

• *Basic Amateur Radio*

Antennas and Grounds for Apartments

What do you do when the landlord says "no antenna"? Where's rf ground when you are 70 feet up? You won't find any simple answers, but these suggestions are sure worth trying.

By Peter O'Dell,* AE8Q

When my wife and I decided to return to Connecticut, we spent a couple of days going over the apartment ads in the local paper. In one particular Sunday edition, there were about four pages of ads for apartments. Of all those advertising, one apartment complex stated that they "accepted pets and children." Since our family consists of two adults, one three-year-old child and a 10-year-old beagle, we didn't feel that we had much of a choice in the matter. The rental agent (a close relative of Attila the Hun) off-handedly indicated that we could take it or leave it, but that the rules of the lease, including the prohibition of *any* external antenna, would stand without *any* modification. I haven't lived in a place yet where I couldn't put up some kind of antenna and get away with it, so we took the apartment.

How many other hams are in similar circumstances? It is hard to say, but it is probably a sizeable number. If you are one of the multitude, where do you start? The first thing to decide is if there is a chance of getting permission to install an outside antenna. If there is any chance at all, pursue it with vigor. Your best bet is to document your case with drawings of the proposed installation (landlords want to protect their property from damage caused by a poor installation). Material that might make them want you to put up the antenna should be included also. (Photocopy a few articles from back

issues of *QST* that tell about the activities of amateurs during natural disasters.)

What Has Been Done Before?

For some amateurs there is little or no possibility of getting permission to erect an outside antenna. There are basically two different approaches to the problem: String wire inside the apartment or use something outside that will not be recognized as an antenna. Let's take a look at the last course of action first.

Antennas made of very small wire work quite well when properly fed. If the wire is size number 26 or smaller and is dull colored, it is almost impossible to see once it is a few feet above ground. Over the years this popular approach has come to be known as an "invisible antenna." Dipoles, loops and random-length end feeds are all possible configurations, depending on the physical layout and oddities of architecture that you have available.

Another approach to the problem is to use some object as an antenna that would not normally be thought of as an antenna. Richard Bell, WA4BNO, once lived in an apartment that prohibited antennas. After a couple of months off the air he tried connecting a short wire from his matching network to a down spout located near one of the windows. Having scraped away the paint from a small area, he used an alligator clip to attach the wire to the gutter whenever he wanted to operate. This system may work in other locations. If the gutters are relatively new and are made of

aluminum, chances of success are better than if they appear "aged and rusty." In the case of the latter, you would run a very high risk of non-linear rectification of rf, which would generate harmonics at a rate unequalled except by rabbits and mink.

Although condominiums and "planned communities" often prohibit outside antennas, many have no rules regarding the erection of flagpoles. The owner's association of one planned community in the Kansas City area will not permit a prominent DXer to put up an external antenna (no one has spotted the invisible dipole that is mounted under the overhang

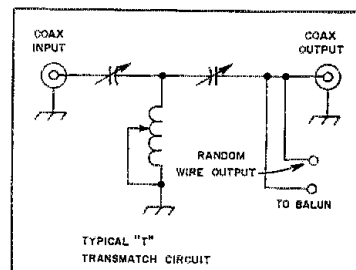


Fig. 1 — This is a typical T-match circuit that has been very popular recently; the "Ultimate Transmatch" is a variation of this circuit. Most commercial versions have a toroidal balun built in to give the user the option of a balanced output.

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of his 2-story townhouse). His initial plan was to buy and erect a 60-foot flagpole. But, he was quoted prices in excess of \$6000 for a new pole. He is busy searching for a used 60-foot flagpole and expects to have it up by early summer. In the meantime, he is "planting radials." He estimates that it would be relatively simple and inexpensive to put up a 32-foot flagpole (less than \$300), but he is interested in 80-meter DX and is determined to have a full-size, 1/4-wavelength vertical for 80 meters.

Another approach, less costly and less involved, uses a flagpole disguise. This was described by Fred J. Schnell, W6OZF, in "The Flagpole Deluxe," which appeared in March 1978 *QST*. Fred built a very thin 40-through 10-meter trap vertical, which he placed inside a 17-foot section of PVC pipe that was fashioned into a flagpole. Anyone for a pair of flagpoles in phase?

