ham radio TECHNIQUES

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the G5RV explained

While it may be premature to speculate, Spring can't be far away. Now's the time to think about that new antenna you're going to put up as soon as milder weather rolls around.

Some Amateurs in the United States have been bemused, even confused, by the short, cryptic description of an antenna used by many European Amateurs. Described as simply a "G5RV," the antenna must work, judging from some of the powerful signals that come "across the pond" from stations using this sky-wire.

The antenna design is named after its designer, Louis Varney, G5RV, an old-timer — (licensed as 2ARU in 1928, and as G5RV in 1929) — still very active on the bands. Louis has used the antenna from many of his overseas DX locations over the past few decades. It enjoys worldwide popularity because it's a good, inexpensive multiband antenna that works very well.[1]

The grandfather of the G5RV was an "all-band" antenna first described in Amateur literature by Arthur Collins, WØCXX, then President of Collins Radio Company. Sold as a kit in 1933, it never attained widespread popularity because it was both expensive and difficult to install.

The Collins antenna consisted of a 3/2-wavelength long 20-meter, center-fed wire with an impedance transformer that provided a satisfactory match to the open-wire line and tuned tank circuit rigs of the pre-war period. The transformer was a linear affair made of copper tubing that was difficult to suspend from the center of the antenna. Art's transformer was quickly forgotten, but the idea of the inexpensive, effective 3/2-wave antenna remained (**fig. 1**). As shown in **fig. 2**, it has an interesting field pattern and a radiation resistance value of about 95 ohms at the center feedpoint. Its power gain over a dipole is about 1 dB.

Antenna dimensions for the higher frequency bands are shown in **table 1**. The antenna can be easily matched to 50-ohm coaxial line by means of a quarter-wave section of 75-ohm coaxial line. Sufficient line isolation can be obtained by wrapping a portion of the 75-ohm line into a simple four-turn RF choke coil directly beneath the antenna feedpoint.

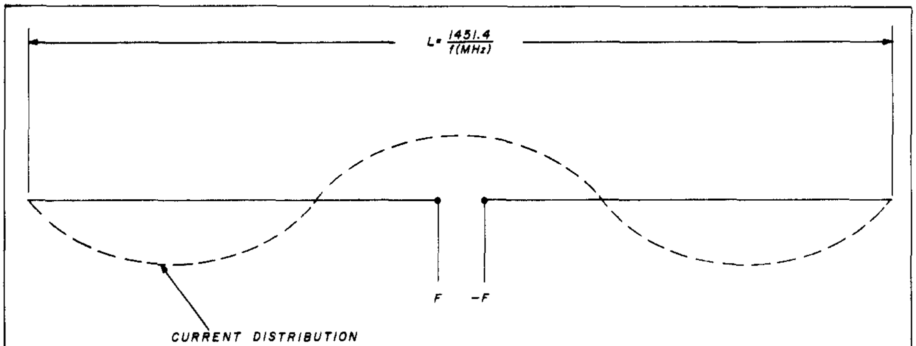

fig. 1. The 3/2-wave center-fed antenna. Feedpoint resistance at resonance is about 95 ohms.

This simple antenna is recommended as a general coverage, single-band antenna for the Amateur bands between 10 and 30 MHz.

a practical G5RV multiband antenna

Louis Varney, G5RV, devised a 1/2-wave matching section that functions as a 1:1 transformer for a 14-MHz 3/2-wave dipole, enabling the coaxial line to "see" a close match on this band (**fig. 3**). On other high frequency Amateur bands, the transformer section acts as a portion of the antenna, folded back upon itself, to provide a reasonable value of feedpoint impedance on all bands between 3.5 and 29.7 MHz. Even though the antenna termination may be reactive, a good antenna tuning unit will match the system to a 50-ohm transmitter. This scheme will satisfy the rather stringent load conditions required by many of the solid-state transceivers employing a "fail-safe" ALC circuit that senses the SWR on the transmission line and reduces amplifier input to protect the output transistors of the transceiver from damage.

