The 'Tenna Dipper: A "Poor Man's" Antenna Analyzer

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AE5PH
Introduction

• Who am I?
• What is antenna tuning?
• What is antenna analysis?
• The minimalist approach
• History of the 'Tenna Dipper
• My spin on a homebrew 'Tenna Dipper
• Using the 'Tenna Dipper to tune an antenna
• Using the 'Tenna Dipper to analyze an antenna
• Comparison Testing: 'Tenna Dipper vs miniVNA Pro
• Questions?
Who Am I?

- Kansas State University: BSEE '79, MSEE '81 (Digital signal processing and instrumentation)
- Motorola GED, Chandler AZ: '81 - '88
- Sunair Electronics, Ft. Lauderdale FL: '88 - '92 (Adaptive Link Establishment modem)
- '92 - Present: E-Systems/Raytheon IIS, Garland TX
- Technician and General Class: '09 - KF5DAF
- Amateur Extra: '10 – AE5PH
- Interests: SDR, home brewing, EMCOMM
What Is Antenna Tuning?

• Adjusting an antenna such that it is near or at resonance for a desired range of frequencies
• Adjusting an antenna such that it has nearly the same impedance of a connected radio for a desired range of frequencies
• Adjusting a transmatch to compensate for the impedance mismatch between an antenna and a radio for a desired range of frequencies
Using a Radio and SWR Meter Can Be Problematic

- Many radios and transmatches do not have built-in SWR meters (especially true for home brew radios)
- Good SWR meters can be expensive and fragile, either electrically, mechanically, or both
- Using a radio to tune the antenna may damage the radio, the SWR meter, or both
- An SWR meter is one more piece of radio gear to hook up (and transport, if in the field)
What Is Antenna Analysis?

- Determining the impedance of an antenna over a range of frequencies
- Determining the Voltage Standing Wave Ratio (VSWR) of an antenna over a range of frequencies
- Determining the resonant frequency (or frequencies) of an antenna
- Determining the gain pattern of an antenna
Using an Antenna Analyzer Can Be Problematic

- They can be expensive (good ones are very expensive) - $99 to $$$$$
- Many antenna analyzers must be calibrated in order to produce reliable, realistic results
- The operator must use the antenna analyzer properly to obtain reliable, realistic results
- Improper use of an antenna analyzer can damage it, resulting in an expensive repair bill (or the purchase of a new analyzer, ouch!)
The Minimalist Approach

• Antenna tuning: Determine that an antenna or transmatch are adjusted such that the radio is not likely to be damaged during transmission for a desired range of frequencies

• Antenna analysis: Determine the range of frequencies that an antenna is unlikely to cause damage to the radio during transmission

• These similar goals can be accomplished with one, relatively simple and (potentially) inexpensive piece of test equipment: A Resistive SWR Bridge
A Resistive SWR Bridge

- A Wheatstone bridge with the antenna as the unknown resistance $Z_x$ (blue circuitry)
- The green circuitry measures the forward voltage
- The yellow circuitry measures the reflected voltage
- The red circuitry measures the bridge imbalance, hence the ratio between $Z_x$ and 50Ω
- Only the red circuitry is required if only an indication of imbalance is needed
History Of The 'Tenna Dipper

• Created by Steve "Melt Solder" Weber, KD1JV
• A digital VCO (74HC46) drives an antenna resistance bridge (Harmonics? You betcha!)
• Four frequency bands are set by four trimmer pots forming a tapped voltage ladder, with another trimmer pot used for fine adjustments
• Two 2N3904 transistors, arranged as a Darlington pair, drive an LED to indicate the amount of antenna mismatch
• Provides a tap for your frequency meter
• Fits in an Altoids® tin with a 9V battery!
4SQRP 'Tenna Dipper Kit

- Commercialized version of the 'Tenna Dipper formerly sold by the Four State QRP Group
- Added a modified version of the Arizona ScQRPions Stinger frequency counter chip, which reports the frequency measured in Morse code at 27 WPM
- Isolates VCO and frequency counter from bridge via a logic gate
- Still fits in an Altoids® tin (if you trim the PCB) with a 9V battery
Hendricks Deluxe 'Tenna Dipper Kit

- Currently sold as a kit by Hendricks QRP Kits for $75 (Is there value for this cost?)
- Provides frequency counter with a four-character LED, with two frequency scales
- Two MPS5179 RF transistors to improve detector performance at higher frequencies
- One, single turn pot to set frequency in two bands
- Kit includes components, PCB, decals, and an unfinished case
- Yahoo group provides support
My Spin On a Homebrew 'Tenna Dipper

• PIC micro-based LED frequency counter designed by Wolfgang "Wolf" Büscher, DL4YHF

• Diode separates bridge from VCO and frequency counter to avoid signal reflection interference

• Still uses two MPS5179 RF transistors, after some enlightening experimentation

• Ten-turn pot to improve frequency selectivity

• Created single-sided PCB using Eagle CAD

• Discovered frequency sensitivity issues - VCO, transistors, bridge transformer?

