A 5-Band Antenna Coupler

Simplifying the "All-Band" Transmitter Loading Problem

BY LEWIS G. McCOY, W1ICP

A RECENT ARTICLE in *QST* described the construction and use of a standing-wave-ratio bridge.[1] It was pointed out that when the s.w.r. bridge was used in conjunction with an antenna coupler, one could easily match the output from his transmitter to the antenna system. Except for a few special types of antennas,[2] nearly all multiband systems need an antenna coupler to match the transmitter output to the feedline. If one is fortunate enough to have a separate antenna for each band, and each antenna is fed with an untuned, or "flat" (low s.w.r.), line, an antenna coupler is of course not required. However, most of us have to struggle along with a multiband antenna and use a tuned line. The purpose of this article is to describe a coupler that has enough flexibility to match practically any antenna system the average ham can dream up. In addition, for the benefit of the beginner, a few simple antenna systems will be described.

The Circuit

There are two basic circuits used in antenna couplers: series or parallel tuning. Which circuit is used depends upon the antenna and feedline length in terms of wavelengths. In order to take care of the different conditions one is likely to encounter, an antenna coupler should be designed to use both types of tuning.

Fig. 1 shows the basic circuits that can be obtained with the coupler to be described. The two capacitors shown are actually one split-stator variable — simple switching takes care of getting the different circuits. A fixed link is used on the coil, but the effective coupling is readily adjusted by varying the capacitor in series with the link.

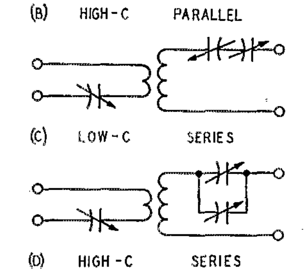


Fig. 1 — In the above drawing, A and B show two parallel tuning conditions: low- or high-*C*. Series tuning, low- or high-*C*, is shown at C and D.

The practical circuit is shown in Fig. 2. The switching mentioned above is accomplished by

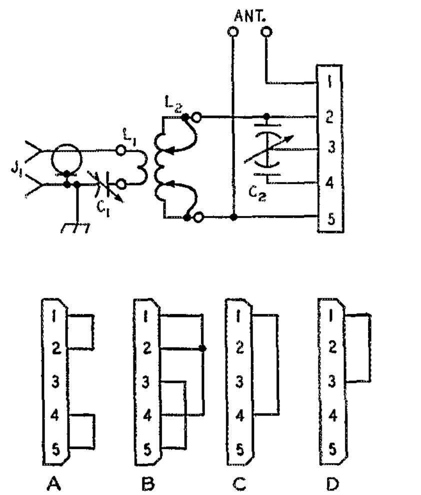


Fig. 2 — Circuit diagram of the antenna coupler.
C_1 — 320-μμf. variable (Hammarlund MC325-M).
C_2 — 100-μμf.-per-section variable (Hammarlund HF-BD-100-C).
L_1, L_2 — See text.
J_1 — Coaxial receptacle (Amphenol 83-1R).

plugging in a suitably-connected bar plug — the letters beneath the plugs correspond to the four circuit conditions of Fig. 1. L_1 and L_2 are both mounted on another plug bar — only two coils are required to cover the bands 80 through 10 meters. Intermediate values of inductance are obtained by shorting turns with clip leads permanently mounted on the coil bar, as can be seen in one of the photographs.

Construction

Although the parts for the antenna coupler might be mounted on a wooden base, we elected to mount them on a 3 × 5 × 10-inch chassis. The condenser spacings and coil wire sizes are adequate to handle powers up to about 500 watts input to the transmitter. Since the Novice cannot run more than 75 watts, the cost of the unit for low-powered applications can be reduced by substituting a smaller capacitor of the same range for C_2. However, the Novice can build for future high-power days by using components with the

[1] McCoy, "Meet the S.W.R. Bridge," *QST*, March, 1955.
[2] Where special matching devices are used to match the antenna to the impedance of the feedline on more than one band.

ratings given in the caption, with the assurance that the coupler will work just as well for him as it will for the ham with 500 watts.