It is tempting to substitute a balun for the antenna tuner to make a "no adjustment," multiband antenna. This is an unsatisfactory solution. Ferrite-core baluns are not effective with reactive loads or loads presenting a high value of SWR, and cannot compensate for the reactive load presented by the G5RV antenna on most Amateur bands. The tuners listed in references 2 and 3, however, will do the job properly.

the linear transformer for the G5RV

The heart of the G5RV antenna is

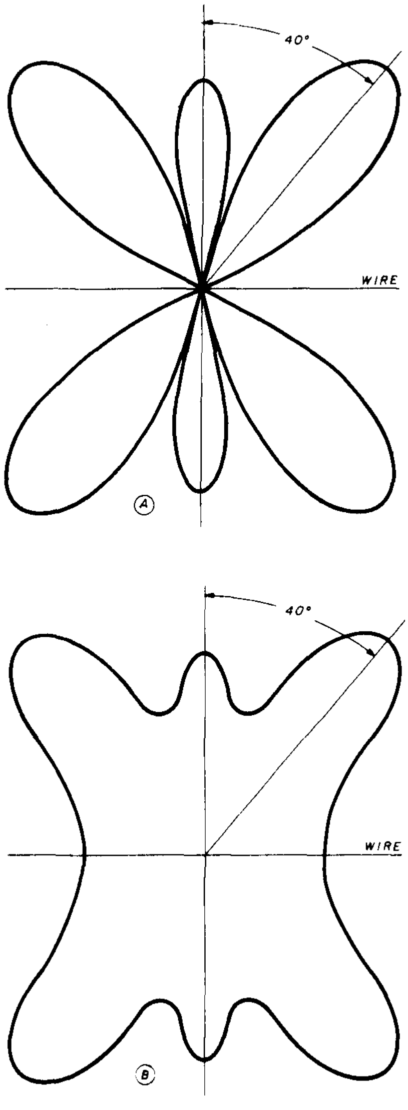

fig. 2. Horizontal field pattern for 3/2-wave antenna: (A) ideal pattern; (B) over imperfect ground.

table 1. Dimensions of flat-top and coaxial transformer for 3/2-wavelength, center-fed antenna.

		L = *		1/4-wave transformer (RG-11/U or RG-59/U	
band	f(MHz)	feet	(meters)	feet	(meters)
30	10.12	143.40	(43.70)	16.04	(4.89)
20	14.15	102.60	(31.30)	11.46	(3.49)
17	18.11	80.14	(24.43)	8.97	(2.73)
15	21.22	68.40	(20.85)	7.66	(2.33)
12	24.94	58.20	(17.74)	6.51	(1.98)
10	28.60	50.75	(15.47)	5.68	(1.73)

$$*L = \frac{1451.4}{f(MHz)}$$

the 14-MHz 1/2-wave transformer placed at the feedpoint of the antenna. Line impedance is not important. Ideally, an open-wire line is best, but is difficult to build and spacers are hard to come by. A good substitute is TV-type "ladder line" that will function with power levels up to 250 watts or so. On occasion, transmitting-type ladder line that will work very well can be found.

Alternatively, 300-ohm line having "windows" punched in the dielectric can be used, but this material is not difficult to obtain. While 300-ohm TV ribbon line will work, the transformer section can be detuned by rain or snow, making antenna tuning erratic in wet weather.

Regardless of construction, the transformer section should drop down vertically beneath the antenna for 20 feet (6 meters) or so before it is brought away at an angle. This will keep undesired coupling between line and antenna at a minimum.

The G5RV can be installed as an inverted-V antenna and still perform successfully.

the 160-meter compact dipole

Have you heard the DX coming through on the 160-meter band? Would you like to work some of it? A great idea, but a lot of would-be "top band" DXers pause when they consider that a 1/2-wave dipole antenna is about 246 feet (75 meters) long when cut for the midpoint of the band. And while a vertical antenna would be appropriate, it requires a good ground connection and a system of buried radials.

An effective alternative is a short, coil-loaded dipole antenna. By reducing the dipole to half size, about 130 feet (40 meters), the antenna becomes more feasible for the ham who lives on a medium-sized lot. A loaded antenna can be just about any length, however, if a compromise between length, efficiency and bandwidth can be accepted. Bandwidth and efficiency drop sharply when the loaded dipole is much less than 1/4-wavelength long.

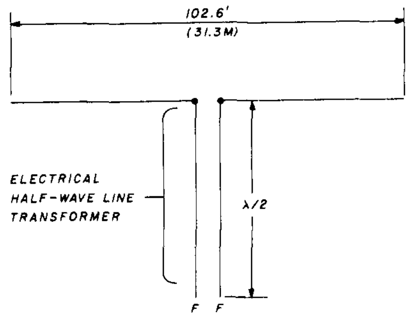

fig. 3. The G5RV antenna for 14 MHz. A parallel-wire transformer 1/2-wavelength long acts as a 1:1 matching device on 14 MHz and as a folded portion of the antenna on other bands. A tuner is required at F-F to match the system to a coaxial feedline. The velocity factor of the line must be used to determine physical line length. On 80 meters the antenna is a foreshortened dipole. On 40 meters the antenna is a folded "two 1/2-waves in phase." On 18, 24 and 28 MHz the antenna functions as a long wire, center-fed.

