R.F. Induced Problems And Solid-State RTTY Terminals

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Over the past 10 years, there has been an explosion in RTTY activity on the amateur bands, due largely to readily available solid state RTTY terminal equipment. As the electronic industry in general has become more and more dominated by digital techniques, our interests as amateurs have also expanded to include digital techniques. Today, amateurs are either building their own solid-state digital RTTY equipment or buying commercially manufactured RTTY gear. The solid-state terminals offer many features over their mechanical predecessors, features that were just not feasible with machines. The solid-state terminals are also quieter and smaller than the machines and they don't drip oil on the floor!

However, the digital terminals do have a weakness that rarely bothered a mechanical TTY machine—r.f.i. from the transmitter. Unfortunately, it is the very nature of the small low-voltage device that makes all the extra features possible. Consider, for a moment, the tube radios and RTTY demodulators we used in the 1950–1965 period; the circuits in that equipment operated from a 150 to 300 volt power supply, and stray r.f. voltages of 0.1 to 5 volts would rarely cause a problem. On the other hand, modern digital circuitry operates from a 5 v.d.c. power supply, and a 1 volt stray r.f. signal will definitely affect its operation. The digital circuits are designed to operate at very high switching speeds, and the addition of a 20 or 10 meter r.f. signal will just be interpreted as a high-speed digital signal, often causing the terminal to "blow-off into space." All is not lost, however; a digital terminal can be made to work with even the highest powered amateur transmitter if suitable precautions are taken in both their design and installation. Although each r.f.i. solution tends to be slightly different, depending upon the particular characteristics of each installation, there are some recognized techniques that should help your situation.

First, the digital terminal **must** be constructed so that it is *itself* well shielded and includes internal r.f. bypassing of all input and output connections (including the a.c. power connection). There is *no* good substitute for a metal shielding enclosure! The shielding and bypassing serve a two-fold purpose: (1) they keep the transmitter r.f. from getting into the terminal, and (2) they keep the digital r.f. "noise" from escaping to interfere with the receiver. The lack of r.f. shielding in plastic cabinets has been a particular problem for amateurs using hobby computers, and it is the reason behind the recent FCC r.f.i. regulations (Part 15, Subpart J) requiring r.f.i. suppression. Some plastic cabinetry now being manufactured includes special conductive coatings to achieve r.f. shielding. However, the shielding materials are expensive, and the do-it-yourself amateur will be time and money ahead if he builds his digital equipment in a metal enclosure.

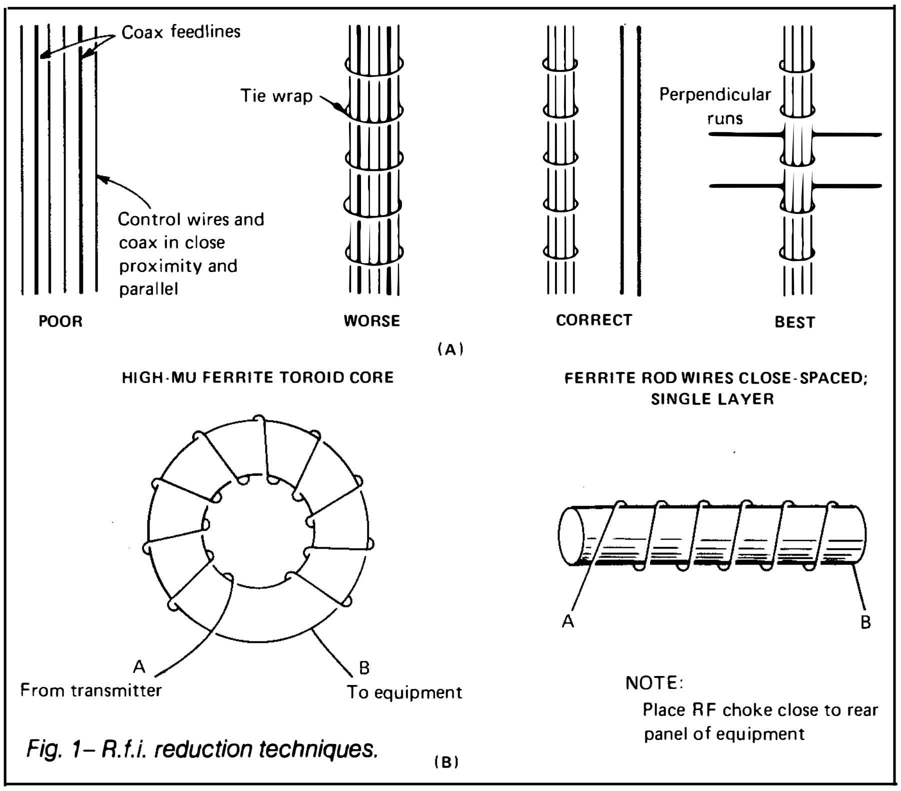

Fig. 1– R.f.i. reduction techniques.