The two coils and their links are made from a single length of B & W 3906 coil stock. To make the 80/40-meter coil, first count off 46 turns of the coil stock and cut this piece from the stock. Then unwind one turn from each end. This will provide leads to connect to the jack bar plug. Next, cut the 19th turn from each end, making the cut at the top of the coil (calling the side where the outside leads come off the "bottom"). The ends of the wires at these cuts are separated from the form and brought around to the bottom of the coil. We now have three coils of 18 turns, 6 turns, and 18 turns. The 6 turns at the center forms the link, L_1. The inside ends of the two 18-turn sections should be soldered together. This gives a coil for L_2 consisting of 36 turns, with the 6-turn link, L_1, at the center. The leads are inserted in the jack bar plug (Millen 40305) and soldered. The last step is to mount clip leads on the coil ends, so that a portion of the coil can be shorted out for 40-meter operation.

The 20/15/10-meter coil is made up in a similar manner. The original piece of coil stock consists of 14 turns. The completed L_2 has 8 turns, 4 each side of center, with a 2-turn link for L_1.

No specifications are given for tap points because these points may vary with the antenna system. The coil and shorting bar holders are made from Millen 41305 jack bars.

Using the Coupler

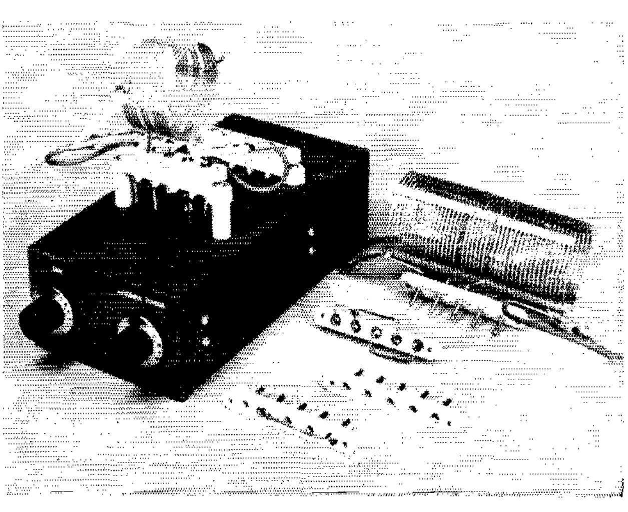
Let's assume we have a half-wave dipole, 135 feet long, fed at the center with open-wire line. We'll start out first on 80 meters and work down through 10 meters, making notes on each setting of the coupler in order to have a permanent record. As pointed out in the s.w.r. bridge article,[1] one of the best methods for adjusting the coupler is with a bridge. The 80-meter coil is plugged into the unit and the feeders are attached to the antenna terminals. For a start, we'll use plug *B*, which will give us high-*C* parallel tuning. The

• One of the stumbling blocks among new amateurs is the problem of properly coupling the antenna to the transmitter. A flexible antenna coupler that will handle a wide variety of situations is the solution, and in this article W1ICP describes such a device and how to use it. Since it will handle powers up to several hundred watts, it won't have to be rebuilt if and when you increase power.

bridge is connected by coax line to the transmitter temporarily with nothing connected to the output side of the bridge. The transmitter is set up near 3500 kc., or 3700 kc., if you are a Novice license holder, and full-scale reading is set on the bridge meter by adjusting the transmitter output or excitation. The coax line from the coupler is then connected to the output side of the bridge. The controls on the transmitter are left as they were for this particular frequency setting.

