Artificial RF Ground

Maximize your antenna's efficiency.

by J. Frank Brumbaugh KB4ZGC

The ideal RF ground is having your station equipment mounted in and thoroughly grounded to a metal tub floating in salt water. Ham stations in boats approach this ideal, but the rest of us usually have to settle for considerably less efficient RF grounds. The many hams living in high-rise apartments and condos, even those with their stations on the ground floor of the typical house, have station ground leads many feet long between the equipment and actual ground. While this provides the DC ground necessary for safety, it is seldom an efficient RF ground on all the bands that you normally work.

For instance, many hams consider a few feet of wire or braid run to a nearby eight-foot ground stake a good solid ground. But—eight feet of wire is about a quarter wave on 10 meters, and presents a high impedance at the transceiver/transmitter chassis when the other end is connected to the ground stake or other good DC ground on 10 meters. This is not an RF ground at all, and the chassis will be "hot." If the mike tingles your lips, or if your fingers get "bit" by the setscrews in the knobs, you know you do not have a good RF ground, and you must do something about it.

Any length of wire or braid between your transmitter/transceiver chassis and actual earth ground presents an impedance which raises the chassis above ground for RF. Because ground connections are a part of your antenna system, impedance in the ground lead reduces the efficiency of your antenna system.

A Better Ground

To correct this problem, you can force a low impedance at the transmitter/transceiver chassis by shunting the station DC ground with a wire an electrical quarter wavelength long, open at the far end. Connect the other end to the transmitter/transceiver chassis, with the wire snaked on the floor along the shack wall. This quarter-wave "transformer" exhibits a very high impedance at its open end and reflects a very low—theoretically zero—impedance where it connects to the chassis. This provides a very good RF ground at the frequency at which the wire is a quarter wavelength in length. However, the RF impedance at the chassis, while low, will vary from one end of the band to the other, and is most effective only at the design frequency.

