Antennas: 
*Hints and Kinks*

North Fulton Amateur Radio League
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Questions and Discussion Welcome!
What’s the MOST Important Component in your Shack?

Your ANTENNA!!!
How did this thing we call an Antenna come about?

Let’s go back in time and find the answer.
Electricity is Magnetic!

_in 1831_

Michael Faraday (English) and Joseph Henry (American) discovered that a moving magnet produces an electric current in a nearby wire!
Electricity is *Magnetic*!

These two fellows discovered the basis for the electrification of the entire world!

Joseph Henry (1797-1878)
Michael Faraday (1791-1867)
Electricity is Magnetic!

33 years later James Clerk Maxwell, a Scottish theoretical physicist and mathematician postulated that Electric and Magnetic fields produce electromagnetic waves that include radio, x-rays and light!
Maxwell’s Equations (Simplified!) (by Oliver Heaviside)

\[ \nabla \cdot \mathbf{D} = \rho \]  
\[ \nabla \cdot \mathbf{B} = 0 \]  
\[ \nabla \times \mathbf{E} = -\frac{\partial \mathbf{B}}{\partial t} \]  
\[ \nabla \times \mathbf{H} = \frac{\partial \mathbf{D}}{\partial t} + \mathbf{J} \]

1. Gauss’ Law
2. Gauss’ Law for magnetism
3. Faraday’s Law
4. Ampère-Maxwell Law

Electric and Magnetic Fields Propagate thru Space
EM Wave Propagation 'Model'
Electricity is Magnetic!

And then in 1888 Heinrich Hertz
...based on the work of Faraday, Henry and Maxwell...
constructed a Radio transmitter and receiver and proved that electromagnetic waves exist!
Electricity is *Magnetic*!

*Heinrich Hertz Transmitter and Receiver*
The Basic Dipole

Current vs. Voltage

Impedance Follows Ohm’s Law: \( Z = \frac{E}{I} \)

e.g. 100W at 50 ohms, \( Z = \frac{70.7V}{1.41A} \)
Impedance of Half-Wave Dipole Over “Ground”

- **Perfect Ground**: 72 Ohms!
- **Real Ground**: Radiation Resistance in Ohms
- **Horizontal Half-Wave**: 50 Ohms?
- **Vertical Half-Wave**: Real Ground
- **Perfect Ground**: Radiation Resistance in Ohms
Demystifying Antenna Gain

- Isotropic Antenna in Free Space
  Gain = 0 dBi

- Dipole Antenna in Free Space
  Gain = 2.15 dBi

- Dipole Antenna Over Ave. Ground
  ½ WL High
  Gain = 7.2 dBi
Height Matters!
For Horizontal Antennas

Total Field

* Primary
40M Dipole 65 Ft EL
40M Dipole 50 Ft EL
40M Dipole 35 Ft EL

7.21 dBi Max Gain

7.15 MHz
Height Matters!
For Horizontal Antennas

Total Field
* Primary
40M Dipole 65 Ft AZ
40M Dipole 50 Ft AZ
40M Dipole 36 Ft AZ

7.21 dBi Max Gain
7.15 MHz
How About Horizontal vs. Vertical Antennas on 40M?

Total Field

* Primary
40M Dipole 65 Ft EL
40M Vertical 65 Ft EL

7.21 dBi Max Gain

7.15 MHz
How About Horizontal vs. Vertical Antennas on 80M?

6.53 dBi Max Gain
No Antenna is Perfect...

But, how about one that you can:

- Build in About One Hour
- Use on 40 and 15M without a Tuner
- Use on 30, 20, 17, 12 and 10M with a Modest Tuner (with some coax loss)
- Work DX and Local Stations
- Fit in as little as 44 Feet of Space
- Build and Install for Less than $20 Including Coax Feed Line!!
40-15M Dipole

66 feet 6 inches long with 100 feet of 75 ohm coax #14 Insulated Wire

40’ High

Club 40/15M Dipole
40-15M Dipole

15M SWR

40 M Club Dipole
40-15M Inverted “V”

- 67 feet long with 100 feet of 75 ohm coax
- #14 Insulated Wire
- 40’ High at Apex

Club 40/15M Inverted V
40-15M Inverted “V”

40M SWR

Freq MHz

7

7.3

Club 40/15M Inverted V
40-15M Inverted “V”

15M SWR

Club 40/15M Inverted V
40-15M Attic “Z”

68 feet 8 inch total length with 100 feet of 75 ohm coax

#14 Insulated Wire

25’ High

Club 40/15M Attic Z
40-15M Attic “Z”

40M SWR

Club 40/15M Attic Z
40-15M Attic “Z”

15M SWR

Freq MHz

21 21.46

SWR

1.5 2 3 10 11

INF
Materials

- Wire – 70 feet for $10
- Insulators – Home Brew for $1
- Coax – 100 feet for $20
- Coax Connector – 1 for $3
How About Loop Antennas?
How Well do they Work?

“I call them Miracle Workers!”
No Antenna is Perfect...