The two condensers, C_1 and C_2, are then tuned for a null indication on the s.w.r. bridge meter. It should be possible to get a reading of zero or very close to it. If a good null isn't obtained, try the other plugs, starting with *A* and working through *D*. It may be necessary to tap in toward the center of the coil, but keep the taps as close to the coil ends as possible. Once a good null is obtained, mark down the settings, because as long as the same antenna system is used, the settings will remain the same. The procedure outlined above can be made for each 25 kc. throughout the 80-meter band, noting the settings at each spot frequency. In this way, one can quickly change frequency and always be sure the system is tuned on the button.

For 40 meters, the same procedure is followed, except that the coil is tapped down from the ends until a good null is obtained. With the antenna system used for testing the coupler, the taps were placed at eight turns in from the ends. However, different antenna systems may take different tap



Top view of the coupler with the high-frequency-range coil in place. The shorting-bar assembly is apparent behind the coil. The low-frequency coil and additional shorting bars are shown at the right.

points, so the correct spots must be found experimentally. Always keep the tap points as close to the ends of the coil as possible, consistent with a low s.w.r. Since the turns on the coil are too closely spaced to accommodate alligator clips, clip points can be made from ordinary soldering lugs soldered to the coil at the proper points.

After the 40-meter settings are noted, similar steps can be followed on 20, 15 and 10 meters. The correct settings for the taps are likely to be more critical than for the lower-frequency bands. In addition, it may be necessary to have more than one set of tap points for the entire 10-meter band.

With the procedure outlined above, it is of course assumed that one has an s.w.r. bridge or can borrow one. If none is available, the coupler can be tuned using an output indicator. An r.f. ammeter can be inserted in series with one of the feeder wires and the coupler tuned for maximum output, as indicated by the greatest reading obtainable on the ammeter. This is not as accurate as the bridge method of adjustment, because one cannot be sure the line between the transmitter and the coupler is perfectly matched. Dial lamps in series with the feedline or tapped across a section of line will also serve as output indicators, as shown in Fig. 3. An absorption-type wavemeter[3] *loosely* coupled to the feedline can be used.

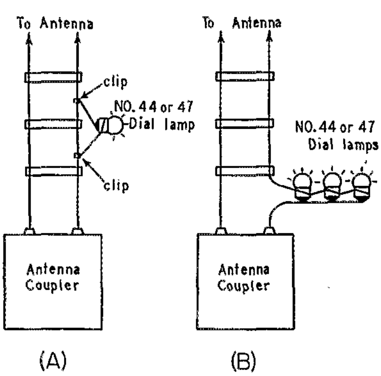


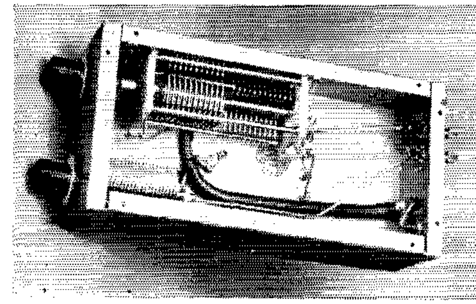
Fig. 3 — Dial lamps serve as an inexpensive output indicator, and either of the two systems shown above can be used. In A, a single dial lamp with one-foot leads is clipped onto the feedline. As the transmitter and coupler are tuned to maximum output, the dial lamp will light up. It may be necessary to move the clip leads up the line to find a point where sufficient coupling is obtained. At B, the dial lamps in parallel are connected in one of the feeders. To start out, all three bulbs should be connected to prevent possible burn-out. They can be disconnected one at a time until the best indication is obtained.

Center-Fed Antennas

A center-fed antenna doesn't have to be a specific length to work well. If you can make the antenna a half wavelength long at the lowest band, fine and dandy. But if your QTH is such that putting up a half-wave antenna would mean tying the far end to your neighbor's TV antenna, use a little discretion and compromise with the ideal. A slightly shorter antenna won't show an appreciable difference in performance. The important thing about a center-fed antenna is to be sure that the feedline is connected at the exact center of the antenna and, if possible, that the feedline runs away from the antenna at right angles for a considerable distance. Some amateurs do this by bringing the feedline straight down from the horizontal antenna to a mast or pole and then running the feedline into the shack. The horizontal section of the feedline should, of course, be high enough to clear the heads of any pedestrians.

