The American Radio Relay League
Headquarters, Newington, CT

A Comparative Look at Multiband Antennas

Ham Con
THE VERMONT HAM RADIO CONVENTION

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Joel R. Hallas, W1ZR
Technical Editor, QST
ARRL
What do I Mean by Multiband Antennas?

♦ Antennas that *efficiently* accept power on more than one band.

♦ Antennas that *radiate* power in useful directions on more than one amateur band.
What Are The Flavors of Multiband Antennas?

♦ Antennas with *multiple resonances* that can be operated on multiple discrete ranges including more than one amateur band.

♦ **Wideband** antennas that cover a wide frequency range including more than one band.
Antennas with Multiple Resonances

- Fortuitous resonance antennas — 40/15 dipole, G5RV, ГØFAH, W3DZZ
- Multiple resonator antennas; parallel, trap dipoles
- Sleeve coupled dipoles
- Non-resonant tuned-feeder dipoles
- Adjustable length single-band dipoles
- Off-center fed dipoles — Windom
Single Band Horizontal Dipole Antenna

Let’s start with a horizontal wire center fed dipole as a point of comparison. We’ll use 40 meters as an example with an antenna 40 feet above ground.
40 Meter (40 feet) Dipole Summary

SWR at 88 Ω: 1.5:1 across band
Max gain: 5.87 dBi @ 50° elevation
Gain: @ 30° elevation; 4.64 dBi
Beamwidth @ 30° elevation; 90°
20 Meter Dipole Summary (40 feet)
SWR at 50 Ω: 1.5:1 across band
Max gain: 7.78 dBi @ 24° elevation
Beamwidth @ 24° elevation; 83°
Horizontal Wire Center Fed Dipole - Summary

Horizontal wire center fed dipole - plusses

*Predictable, reasonable performance, low cost*

Horizontal wire center fed dipole – minuses

*Takes a big yard and many supports to cover multiple bands*

*Not low cost for 80+60+40+30+20+17+15+12+10 meters!*
Multiple Resonators — Perpendicular Parallel Dipoles On 40 And 20 Meters

Electrical $\lambda/2$ at 40 meters

Electrical $1/2\lambda$ at 20 meters

$90^\circ$
Multiple Resonators — Perpendicular Parallel Dipoles On 40 And 20 Meters

40 Meter 50 Ω SWR

20 Meter 50 Ω SWR
Multiple Resonators — Close Parallel Dipoles On 40 And 20 Meters

Electrical $\lambda/2$ at 40 meters

Electrical $1/2 \lambda$ at 20 meters
Multiple Resonators — Close Parallel Dipoles On 40 And 20 Meters

40 Meter 50 Ω SWR
40 Meter (40 feet) Dipole Summary
SWR at 50 Ω: 1.9:1 across band
Max gain: 6.53 dBi @ 50° elevation
Gain: @ 30° elevation; 5.3 dBi
Beamwidth @ 30° elevation; 90°

20 Meter 50 Ω SWR
20 Meter Dipole Summary
SWR at 50 Ω: 2.5:1 across band
Max gain: 7.54 dBi @ 24° elevation
Beamwidth @ 24° elevation; 96°
Parallel Dipole Summary

Parallel dipole - plusses

Reasonable performance, low cost

Parallel dipole - minuses

Perpendicular dipoles work well – hard to get more than three
  Two work very well as guy wires in inverted V config

Close spaced dipoles interact, are touchy, have reduced bandwidth
Folded Skeleton Sleeve Two Band Dipole

Dimensions shown worked with window line marked:
JSC WIRE & CABLE #1317 18 AWG 19 STRAND MADE IN USA
Other types should work, but the dimensions will be different.
Folded Skeleton Sleeve Two Band Dipole

Height 25 feet, X, measured at 45 feet of RG-8X
Multiple Resonances Using Parallel Resonant Traps

