Do Non-Resonant Antennas Work?

By Wayne Estes, W9AE
Ham transmitters have a 50 Ohm impedance.

Performance is best when antenna impedance matches the transmitter impedance:

- Transmitter produces maximum power
- Feed line has minimum loss
- Antenna radiates maximum power!
• *Half wave dipole* and *quarter wave vertical* antennas have an impedance close to 50 Ohms at their resonant frequency. Great!

• Impedance is only near 50 Ohms for a narrow range of frequencies.

• Antenna impedance varies wildly at frequencies far from the resonant frequency.
Feed Point Impedance of 66 Foot Long Center Fed Dipole with Apex at 50 Feet

<table>
<thead>
<tr>
<th>FREQUENCY MHz</th>
<th>RESISTANCE Ohms</th>
<th>REACTANCE Ohms</th>
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<tbody>
<tr>
<td>3.8</td>
<td>10</td>
<td>879</td>
</tr>
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<td>7</td>
<td>65</td>
<td>40</td>
</tr>
<tr>
<td>14</td>
<td>5287</td>
<td>1310</td>
</tr>
<tr>
<td>21</td>
<td>103</td>
<td>181</td>
</tr>
<tr>
<td>28</td>
<td>3089</td>
<td>774</td>
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</tbody>
</table>
• The transmitter doesn’t work when connected to a wildly mismatched antenna.

• Many hams use an antenna tuner to make the transmitter happy.

How well does that work? Let’s find out...
The following 6 diagrams show power losses when transmitting at 14 MHz to a dipole that is resonant at 7 MHz (antenna 2X too long)
Open Wire Line with Balanced Tuner

- 1325 Watts out
- 97 Watts
- 1500 Watts in
- 78 Watts

40 Meter Half-Wave Dipole

100' #12 Open-Wire Line

Balanced Tuner

RG-213 Coax

Transceiver/Amplifier
Open Wire Line w/ Unbalanced Tuner

40 Meter Half-Wave Dipole

100' #12 Open-Wire Line

1500 Watts in

97 Watts

90 Watts

1314 Watts out

RG-213 Coax

Transceiver/Amplifier
Window Line w/ Balanced Tuner

1500 Watts in

475 Watts

959 Watts out

66 Watts

1500 Watts in
Coax w/ Tuner at Transmitter

1500 Watts in

6 Watts

1322 Watts

122 Watts out

48 Watts

100' RG-213

40 Meter Half-Wave Dipole

Choke Balun

Antenna Tuner

RG-213 Coax

Transceiver/Amplifier
Coax w/ Tuner at Antenna

40 Meter Half-Wave Dipole

1160 Watts out

92 Watts

Auto Tuner

248 Watts

100' RG-213

1500 Watts in

RG-213 Coax

Transceiver/Amplifier
G5RV Configuration

40 Meter Half-Wave Dipole

100' Window Line

156 Watts

Choke Balun

20' RG-213

Antenna Tuner

397 Watts out

157 Watts

696 Watts

1500 Watts in

Coax

Transceiver/Amplifier
Antenna Too Short: 3.8 MHz to 7 MHz Dipole

1500 Watts in

1089 Watts

144 Watts

267 Watts out

1500 Watts in
OCF (off-center-fed) Dipole

- Resonant at even multiples of fundamental:
  3.5 MHz, 7 MHz, 14/17 MHz, 24/28 MHz

- Low SWR. Coax loss is minimal on resonant bands.

- 21% of power is lost in the balun. It can melt!

- Coax loss and balun loss are very bad on the non-resonant bands (10 and 21 MHz). Don’t do it!
Random Wire With Tuner

• Efficiency is good because there is no feed line with high SWR.
• RF feedback/overload is possible.
• Good RF ground can mitigate RF feedback.
• Remote auto tuner is preferable to get more power in the air and less power in the shack.
• High power will exceed RF exposure limits when tuner is in the shack.
Conclusion

• Resonant antennas (impedance near 50 Ohms) have minimum feed line loss and no tuner loss.

• Non-resonant antennas require a tuner and have power loss in the tuner, feed line, and balun.

• Balanced feed line has less loss than coax cable.

• Tuner at antenna is better than tuner at radio.

• Feed line and balun can melt when running high power to a non-resonant antenna.
Why a Balun is Needed on a Dipole

• With no balun at the feed point of a dipole, common mode current causes the feed line to become part of the antenna.

• A balun is a common mode choke which blocks common mode current on the coax.

• Differential mode current passes through the balun and radiates from the antenna.
If You Don’t Use a Balun

• SWR varies with coax length, usually higher.
• Coax cable picks up noise, degrading reception.
• Radiation from the coax may cause interference to other devices in your house.
• Less power is radiated from the antenna, where it does the most good.
When to Use an Antenna Tuner

Antenna tuners are great to correct *minor* antenna impedance mismatch. Losses are minimal and it enables your transmitter to safely run full power.

When tuning a *big* impedance mismatch much of the power heats the feed line, balun, and tuner instead of radiating from the antenna.
Do Non-Resonant Antennas Work?

• Yes if you use a *balanced* feed line and tuner.
• Yes if you use coax with a tuner at the *antenna*.
• Yes* if you use a tuner with a random wire.
• Poor with a G5RV configuration.
• Very poor if you use coax with a tuner at the *transmitter*. 
Where the Numbers Come From

The power loss analysis in this presentation was done by N6BV using PC software called TLW (Transmission Line for Windows).

This transmission line modeling software is included on a CD with the ARRL Antenna Book. The CD also includes a version of the famous antenna modeling program EZNEC.