The other major option is to string wire inside the building. Normally, with the exception of 10 meters and, in some cases, 15 meters, it will be necessary to "shorten" or "bend" any resonant antenna. Also, the proximity to house wiring, metal gutters and metal framework will affect the performance of the antenna. The antenna may be any configuration that works, e.g. dipole, loop, end-fed random length or the like. It may be horizontally or vertically polarized, or both. You can attach it to the ceiling, string it in the attic or even run it under the rug. The secret is to keep trying until you find something that works. Whatever your final choice is, it will probably be something of a compromise.

Got A Match?

As a general rule, any antenna that can be put up inside or disguised on the outside will probably not present a 50-Ω load to the transmitter. Most modern transmitters do not have a wide matching range built in, so more than likely you will need some kind of matching device to trick the transmitter into seeing a 50-Ω load. In recent years the most popular circuit has been the T match (Fig. 1). Variations of this circuit are available from a number of manufacturers; for those interested in "rolling their own," complete construction plans can be found in *The ARRL Antenna Anthology*. (Incidentally, this excellent source of ideas for practical antennas is available from ARRL for \$4. Even though most of the content is oriented toward outside, nondisguised antennas, the apartment dweller should derive a great deal of "inspiration" from the contents.) The chief advantage of the T match is that it will match an extremely wide variety of impedances to the transmitter — and it is not particularly critical to tune. The major drawback is that it does not do much to reduce harmonic energy; therefore, if you have one

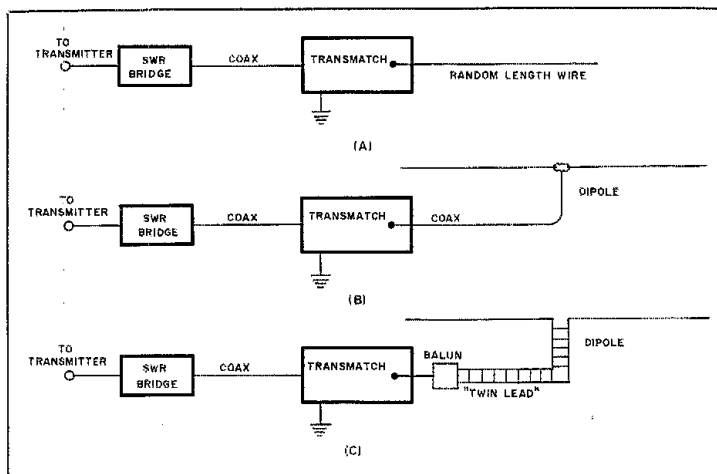


Fig. 2 — Three typical antenna systems used by apartment dwellers. Most suffer from trying to "force" an earth ground when it is physically impossible to have one. Probably the worst course of action for an apartment dweller is to "ground" his station to the cold water pipes.

of these matching networks, it is a good idea to put a low-pass filter ahead of it.

Fig. 2 shows the three most typical setups used by apartment dwellers and others restricted to compromise antennas. Much can be done to improve on these installations. The antenna depicted in part A of Fig. 2 is similar to the system that I set up for our apartment, which was of the two-story town-house variety. A metal box had been built into the side of the apartment for installation of an air conditioner. The box provided a convenient means of getting the wire outside of the apartment. Unfortunately, this box was located on the side of the building that faced the other buildings of the complex instead of the swamp in the rear. After I acquired about 300 feet of wire and secured the help of a couple of friends, we spent one Sunday afternoon putting the darned thing up.

I purchased a powerful slingshot (about \$5) and an inexpensive fishing rod and reel (about \$8) from the sporting goods section of a discount store. We attached a lead weight to the fishing line and used the slingshot to shoot the weight and line over the building. We then removed the lead weight, attached the line to the end of the antenna and "reeled it in." The same procedure was used to get the wire into the tops of several trees.

Because it was Sunday afternoon, the maintenance crew was not around. Few, if any, of the other residents noticed us. The only "incident" came when we attracted the interest of a half-dozen boys playing in the vicinity. They came closer to watch us with fishing tackle and the slingshot. After a few minutes of speculating among themselves as to what we were doing, one fellow bluntly asked us what we were up

to. At first I ignored him, but he was persistent and kept asking the same question. A glance from my friend indicated that he felt I would have to give him some sort of an answer. A scenario rapidly went through my mind in which the boy told his father that a radio antenna was up, followed by rumors and complaints to the management for every perceived incidence of interference. I decided that discretion was the better part of valor; I told him such a preposterous lie that he wouldn't dare to repeat it. "I'm putting this up to keep the UFOs away," I said. "Every place I go the UFOs drive me crazy unless I put one of these up. As soon as I put one of these up, they go away and leave me alone." The boys rapidly lost interest in what we were doing and left.

