Using Ferrite Beads

Keep RF Out of TV Sets, Telephones, VCR's
Burglar Alarms and other Electronic Equipment

RFI and TVI have been with us for a long time. Now we have microwave ovens, VCR's and many other devices that do wrong things when they pick up RF.

There are several ways to tackle the problem but most of them involve opening the affected equipment and adding suppressor capacitors, filters, and other circuit modifications. Unfortunately there is a serious disadvantage associated with this approach. Any modifications made to domestic entertainment equipment can - and often are - blamed for later problems that arise in it. Modifying your own equipment is not so bad, but taking a soldering iron to your neighbor's stereo is risky. An alternative approach is to use ferrite beads to reduce the amount of RF entering the equipment. If the equipment is in a metal box, or even if it's in a plastic box, if RF is prevented from entering the box on the antenna lead, the power cable, the speaker leads, the phono pickup leads, and on any other wires entering the box, it is possible to solve the problem without any modification to the equipment. Ferrite beads just slip over the wires and stop RF from going in.

Ferrite beads are made of the same materials as the toroid cores used in broadband transformers but are used at much higher frequencies. For example, ferrite Mix 43 is used for tuned circuits in the frequency range 0.01 to 1 MHz. It is efficient and losses are low. But, if it is used in the 1-1000 MHz range it is lossy. So when you slip a bead of Mix 43 over a wire and there is RF in the 1 -1000 MHz range going down the wire, it is just as though you put a resistor in the wire. But you did not have to cut the wire to insert the resistor; you just slip a bead over the wire. If the resistance of one bead is not enough you can add more beads or add longer beads to get more resistance. The beads, unlike a resistor, do not affect the wire at low frequencies so the audio, DC, and other low frequency components go through the wire just as though the bead were not there.

There are three bead materials in general use: Mix 77, Mix 43, and Mix 64. Mix 43 is the best for all-round use. It works from 1 to 1000 MHz. Mix 77 is a little better at the lower frequencies, so if your major problems are on 80 and 160 meters use it. Mix 64 is a little better on the higher frequencies so if your problems are mostly on two meters and up use it.

It is important to remember that the frequencies mentioned are those of the interfering signals to be eliminated, not the operating frequencies of the equipment being protected. For example: To protect a telephone operating

at voice frequencies of 0.002 MHz we use type 43 or 77 beads to keep 14 MHZ RF out.

So when you buy beads you must specify both the physical size (FB-3, FB-8, etc.) and the material (Mix 77, Mix 43, etc.) depending on the frequency of the RF interference. FB-1, FB-3, and FB-7 have 0.05" holes that will slip over bare #18 gauge wire. FB-8 has a 0.09" hole and will slip over the insulation of #22 wire. FB-24 and FB-63 have 0.2" holes to go over larger wire or cable. FB-56 has a 1/4" hole to clear RG58/RG-59/RG-58X. FB-102 and FB-124 have 1/2" holes to clear RG-8/RG-11.

Cables. So far we have talked about slipping beads over individual wires. But, in many cases, we are going to find two wire speaker cables, two wire or three wire power cables, twinlead antenna cable, and multi-wire control cables. Cable wires are close together and act just like a single wire as far as RF pickup is concerned. So the whole cable can go through the bead and this will suppress RF transmission through all the cable-wires. This is a lot easier than putting beads on each wire.

Twinlead is a special case. If you put a bead on each wire you'll kill the TV signal. But if the whole twinlead goes through a single bead, the TV signal goes on through but the RF interference is suppressed by the bead. This is because the twinlead is a transmission line to the TV signal but looks like a single wire to the RF interference.

This brings us to coaxial cable. The signal going through the coax is confined to the inside of the coax shield. But the outside of the shield acts just like any wire; it can pick up RF and that RF can be carried to the TV or monitor. Shield beads placed over the cable will suppress this interference.

Toroids. When we start talking about slipping beads over coaxial cable and multi-wire cable we see that we may need beads with pretty big holes. Also, if the cable has a molded plug on the end (like some power cords, for example) the plug has to go through the hole and we may need a very big hole indeed. Fortunately a variety of ferrite toroid cores are available with holes as big as 1.4" diameter. They are not available in all the same materials as beads but in similar ones. As a guide when specifying toroids for RF suppression: Mix 43 is the best for all-round use. It works from 1 to 1000 MHz. Mix 77 is a little better at the lower frequencies, so if your major problems are 80 and 160 meters use it. Mix 61 is a little better on the higher frequencies so if your problems are mostly on two meters and up use it.

After you put that big plug through the toroid hole you'll find that the toroid fits the cable very loosely. Don't worry. It will still work fine. If there is

room to do it, loop the cable around and run it through the toroid again. Do this as many times as you can. Each turn is just like adding another toroid. And, using the big Mix 61 cores, you add an inductive choke where two turns is four times as good as one turn, three turns is nine times as good, etc.

Split Beads. This is a new development to solve the problem of putting beads or toroids over cables that have big plugs on the end. They are beads that have been cut in half. You put the two halves over the cable and wrap them with tape to hold them together. The mating edges are polished smooth so the two halves mate very closely.

They are available with center holes of 1/4" and 1/2' diameter. Also for flat computer cable 2 or 2-1/2" wide. It is important that the two halves of the split beads fit exactly together. So the 1/2" hole beads cannot be used for cables larger than 1/4". It does not matter if the cable is smaller than the hole. All split beads now available are of 43 material which is the best overall material for 1-1000 MHz interference suppression.

