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Tuning a dipole antenna

LA1SSA

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(norwegian text)

I have set up a 20-meter dipole outside my house in the garden. The antenna is home-constructed from a 2,5 mm² (15 gauge) isolated line, fed with a RG-58 coax cable to a 1:1 balun i the center of the dipole.

I started with a 10-meter overall length, cut i two halves, not considering SWR nor resonance to begin with. Since the line is PCV-isolated, the only thing I knew about it was a reduction by at least 90-95 %. The dipole is to be used on the 20 meter band.

Measurements

The following table is constructed by measuring the antenna with an MFJ-259B antenna analyzer:

Frequency MHz	R	X	SWR
5,0	2,0	1,0	14,4
12,9	50,0	0,0	1,0
14,2	10,0	8,0	4,5
21,2	6,0	1,0	7,3
61,2	34,0	17,0	1,7

All measurements are at more or less random in increasing intervals, but in such a manner that I keep the measurements "inside" amateur bands. The first thing I note is a pure resistance of 50 ohm at 12.9 MHz.

A rule of thumb formula for SWR is to divide the magnitude of Z with the antenna impedance of 50 Ω. Consequently, for 14.2 MHz it should be appr. ($\sqrt{}$ $(10^2+ 8^2)/50$ which yields an SWR at about 1:4.5. The real SWR formula is based on transmitted and reflected power in Watts.

Remember that an impedance actually is a complex number, including both the antenna's R and X values, where X is the inductive or capacitive component. In other words, an antenna might very well have an impedance of Z= 50 Ω without being pure resistive!

The reactive component (X) doesn't produce radio waves!

To compute the Z, we use the traditional formula: $\mathbf{Z} = \sqrt{\mathbf{R}^2 + \mathbf{X}^2}$ where X is either postive or negative if the antenna is accordlingly reactive or capacitive in total. X raised to X^2 will always be a positive number anyway.

This Z formula will show Z as a magnitude, and that is |Z|. The phase of the Z value is computed as the ArcTan of X/R where we also include X with its sign, plus or minus. You can compare this in a Smith diagram.

As the above table shows, both the resistive and reactive parts are spreading out quite a lot. But at 12.9 MHz, the antenna is in perfectly resonant with R = 50 ohm and X = 0. This is very close to 14.22 MHz that is the centre of the 20-meter band. Hence a 2x10 meter dipole is obviously already a good start!

Where is X = 0 ?

My next move is to find which frequencies where X is 0, regardless of what R might be for a zero-value X.

Further measurements give this table:

X=0	
Frequency MHz	**R**
13,0	50,0
14,1	11,0
29,8	6,0
38,1	14,0
43,1	294,0

47,2	9,0
51,8	245,0
62,6	118,0
113,0	16,0
117,8	200,0

If one should work on 118 MHz (actually 117.8 MHz) with this dipole, for example, the balun had to be a 4:1 balun instead of a 1:1 balun. A 4:1 balun would transform the impedance from 200 Ω to 50 Ω. In coarse features from the first table above, the antenna has a 1:4.5 SWR at the actual frequency of 14.2 MHz.

Tuning the antenna

A quick and easy way to tune the antenna length (shorten or lengthen it) goes like this:

1. Find the frequency where SWR is at it lowest value, most often this is close to its resonance. In the first table above, it's at the the frequency of approx. 13 MHz (SWR = 1).
2. Divide the frequency from point 1) with the actual frequency you are aiming at.
   In my case it will be $\frac{13}{14,2} \approx 0,915$
3. Multiply 0.915 with the physical length (0.915 * 10 meters) which gives 85 cm (≈33.5") in total, that is appox. 42 cm (≈17") for each leg of the dipole. **Let the antenna tuner tune the rest!** (I don't want to work in millimeters here...)

The result

Now, after cutting off 42 cm (17") from each leg, I make another measurement with my MFJ-259B analyzer:

> It shows a neat Z = 48 + j4 Ω, with an SWR of less than 1:1.1 **without** an antenna tuner (that's why I say "Let the tuner fix the rest"..)

You can also tune your antenna to a good result without an MFJ-259B analyzer, by reading the SWR at random intervals near resonance of your desired band.

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