Fig. 2B shows the output of the T match feeding coax transmission line, which in turn feeds the dipole. Because the antenna impedance may be influenced by nearby objects or because the antenna may not be resonant, the Transmatch probably sees something other than a 50-Ω load looking into the antenna. A similar system exists at C, except that the coax has been replaced with twin-lead and a balun. One form of balun is a network that transforms a balanced impedance to an unbalanced impedance. Although it is shown as a separate and distinct item from the Transmatch, the balun is frequently built into the Transmatch housing. Balun transformers are wound for some specific transformation ratio. The norm seems to be to wind them on toroid cores, but they can be wound on air cores also. At very high impedances, the baluns (particularly the toroidal ones) may not perform well.

Each installation depicted in Fig. 2 shows the Transmatch connected to an

earth ground. This is what most of the books and articles have called for over the years. There is just one catch. Suppose your station is located on the second floor and that it is 16 feet (5 meters) from the end of the ground wire attached to your equipment to the end attached to a ground rod. Keep in mind that the whole

idea of grounding the station for rf is to have the equipment at a low-impedance (and, therefore, low-voltage) position. How effective is the ground when the station is transmitting on the 20-meter band? At 20 meters, 16 feet (5 meters) is approximately 1/4 wavelength long. A quarter-wavelength of wire will act as an im-

pedance inverter from one end to the other. Since the grounded end is at a very low impedance, the equipment end will be at a very high impedance!

The likely result will be rf hot spots all around the station. Suppose that instead of a wire to ground, you connect a wire to the cold water pipe in your apartment, which will ultimately go to ground. Is it a high or low impedance? But what if this pipe is connected to other pipes in other apartments? What if the telephone company has grounded its equipment to the same pipe? Cable TV? In all probability, you have created more problems for yourself than if you had left the station totally "ungrounded." Actually, in the "ungrounded" situation there may be some capacitive coupling to the ac power line, which may act like a phantom ground. This is why a brute force filter is sometimes needed to clear up TVI.

A workable compromise is depicted in Fig. 3. No attempt is made to ground the station to an earth ground. Rather, the equipment is tied to a central point in the station through short pieces of braid. Quarter-wavelength radials are cut for each band to be used and attached to the central point in the station. This is similar to what the old timers referred to as a counterpoise, and it does work. If you have an outdoor antenna, you may want to provide a dc path to ground to allow safe bleed-off of static buildup. If this dc ground is more than a few feet long, I would suggest disconnecting it during operation (you don't operate during a storm, do you?), or at least put an rf-choke in series with the dc ground.

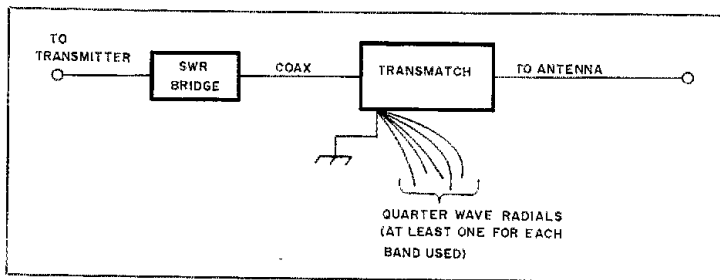


Fig. 3 — Here is an alternative to earth ground for the apartment dweller. At least one quarter-wave-length radial is cut for each band used and attached to chassis ground for the station. This is similar to what the old timers referred to as the counterpoise.

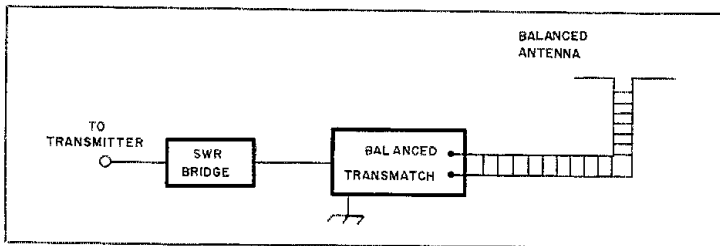


Fig. 4 — A balanced Transmatch is an alternative to the T match. Coax losses and balun losses are avoided by using this system.

