whips and loops
as
apartment antennas

If you're stuck with a poor antenna because you live in an apartment, try one of these recommended by W2EEY

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I have lived in a lot of apartments and tried various solutions to the problem of putting up a reasonably useful indoor or balcony-type antenna for 80- through 10-meter coverage. Most apartments have sufficient space to string enough wire around so that a transmitter will load properly, but getting efficient radiation often calls for the experimental approach.

Strictly indoor antennas—types which are erected **wholly** within an apartment—seem to be the least effective. They often load well, and the SWR may be extremely low when they are carefully cut to resonance. However, much of the radiated energy is absorbed by the surrounding structure and lost. When the same antennas are placed in a wooden frame building they perform fairly well. This is particularly true when they are mounted in the attic away from the wooden structure.

Generally speaking, however, a smaller antenna erected on the outside of the building will perform better. I should point out that antennas which are placed outside a building, but very close to it, don't work too well. An example is a wire from an apartment window or balcony along the side of the building. This antenna can be made to load rather well, but it will couple most of the rf energy into the building. Antennas of this type are generally only useful when local coverage is desired.

I will describe two antennas here which can be used for this purpose: the loaded-whip and the loop antenna. The loop is particularly interesting because when it is properly fed, it is surprisingly efficient, even when relatively small.

loaded-whip antennas

When you must operate from an apartment, the antenna problem is very similar to the mobile installation. When the antenna is indoors, the structure effectively shields it. Unfortunately, there is usually only limited space available to erect the antenna outdoors. The ground point is an indefinite thing, especially at the lower frequencies where a good electrical ground is desirable.

Since apartment antenna problems are similar to mobile operation, many of the techniques which have been applied to mobile antennas are useful for apartment dwellers.

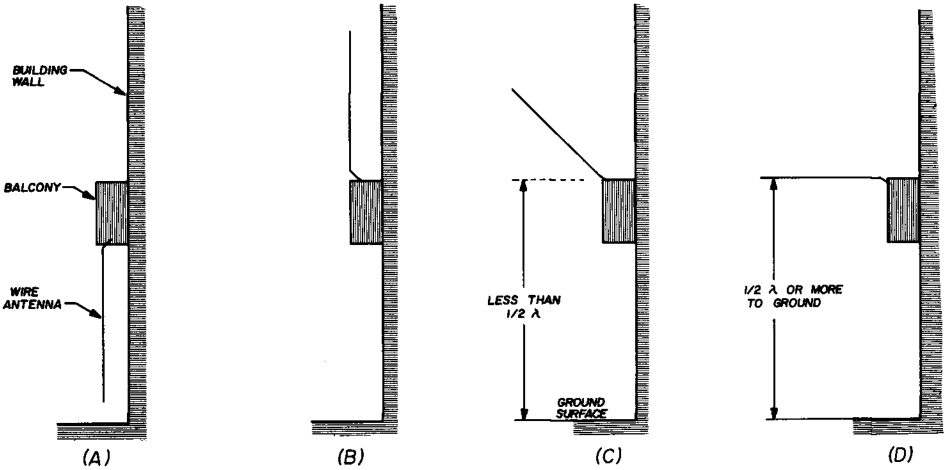


fig. 1. A wire antenna hung along the wall of a modern apartment building (A) couples most of its energy into the building structure as does a window- or balcony-mounted vertical whip (B). The whip should be installed with as great an angle as possible (C and D) from the surface which acts as its ground plane.

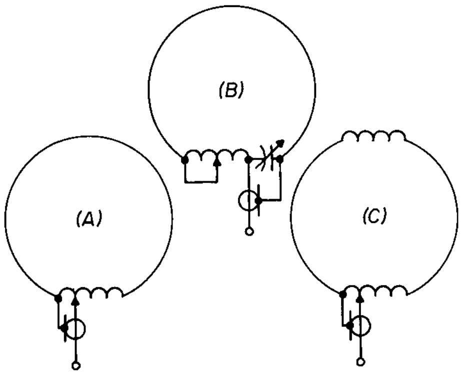
The loaded-whip antenna is not an efficient radiator, particularly on the lower-frequency amateur bands, but it is still one of the best solutions to the mobile antenna problem. Mounted vertically on the automobile, it provides a vertically-polarized radiation pattern of more or less circular shape, depending where it is mounted on the car. The antenna works against the ground plane provided by the automobile and the earth.