The bandwidth of a full-size 160-meter dipole mounted close to the ground (40 to 60 feet — or 12 to 18 meters — high) is quite narrow — only about 150 kHz between the 2:1 SWR points on the passband. Shortening the dipole and loading it to resonance sharpens the passband. The antenna design shown in **fig. 4** has a passband of about 50 kHz between the 2:1 SWR points. That's the penalty you pay to get a compact antenna on 160

table 2. Coverage of the entire 160-meter band requires changing dimensions and component values.

design frequency (MHz)	overall length (S) feet	(meters)	length center-to-coil (D) feet	(meters)	loading coil (L_1) μH	turns (L_1)	matching coil (L_2) μH	turns (L_2)
1.80	130.0	(39.6)	32.5	(9.9)	91.9	38.9	3.9	11.6
1.85	126.5	(38.6)	31.6	(9.6)	89.2	38.0	3.8	11.3
1.90	123.2	(37.6)	30.8	(9.3)	86.5	37.2	3.7	11.1
1.95	120.0	(36.6)	30.0	(9.1)	84.0	36.4	3.6	11.0
2.00	117.0	(35.66)	29.3	(8.9)	81.6	35.7	3.5	10.8

Notes:

Dimensions rounded to nearest tenth, metric dimensions in ( )
Coil L_1 diameter = 3 inches (7.6 cm) use No. 14 wire, close-spaced
Coil L_1 length = approximately 2.5 inches (6.3 cm)
Coil L_2 diameter = 1 inch (2.54 cm), use No. 18 wire, close-spaced
Operating bandwidth = 50 kHz between 2:1 SWR points
Adjust tip sections for antenna resonance
Adjust coil L_2 for best match at resonant frequency

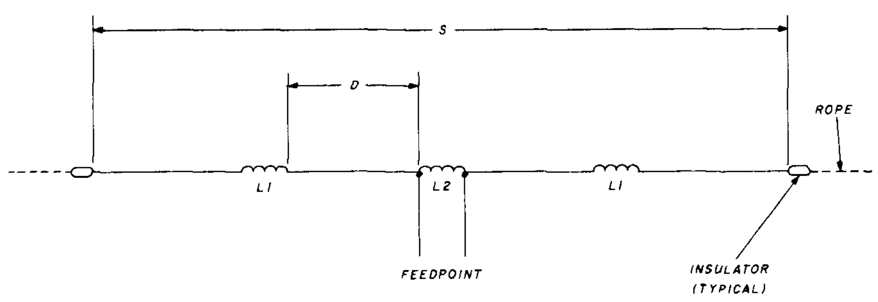

fig. 4. The 160-meter compact dipole (see table 2).

meters! You can make the dipole shorter with larger loading coils, but your operating passband will shrink until it becomes impractically narrow.

simplifying the design

The chart shown in **table 2** reveals a number of interesting points. Overall antenna length varies from 130 feet (39.6 meters) at the low end of the band to 117 feet (35.6 meters) at the top end. That's a difference of 13 feet (4 meters). The length of the center-to-coil distance also changes appreciably (from 32.5 feet to 29.3 feet). The loading coil (L1) inductances change only slightly, as the number of turns changes only from 38.9 to 35.7. And the matching coil at the center of the antenna changes hardly at all.

It seems to me that things could be simplified by using the center-band design (1.90 MHz) and then varying the resonant frequency of the whole antenna by merely changing the length of the tip sections. Leave all the other dimensions alone. Fold-back tip sections can be wrapped around the antenna wire and then unwrapped and left to hang down when operation is desired over a lower frequency range.

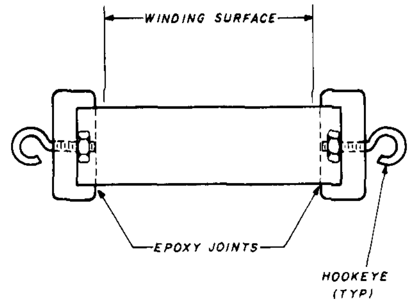

fig. 5. Loading coil can be made up of PVC-type plastic pipe and end caps. Hookeyes permit connection to the antenna wire.

adjusting the antenna

Accepting the 1.90 MHz dimensions as par, then, what's to be done? The antenna is built, erected in place, and lowered so that a dip-meter can be coupled to the matching coil, L2. The end sections of the antenna are trimmed equally until resonance is established at 1.90 MHz, or at any other point you decide is your "pet" operating frequency. (The feedline is removed for this test.)

