Dipole Length

A Bit of Theory

In general, the wavelength (λ), frequency (f), and speed (v) of a travelling wave are related by the three equivalent relations:

$$v = \lambda f \qquad \text{or} \qquad f = \frac{v}{\lambda} \qquad \text{or} \qquad \lambda = \frac{v}{f}$$

In ham radio, we often use the last equation to calculate the length of the legs of a dipole antenna:

- The speed of a radio wave travelling in free space is the speed of light:

$$v = 300000000 \text{ m/s}$$

- So using the last equation, if the frequency is in Hz, then the wavelength (in metres) is:

$$\lambda = \frac{300000000}{f}$$

- But if we measure the frequency in MHz, then the equation becomes:

$$\lambda = \frac{300}{f}$$

- Since each leg of a dipole is a quarter of the wavelength, each leg should measures $L = \frac{\lambda}{4}$:

$$L = \frac{75}{f} \text{ (in metres)} \qquad \text{or} \qquad L = \frac{246}{f} \text{ in feet}$$

- However, the speed of the electric field in a dipole is about 95% of the speed of light in freespace, so you'll often see these formulas instead:

$$L = \frac{71}{f} \text{ (in metres)} \qquad \text{or} \qquad L = \frac{234}{f} \text{ in feet}$$

Some Experimentation

The problem is that the velocity factor of 95% depends on many things like the size of the cable, the geometry of the antenna, what's around it, etc. So what we can do instead is use the first formula $v = \lambda f$ to measure what the actual speed is for our setup. Here's how I figured out how to cut my inverted V antenna be resonant at 5.3305 MHz.

- The first step is to build an antenna that's a bit too long (so I can trim it). For that, I used the original equation to get the length of each legs, and added a bit to tie the end points:

$$L = \frac{75}{f} = \frac{75}{5.3305} \approx 14.06 \text{ m}$$

- Next, I set up the antenna at its final install location.
- I use my SWR metre to find the frequency of lowest SWR. Mine was 4.98 MHz.
- Now I use that with the length to calculate the speed using the first formula:

$$v = \lambda f = 14.06 \times 4.98 = 70.0$$

- I can now re-calculate the length I need based on this empirical speed:

$$L = \frac{70.0}{5.3305} \approx 13.12 \text{ m}$$

- Finally, I simply trim each leg by:

$$14.06 \text{ m} - 13.12 \text{ m} = 0.94\text{m}$$

Other Considerations

A point that's not obvious is that while folding the end of the antenna on itself will shorten it, thus raising its resonant frequency, folding a metre is not the same as cutting a metre.

The 60m band has four 3 kHz channels and one 15 kHz band between 5.3305 MHz and 5.4065 MHz. Our club uses the lowest channel of 5.3305 MHz. I chose to cut my antenna there instead of the middle of the band because it'll be very easy to fold the ends a bit if I ever need to use it higher up in the band.