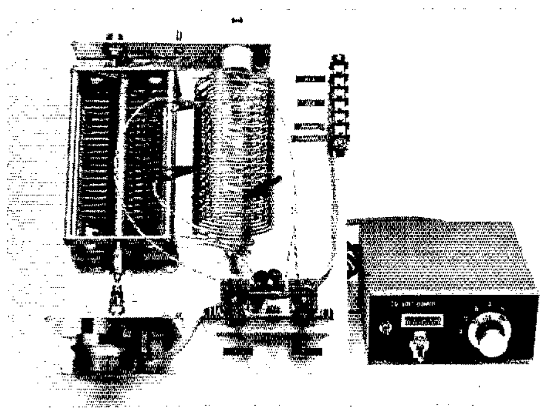
Antenna Matching, Remotely — Some Thoughts



Network switching for multiband antennas is no fun out of doors in foul weather. Remote control saves time and keeps you indoors. Here are some design thoughts.

By Doug DeMaw,* W1FB

Remote matching networks too complicated for you? Too much trouble with arcing and flashover at high power? And what about the cost of parts for a remotely controlled matcher? Well, I pondered the same questions during an extended period of practical deployment for the VE2CV Half-Delta Loop antenna.[1] Not only that, I grew weary of dashing out to the back lot in the rain, snow and darkness to change bands and adjust for a VSWR of 1:1. Fall and winter on the East Coast can bring with it some cold, dismal weather. That, plus the time lost in doing a manual adjustment, can leave one less than enthusiastic about hand-operated outdoor tuning systems!

I was in a hurry to correct the annoyance that beset me as winter hustled into Connecticut. I hoped that there were enough components in my workshop to permit the building of a three-band, remotely controlled network that would sustain 600 watts of rf energy. The first try was okay except for occasional flashover of the two control relays when running 1 kW of dc input power. A simple technique was developed to resolve the matter (more on this later), and the system was finalized, then installed in a homemade "dog house" to keep it high and dry. The general approach may be of interest to you if your station requires remote band switching or matching of an antenna for which the feed point is far removed from the shack.

Network Types

The choice of matching circuits is dependent upon the type of antenna in use — a truism for certain! There is no reason why one could not use any popular L-C network, Omega match, gamma match or whatever, assuming it was appropriate for the type of feed system in use. Wide-range Transmatch circuits like the Ultimate or SPC[2] are suitable for remote installations, but would require a reversible motor with stops for the rotary inductor (Fig 1). A fixed-value inductor with preselected taps would be a practical substitute for a rotary inductor, however, since the various impedance values for a multiband antenna would not likely change beyond the correction range of the variable capacitors.

My situation called for a simple L network for which the impedance transformation was up from 50 ohms on 80, 40 and 20 meters. The circuit is shown in Fig. 2. It is used with the Half Delta Loop, but could be employed for slant-wire feed of a tower (a poor man's form of delta matching). The latter is used among some amateurs by isolating the tower guy wires with insulators, but leaving one guy common to the tower, then feeding it at the ground end (Fig. 3). This can be an effective DX antenna for 160 and 80 meters, even when a triband Yagi is atop the tower. It does require a good ground system, such as a fan of buried radials.

The Half-Delta Loop (grounded half-wave loop at f_o) used at W1FB with the L network provides excellent DX results on 80 meters at f_o, on 40 meters (2f) and at 20 meters (4f). Radiation is vertically polarized on all bands and is essentially omnidirectional at f_o. There is increasing directivity as operation is carried out at progressively higher harmonics. The directivity is in the slope of the slant wire. If a good ground system is used with the loop the angle of radiation will be low, and some gain will prevail at the harmonic frequencies. The half-wave grounded loop is shown in Fig. 4. The maximum-current resonance is not exactly related in terms of the harmonics. Therefore, the feed impedance varies from band to band (90 to 250 ohms in my installation for 3.5 to 14 MHz). The L network was a good choice for obtaining a matched condition to 50-ohm coaxial cable.

L-Network Circuit

Moderate plate spacing for C1 of Fig. 2 is adequate for my installation, owing to the relatively low impedance transformation at the feed point of the loop. A plate spacing of 1/8 inch (3 mm) has been suitable for the output from my SB-221 amplifier. Higher feed impedances will probably require larger plate spacing. This can be calculated if the feed impedance is measured. Then, it's simply a matter of using $E_{rms} = \sqrt{WR}$, where W is the output power of the transmitter and R is the feed impedance in ohms. Thus, 600 watts across 150 ohms would produce an rms voltage of 300. This would equate to a pk-pk ac voltage of 846. The plate spacing should be chosen for 846 volts minimum, thereby allowing for dielectric (air) degradation when the air is damp or

[1]Notes appear on page 16.