But, how about one that you can:

- Build in About Two Hours
- Use on 40, 20, 15 and 10M without a Tuner
- Use on 30, 17 and 12M with a Good Tuner
- Work DX and Local Stations
- Fit in 60 Feet of Space Between Supports
- Buy for Less than $70 Including Feed Line!!
- Add a 4:1 Balun for $50
Side-Fed Inverted Delta Loop

- 300 ohm window line
- 58, 87, 116 ft.
- Short 50 ohm coax
- 4:1 Balun
- #14 Insulated Wire
- 54 Ft.
- 30.5 Ft.
- 42.5 Ft.
- 12 Ft.
- 60’ High at Top
Resonant on 40, 20, 15 and 10M
Plus 30, 17 and 12M with a Good Tuner
Takeoff Angles Good for DX and Local Contacts

5.58 dBi Max Gain
Materials

DX Engineering
160M Dipole Kit
$69.95

Balun Designs
4:1 300 Watt Balun
$49.95
No Antenna is Perfect...

But, how about one that you can:

- Build in About Three Hours
- Use on 80, 40, 20, 17, 15, 12 and 10M with an SWR under 3:1...most under 2:1
- Use on 30 with a Modest Tuner
- Excellent DX on 40M and above
- Low Transmission Line and Balun Losses
- Buy for Less than $80 Including Feed Line!!
- Add a 4:1 Balun for $50 (300 Watt or less)
Horizontal Loop Skywire

de Dave Fisher, W0HMS

#14 Insulated Wire

68.5 Ft.  68.5 Ft.  68.5 Ft.

22.5 Ft.  46.0 Ft.

300 ohm window line 100 ft.

Short 50 ohm coax

4:1 Balun

60 Ft. High
Under 3:1 SWR on All Bands Except 60 and 30M
80M - High Takeoff Angle & Mod. Gain (4.2 dBi)
Circular Pattern

Elevation Plot
- Bearing: 90.0 deg.
- Outer Ring: 4.15 dBi
- 3D Max Gain: 4.15 dBi
- Slice Max Gain: 4.15 dBi @ Elev Angle = 90.0 deg.
- Beamwidth: 97.2 deg.; -3dB @ 40.8, 138.0 deg.
- Sidelobe Gain: < -100 dB
- Front/Sidelobe: > 100 dB

Circular Pattern

Azimuth Plot
- Elevation Angle: 90.0 deg.
- Outer Ring: 4.15 dBi
- 3D Max Gain: 4.15 dBi
- Slice Max Gain: 4.15 dBi @ Bearing = 90.0 deg.
- Front/Side: 0.0 dB
- Beamwidth: ?
- Sidelobe Gain: < -100 dB
- Front/Sidelobe: > 100 dB

Max Gain: 5.58 dBi
40M – Med. Takeoff Angle & Good Gain (6.1 dBi)
Nearly Circular Pattern

Freq: 7.2 MHz

Total Field

Elevation Plot

Bearing: 255.0 deg.
Outer Ring: 6.06 dBi
3D Max Gain: 6.06 dBi
Slice Max Gain: 6.06 dBi @ Elev Angle = 35.0 deg.
Beamwidth: 36.8 deg.; -3dB @ 15.9, 52.7 deg.
Sidelobe Gain: 5.1 dBi @ Elev Angle = 150.0 deg.
Front/Sidelobe: 0.96 dB

Cursor Elev: 35.0 deg.
Gain: 6.06 dBi
0 dBmax
0.0 dBmax3D

Azimuth Plot

Elevation Angle: 35.0 deg.
Outer Ring: 6.06 dBi
3D Max Gain: 6.06 dBi
Slice Max Gain: 6.06 dBi @ Bearing = 255.0 deg.
Front/Back: 1.11 dB
Beamwidth: 71.7 deg.; -3dB @ 223.1, 294.8 deg.
Sidelobe Gain: 5.67 dBi @ Bearing = 345.0 deg.
Front/Sidelobe: 0.39 dB
20M - Low Takeoff Angle & High Gain (9.99 dBi)
Moderately Sharp Lobes and Nulls

Azimuth Plot
Elevation Angle 15.0 deg.
Outer Ring 9.99 dBi
Gain 9.99 dBi
3dB @ 155.7, 171.7 deg.
Slice Max Gain 9.99 dBi @ Elevation Angle = 165.0 deg.
Front/Back 0.9 dB
Beamwidth 16.0 deg.; -3dB @ 155.7, 171.7 deg.
Sidelobe Gain 9.09 dBi @ Elevation Angle = 15.0 deg.
Cursor Bear 30.0 deg.
Gain 9.09 dBi
3dB @ 195.9, 222.9 deg.
Slice Max Gain 9.99 dBi @ Bearing = 210.0 deg.
Front/Back 0.9 dB
Beamwidth 27.0 deg.; -3dB @ 195.9, 222.9 deg.
Sidelobe Gain 9.53 dBi @ Bearing = 120.0 deg.
Front/Sidelobe 0.46 dB

Elevation Plot
Bearings 30.0 deg.
Outer Ring 9.99 dBi
Gain 9.99 dBi
3dB @ Elevation Angle = 165.0 deg.
Slice Max Gain 9.99 dBi @ Elevation Angle = 165.0 deg.
Beamwidth 16.0 deg.; -3dB @ 155.7, 171.7 deg.
Sidelobe Gain 9.09 dBi @ Elevation Angle = 15.0 deg.
Front/Sidelobe 0.9 dB

Cursor Elev 165.0 deg.
0.0 dEmax
0.0 dEmax3D

14.2 MHz
15M - Low Takeoff Angle & High Gain (13.7 dBi)
Sharp Lobes and Nulls
Materials

DX Engineering 160M Dipole Kit - $69.95
Plus 4 corner insulators and 20 feet more wire.