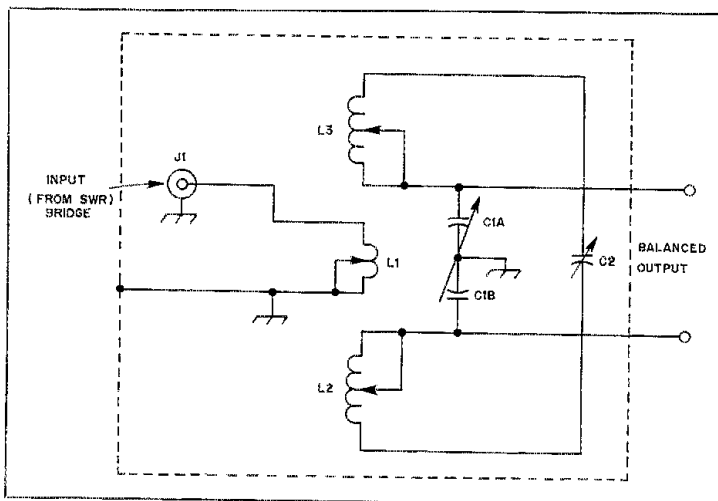


Fig. 5 — Schematic diagram of balanced Transmatch. See text for parts description. Copper-plated alligator clips should be used instead of the ordinary steel clips (Radio Shack #270-373 are suitable). A multipositioned, two-pole ceramic rotary switch may be used instead of the alligator clips on L2/L3. Similarly, a single-pole, ceramic rotary switch may be used at L1. B&W coil stock, shaft couplings, stand-off insulators and miscellaneous parts may be purchased from Radiokit, Box 411, Greenville, NH 03048, Tel. 603-878-1033.

A Critical Balance

When you start with a compromise antenna, it is a good idea to avoid compromises elsewhere in the system since the compromises tend to compound. As mentioned above, in recent years the T match has been the most-often-used Transmatch. The T match has an unbalanced input and feeds an unbalanced output. If a coax-fed dipole is attached to the T match, it should work fine if the antenna is reasonably close to a 50-Ω load to start with. If not, the high SWR on the coax can increase losses. Twin-lead or ladder line is not nearly so lossy. So another approach is to feed the dipole with twin-lead and use a balun at the T match to convert the unbalanced output of the Transmatch to the balanced input of the twin lead. Unfortunately, at extremely high mismatches transformer baluns can also be quite lossy. Under certain conditions transformer baluns can actually generate harmonics!

Fig. 4 shows an alternative to these two systems. If we use a balanced-output Transmatch we can avoid the potential losses of coax and baluns. It can be positioned in the system just as the T match. An SWR bridge ahead of the balanced

Transmatch is used to indicate a matched condition, just as it is with the T match. Several different circuits have been developed over the years, but we recently came across one that is easy to construct and works very well (Fig. 5).¹ Additionally, it can be duplicated in short order at a very modest cost.

Component values are not critical; substitute with whatever you happen to have available. C1A and B are two sections of a three-section, ganged, variable capacitor removed from the carcass of a defunct tube-type a-m broadcast receiver. At the 100-watt output level I have not experienced any arc-over; if that does happen you may have to find a dual-section variable capacitor with wider spacing. Surplus dealers and hamfest flea markets are the suggested sources for the capacitors. C2 is a single-section, 150-pF variable capacitor (it can be one section of another ganged capacitor). Again the exact range is not critical; use whatever you can find. One thing that is somewhat critical is using insulated shaft couplings on both capacitors. Without the couplings, your body capacitance will affect the tuning. C1 can be mounted directly to the chassis, which will ground the rotor; connections to the A-section stator and the B-section stator can then be made to the solder lugs. Both the stator and the rotor of C2 should be insulated from ground; it will probably be necessary to mount C2 on ceramic standoff insulators.

L2 and L3 are made from one piece of coil stock. The coil stock that I happened to use is B&W Air-Dux 1008T (1-1/4-inch diameter, 8 turns per inch, no. 16 wire). Again, reasonable substitutions may be made. Count the number of turns on the total length of coil stock and determine the middle turn. Cut the wire portion of the coil stock at the mid-point, but do not sever the plastic spacers. Solder two insulated wires to each of the ends created by cutting the coil in two. One wire should be 6 inches long and the other should be long enough to reach C1. Attach copper-plated alligator clips to each of the 6-inch wires. The alligator clips will be used to vary the inductance of L2 and L3.

