest for a compact omni-directional passive antenna of reasonable dimensions, I did some measurements on vertical and sloping dipoles measuring only 33 ft. / 10 m total length (16.5 ft. / 5 m each side of the center feed point). This antenna is less than 0.02 wavelength at 530 kHz and 0.06 wavelength at 1700 kHz. Obviously, in this frequency range, such an antenna is a very poor match to direct 50 ohm feed.

The way to get a reasonable amount of signal capture out of such a compact antenna, without resorting to distortion and noise producing amplification, is through the use of passive devices to improve the match. A narrowband technique (a remotely adjustable inductive - capacitive (L-C) tank at the feed point) is ultimately the best approach in terms of efficiency, but it is difficult to implement and does not lend itself to frequency-agile DXing.

Matching with a broadband balun transformer is the other approach that can be used. The ratio to be used is fairly high because an electrically-short dipole presents a much higher impedance than 50 ohms. I did tests with two transformers: one had a 36:1 impedance ratio, the other a 16:1 ratio. The high impedance winding leads went to the antenna elements and the low impedance winding to the coaxial cable. I also had 9:1, 4:1, and 1:1 transformers available for testing if results indicated the 16:1 better than the 36:1 unit. This, however, was not necessary as the 36:1 transformer gave the better results across the medium wave dial. I set up a 10 m (total length) center-fed dipole in a nearly-vertical configuration suspended by a nylon rope over a high branch on a black locust tree in the backyard at my home location in Billerica, MA (GC =71.221 W / 42.533 N). The bottom of the antenna was about 1.5 m off the ground and the coaxial feed ran about 20 m from the balun box (at the middle of the antenna) into the house: I tried to keep the feedline close to a right angle to the dipole as much as possible. Daytime signal measurements on some groundwave locals were made using the Drake R8A in PREAMP ON mode. Across the band, the 36:1 transformer showed a 4 to 8 dB advantage over the 16:1.

Measurements with the 16:1 transformer (Mini-Circuits T16-6T-X65)
WEZE-590: S9+16
WRKO-680: S9+51
WEEI-850: S9+28
WBZ-1030: S9+27
WKOX-1200: S9+12
WWZN-1510: S9+35

Measurements with the 36:1 transformer (Mini-Circuits T36-1-X65)
WEZE-590: S9+20
WRKO-680: S9+55
WEEI-850: S9+36
WBZ-1030: S9+35
WKOX-1200: S9+20
WWZN-1510: S9+39

Homebrew transformers of various ratios may be tried in future experiments. One possible design is a 25:1 transformer consisting of a 40 turn high impedance winding on the opposite side of an FT-140-43 toroid from an 8 turn low impedance winding. The larger core than what's used in the Mini-Circuits models would tend to reduce the likelihood of harmonic and intermodulation distortion in strong-signal areas. With the Mini-Circuits transformers I used, I did notice a slight amount of WRKO-680 audio under WLYN-1360 (680 * 2). WRKO's 50 kW transmitter is about 5 km from my home location.

The short dipole picked up less local electrical noise (relative to desired signals) than an active whip. If a 1:1 isolation transformer is used at the "shack" end of the coaxial cable, noise can be reduced a bit more in some circumstances. A broadband loop (square loop at 3 m per side, coupled through 1:1 transformers on each end of the coaxial feedline) was still quieter than the dipole in terms of locally-produced TV / other electrical noise pick-up.

Signal levels produced by an efficiently-coupled short dipole are adequate for typical DXing. When more gain is needed, a good high-Q regenerative preselector amplifier will bring marginal signals up out of the mud.

The primary niche that the short dipole has is a very space-conserving antenna for small pieces of land. A broadband loop (as described above) can be located close to the dipole and the two antennas can be phased to produce a cardioid pattern. When more land is available, you can phase two vertical dipoles spaced at approximately 60 m on the desired peak-null axis.

Sloping the short dipole off true vertical only has a slight effect on directivity. An antenna of such small dimensions does not have much in the way of inherent nulls. If setting up two of these antennas about 60 m apart for phasing, it might help to slope one the opposite way of the other to make the antennas a little "more different". Setting the antenna up in a horizontal position probably does reduce the low angle pick-up some.

If a tree or other support much taller than 10 m is available, the dipole can be scaled up in size. With a 20 m antenna length, the transformer ratio can probably be lowered to something in the 4:1 to 12:1 range. As you approach a half wavelength, the required ratio goes down to 1:1. The closer the size of the antenna gets to resonance, the greater the sensitivity. Still I was quite surprised at how much signal can be obtained from an electrically short dipole when the correct matching transformer is used.