Telephone Interference. The standard telephone is highly susceptible to RFI. The telephone wiring in the house and outside on poles make a large receiving antenna. And in the telephone instrument are voltage-variable resistors that act like detector diodes so nearby radio stations are clearly heard. The solution is to keep RF out of the telephone by putting ferrite beads on the telephone cable as it enters the instrument. The plug of modular telephones will go through F82 toroids. Unplug the wire from the telephone, put it through the hole of the toroid (three or four times if there is room) and plug it back into the telephone. Or use a split bead.

Burglar Alarms. These are much like telephones in that they have extensive wiring throughout the building that acts like an antenna to pick up RF. The solution is the same: Use beads or toroids on the wire entering the electronics box to keep RF out. It also may be necessary to put beads on the 115-v AC power cord.

TV Sets. Put a bead or toroid on the power cord as it enters the set. Toroids or split beads on the antenna cable also may be needed.

VCR's. The VCR is a real RFI problem. Ferrite beads on all wires entering the VCR can eliminate RFI from most amateur bands. But on 80 meters even this doesn't always work. It may be necessary to shield the VCR housing to completely eliminate RFI.

Stereo. Long speaker wires can act like an antenna to pick up RF and feed it into the output of the amplifier. The amplifier's feedback circuit allows the RF

to reach the input where it is rectified, amplified and then heard in the speaker. The solution is to use beads on the speaker wires just as they leave the amplifier. RF can enter the stereo system through the power cord. Use a split bead or a toroid on the cord just as it enters the stereo.

We have been talking about keeping RF out of equipment. You can also use beads and toroids to keep RF in. That fish tank heater that makes all that racket on 80 meters is using its power cord and the house power wiring to radiate interference. A bead or toroid on the power cord right at the heater can keep the noise from entering the wiring. Computer power cords and connecting cables can be treated in the same manner. Sometimes RF comes out of a transceiver's power cable. A toroid can stop it. Or RF flows on the outside of the antenna cable, going right around your lowpass filter. Again, toroids to the rescue.

Computers. Computers are a part of many modern amateur radio stations. Often they are directly connected to the transceiver for RTTY, packet and other digital modes. They also are used for contest scorekeeping and other uses. Computers generate RFI because they use digital waveforms in the high frequency band that have high harmonic content. They can cause interference throughout the shortwave band and even into VHF.

Some of the interference is radiated from the circuit boards but the most common source is interference conducted out of the computer on the many cables that connect it to its monitor, its keyboard, its printer, and the radio or its data controller interface.

To get rid of the interference, it is helpful to try to find which cable it's coming out of. Start by tuning in the interference and writing down the "S" meter reading. Then disconnect, one at a time the devices connected to the computer and as you do so note any change in "S" meter level. Disconnect the printer, the modem, the keyboard, the mouse, the monitor, the data controller, and anything else connected to the computer. Hopefully this procedure will give a good clue as to where the problem lies.

If you isolate the major problem to one external device, place toroid cores or split beads over the lead from the computer. Do this right at the exit point from the computer. Also, if the affected device is itself an active generator, a monitor for example put beads right where the leads come out of it. Watch the "S" meter for any change - this tells you if you are getting somewhere. Also, if the device has a power cord or a telephone cord put beads on them. Always remember that telephone and power wires can conduct interference outside your residence and near your antenna.

Split beads usually are the best for computer RFI. The cables have big connectors that won't go through a reasonable size toroid. Removing the connectors to slip on a toroid and then rewiring the connector is a lot of work and you might make a rewiring mistake and get into real trouble. Split beads are great! And they are effective from 1-1000 MHz. Just be sure that the two halves of the bead fit tightly together.

If a bead reduces but does not eliminate an interference signal, try more beads. If one is good, two are better. In stubborn cases add capacitors. A capacitor from a lead to a ground converts the bead into a low pass filter. Use ceramic disc capacitors of 0.001 to 0.01 mfd. In a multi-wire cable one bead serves all but you will need a capacitor to ground from each wire.

Each interference problem is different. You have to try this and then try that until you find a solution. Using the principles outlined here, ferrite beads and toroids can be extremely helpful. –30-

Editor's Note

Q. What is the best place to insert such devices? Is it at the antenna, as the article recommends? What would be wrong with putting it at the transmitter? Isn't a series resistor still a series resistor, as long as it's anywhere between the source and the load?

A. The balun must be right at the antenna. It is not in series between the source and load. Coaxial cable acts like a 3 wire cable: 1) The inner conductor, 2) The inside of the shield, and, 3) The outside of the shield. The power flows through 1 & 2. Due to skin effect the current on wire 2 (inside of the shield) does not penetrate the shield and flows only on the inside. This leaves the outside of the shield free to carry a different RF current. The current coming up the inside of the shield is supposed to go to one side of the antenna but there is nothing to stop it from flowing down the outside of the shield. Without a balun some part of the current will flow down the outside. The balun prevents that by presenting a resistance (or an inductance) to this path. If the balun is down at the transmitter this current can flow that far and thus will radiate. The balun does not affect the path between transmitter and antenna; just this unwanted current path on the outside. Ferrite bead baluns are only practical as 1:1 ratio. Ferrite transformer baluns can be made also in 4:1, 9:1 etc.