Radio and "YOUR COMPUTER"

One of the most frustrating problems about using computers with radios, whether it be for controlling purposes or for decoding, is the amount of RFI generated by these machines. Most of the time, the RFI generated is enough to render certain bands useless and on other bands, it may drown out any weak signals and distort or interfere with signals that you want. This is totally unacceptable for working with digital modes and even for CW.

Thus one of the most frequently asked question is how this RFI may be reduced or eliminated. The bad news is that, there is no way that I know of to completely remove the computer generated RFI in most situations. **You could Turn It Off!!!** The good news is that there are definite steps that we can take to reduce the RFI to a very acceptable level and in some cases, it will almost disappear altogether.

This document is a compilation of suggestions from various persons and some of the things I have tried with my own system when dealing with this problem. Many of the documents I have seen relate to situations involving transmitters and how not to generate them (RFI). This document is written from a receiving point of view. I suppose most people would have already tried the basic steps to improve signal conditions by having the receiver and antenna as far removed, physically and electrically from the RFI source (computers and monitors in our case) but I am also aware that sometimes there are limitations and constraints as to how much distance can be had.

One may have also tried changing the orientation of the computer, monitor, receiver and antennas and feeds to see if things get better. Having done all that, what else can be done? This is the predicament I had and thus this document.

The standard disclaimer applies and I will not be responsible for any accidents although I have tried my best to present the following information in the best integrity. Before we actually begin tackling the problem, it might be helpful to know something about why computer generates RFI and how these get into the receiver. The two main components of the computer is the main CPU and the monitor (for simplicity sake).

The computer runs at a certain clock rate as determined by an internal oscillator. Most of the time the rates are something like 4.77 mHz, 8 mHz, 12 mHz, 16 mHz, 20 mHz, 25 mHz, 33 mHz, 40 mHz, 50 mHz, 66 mHz and 80 mHz. This is not the only clock involved, there is also another oscillator on the video generator card and sometimes a few oscillators, plus those on other cards. As you can see, these clocks are all oscillating in the HF and L-VHF regions which may interfere with signals we would like to receive.

To make things worse, these clocks are usually sub-divided into a number of other frequencies within the computer. Since the computer is a digital system, the characteristic waveform of these signals are square-wave and square-waves tends to result in a lot of harmonics. The video card also generates RFI because the data-pixel-rate is often high enough to fall into the HF regions. All these reasons are why computers and monitors are tops when it comes to generating RFI. This is often made worse by computers with cheap plastic casings which do not shield the system.

Many people have the opinion that monitors are one of the main RFI sources and this may well be the case. I have also noticed that the PC keyboard generates a considerable amount of RFI despite its innocent look. This is because it contains a microprocessor on board which runs off a clock in the 3 mHz range. This problem is compounded by the way the keyboard PCB runs which makes like a pretty good loop antenna type radiator and so the harmonics can be heard in the 2nd and 3rd harmonic range. The monitor probably has an on-board crystal at about 14.316 mHz so you will find a strong carrier there too.

The first thing we want to do is to determine how much RFI is being generated by the CPU and the monitor. It may be that the CPU is not radiating at all but the monitor is the culprit, or vice versa. This can be done by

switching off the monitor and leaving the CPU on just to see how much RFI is getting into the radio. The following is a suggested procedure:

1.Do a quick sweep across the bands to find out where the RFI is the strongest. This is helpful because if we can reduce the RFI here, there should normally be a corresponding decrease of RFI everywhere else but not necessarily so.

2.Disconnect the mouse, serial cables and printer cables, keyboard, video cable, video power. If you can, run the receiver on batteries for this part. Now turn on the computer and see if the RFI is increased by any appreciable amount.

3.Now, connect the keyboard (with the CPU on), then the mouse, then the serial cable, the parallel cable, the video cable, monitor power cable (don't turn on yet). As you reconnect these, note the increase of RFI if any. You should now have some idea as to which is the main contributor of RFI. If you should have the good fortune that none of these result in any appreciable increase of RFI then you're in luck.

4.Turn on the monitor and note the increase in RFI. Run both text and graphics modes to see if the RFI is affected.