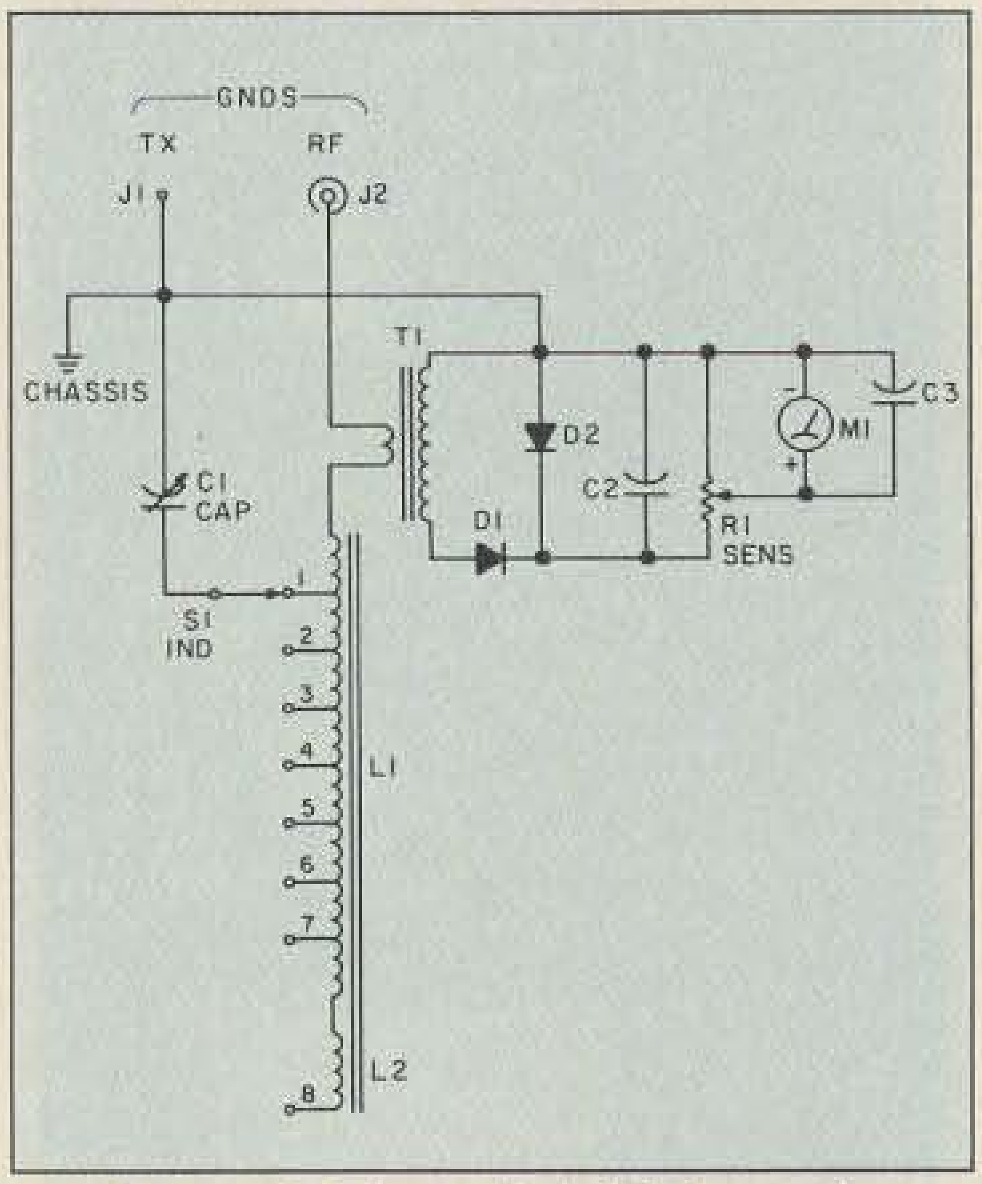

Figure 1. The artificial RF ground.

An eight-foot piece of wire connected to the chassis for an RF ground on 10 meters may be easy to hide, but what if you prefer to work 80 meters? Or even worse, if you like to work all the HF bands? You would need one or more quarter-wavelength wires for each band you normally use—and this can present problems. Few XYLs will tolerate a rat's nest of wires all over the floor, especially if the ham station is not located in a room by itself.

The Artificial RF Ground

This instrument is my solution to the problem of getting a low impedance RF ground on the bands I operate. My station consists of three monoband transceivers running 10 to 25 watts on the 10, 15 and 40 meter bands. It is located on the second floor of a frame house, in my bedroom. (Actually, my bed is in the shack!) My DC ground—a copper water pipe in the bathroom—is 34 feet from the station equipment, and an unknown number of feet from the bath to Mother Earth. I used to use open-ended quarter wavelength wires draped on the floor along the wall for RF grounds, but my cat insisted on dragging them all over the floor in a tangled mess. This made a different approach to RF grounding a virtual necessity.

Circuit Description

The Artificial RF Ground schematic is illustrated in Figure 1. A series circuit, consisting of C1, L1 and L2, is connected between the transmitter/transceiver chassis and a short length of wire which is open on the far end. The chassis, of course, is connected to your DC ground for safety reasons. This series circuit is capable of resonating in all bands between 40 and 10 meters, thus providing a low impedance ground for RF at the transceiver chassis. Current flowing in this series circuit is sampled between C1 and L1 by the primary of T1, and its level monitored on the meter M1. When the series circuit is tuned to resonance as indicated by a peak meter indication, the transmitter chassis is at ground potential for RF.

Theory of Operation

A series circuit consisting of capacity and inductance presents a very low impedance at its resonant frequency. When the transmitter is keyed (on CW, FM or AM) and the chassis is not at RF ground potential, a current will flow in the series circuit of C1, L1/L2 as determined by the position of S1 and C1, and when resonance at the transmitter frequency is achieved, this current will be at maximum. Switch S1 lets you insert varying amounts of inductance in series with C1, depending upon the frequency in use.

The primary of T1, a step-up transformer, is connected between C1 and L1 where the highest current is available. RF current flowing in the series circuit can be sampled, stepped up in the secondary of T1, then detected by voltage doubler diodes D1 and D2, filtered by C2, and applied to the sensitivity potentiometer, R1. The DC voltage across R1 is directed to meter M1, which is bypassed by C3 to eliminate any RF from the meter. M1 will show a peak indication when the series circuit is tuned to resonance at the transmitter frequency.

At this point the transmitter chassis is at ground potential for RF. To ensure the best possible ground, use the shortest possible piece of braid or wire to connect J1 to the transmitter chassis.

Because a series circuit presents an extremely low impedance at resonance, this combination of C1 and L1/L2 and the length of wire which is connected to J2 forms a very low impedance RF ground which is electrically an odd multiple of a quarter wavelength at the operating frequency.

Parts List

C1	365 pF variable capacitor, broadcast radio type
C2, C3	0.01 or 0.02 μF disc capacitor
D1, D2	1N914, 1N4148 or equivalent silicon diode
J1, J2	Banana, pin, RCA jack, etc. (J2 is insulated from chassis.)
L1	36 turns No. 26 AWG e.c. wire on T68-2; tapped at 4, 8, 12, 16, 20, 24 and 28 turns from T1 end
L2	13 turns No. 22 AWG e.c. wire on T68-3 core
M1	100 to 200 μA DC meter
R1	10k linear potentiometer
S1	Wafer switch, 1 pole, 8 positions
T1	36 turns No. 26 AWG e.c. wire on T68-2 core; primary 1 to 3 turns insulated hookup wire

Suppliers

Amidon Associates, P.O. Box 956, Torrance CA 90508. (213) 763-5770. (Toroids.)

