Palomar Engineers™

Consumer Electronics

Radio Frequency Interference Solutions

RFI Tip Sheet #3

Using ferrite beads, split-beads, and toroid rings to keep RFI out of consumer electronics equipment including home theater systems, telephones, garage door openers, sprinkler systems, alarm systems, computers and other electronics

RFI has been with us for a long time and is becoming an increasingly. common occurrence (and nuisance) between electronic devices acting as unintended transmitters and receivers causing disruption of normal device operations.

There are several ways to tackle the problem but most of them internal circuit modifications. Unfortunately there is a serious disadvantage associated with this approach. Any modifications made to consumer electronics 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 electronics is risky.

An alternative approach is to use ferrite filters to reduce the amount of RFI entering the equipment (called protecting the VICTIM) or alternately, suppressing the RFI leaving a SOURCE that uses any attached wires for transmitting antennas.

In the case of a typical home theater system with multiple electronic devices, any one of the components can act s a SOURCE of RFI or can be a VICTIM of RFI from another SOURCE. The individual wires connecting the equipment, the power cable and the speaker leads can all act as "antennas" either receiving the interference or transmitting interference to other devices. It is possible to solve the interference problem without any modification to the equipment by using ferrite beads that slip over the wires and stop RFI from going in or out.

Ferrite filters are made in three basic shapes; namely **beads**, **split beads** (snap on), or **toroids** (rings) in various sizes to fit the wires and cables they protect. Ferrite material composition also varies and the particular composition (called a "mix") varies depending upon the frequency range to be filtered.

There are four mixes commonly used and they cover the frequency range off 100 KHz to 2,000 MHz as follows: Mix 77 - .1-50 MHz, Mix 31 - 1-300 MHz, Mix 43 - 20-300 MHz, and Mix 61 - 200-2000 MHz. Mix 31 is the best for all-round use but it not available in all shapes and sizes like mix 43 which is less effective under 20 MHz. . Mix 77 is excellent for low frequency RFI generators such as switching power supplies and energy controllers using square wave regulation. Mix 61 is the only choice for RFI suppression on frequencies above 300 MHz.

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 an audio amplifier operating at voice frequencies of .002 MHz, use Mix 31 beads to suppress ham radio and CB radio transmitter RFI from 1-300 MHz.

When buying ferrites you must select the proper mix and frequency range otherwise they may not be effective for your RFI!

Ferrite beads are very useful for wires and cables without connectors as they easily slip on the wire or the wire can be passed through the center multiple times to increase the effective RFI suppression. (Note: for all shapes, RFI suppression (resistance) increases as the square of the number of turns through the center. E.g. 2 turns through the center is equivalent to 4 ferrites with 1 single turn, 3 turns is equal to 9 ferrites with a single turn, etc.).

Ferrite beads from Palomar Engineers have center holes from .063″ to 1" diameter and in mix 77, 31, 43 and 61 (20 KHz to 2000 MHz).

Split Beads are a convenient way to solve the problem of putting ferrite filters over wires or 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 close the cover to hold them together. The mating edges are polished smooth so the two halves mate very closely. It is important that the two halves of the split beads fit exactly together. It does not matter if the cable is smaller than the hole.

Split beads from Palomar Engineers have center holes of 1/4″ to 1" diameter and in Mix 75/77, 31, 43 and 61 (20 KHz to 2000 MHz).

Toroid Rings are usually chosen for ferrite filters due to their large inside diameter useful for multi-turn wire and cable use and their ability to accommodate large connectors or plugs at the end of power and control cables. Fortunately a variety of ferrite toroid core sizes are available with holes up to 3″ in diameter. Rings are not available in all mixes in all sizes like beads, but cover the same frequency suppression range and have higher RFI suppression due to a larger number of turn's capability.

Using Ferrite Filters

Placement. Ferrite filters should be installed as close as possible to the VICTIM or SOURCE input/output wires or cables (a.k.a. "antennas") so as to suppress the RFI entering a VICTIM or suppress the RFI generated by a SOURCE.

Wires. When you slip a ferrite bead over a wire and there is RFI (also called common mode current) conducted down the wire (in addition to the "normal" AC or DC signal), it is just as though you put a resistor in the wire which only reduces the common mode current. You do 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 put the wire through the ferrite center multiple times to get more resistance, The beads do not affect the audio, DC, and other low frequency components going through the wire, but are highly effective

in suppressing the common mode current. A good rule of thumb is to make the filter resistance at least 10 times the line impedance (e.g. a 50 ohm coax line needs at least 500 ohms of filter resistance at the frequency of operation – 5,000 ohms would be 10 times better).

Multi-wire 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 or three wire power cables, USB or Ethernet cables, and multi-wire control cables. Cable wires are close together and act just like a single wire as far as RFI is concerned. The whole cable can go through the bead which will suppress RFI transmission through all the cable wires. This is a lot easier, and cheaper, than putting beads on each wire.