Balun Designs
4:1 300 Watt Balun
$49.95
Has Anyone Tried a “Coupled Resonator” Antenna?

What are they Good for

How Well do they Work?
A “Fan” Dipole Offers Multiband Operation But Can Be Tricky To Tune
40-15M Dipole

66 feet 6 inches long with 100 feet of 75 ohm coax

Club 40/15M Dipole
Coupled Resonator Dipoles for 40, 30 and 15 Meters

~67'
~46'
40-15M
30M
V1
T1

#14 Insulated Wire

65’ High

3.5” Spacing not to scale
Coupled Resonator Dipoles for 40, 30 and 15 Meters
Coupled Resonator Dipoles for 40, 30, 20 and 15 Meters

#14 Insulated Wire

3.5” and 2.5” spacing not to scale
Coupled Resonator Dipoles for 40, 30, 20 and 15 Meters

Freq  14.2 MHz
SWR   1.25
Z     40.77 at 4.89 deg
      40.72 at 3.476 ohms
Ref Cond 0.1013 at -157.37 deg
        -0.1019 - j0.04228
Ret Loss 19.1 dB
Coupled Resonator Verticals for 80 Meters – Easy Addition to 80M Vertical

Wire 1 ~ 67’
Wire 2 ~ 59’
Spacing = 3.5”

#14 Insulated Wire
Coupled Resonator Verticals for 80 Meters – Covers The Entire Band!

80M SWL < 2:1 Across Entire Band
Hints and Kinks Summary

Height Matters
• Affects impedance and wire length
• Affects gain and take-off angle

Gain Matters
• Every 3 dB of gain double your power

Loops Rule!
• Multiple bands with a single wire
• Increased gain on higher bands

Coupled Resonators
• Additional bands or greater bandwidth

Modeling
• Saves time, material and money $$$
• Gets you on the air with a better antenna
Questions Please?
Thanks for Your Attention and Participation!

The End
No Antenna is Perfect...

But, how about one that you can:

- Can be home-brewed or purchased
- Use on 20, 17, 15, 12 and 10M with an SWR under 1.5:1 plus 6M option
- Excellent DX and U.S. Antenna
- Small footprint and very good gain
- Build for Less than $400; buy for < $500.
Broadband Hex Beam
de Steve Hunt, G3TXQ
20M - Low Takeoff Angle & High Gain (10.2 dBi)
Broad Lobes and Good Side/Back Reject.
15M - Dual Takeoff Angles & High Gain (10.2 dBi) Broad Lobe and Good Side/Back Reject.

- Dual Takeoff Angles & High Gain (10.2 dBi)
- Broad Lobe and Good Side/Back Reject.

21.2 MHz

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
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<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elevation Plot</td>
<td>0.0 deg.</td>
<td>Cursor Elev</td>
<td>15.0 deg.</td>
</tr>
<tr>
<td>Bearing</td>
<td>0.0 deg.</td>
<td>Gain</td>
<td>10.15 dBi</td>
</tr>
<tr>
<td>Outer Ring</td>
<td>10.15 dBi</td>
<td>0.0 dBmax</td>
<td>0.0 dBmax3D</td>
</tr>
<tr>
<td>3D Max Gain</td>
<td>10.15 dBi</td>
<td>Slice Max Gain</td>
<td>10.15 dBi @ Elev Angle = 15.0 deg.</td>
</tr>
<tr>
<td>Beamwidth</td>
<td>14.8 deg.; -3dB @ 8.0, 22.8 deg.</td>
<td>Slice Max Gain</td>
<td>10.15 dBi @ Bearing = 0.0 deg.</td>
</tr>
<tr>
<td>Sidelobe Gain</td>
<td>8.1 dB @ Elev Angle = 50.0 deg.</td>
<td>Beamwidth</td>
<td>94.0 deg.; -3dB @ 313.0, 47.0 deg.</td>
</tr>
<tr>
<td>Front/Sidelobe</td>
<td>2.05 dB</td>
<td>Front/Back</td>
<td>16.25 dB</td>
</tr>
<tr>
<td>3D Max Gain</td>
<td>10.15 dBi</td>
<td>0.0 dBmax</td>
<td>0.0 dBmax3D</td>
</tr>
<tr>
<td>Sidelobe Gain</td>
<td>-6.0 dB @ Bearing = 215.0 deg.</td>
<td>Front/Sidelobe</td>
<td>16.15 dB</td>
</tr>
</tbody>
</table>
10M - Dual Takeoff Angles & High Gain (10.3 dBi)
Broad Lobe and Good Side/Back Reject.