5.Reconnect the radio to the power supply and again note the RFI increase if any.

6.Disconnect the radio from any antenna, both external and internal, and note if the RFI goes away. Note that on some radios, when you unplug the external antenna connection, the internal antenna is automatically activated. To prevent this, plug in a dummy plug to the antenna socket. By now you should have a pretty good idea of which components are contributing to RFI. Keep these notes, while we move on to another point, RFI paths.

In the event that this does not work you will need to investigate for cabinet radiation from the monitor and computer. Make a loop from some RG58 coax by stripping back the shield a few inches and making a couple of turns about an 1-2 inches in diameter. Solder the center lead towhere you stripped back the shield. Plug this loop into your receiver and use it to probe the computer setup. A faulty computer cabinet can be easily closed up with finger stock, braid, or other conductive materials. Shielding a monitor cabinet is a lot more difficult and could cause safety problems (high voltage) or overheating.

If you find the above method too troublesome, just get hold of a battery operated portable AM/SW receiver with an internal ferrite rod antenna and start moving around, rotating the radio as you go. Often you can pinpoint the major RFI sources just by following the radio to the place where the strongest hum is found. Of course, the radio should be tuned to a section of the spectrum where the RFI can already be heard somewhat. Do this with the radio near the suspected equipment and fine-adjust from there. This will also give you an idea of what kind of RFI and on what frequency it is focused on.

RFI gets into the receiver from the source through a number of paths. This can be through the power supply, through the "earth" point of the power supply, through direct radio emission, even through "shielding" which are not properly designed or used. There are a number of ways to deal with these situations.

If your radio is still picking up RFI with no antenna connected then, the shielding in your receiver is poor. If the RFI increases as you reconnect the radio to the mains power supply or adaptor, then RFI is coming in through the power supply. If your radio is connected directly or indirectly to the computer through the serial port or some other interface, that too could be a path for RFI. You will know if this is a problem as you go through the steps above. If the RFI increases appreciably as you reconnect the external antenna, then the RFI may be coming from direct emission or is being picked up from the antenna feed.

Remember that in many cases, RFI is coming in from more than one path so it is important to check out all possibilities. On the other hand if one path is the overwhelming problem, you may want to deal only with that. Other basic measures are to keep cables and connections as short as possible. This will prevent these connections from becoming radiating elements for the RFI from the equipment. If possible, have your radio equipment connect to a different power circuit butwatch the earth so that no dangerous voltage-potentials are formed.

As you can probably see, RFI is a combination of problems and not one problem. It can be classified into 3 categories:

Shielding problems

Filtering problems

Design problems

These are not definitive categories but are used for simplicity. In many cases, poor shielding is a prime suspect. So we will deal with this first. Now to get on with the real action.

When we talk about shielding, there are 4 things to consider:

The radio itself

The monitor

The CPU

The antenna/feed combination

Poor shielding can be an inherent problem to some designs but can also be due to dirty connectors and old parts. Go through the equipment to make sure that all the connection points are secure, this is especially in connection to the antenna shielding, radio power supply, CPU casing, cabling. Make sure that the wires are not old and all the connections are clean, no oxides on surfaces. The presence of oxides makes for poor conduction and in some cases it results in rectification of signals which can then lead to a host of other problems.

If the problem is a design one, such as poor shielding in a radio as determined previously, or poor monitor or CPU shielding, then we need to provide an adequate shield. This can normally be done using tin/aluminum foils or conductive spray. The basic idea is that we must line the casing of the equipment to be shielded with a barrier to RFI. I personally cured a major RFI problem with my own PC General Monitor by Lining the inside with Tin Foil, being extra careful to ensure it is stuck down secure and that slits are cut where the Air Circulates.

It must be done carefully because since the shielding is conductive, it is possible to accidentally short circuit something and fry your radio or whatever it is you are trying to shield. The spray is probably the easiest to use but also quite expensive. My feeling is that metal foil probably provides better shielding but is harder to apply. The conductive spray or paint has a lower conductivity but spreads more evenly and gets into difficult to reach locations more readily. PVA Glue works fine.