Coaxial Cable. The desired signal going through the coax is confined to the center conductor and the inside of the coax shield. But the outside of the shield acts just like another wire; and it can pick up RFI which is conducted to the VICTIM device. Beads, split beads or rings placed around the cable shield will suppress this interference without affecting the desired signal carried inside the coax cable. Likewise, you can suppress RFI conducted on the shield from a SOURCE connected to coax by using beads, split beads or rings.

Common Sources and Victims

RFI Sources include AM broadcast transmitters, Ham & CB transmitters, switching power supplies (including all electronics powered by wall warts), cable TV boxes, computers, heating and air conditioning motors and controls, AC powered exercise equipment, washer and dryer motors, solar system components, LED lights, routers and cable modems, fish tank heaters, fluorescent lights, plasma and some HDTVs, electric fences, alarm systems, and battery chargers.

RFI Victims includes any electronic device that malfunctions by acting as an unintended "receiver" of RFI via input/output connections. Typical sources listed above can also by Victims of RFI.

Specific VICTIM Solutions

Home Theater Systems including HDTV, cable boxes, Roku®, CD/DVD players, powered sub-woofers, stereo equipment, VCR's, etc. The Palomar Engineers Home Theater RFI kit (part# RFI-HTS) is an ideal solution which contains ring filters for the power lines, and split beads for the interconnect cables. To suppress AM broadcast interference use our AM Broadcast RFI Kit (part# RFI-AM). Each of these kits provides filters for the AC power lines and interconnect cables.

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 also enter the stereo system through the power cord or any interconnect wires. Use A ferrite ring on the cord just as it enters the stereo and use split beads on the interconnect wires (use multiple turns for best results).

Alarm Systems include the alarm system and all sensors, AC/DC power and telephone line (if used). These systems have extensive wiring throughout the building that acts like an antenna to pick up (or generate) RFI. The solution is to use beads or toroids on the wire entering the alarm controls to keep RFI out. For best results use our Home Alarm System RFI Kit (part # RFI-3). Wired audio sensors like smoke detectors and heat detectors can also benefit from additional filters on the cable next to the sensor.

Computers. Computers are a part of our daily life and they can be a SOURCE or VICTIM of RFI. They 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 affecting many electronic devices.

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 internet interface.

To get rid of the interference, it is helpful to try to find which cable it's coming out of. Start by listening to the RFI (on a radio or TV or affected device) and observe the intensity of the RFI. Then disconnect, one at a time, the devices connected to the computer and as you do so note any change in RFI intensity.

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. Palomar has RFI kits for routers, Ethernet hubs, Desktop and Laptop computers consisting of snap on and ring filters sized for the typical device cables. Check the website for specific computer solutions.

Garage Door Openers can open (or close) seemingly at random, but, in most cases, this is due to an RFI signal interfering with the control lines or AC power lines to the opener. Palomar has addressed this issue many times and designed a Garage Door Opener RFI Kit (part # RFI-GDO) which solves this problem. Use one kit for each opener.

Sprinkler Systems can turn on or off at random times and this can be due AC power line loss or RFI interfering with the AC power or control lines to the timers, control boxes or electronic valves. Use the Palomar RFI kit to solve this problem (part # RFI-Sprinkler).

Miscellaneous Electronic Devices can benefit from our Ferrite Snap On Combo pack of 22 filters in various sizes for a variety of wire and cable sizes. Combo packs are available in all frequency ranges from 150 KHz to 2 GHZ, but our most popular generic RFI kit for consumer electronics is the mix 31 kit (part # FSCP-31).

Specific SOURCE Solutions

We have been talking about keeping RF out of equipment; you can also use beads and rings to keep RFI in the equipment by placing a bead or ring on cables attached to the device. A bead or toroid placed on coax cables for cable, satellite or AV systems can also suppress RFI entering (or leaving) the attached electronic device. benefit.

Wall Wart Power Supplies are a known RFI generator and both the output and the input must be isolated with ferrites to suppress the RFI from the wall wart "transmitter". You can use the Palomar Wall Wart filter kit (Part # RFI-WW-10) which provides filters for the AC/DC power output.

If a bead reduces but does not eliminate an interference signal, try more beads. If one is good, two are better or use multiple turns through the center of each bead. In stubborn cases add capacitors. A capacitor from a lead to ground converts the bead into a low pass filter. Use ceramic disc capacitors of .001 to .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. Selecting the correct ferrite mix, determining the RFI path and where to place the filters can be challenging. If you need advice give us a call or email your situation and we will be glad to help find a custom solution.

Palomar-Engineers.com

RFI Solutions from KHz to GHz

Phone: 760-747-3343

Email: Sales@Palomar-Engineers.com

Check website for latest product offerings