L1 is fashioned from another piece of coil stock of larger diameter, such as B&W 3051 (1-1/2-inch diameter, 4 turns per inch, no. 14 wire). Six to eight turns should be adequate; again attach a short wire with a copper-plated alligator clip on the end to one side of the coil to enable you to tap L1 for the proper amount of coupling. L1 is then slid over L2 and L3 and positioned directly above the center of the coil stock. Mount the coil assembly to the chassis with ceramic standoff insulators at each end of the coil stock (L2/L3). Solder the L1 leads to ground and to the input jack J1. If L1 is not held

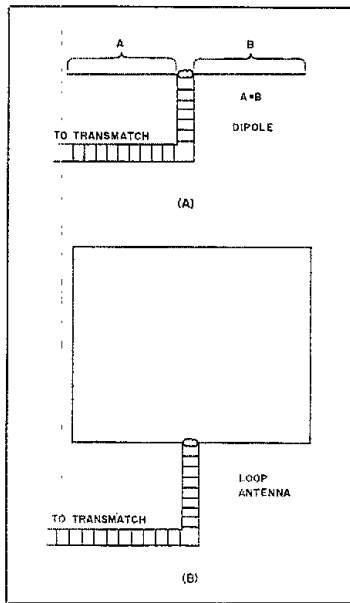


Fig. 6 — Two balanced antennas that should work well for the apartment dweller. The legs of the dipole shown in A should be as long as practical — 65 feet would be considered ideal for each for an 80-meter installation. The balanced Transmatch in Fig. 5 should match any size dipole to the other amateur bands. The loop in B is of any convenient size. It does not have to be laid out in a single plane (flat).

rigidly in place, it may be necessary to wedge strips of plastic or other insulating material between L1 and L2/L3. Complete the wiring according to the diagram in Fig. 5.

Match It

Adjustment is relatively simple and straightforward. Attach a 50-Ω dummy load to the output of the SWR bridge. Adjust the transmitter for a relatively small amount of power out (e.g. 15 watts from a transmitter capable of delivering 100 watts). Set the controls of the SWR bridge to read full scale in the reference (forward) position. Adjust the SWR bridge to read reflected (SWR); if there are no problems with your equipment, it should read something near 1.1 to 1. Replace the dummy load with the Transmatch and connect a balanced antenna to the Transmatch. Don't touch the transmitter controls during Transmatch adjustment.

Make sure that the taps for L2 and L3 are equidistant from the center of the coil stock; L1 can be tapped at any convenient position. Key the transmitter and adjust C1 and C2 for a dip in the SWR reading. If none is found unkey the transmitter and move the taps on L2/L3 (keeping them the same distance from the center).

Repeat the above steps until a match is found. It may be necessary to vary the tap on L1 to obtain the lowest possible SWR reading. Now you can adjust the transmitter for more power and fine tune the Transmatch. Keep a record of the taps for each portion of the band used. This will speed adjustment for future operation. You may also want to use various colored marking pens to mark L2/L3 and L1 at the appropriate spots to speed adjustment.

Two useful balanced antennas are depicted in Fig. 6. The twin-lead can be any convenient length. The legs of the dipole in Fig. 6A can be any convenient length also. If the loop happens to be approximately one wavelength long, maximum radiation will be perpendicular to the plane of the loop; i.e., if it is mounted in a horizontal plane, maximum signal will be straight up. At frequencies other than a full wavelength, maximum radiation will occur in different directions. It is best to experimentally determine the ideal installation for each situation. Either of these in conjunction with the balanced Transmatch should perform adequately inside an apartment, but like other antennas, they will work better if you can get them outside.

There are a few little gimmicks that you learn as you "play around" with indoor antennas. Alan Pike, W8MGF, pointed out to me that plastic mirror clips (found in most hardware stores) are quite useful for holding coax and antenna wires in place. The clips can be mounted to a plasterboard wall with plastic anchors and matching screws. When moving time rolls around, the screw can be removed, the clip taken down and the anchor extracted from the wall. A small amount of spackling compound and a putty knife restores the wall in a few seconds. Holes to attics can be drilled or punched for routing cables and repaired the same way when moving time comes.

Where Do You Start?

The first thing to do is to survey your situation. Is it possible to get something outside? Can you get something in the attic? Is there something that you can use as an antenna that will not be recognized? Start trying things until you find something that works. Keep your eyes open for new ideas or new twists on old ideas that may be applicable to your situation. "Grounding" will probably be the trickiest part of putting in an indoor antenna system. Avoid attaching "ground" wires to the cold water pipes! Strive to optimize everything else since the antenna will probably be a compromise. If at first you don't succeed . . . oh, yeah, I thought I had found the ultimate solution to apartment antennas — a house. But now I am fighting with the city building inspector for the privilege of putting up an antenna on my own property!

¹Hawker, "Technical Topics," *Radio Communications*, RSGB, September 1980, p. 905.