Most of the commercially available amateur RTTY terminal equipment has been designed to operate in close proximity to radio frequency transmitting and receiving equipment. Particular attention should have been paid to the shielding and by-passing of the terminal circuitry. However, under certain conditions in an r.f.-saturated environment, the terminal may still be susceptible to r.f.-induced interference. This may manifest itself in any of a number of ways, such as partial or complete lack of response to switches or keyboard operations, or erratic behavior of the video display.

The first thing that should be checked if r.f. problems are suspected is the **ground** system. The transmitter should be properly grounded for r.f. (in addition to an electrical safety ground), and all other station equipment grounds should be connected to the transmitter chassis. The r.f. ground should consist of a short length of heavy copper wire or braid terminated at a good earth ground (ground rod, cold water pipe, etc.). If a water system ground is used, be sure that the pipes are 100 percent metal from the connection point to the water mains; plastic plumbing obviously will break the ground path. If the distance between your transmitter and ground connection is more than a quarter wavelength at the highest operating frequency, make the ground wire an integral number of half-wavelengths long. If you plan to operate 10 and 15 meters, you may need to run separate ground wires for each band.

Stations located on the second floor of wood frame houses can present special problems for r.f. grounding. One technique that has worked well when none of the usual ground returns work is to spread copper screen material on the floor of the room under the operating position. The equipment ground is then attached to the screen with one or more low inductance leads. The screen creates an "artificial" ground plane in the room. A carpet is usually placed over the screen to improve the appearance of the room! Consult any of the amateur handbooks or antenna books for a more in-depth discussion of grounding techniques.

The best way to confirm that a problem is caused by r.f.-induction is to temporarily eliminate the source. This may be done in stages, starting with a partial reduction in exciter drive, and ending with transmitter shut-off. Since r.f. energy may be induced in the terminal through several paths, connecting the transmitter to a dummy load may not eliminate *all* r.f. related problems, although this is an excellent first step in verifying r.f. problems.

Radiation of r.f. energy from linear amplifiers, antenna tuners, coaxial switches, monitor scopes, and interconnecting coax-cable jumpers is also possible. In fact, it is this type of radiation that is most likely to be coupled into nearby I/O and power cables of the terminal. To locate the point or points of radiation, experiment with different cable arrangements to see if the r.f.-induced problem can be eliminated by reducing coupling between any of the terminal cables and nearby coaxial lines carrying r.f. power. Fig. 1(A) shows several cable arrangements, both good and bad, showing how to keep r.f. coupling to a minimum. Fig. 1(B) shows how to use high-mu (950–2000) ferrite toroids or rods to choke the flow of r.f. on audio and control lines.

If cable rearrangement doesn't yield positive results, then begin eliminating pieces of equipment and sections of coaxial cable until the transmitter is connected directly to a shielded dummy load. As each piece of equipment is removed from the transmission line, check to see if the r.f.-related problems have diminished or disappeared. If the r.f. problem persists with the exciter connected directly to a dummy load, reduce the drive level to see if that eliminates the problem.

If operation into a dummy load does not significantly reduce the r.f.-related problems, disconnect all I/O cables from the terminal. Test the operation while it is connected only to a.c. power. At the same time, enable the transmitter so that it sends a c.w. signal into a dummy load. If r.f. problems are still present, then r.f. energy is probably being introduced to the terminal through the power cord by way of the common a.c. mains power line. This is usually indicative of poor a.c.-line filtering in the radio transmitter power supply section. Fig. 2(A) shows a common by-pass filter method used in many transmitters. Figure 2(B) shows a "brute-force" a.c. line filter that can be added to the transmitter or other equipment to eliminate the flow of r.f. on the a.c. power line.

In addition to the liberal use of r.f. bypassing capacitors on station equipment, the use of certain antennas may offer reduced levels of r.f. in the radio room in many cases. Whenever possible, use **resonant** dipole, vertical, quad, or Yagi antennas and try to achieve a good impedance match **at the antenna** instead of relying on an antenna tuner. Random-length wire antennas and others that require extensive antenna tuning are more likely to create high levels of r.f. within the vicinity of the operating position.

The location of the transmitting antenna with respect to the radio room also has an effect on the r.f. energy that is coupled into interconnecting cables. Apartment dwellers may have the most difficulty achieving a good installation, since many times an indoor antenna is the only type allowed. Where outdoor antennas are allowed, they should be placed as high as practical. Not only will this provide for better reception and transmission, but it will also reduce the level of r.f. in the shack. Also, if possible, avoid bringing an end of a half-wave dipole in close proximity to the operating position; there is a high voltage field at the ends of the dipole that may be hard to shield.