Once antenna resonance is determined, matching coil L2 is adjusted, a quarter-turn at a time, for the lowest SWR indication on the feedline at the frequency of antenna resonance. The antenna must be in the final operating position when this is done.

building the antenna

The loading and matching coils can be easily made up using PVC tubing, as shown in **fig. 5**. If the coils are given a good coat of acrylic spray, they'll be weatherproof. Some detuning may be noticed in damp or wet weather, or if snow clings to the coils.

An alternative for Amateurs living in mild climates is to make the coils of prefabricated coil stock. The latest Barker & Williamson catalog lists show both "Airdux" and "Miniductor" coils.* I understand the "Airdux" coils can be specially ordered with LEXAN® insulation, which is impervious to ultra-violet rays. This means that the coil support strips will not disintegrate after being exposed to sunlight over a period of time.

the easy way out

If you don't want to build the compact 160-meter dipole yourself, you can purchase either the loading coils (Model LC-1) or the complete antenna (Model AES-160) from Barker & Williamson. Keep in mind, however, that this antenna is shorter than the one described earlier in this article, and while it works just as well, it may have a smaller passband because of its shorter 96-foot length. Take your choice.

heavy-duty equipment

Do you need mica transmitting-type capacitors? One possible source is Milton Levy, W5QJT, Apartment 303, 350 North Resler Drive, El Paso, Texas 79912. Milt has a large collection of capacitors and vintage radio tubes for sale at modest prices. (By the way, have you priced receiving tubes lately? The new Newark Electronics catalog lists a 6SJ7 at $29.46 and a 6SN7 at $16.82.)†

lightning protection

Many VHF/UHF repeater antennas are mounted to the side of a metal tower and grounded to it. Even so, the antenna and equipment can be damaged by the electric field of a nearby lightning stroke. A simple and effective way to protect the side-mounted antenna is shown in **fig. 6**. A "lightning rod" is mounted to the tower just above the repeater antenna. The horizontal metal rod, a few inches longer than the spacing between the antenna and tower, is placed 6 inches or more above the tip of the antenna. The lightning rod will not affect antenna performance, but it will help to protect the antenna and the equipment attached to it during a nearby storm.

*Barker & Williamson, 10 Canal Street, Bristol, Pennsylvania 19007.

†Newark Electronics, 500 North Pulaski Road, Chicago, Illinois 60624.

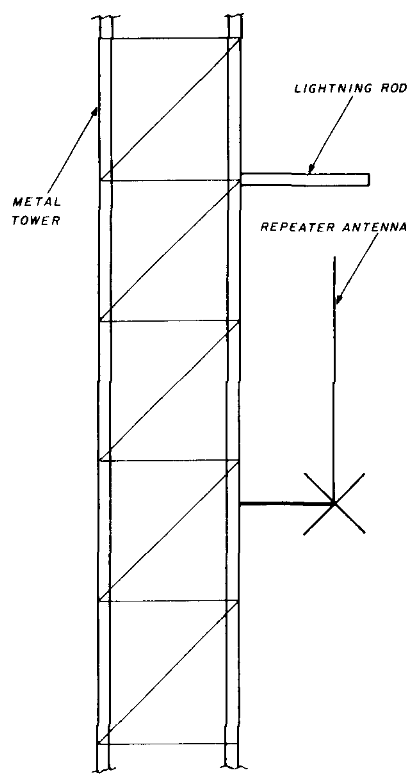

fig. 6. Lightning rod will protect repeater antenna mounted on side of metal, grounded tower.

reprint available

I have a limited number of reprints of the article "A High Power 2-Meter Amplifier Using the New 3CX800A7" from the April, 1984, issue of *QST*. Address your request to me, c/o EIMAC, 301 Industrial Way, San Carlos, California 94070. (Include two first-class stamps or two IRCs.) Thanks to the American Radio Relay League for permission to reprint.

references

1. Louis Varney, G5RV, "G5RV Multiband Antenna . . . Up-to-date," *Radio Communications*, July, 1984, page 572.
2. "Band Switched Link Coupler," *The ARRL Antenna Book*, 14th edition, 1982, page 4-4 and 4-5.
3. William I. Orr, W6SAI, "Antenna Tuner for Center-Fed Antenna," *Radio Handbook*, 22nd edition, 1981, page 27.23.

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