What you need to do is to carefully remove the plastic casing of the radio or monitor, paying attention to cabling and electrical contacts. Remember that opening the case will almost certainly invalidate the warranty on the equipment. Clean the insides of the case thoroughly and make sure that it is dry and free of dust or grease before applying the spray. You may need to apply several coatings to get better shielding.

Make sure that at some point in the casing, the applied shielding comes into contact with ground. Remember that in monitors, chassis is not always connected to ground so check this out first. For the shielding to be effective, you need to provide as complete a "wrap" as possible but remember not to spray onto switches or anything that might cause a short circuit. Also prevent blocking up ventilation holes.

You may at this point wonder about the screen itself. Well in most color monitors, the mask inside the monitor acts as a shield of sorts. Wait for the coat of paint or spray to dry before replacing the cover. Try to ensure good grounding for the shield and avoid scratching off the paint. If arcing should occur, use some insulating tape over the area.

In the event that you cannot find either paint, spray or suitable foil, conductive tape will do also. Remember, the conductive screening must NOT touch the components. Pay attention as there is always shock hazard when messing with monitors. Don't do this yourself unless you know exactly what you aredoing. :) Stay alive.

If the monitor is the culprit, there are conductive sprays you can use on the inside of the plastic cabinet to reduce the hash. You have to strip the monitor and spray the cabinet. Usually you want to spray inside for appearance sake. When you put it back together, watch out that the HV section has adequate clearance with the now conductive case. If it doesn't, glue some fish paper in the proper spots to prevent arc overs.

Unless the monitor is a "hot chassis" design, bond the conductive coating to the chassis, and bring a bond wire out from the chassis to station ground. If the monitor is color, the shadow mask in the tube will form an adequate shield, but if it's mono, then you may need to put fine copper screening over the face of the tube. Spray paint it flat black and it'll double as an anti-reflection screen.

If the cable is radiating, first make sure you're using a shielded cable, then use some snap-on ferrite chokes on the cable. These chokes are good things to put on *every* external cable.

If the PC is the culprit, scrape paint so that the case halves can bond properly, and add extra screws so that every seam has a screw at least every two inches of its length. That's what it takes to get a good Faraday cage. Any openings in the case should be covered with copper screen wire. The floppy drive opening is a problem because you need access. The best way to handle this is to shield the entire drive bay from the inside and accept the hash when the drive is in use. Bring a bond wire from the case to station ground. Of course it always helps to have the radio's antenna as far from the PC as possible, and brought back to the radio via a well shielded coax. The radio chassis should be bonded to the station ground.

If you're using a HT (Handheld) then you may have to locate the radio and TNC far from the PC via a long RS232 cable. Note that the TNC can also be a source of noise. In some cases it's better to leave the TNC next to the computer and remote locate the radio with long audio and control cabling. The TNC should be treated the same way as the PC. Sand off the paint and add bonding screws. If it's plastic cased, either use the conductive spray, or put it in a metal box.

If you are using the spray, make sure to apply an even layer and you may want to repeat the process a few times to get a better screen. Do not waste excessive spray on one spot but make sure that the coat does not have "thin" spots. The same method be applied to the CPU casing or to the keyboard casing. The effectiveness of such a method on the keyboard is debatable however, seeing that it is difficult to build a proper Faraday's cage around the offending circuitry. Care must also be taken seeing the tight enclosure of most keyboards.

Shielding of cables is also important. Try to make sure that the video cable has a good shielding/screening. The same applies to serial and parallel cables and, of course, the antenna feed should be well shielded. For antenna feeds, avoid TV 75 ohm coaxes as these normally do not provide sufficient screening. Try RG-58-C/U (which I think has better screening than RG-58-A/U) or some other high-screening type cables like RG-8 and the like. Well-screened antenna feeds go a long way to remove RFI.

I have been told that the equipment should all be connected to a firm ground via heavy gauge wire or braid. This is probably true and if you can, why not. Where cables terminate, use good and appropriate connectors such as PL-259 or something similar. In all cases, provide the screening with a good ground. A well screened antenna feed may eliminate up to 80% of the RFI in some case, or more.