*QST Senior Technical Editor

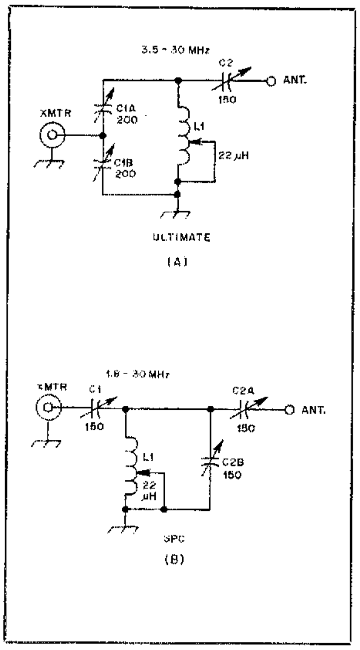


Fig. 1 — Basic circuit of the Ultimate Transmatch (A) and the SPC network (B).

polluted. Dust accumulations must also be considered. Most manufacturers of variable capacitors provide voltage ratings for the various plate spacings. If in doubt, consider that dry, clean air has a dielectric factor of 1 at 1 MHz. The breakdown voltage is 240 per mil (0.001 inch).[3]

Relays K1 and K2 of Fig. 2 were used because they happened to be on hand. Intuitively, one might prefer fancy, expensive antenna relays with steatite insulation. But, by "floating" the plastic-insulated relays at K1 and K2, the arc-over problem mentioned earlier was solved. The rf voltage no longer has a path to ground because of the toroidal chokes in the field-coil leads of the relays. The contact area of the relays must be able to sustain the rf current without losses, heating and subsequent heating damage. Again, if the feed impedance and rf power are known, we can determine the current rating for the relay contacts. This is obtained from

$$I = \sqrt{\frac{W}{R}} \qquad \text{(Eq.1)}$$

where I is in amperes, W is in watts and R is in ohms. Hence, if the antenna impedance is 150 ohms and the power is 600 watts, the maximum rf current through the contacts will be 2A. Always allow some leeway for this rating. A set of 5-A contacts should suffice for the example.

My relays are 24-V dc types. The mechanism for rotating C1 is a geared-down clock motor (surplus) that provides a 1-rpm speed. It requires 24 V ac for operation. I found this convenient because the motor voltage is taken off the 24-volt power transformer ahead of the rectifier diodes, and the relays are operated from the resultant dc voltage. The shortfall of using the clock motor is that it is not a reversible type. This means that if I adjust C1 past the setting that yields a VSWR of 1:1, I must wait nearly one minute before the capacitor is back to the setting I desire. A reversible motor is recommended if you are an impatient person! Check the surplus stores and flea markets for sources of clock motors, but look for a robust one. If possible, adjust the tensioning springs or bearings of C1 for minimum practical torque to lighten the load on the motor.

Power Supply

Fig. 5 contains the circuit diagram of the power supply for the tuning network. I modified an existing unit that I had built for controlling a remote coax switch at the top of my tower. Hence, there are some

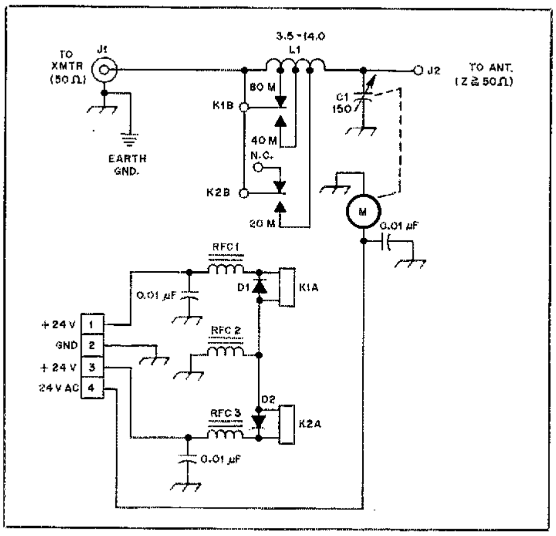


Fig. 2 — Schematic diagram of the L network used with the Half-Delta Loop. It is suitable for use with other types of antennas as well.