In general, a shielded, coaxial cable feedline with low s.w.r. is much preferred over open wire, twin-lead, or single wire feed systems. The self-shielding property and lower voltages present act to make the coaxial feedline much less susceptible to radiation of r.f. energy in the shack rather than at the antenna. R.f. energy may also find its way back to the station by conduction down the outside of the co-

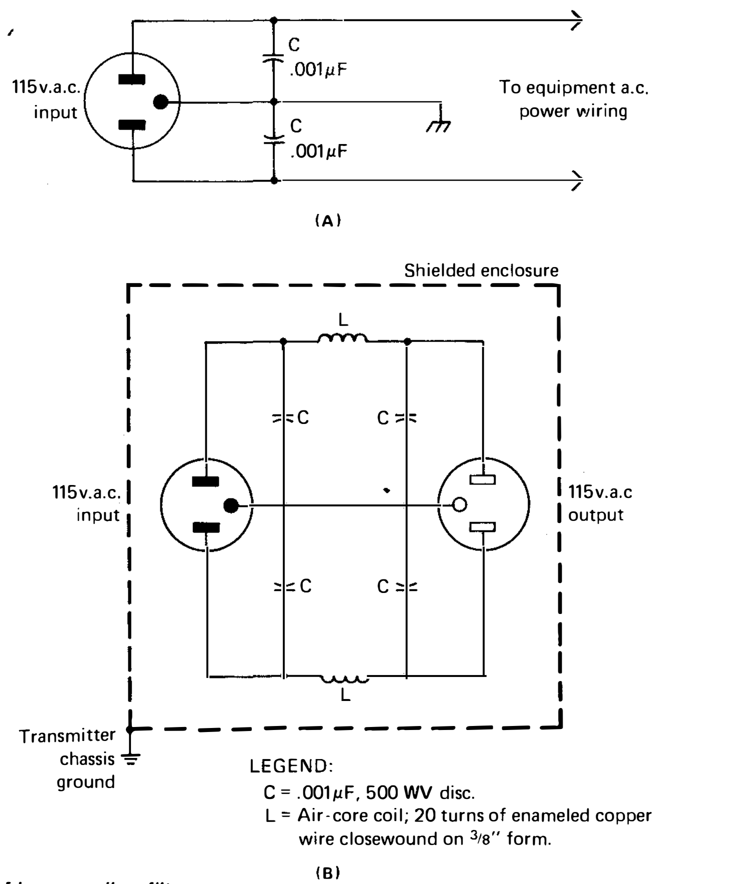

Fig. 2– R.f.i. power line filters.

axial cable shield. This may be a particular problem with half-wave dipoles on 40 and 80 meters that are center-fed with only coaxial cable. A balun at the antenna tends to reduce this problem. Also, dress the coaxial cable from the balun so that it drops *perpendicular* to the dipole, rather than parallel. In stubborn cases, you may find that dropping the coaxial cable clear to the ground and burying it (5 or 6 inches) for the horizontal run to the shack may help reduce r.f coupling considerably. This technique has worked particularly well for second-story station installations. As an alternate to the balun, construction of an r.f. choke out of the coax itself is sometimes effective; wind six or more turns of the coaxial cable in a six inch diameter coil. Place the coil at the antenna and wrap it with electrical tape to hold its shape. If there is a moderate to high s.w.r. on the line (2:1 or more), you may find that varying the length of the line helps, although this is a poor substitute for a properly matched antenna.

Experience has shown that the TV monitor itself may be a source or conductor of r.f. interference. Various circuits of the TV monitor (particularly the sweep circuits) can and do generate r.f. interference which may be heard in the receiver. Also, the video output to the monitor is a wide-bandwidth digital signal with rich harmonic content as is required to produce the crisp character display. If the TV set is poorly shielded (or not at all in some plastic-cabinet models) or lacks proper power line by-passing, the r.f. from the monitor's circuits or from the video output may escape to cause receiver interference. Also, r.f. from the transmitter may enter the monitor and disrupt the monitor or terminal operation. This may be quickly tested by simply disconnecting the video cable from the terminal. There is no substitute for good shielding and by-passing; metal cabinet monitors are highly recommended!

These are some of the r.f.i. suppression techniques that are known to work with digital devices. As we mentioned earlier in the discussion, each r.f.i. problem tends to be unique, and you may have to try some or all of these ideas to solve your own problem. The following is a short bibliography of articles and books where more information about r.f.i. suppression may be found.

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