If you are listening on VHF and UHF however, the length of the feed may need to be weighed against signal losses inthe feed itself. Feeds such as the 9913 have lower losses but are quite expensive. Use them if you can however. Personally I still find the RG-58 to be the easiest to work with. Sometimes, in some CPU units, there may be some parts which are difficult to shield, such as the disk-drive.

This is not too serious since the drive is not operative most of the time, but if you elect to try to screen that also, remember that the screen must all be well connected electrically. The same goes for the rest of the computer casing. If you can, use one with a proper metal casing on all sides. What we want is a Faraday Cage so see that the whole case is well grounded. Scrape off some paint at the screws so that there can be good electrical contact everywhere. Other exposed connectors and splitters (which are not recommendable) can also be letting in RFI so you may want to check out their screening as well.

Filtering Problems

This represents the next major path for RFI. In some poor designs, RFI is not properly filtered out of the computer or monitor power supply and it thus leaks out into the mains, and from there into the radio power supply and finally into the RF section (or AF sometimes) of the receiver. This type of problem can normally be

improved by using a line filter for the equipment's power supply. Make sure that the line filter is rated for the power the cable is meant to carry or it may burn up. There is a kind of line filter which is essentially built as a socket which you need to replace the one on the power supply with. I am not sure how much improvement this kind of filter affords but if you elect to do this, do it with care!

Other than using line filters, you can also use ferrite beads and toroids on most any lines. Experiment around with a bunch of these things. You could also put a bunch of ferrite beads on the antenna feed line and this will act as a kind of balun as well as preventing RFI from traveling on the screening. There are many types of ferrite RF chokes, clip-on types and ready-made types, which can be used. The ARRL Handbook has a description of some of these devices. I have built myself a 4:1 balun (BAL-anced to UN-balanced) for my coax fed dipole and now I get very much less computer RFI and other noise from my antenna system due to the impedance matching and improved power transfer characteristics. Call me and I can send you the relevant info from the book.

Better selectivity is also a benefit of a good antenna system. Line filters and RFCs can do wonders so experiment with them at various strategic locations such as power supplies, some audio lines etc.

Other than that, RFI often comes through other data lines and control lines in parallel and serial ports as well as video ports. Besides using ferrite beads on these, you may want to connect small value capacitors between the lines to ground. For parallel and serial lines, use 0.01 uF capacitors (multi-layer, MKT if possible, others may work well too), and for video ports, connect 100pF capacitors from the RGB, H-Sync and V-Sync to ground. These may have some other effects on the lines so experiment with slightly higher or lower capacitor values.

If you are receiving on certain bands only, a band-pass, high-pass or low-pass filter may help if used on the receiver front-end. This, however, will not be effective for reducing in-band noise. A notch filter can be used on the antenna feed to notch out certain strong emissions such as the 14.316 mHz crystal oscillator on the video card or on the baud-rate generator. Note that all kinds of filters (barring active ones) incur losses to some degree and if your signal lands too near the unwanted emission then you cannot use the Notch since the wanted signal may also get filtered out. A high-Q notch is often preferred in this regard.

Concerning the use of clip-on filters (such as those sold by RF Parts in USA), -"clip-on choke" is a split ferrite bead in a plastic case, sold for RFI suppression from personal computers. The two halves of the bead fit around the cable; the plastic case has a hinge and a latch to hold the two halves together. You could get the same effect by slipping a ferrite bead onto the coax before attaching the connector. And infact are far more efficent than "Clip Ons".

This idea is similar to the ferrite bead baluns used in amateur radio. The idea is to increase the impedance to RF current flow on the outside of the coax shield - this ideally prevents the coax from becoming part of the antenna. I'm skeptical that one or a only a few of these beads would have much effect when placed on the coax lead-in. I think it would take quite a few beads to get enough inductance to help. It might be better to use the beads on the offending appliances. I'd recommend the method of grounding the coax shield at the antenna, and running the coax buried or along the surface of the ground. I think this will minimize pickup of local noise sources more effectively than a few ferrite beads at the receiver. Power line decoupling and filtering is essential for optimum performance.