- Electrical $\lambda/2$ at 40 meters
- Electrical $\lambda/2$ at 20 meters

Parallel resonant trap
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Multiple Resonances Using Parallel Resonant Traps

Note “free” W3DZZ type response on 10 meters (5:1 SWR)
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Multiple resonances using parallel resonant traps

5.47 dBi compared to 5.87 dBi

7.25 dBi compared to 7.78 dBi
Multiple resonances using parallel resonant traps

40 Meter 75 Ω SWR

20 Meter 75 Ω SWR
Multiple Fortuitous Resonances — The 40 Meter Dipole On 15

Electrical $\lambda/2$ at 40 meters

Electrical $3/2 \lambda$ at 15 meters
Multiple Fortuitous Resonances — The 40 Meter Dipole On 15

SWR of 40 meter dipole on 40

SWR of 40 meter dipole on 15
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**Multiple Fortuitous Resonances — The 40 Meter Dipole On 15**

40 Meter dipole lengthened to resonate on 15 meters

50 Ω SWR of lengthened 40 meter dipole on 15  
50 Ω SWR of lengthened 40 meter dipole on 40
Multiple Fortuitous Resonances — The 40 Meter Dipole On 15

40 Meter dipole lengthened to resonate on 15 meters

75 Ω SWR of lengthened 40 meter dipole on 15

75 Ω SWR of lengthened 40 meter dipole on 40
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Multiple Fortuitous Resonances — The 40 Meter Dipole On 15

40 Meter dipole lengthened to resonate on 15 meters — Phone version

75 Ω SWR of lengthened 40 meter dipole on 15
Azimuth pattern of 40 Meter dipole on 15 meters at 16°. Good choice for wire antenna for two bands. Pattern may be useful.

80 meter dipole on 30, 30 on 10 – 26:1 SWR
Multiple Fortuitous Resonances — the G5RV

102 feet – center fed dipole

30 feet 300/450 Ω window line

50 Ω coax – any length
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Multiple Fortuitous Resonances — the G5RV

G5RV Amateur Band SWR:
3.7 MHz – 3.6:1
7.2 MHz – 2.2:1
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Multiple Fortuitous Resonances — the G5RV

G5RV 80 Meter SWR:

G5RV 40 Meter SWR:
Multiple Fortuitous Resonances — the G5RV

G5RV 20 Meter SWR:

G5RV “15 Meter” SWR:
Multiple Fortuitous Resonances — the G5RV

G5RV 20 Meter Azimuth Pattern

G5RV 15 Meter Azimuth Pattern
G5RV Summary

G5RV dipole - plusses

Low cost, simple
Works well on 80, 40 and 20 meters – with tuner
Shorter than full size 80 meter dipole
Can be lossy back-up antenna on other bands

G5RV dipole - minuses

SWR too high on higher bands – heavy loss in coax run
Hard to adjust – only two adjustments for five bands
Multiple Fortuitous Resonances — the GØFAH

94 feet – center fed dipole

41 feet 450 Ω window line

50 Ω coax – any length

See QST, June 1995
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Multiple Fortuitous Resonances — the GØFAH

GØFAH Amateur Band SWR:

- 3.7 MHz – 13:1
- 7.2 MHz – 1.2:1
- 10.1 – 90:1
- 14.2 – 1.5
- 18.1 – 1:1
- 21.0 – 73:1
- 24.9 – 4:1
- 28.3 – 3:1
Multiple Fortuitous Resonances — the W1VT WARC

57.2 (56) feet – center fed dipole, #14 THHN

35.5 feet 600 Ω open wire line
(450 Ω window line)

50 Ω coax – any length

11 turns RG-58 on two FT-240-52 core

Zack Lau, W1VT, QEX, Mar 2015 –
A Dipole for 30, 17, and 12 Meters
40/20/10 version scheduled for 3/16
Multiple Fortuitous Resonances — the W1VT WARC