When an antenna is used by an apartment dweller, the idea of this **ground plane** is very important. If the antenna is used in an apartment high above the ground, the side wall of the building becomes, in effect, the plane against which the antenna operates. And, for best results, the antenna must be mounted at right angles to this ground plane.

As the antenna is tilted closer to the building surface (toward the vertical), the effective radiated signal decreases rapidly. Although I have made no formal measurements, experience with a ten-foot base-loaded whip in a fourth-floor apartment bears this out. As a balcony-mounted antenna was tilted from a position 90° to the building structure to within about 30° from the structure, signal reports decreased at least 4-6 S-units. The effect is similar to a vertical quarter-wave whip when it is lowered toward the ground.

Because of this effect, recognition of the true ground plane is important. Therefore, a

fig. 2. A simple inductive-loaded loop antenna (A) and variations which may be used for operation from 80 through 10 meters. This type of antenna is inefficient because of the loading.



whip used by the apartment dweller should be placed at right angles to its ground plane, not 90° to the earth. This may change for lower-level apartments because of the effect of the closer ground level. In any case, only a series of actual on-the-air checks can determine the best position for a particular installation.

The effectiveness of the ground connection used in an apartment station is just as important as in a mobile. The mobile ground connection is limited by the fact that the tires effectively isolate the body of the automobile from earth ground. Also, the metal parts of the automobile are not bonded together with low-loss electrical connections. On the lower high-frequency amateur bands it is often necessary to bond the major surfaces of the automobile together with ground straps for best performance.

In an apartment, metal balcony frames and window frames can be used for ground connections but these surfaces must present a relatively large low-loss interconnected mass to be effective. Welded balconies are effective, but screened surfaces which are pressure bonded may present high electrical resistance. Water or heating pipes in an apartment building usually present such a high-loss path to ground that they are useless.

With care in orientation to the building, and a decent ground connection, balcony- or window-mounted whips can be as efficient as a mobile whip. In practice, they are sometimes more effective because of their elevation above ground obstructions. It doesn't seem to matter a great deal whether the whip is base-, center- or top-loaded.

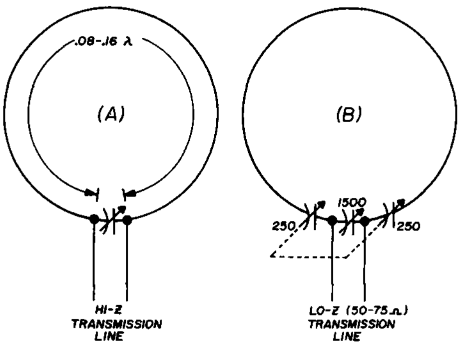
A good ground connection is more readily achieved in an apartment installation than in a mobile. On 10 and 15 meters, where the physical length of a whip can approach a quarter wave, there seems to be a definite advantage to moving the loading coil as far out on the whip as possible. Otherwise, the location of the loading coil on a whip which is less than 10 feet long seems to have little effect on field strength; and, when the coil is mounted at the base of the whip, bandswitching is simplified.

The use of a base-or center-loaded whip antenna in an apartment will generally prove superior to an antenna erected inside the apartment or a wire hung along the side of the building. However, the whip must be properly oriented and a low-loss ground connection or ground surface must be provided.

small-loop antennas

Loop antennas are often used for restricted-space antennas because they may be resonated without the need for a low-loss ground connection. Also, when they are physically small, they are vertically polarized and can be mounted next to any large surface mass. A loading coil is generally used

fig. 3. Because of its inductive property, a loop can be resonated by a capacitor (A) or capacitive divider (B). The scheme in A is useful with high-impedance feedlines while B is more suitable for 50- or 75-ohm lines. The values shown in B are for a 20-meter loop antenna, 20 feet in circumference, constructed of one-inch tubing.



as shown in **fig. 2A** to increase the electrical length of the loop to one-half wave, the length of a self-resonant loop.