The standard power supply of most PC's is a switching power-supply. Such systems, while power efficient, tend to generate spikes and unwanted harmonics due to the switching effect. Needless to say, if not handled properly, these spikes will get into the mains and from there into your radio. This is usually not severe because the design usually takes this into consideration already. What is more worrying is the CPU clock leaking into the mains through the power supply. Once again, the line filter is the way out.

Often, when only the audio from the receiver is required to go into the computer, you might want to consider some way of isolating the signal from direction connection to the computer. One simple way is by the use of 1:1 audio transformers. Personally I have found a slight improvement here but not to my satisfaction.

I also tried connecting the audio from the receiver to an adapted FM microphone and having another FM radio pick up the audio which goes into the computer. This seems a lot of hassle but may be a last resort or for people who really want distance between the radio and the computer. Other forms of isolation can be implemented using IR oroptics. These will provide excellent isolation as far as the audio line is concerned and no RFI worries from that path.

RFI problems are sometimes compounded by poor antenna or receiver design. Antenna impedance mismatch, for example, can make things worse that it needs to be. As such, use of baluns and transmatches may help. Although the coax antenna feed is supposed to keep out RFI,a mismatched antenna and feed may result in the coax screening itself picking up RFI.

So if you are using coax feed into a balanced dipole, try using a balun (Dimond BU50) at the feed point. The impedance matching ofthe antenna to the feed can also be handled by the balun. Baluns, being what they are, normally incur some signal loss but in a good balun, this is insignificant compared to losses in the feed itself.Besides, loss of signal strength is often made up for by improved S/N ratio.

I have not confirmed this but some out of band RFI can be reduced by the use of antenna tuners which provide better selectivity. Such tuners can easily be made from any number of designs found in amateur circles because commercial ones tend to be rather expensive and come with S.W.R. meters and otherfancy things that the RX-only SWL does not need. In my case, a coax feeding into an off-center-fed-dipole, the balun did wonders to the S/N ratio and I actually say a signal strength improvement.

This does not mean that the balun improves gain but the selectivity it provides may prevent the receiver AGC from kicking in and drowning out the weaker station thus resulting in a higher apparent signal strength.

And, finally, finally, just as connecting a coax to a balanced antenna will cause feedline to radiate,the reciprocal also happens. If you feed a balanced receiving antenna with an unbalanced line like coax, the outside of your coax will pick up noise and send it to the antenna input of the receiver.Place a balun between the coax and the antenna itself.

Excessive gain, such as may be the case with antenna pre-amplifiers will not always improve the S/N because then the noise gets amplified along with the signal. In this respect, normally a masthead pre-amp will perform better.Decoupling in some digital equipment is not properly done and can lead to RFI being insufficiently suppressed.

This can be remedied by placing 0.1 uF capacitors along all points in the power supply of the equipment between supply and ground. This may sound silly to some because it may seem easier to use one big capacitor, but while the electrical property at DC may be similar, the distributed capacitance has a different effect on RF.

You want to ensure that your power supplies are properly decoupled and no unwanted oscillations are taking place in the regulators.The directivity properties of the antenna can also help improve signal conditions under RFI. The loop antenna, for example, can be positioned so that it nulls out at the RFI source. Similarly the dipole also exhibits certain directive properties which can be taken advantage of to reduce RFI. The use of antenna tuners and pre-selectors may help reduce out of band noise and may provide a clearer signal especially if a high-Q tuner is used in the front-end. If an active antenna is used, it is probably more advisable to have that antenna mounted at the mast/feed-point.

This is so that only the signal gets amplified and not the RFI from the computer. This is especially so when weare talking about broadband RF pre-amps which are more susceptible to noise. I now have an MFJ-1020-A active antenna pre-amp which also contains pre-selector section and it works well for me, removing a considerable amount of out-of-band signals but at the same time, the noise floor is also amplified.

Judicious use of such a system can help improve reception on many signals,especially of the continuous carrier types like RTTY and FAX or SSTV.If you are constructing your own interface equipment, try as best as possible to build it into some kind of shielded casing, or a metal box. This may help reduce some RFI input to the radio.