C1 — Transmitting variable rated for developed rf voltage (see text).
D1, D2 — Small-signal silicon diode, 1N914 or equiv.
J1 — Chassis-mount coaxial connector (SO-239).
J2 — Steatite feedthrough bushing.
K1, K2 — 24-V dc relay, spdt type (J. W. Miller Co. 1W6 suitable). A 2W6 was used at W1FB, with the extra spdt contacts wired in parallel with the first set on each unit.
L1 — Section of 2-1/2 in. diameter Miniductor stock to yield 18-20 µH of inductance. Home-made coil on low-loss form also suitable.
M — 1-rpm motor (see text).
RFC1, RFC2, RFC3 — 10 turns no. 20 insulated wire wound on stacked Amidon FT50-43 ferrite toroid cores. Use two cores for each choke.

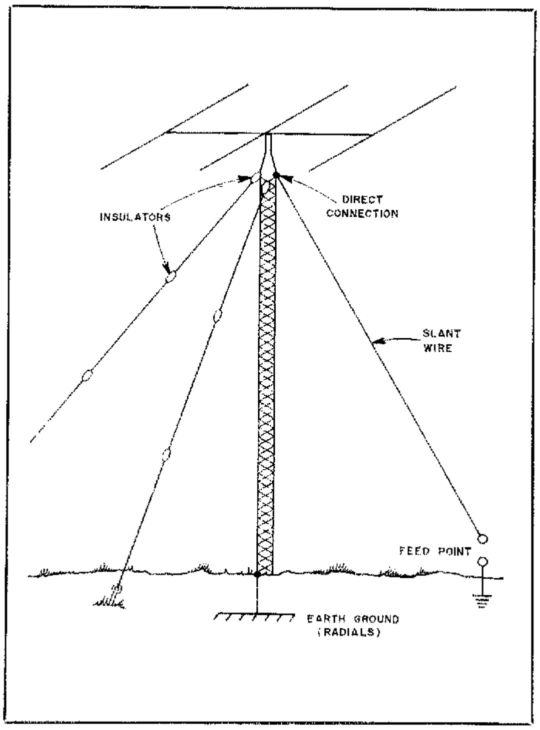


Fig. 3 — Example of slant-wire feed of a tower that contains a triband Yagi. One guy wire is used for feeding the tower. The remaining guys are insulated from the tower.

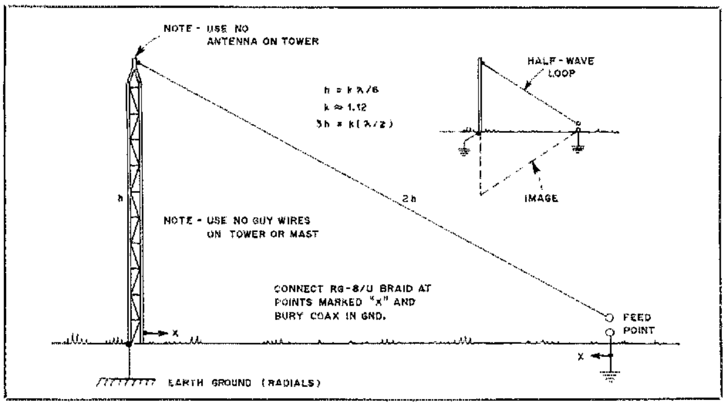


Fig. 4 — Essentials of the Half-Delta Loop antenna designed by VE2CV. The dimensional factors provided are for the ideal condition. Reasonable variations in h and 2h will not degrade the performance significantly.

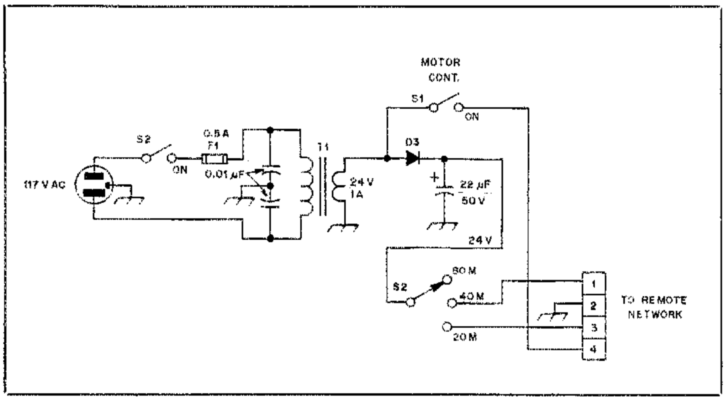


Fig. 5 — Schematic diagram of the control box and power supply for the circuit of Fig. 2. D1 is a 1-A, 50-PRV rectifier diode. S1 is a momentary push-button switch, and S2 is a single-pole, 3-position rotary switch. A Radio Shack 24-V transformer is suitable for T1. F1 is a 0.5-A fuse.

unused switch positions on the front panel.