The radiation resistance presented by loops is very low; their efficiency is dependent upon the losses of the loading coil. Variations of the basic loaded loop are shown in **fig. 2B** and **2C**. In both cases, if the loop is made from one inch or greater diameter tubing, the major losses occur in the loading coil.

The loops I am talking about here are on the order of 0.08 to about 0.16 wavelengths long. These loops are short enough so that the current is in phase and essentially the same amplitude throughout the loop. The radiation is vertically polarized and the directive pattern is similar to a dipole. Maximum radiation is in line with the plane through the sides of the loop.

Inductive loading is not the only method that may be used to make a small loop resonate. Unlike any other short antenna, the loop has a unique, inductive property which is determined by the area of the loop and the type and size of conductor used in its construction. You can take advantage of its inductive quality and use an external capacitance as shown in **fig. 3A** to resonate it. The overall effect is basically the same as inductive loading. Theoretically, you can't obtain more efficient coupling of power by either method. However, in practice, air-variable or mica capacitors have far less dissipative losses than a loading coil; and, the capacitive method of resonating the loop is far more efficient. The efficiency of a 0.16-wavelength loop approaches that of a full-size half-wave dipole antenna. Smaller loops are less efficient, but far better than inductively-loaded, shortened antennas.

You can visualize the loop as a simple parallel-resonant circuit consisting of the inductance of the loop and the resonating capacitor. When a low-impedance transmission line is connected across such a circuit, a high standing wave ratio results. To match the low-impedance line, either an inductive or capacitive tap system can be used. However, the capacitive system is much more practical and easily achieved by splitting up the resonating capacitor as shown in **fig. 3B.** If you are familiar with the **Transmatch*** antenna coupler, you will recognize that this is basically the same matching system.

If we assume that the capacitor losses are fixed, the overall losses will depend upon the conductor losses in the loop. Low conductor losses are achieved by constructing the loop of one-inch or larger diameter tubing. Low-resistance connections between the loop and the resonating capacitors are an absolute necessity. A wide, flat, strip of metal may also be used to form the loop since the objective is to achieve as large a surface area and, therefore, inductance. A square loop with the same maximum radii as a circle will enclose about one-third less area; the inductance and efficiency will decrease in about the same order.

* L. McCoy, "The 50-Ohmer Transmatch," *QST*, Vol. 45, July 1961, p. 30.

Fig. 3B shows typical values of capacitance necessary to resonate a twenty-foot loop (circumference) on 20 meters. Proportionately more capacitance will be required on lower frequency bands and less on 15 meters. The capacitors should be air-variable types for the greatest possible Q. Matching adjustments are basically the same as a Transmatch antenna coupler. First, the center capacitor and then the two outer capacitors are varied (simultaneously) to obtain a low SWR on the transmission line. The adjustment is a back-and-forth procedure from the center to the outer capacitors.

Once the approximate capacitance value has been determined, two of the variable capacitors may be replaced with fixed values —fine tuning is accomplished with one capacitor variable. Bandswitching can be accomplished in the same fashion since the capacitor values for each band have been determined experimentally.

Such conventional qualities as angle of radiation and directive patterns are almost impossible to establish for such an antenna. The directive pattern will usually be entirely dominant in the direction away from the building surface. However, the lowest angle of radiation and best DX will generally be achieved in directions which are an extension of the building plane against which the antenna is mounted. This factor is true for the loop-type antenna as well as the whip.

summary

Apartment antennas present a frustrating but challenging situation as far as antenna erection is concerned. Probably more than any other factor, aesthetic considerations govern the type of antenna which can be used. An outdoor antenna will invariably produce better results than an indoor one.

The most efficient small antenna is the loop; it is also an antenna which can be made small and unobtrusive. If the loop antenna is properly tuned with a capacitive matching circuit and constructed of heavy low-loss "hardware," it will delight the apartment dweller who has given up hope of satisfactory operation on the high-frequency ham bands.

ham radio