- SWR Plot: WARC Dipole
- Freq 18.1 MHz
  SWR 1.79
  Z 72.55 at 24.28 deg.
  = 66.14 + j 29.83 ohms
- SWR 24.9 – 2.2:1
  18.1 – 1.8:1
  24.9 – 2.2:1

Source # 1
Z0 50 ohms

- Source # 1
- 100 ohms
Multiple Fortuitous Resonances — The W3DZZ Multiband Dipole

- Electrical \( \lambda/2 \) at 80 meters
- Multiple Electrical \( \lambda/2 \) at 20, 15 and 10 meters
- Electrical \( \lambda/2 \) at 40 meters

40 meter parallel resonant trap
Multiple Fortuitous Resonances — The W3DZZ Multiband Dipole

W3DZZ Amateur Band SWR:
3.7 MHz – 2:1 10.1 – 74:1 18.1 – 81:1 24.9 – 55:1
7.2 MHz – 2.2:1 14 MHz – 3.6:1 21.0 – 10:1 28.3 – 64:1
The W3DZZ Multiband Dipole Summary

W3DZZ dipole - plusses

Works well on 80, 40 and 20 meters – with tuner
Can be lossey back-up antenna on other bands
Easier to adjust than G5RV – three adjustments for 80, 40 & 20

W3DZZ dipole - minuses

SWR quite high on higher bands – heavy loss in coax run
Still hard to adjust – only three adjustments for five bands
Traps add weight and cost, slight loss
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**Non-resonant Tuned-Feeder Dipole**

Best if $\lambda/2$ on lowest band

Antenna System with Multiple Resonances

Balanced antenna tuner

“Any” length
450 $\Omega$ window line, or
600 $\Omega$ open wire

50 $\Omega$ coax – any length
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132 Foot Resonant Tuned-Feeder Dipole

20 meter azimuth pattern

10 meter azimuth pattern
102 Foot Non-resonant Tuned-Feeder Dipole

20 meter azimuth pattern

10 meter azimuth pattern
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86 Foot Non-resonant Tuned-Feeder Dipole

20 meter azimuth pattern

10 meter azimuth pattern
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Non-resonant Tuned-Feeder Dipole Summary

Plusses

Very efficient, low loss
In most cases will work at even lower frequencies;
G5RV length works on 80 meters at W1ZR
Dipole like pattern at one wavelength and below
Complex pattern on higher bands

Minuses

Requires wide range tuner
Balanced line can be hard to handle
Tuner adds adjustments and cost
Complex pattern on higher bands
Wideband Antennas for Multiband Use

Travelling Wave Antennas
   Terminated Rhombic
   Terminated V-Beam
   Half Rhombic
   Useful gain, but large for many applications
   Typical 4:1 frequency range, if compromise design

Log Periodic Dipole Array
   Collection of “Parallel” Dipoles
   Provide directional gain similar to small Yagi
   Typical 4:1 frequency range

Tilted Terminated Folded Dipole (T2FD)

Discone
A Comparative Look at Multiband Antennas – Wrap Up

- **Multiple single-band dipoles**: good but takes many
- **Fortuitous resonance antennas** —
  - 40/15 dipole: not quite as good as it sounds
  - G5RV: doesn’t quite match – coax loss
  - W3DZZ: some bands for free
- **Multiple resonator antennas** —
  - parallel dipoles: best if few and wide apart
  - trap dipoles: can work well, heavy, expensive
- **Non-resonant tuned-feeder dipole** —
  - excellent efficiency, light and cheap
  - requires wide range tuner
  - adjust operating to multiple patterns
A Comparative Look at Multiband Antennas – Going beyond the Simple Dipole

♦ All applies as well to vertical antennas.
   Half as long – feed against ground
   Turn patterns on their side

♦ All applies to multiband arrays —
   Just multiple dipoles
   Feeding issues are similar
A word from our sponsor — ARRL books by Joel R. Hallas, W1ZR

New last Fall, “The Radio Amateur’s Workshop and Laboratory”
Thanks for Your Attention!

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