Fair Radio Sales, 1016 E. Eureka, Box 1105, Lima OH 45802. (419) 227-6573. (365 pF variable capacitor.)

Radiokit, P.O. Box 973, Pelham NH 03076. (603) 437-2722. (Toroids and 365 pF variable capacitor.)

Construction

This instrument should be constructed in a metal cabinet or box such as the Radio Shack 276-238, which measures 5½" x 3" x 2⅛". Tuning capacitor C1 is a standard broadcast radio capacitor with a maximum capacity of approximately 365 pF. If you don't have one in your junk box, they are available from Fair Radio Sales (P.O. Box 1105, Lima OH 45802) and other mail order dealers. Plate spacing is not a problem because of the high current/low voltage characteristics of a series circuit. Toroids for L1, L2 and T1 are available from Amidon Associates (12033 Otsego St., North Hollywood CA 91607) and other mail order dealers. Meter M1 can be any of the small surplus tuning meters with a full scale reading of 100 or 200 μA.

Most of the parts for this invaluable addition to your operating position can be found in your junk box with a little help from flea markets or other hams. I had to buy the aluminum box from Radio Shack ($2.49), but all the rest of the parts came from my junk box. Even if you have to buy all new (surplus) parts, the total cost should not exceed $10. This is a cheap price to pay for knowing your station is properly grounded for RF as well as DC, and your antenna installation is operating at peak efficiency.

Operation

Connect the shortest possible length of braid (preferred) or wire from J1 to the ground post on your transmitter/transceiver chassis. This chassis must, of course, also be connected to your station DC ground. Then attach a wire 10 or 12 feet long to J2, leaving the far end open. Be sure to tape up the open end of this wire so no one, including children or pets, can touch the bare end while your station is on the air. There will be a high RF voltage present at this end of the wire when transmitting. Dress this wire on the floor along the wall behind your operating position, or under the carpet if you have a fancy shack.

Tune up your rig on any chosen band. Then, with a constant carrier output—5 to 20 watts output will be sufficient—tune C1 (CAP) and S1 (IND) for a peak indication on meter M1. There may be more than one position of S1 which works. Choose the position that provides the highest peak meter indication. Use the sensitivity potentiometer R1 to keep the needle on the meter scale.

Each amateur radio installation is unique. No two are exactly alike. At my station, position 8 of S1 is used to tune 30 and 40 meters. The higher bands use various taps selected by S1, providing less inductance. If you find that you have a meter indication on 10 meters, but it will not peak at minimum positions of S1 and C1, shorten the wire connected to J2. If the same thing occurs on 40 meters at position 8 and maximum position of C1, lengthen the wire connected to J2. If you wish to operate 80/75 meters, either add a much longer wire to J2, or ignore the problem. This instrument is designed to provide an excellent, low impedance RF ground on those frequency bands where such a ground is most important—40 through 10 meters. Most ham stations operating on 80/75 meters already have a good RF ground because of the long wavelength and the relatively short DC ground lead to earth.

When you achieve a peak indication on the meter, the cabinet of the Artificial RF Ground is at ground potential for RF. If the length of braid or wire between J1 and your transmitter chassis is short, it too is at RF ground potential. Thus, you will have an excellent RF ground.

On some frequencies you may find that you can get a very low indication, or nothing, on the meter. If this occurs—congratulations! You already have an excellent RF ground on that frequency.

Caution

Although J1 and the chassis of the Artificial RF Ground are both at DC ground and connected directly to your transmitter chassis, it may sometimes be above ground for RF, especially while tuning for a peak on the meter. Touching the metal cabinet of this instrument may cause errors in meter indications. There is no danger involved but, by touching the metal cabinet, you are effectively placing your body in parallel with the series circuit, detuning it, and preventing a proper indication of resonance on the meter.

It's Worth the Work

Use of the Artificial RF Ground does more than please your rig. It will also eliminate any television interference that is not a result of harmonics or stray rectification. This will also please XYLs and close neighbors, a matter of importance to many hams, especially those in apartments or condominiums. Before I designed and installed this instrument, and operating at 10 watts PEP, my signals eliminated video and distorted the audio on several television sets in the house, as well as in a few surrounding houses, even though my rigs are clean and all the connections are solid in the antenna system. When installed and tuned to resonance, the Artificial RF Ground totally eliminated all TVI (we are served by a Cable system here), even on a 12-year-old color set sitting in the shack beside the rigs. Although fundamental overload may still be a problem for high power ham installations, using the Artificial RF Ground should eliminate all other sources of TVI, especially in Cable TV installations. 73

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