Other Measures

Besides the above, if one is using the computer for receiving CW/RTTY or other digital signals, a good IF or AF filter will help in removing unwanted noise.

The advantages of the different filter types are detailed in the ARRL Handbook. For those who are more well off, a DSP adaptive filter can be of added convenience, aside from all the other SC (Switched Capacitor) filters, Notch filters. Again, I do not have the privilege to speak from experience. Bandpass filters are quite easy to construct and you may want to experiment with certain designs before investing inthe real thing. Digital Filtering is becomming very common and a standard feature in most
new Amateur Radio HF/VHF and UHF DX Transceivers.

For those who are thinking of a new computer, I hear that notebooks have very low RFI emissionand may be very suitable for radio use. In case you are like me and don't live near the ground floor, you may want to use a balanced antenna system which does not require a ground.

Just remember that electrical outlet ground is ground at 50 Hz, but NOT in the MHz. Your whole wiring system will act as anantenna! As far as the wiring of the feed goes, remember to keep the feed from running parallel with mains wiring and try to avoid fluorescent lamps if possible. Some of these old lamps have faulty chokes which tend to generate some noise. Most modern buildings should be okay but older places tend to have this problem.

While on the subject of wiring, remember that it may not always be your computer/monitor which is generating the RFI. Especially now that more and more people are staying in apartments or terrace houses, your neighbors computer system may also be a source of noise. One way to go about this is to have a nice talk with your neighbor or use some kind of grounded metal sheet or grid at the walls.

In concrete buildings, there are steel bars in the walls and so this may not be absolutely necessary.

The ARRL Handbook offers many helpful information concerning baluns, transmatches, filters and chokes. These will come in helpful for those who want to find out more about antenna and transmission line theory. Information can also be obtained from the ARRL e-mail server. Simply send a mail containing nothing but HELP to info@arrl.org to get started. The server contains some more information on RFI and related problems. Have fun, down with QRM and RFI.

A final word of caution, be sure to know what you are doing or you may fry your equipment in the process, or fry yourself (which will arguable solve all your RFI problems! :). In case of doubt, get an ELMER or someone experienced with electronics to help you out, or to walk you through the steps.

RFI has been a most perplexing problem and will continue to be so as long as manufacturers of computers do not think if it as a problem.

Here are my conclusions for what they are worth:

1. You can make any noisy computer or monitor quiet but it takes a lot of time and patience (plus ferrite beads, filter caps, chassis mods, etc).

2. It's better to start with a quiet design. If you buy a "no-name clone" that you assemble or have assembled buy the most expensive chassis and power supply they offer. Look at the chassis and you'll see the lips fit together tight with the cover and almost look like fingerstock RFI shielding. Lots of screws that cause the cover to fit on tight with shiny unpainted surfaces where contact is made. The power supply has AC line filtering in it (filtering works both ways).

3. Almost all laptops are RFI quiet. It's inherent in the design.

4. I suspect most of the "name" brands like these, Compaq, etc. are OK. You get what you pay for. Save $100 with the cheap ones but remember they take the $100 from where most users won't notice -- RFI suppression. Meeting F.C.C. Part 15 is now mostly self-policed and ignored by many. Anything seems to go. Try one of those "touch-sensitive" lamps that have become popular. With a good antenna you could probably key the AC line and work DXCC in a few weeks!

5. Computer noise is usually seen at VHF more than HF. If you have a two meter handi-talkie set the squelch on the edge and then hold it close to the monitor and computer. You can probably get away doing this in a store before buying the system. Asking even a competent computer salesperson "how is the RFI protection?" will get you a blank stare.

6. I had major problems with my PC General Monitor, causing noise all over the HF Bands, and that was with the computer some 20 or so metres away! In no way would of it passed any FCC Requirements. I removed the Monitor cover, coated the inside with PVA Glue and line the inside with Tin Foil.....then made sure it was safe and that when it screwed together there was some sort of continuity from the earth side of the Monitors ground to the foil screening. Plus I made sure the foil had slits cut wherever there is air ducting on the cabinet. YES! No more Noise!