The power unit contains a momentary switch for controlling the ac motor in the remote network. Four-wire control cable is buried in the ground (along with the 50-ohm feed line) between the house and the weatherproof box at the rear of my property. Since the current taken by the motor and relays is low, the conductor size of the control cable can be small (I used 100 feet of cable with no. 24 gauge conductors). The vinyl jacket of the cable is sealed at the far end (outdoors) to prevent moisture and dirt from entering it. The 50-ohm cable is Decibel Products VB-8, which is an impregnated type of RG-8/U, and is designed for underground use. Times Wire and Cable Co. makes a similar weatherproof, chemical-resistant line.

Construction Notes

A steatite feedthrough bushing is used for the loop-wire feed from the matching network of Fig. 2. A terminal strip (right top of picture) provides a connection point for the control lines. A 4-pin socket can be used instead of the strip.

K1 and K2 are mounted on a vertical section of plastic to further insure against rf flashover to the aluminum chassis, which is grounded. A transient-suppression diode is used in parallel with the field coil of each relay.

A flexible shaft coupling is employed between the motor shaft and that of C1. This will help to reduce tension on the motor in the event alignment of the mating shafts is not perfect. The motor is affixed to an aluminum L bracket. A second L bracket contains the coax connector, steatite bushing and a no. 10 screw for grounding. Miniductor L1 is elevated 1 inch above the chassis on steatite standoff posts. The completed assembly is placed in the wooden dog house, which is mounted on a 4 × 4-inch post, 3 feet above ground. The housing is situated at the feed point of the loop antenna.

Adjustment

The photograph shows alligator clips on the leads that form the coil taps. These clips are used during initial adjustment of the network. After the proper coil taps are found, the clips are removed and the wires are soldered permanently to the appropriate coil turns. I poked every other coil turn inward before starting the tuning. This provided clearance for the clips and prevented the creation of shorted turns.

A 2-watt QRP rig (HW-8) and a homemade, low-power VSWR indicator were used for the tune-up. The VSWR meter was connected between the 50-ohm feed line and the matching network. An extension cord provided 117 V ac to operate the control box and the HW-8 at the rear of my lot.

Tuning commenced at the lowest band (relays both turned off). C1 and the tap point on L1 were adjusted for a VSWR of 1:1 at 3.510 MHz. Next, K1 was energized with the rig tuned to 7.025 MHz. The 40-meter tap on L1 and the setting of C1 were juggled until a match was obtained. Finally, K2 was energized (K1 deactuated) and the 20-meter coil tap was set for a matched condition at 14.025 MHz. The wires were then soldered in place. ***Remember to keep your transmissions short and to identify your station periodically while testing.*** This completed the setup for a VSWR of 1:1 on each of the three bands.

My dog house is built so that the roof lifts off to expose the matching network. It is much easier to work from the top than to reach through a side door. An oval-shaped hole was cut on the bottom-rear surface (floor) of the enclosure to permit routing the ground wire, the 50-ohm line and the feed wire to the network.

Summary Comments

Although you may not be interested in using an L network or a Half-Delta Loop antenna, some of the ideas in this article should be helpful when designing other switching and matching systems. I can say in conclusion that the results and convenience resulting from this installation more than offset the work of building the network, burying the control line and feeder, and assembling the dog house! No more junkets into the back lot at night with a flashlight in hand, especially on those cold nights when it's pouring rain or snowing. QST

Notes

[1]J. Belrose, "The Half-Delta Loop — A Grounded, Vertically Polarized Antenna," *Ham Radio*, May 1982.

[2]Most commercial Transmatches employ the circuit of the Ultimate Transmatch, but some use coil taps rather than a roller inductor.

[3]mm = in. × 25.4, and m = ft. × 0.3048.