It is a good idea to make the length of the feedline plus one-half the antenna length a multiple of a quarter wavelength at the lowest operating frequency. A quarter wavelength is found by dividing 246 by the operating frequency in Mc. As an example, suppose the lowest operating frequency is 3.7 Mc.; 246 ÷ 3.7 = 66½ feet, so half the antenna plus the feedline would want to be 66½ (impractical because it makes either the antenna or the feedline too short), 133, or 200 feet long. If the antenna is 100 feet long, half of this is 50 and the feedline should be either 83 (133 − 50) or 150 (200 − 50) feet long. But if these feedline lengths are inconvenient, don't worry about it too much. Put up the antenna you can, with the feedline coming away from the center, and try tuning it on the bands available to you. There are some combinations that turn out to be a little awkward, but the antenna coupler can handle a wide variety of combinations. If you run up against one it can't, try lengthening or shortening the feedline a few feet.

[3] McCoy, "The Baking-Pan Wavemeter," *QST*, February, 1955.



In this view the link capacitor is shown at the bottom and the tuning capacitor at the top. The line connected to the coaxial socket is a short piece of 52-ohm cable.

End-Fed Antennas

The foregoing flexibility of antenna length does not apply to the end-fed "Zepp" antenna. In this case, if the feedline is not to radiate, the antenna length should be a half wavelength long, or a multiple of a half wavelength. Formulas and charts for these lengths are given in the *Handbook*. However, with the right antenna length, the preceding remarks about tune-up procedure hold, except that the preferred over-all lengths involve

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was wound in the form of 3 pies on a 1-inch-diameter bakelite rod. Commercially-available chokes could be used and turns removed to give the right inductance value. For Qs much different than specified, some adjustment of the feed-back condensers C_2 and C_3 and the anode load resistance will be necessary. The oscillator was built in a 3 × 4 × 5-inch metal utility box with the tube mounted on one side. The cathode choke coil was pi-wound on a small form. This choke coil is, however, readily obtainable from commercial stock. The oscillator tunes from 20.4 to 23 kc. The low-frequency limit is set by the fixed bandset condenser.

Power Supply

Although an electronically-regulated power supply was used, it is not absolutely necessary. It does, however, provide a power source having a low output impedance at 20 kc., and thus lends to the over-all stability of the amplifier. The voltages are made available for use with external audio filters and clippers through an octal plug. It is convenient to be able to draw current from the power supply without upsetting the amplifier supply voltages.

5-Band Antenna Coupler

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the feedline plus antenna, not feedline plus half the antenna.

In many instances it is more convenient to put up a Zepp antenna than a center-fed one. If, however, there is only room for a 66-foot antenna (half wavelength at 7 Mc.) and 80-meter operation is desired, the feeders can be tied together in the shack and connected to one of the antenna terminals of the coupler. If it will work with a parallel connection, fine; if it won't, a series connection can be tried, with the other antenna terminal of the coupler connected to ground. An antenna worked this way is a "random" length of wire, and consequently, the same tuning procedure applies to a piece of wire that is actually a random length and doesn't have any feedline. The trouble with antennas lacking a true feedline is that they are sometimes responsible for "r.f. around the shack," as evidenced by r.f. on microphones and cabinets.

Harmonics

One last bit of information worth passing along to the newcomer who may not know one of the values of using a coupler: As many amateurs have found to their sorrow, harmonics of their transmitted signal can get them into trouble with the FCC. The use of a link-coupled antenna coupler provides considerable attenuation of harmonics, usually enough to keep them from interfering with other services. And if one is experiencing TVI caused by harmonics, the coax link line between the transmitter and the coupler furnishes an ideal spot for the installation of a low-pass filter.