Homebrewing is a learning experience!
Completed AE5PH 'Tenna Dipper
Power Output Frequency Sensitivity

Possible causes of power loss are VCO duty cycle reduction, transistor gain frequency roll-off, or frequency sensitivity in the bridge transformer – Hendricks QRP Deluxe 'Tenna Dipper probably has this problem too!
Using the 'Tenna Dipper to Tune an Antenna

- Select the frequency band and adjust the pot to display the desired frequency
- Adjust the antenna until the LED brightness "dips" to a minimum, or ...
- Adjust the transmatch until the LED brightness "dips" to a minimum
- Adjust the pot and watch the brightness of the LED and the frequency counter value to estimate the match frequency range
- Multiple LED "dips" may be due to VCO harmonics
Using the 'Tenna Dipper to Analyze an Antenna

• Switch between bands and adjust the pot until the LED brightness "dips" to a minimum

• The frequency counter displays a local maximum resonance point

• Adjust the pot and watch the LED brightness and the frequency counter to get a sense of the range of locally maximal resonance

• Perform this task over the frequencies of interest, as there may be multiple resonance points

• Multiple LED "dips" may be due to VCO harmonics
Comparison Testing

• How does the 'Tenna Dipper compare to a real antenna analyzer?

• The mini Radio Solutions miniVNA Pro is a PC-based Vector Network Analyzer (VNA)

• It will be used to provide “truth” measurements for a test antenna

• Provided by Doug Knabe KN5DK
Testing at QTH of Doug KN5DK
Subject: Homebrew Buddipole

- A Buddipole is a “walking portable”, loaded dipole developed by Budd Drummond W3FF
- Band selection (20, 17, 15, 12, or 10 meters) through selection of loading coils
- Tuning done by adjusting the length of the whips
Buddipole Setup

• Buddipole configured with 20-meter coils
• Black whip - Fully extend all five sections
• Red whip - Fully extend the inner four sections and extend the outer, fifth section by 3½ inches
• Raise Buddipole to sixteen feet above the ground
• Goal: Operate at 14.180 MHz with an SWR < 2:1
Reflection Measurement
Single Frequency Measurement

**Frequency:** 14.180 MHz
**SWR:** 16:1
**Impedance:** |Z| = 36.0 ohm
Smith Chart Measurement

14.180 MHz
'Tenna Dipper Results

• LED dimmed, but did not fully extinguish, at about 14.15 MHz
• This is the frequency at which the complex impedance vector is closest to 50 Ohms
• Errors in the 'Tenna Dipper's frequency counter are not taken into account
• Bench testing indicated that frequency counter may be have about ±10 KHz error
# 'Tenna Dipper Tuning Table

<table>
<thead>
<tr>
<th>Red Aerial Whip Sections*</th>
<th>Frequency where LED is Dimmest</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 Sections + 6.5” of Section 5</td>
<td>14.00 MHz</td>
</tr>
<tr>
<td>4 Sections + 6.0” of Section 5</td>
<td>14.02 MHz</td>
</tr>
<tr>
<td>4 Sections + 5.5” of Section 5</td>
<td>14.05 MHz</td>
</tr>
<tr>
<td>4 Sections + 5.0” of Section 5</td>
<td>14.07 MHz</td>
</tr>
<tr>
<td>4 Sections + 4.5” of Section 5</td>
<td>14.10 MHz</td>
</tr>
<tr>
<td>4 Sections + 4.0” of Section 5</td>
<td>14.12 MHz</td>
</tr>
<tr>
<td>4 Sections + 3.5” of Section 5</td>
<td>14.15 MHz</td>
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<tr>
<td>4 Sections + 3.0” of Section 5</td>
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<td>14.19 MHz</td>
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<tr>
<td>4 Sections + 2.0” of Section 5</td>
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</tr>
<tr>
<td>4 Sections + 1.5” of Section 5</td>
<td>14.23 MHz</td>
</tr>
<tr>
<td>4 Sections + 1.0” of Section 5</td>
<td>14.25 MHz</td>
</tr>
<tr>
<td>4 Sections + 0.5” of Section 5</td>
<td>14.28 MHz</td>
</tr>
</tbody>
</table>

*Black aerial always has all five sections of whip fully extended
Questions?

Thanks and 73, Mac / AE5PH

...and a big thanks to Doug Knabe KN5DK for his hospitality and support during testing!
Back-up Slides
Smith Chart Measurement

14.180 MHz