PC RFI reduction and sound-card interface

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Computers have changed and enhanced many aspects of amateur radio, making available tools and modes of communication previously unimagined. The processing power available to generate or analyse audio signals via a sound card can replace a large amount of traditional components.

Suitable interfaces to connect the computer to the radio exist and can be purchased or built (see Reference 1, for example), which make use of the 'sound card' modes very easy.

However, laptop and workstation Personal Computers are full of high speed logic and switching power supply circuitry that can generate significant radio frequency interference (RFI) which often makes their use with sensitive receivers difficult. The emphasis of this article is on noise reduction, describing techniques that have been applied to a typical equipment setup. No originality is claimed for any part of the circuitry.

Application of the following techniques have allowed many hours of happy use of the various 'sound card modes' that are now available. The equipment used was a second hand Dell laptop and an elderly Yaesu FT-707 transceiver.

Noise sources and types

Interference is emitted by the PC in two ways: direct radiation and conduction.

This means that two distinct, but related, approaches may be required to eliminate or reduce problems caused by RFI. Direct radiation of RFI occurs when the PC radiates radio frequency noise that is picked up by the receiving antenna or directly by the radio because of inadequate screening. Conduction of noise can occur through signal cables (analogue or digital) that connect the PC to the radio, or through mutual power supply connections.

Signals that are conducted by cables may also be re-radiated, so solving the conduction problem may also help reduce radiated noise. In my case it was easy to determine if the noise was conducted or radiated; this was done by listening to the receiver output and

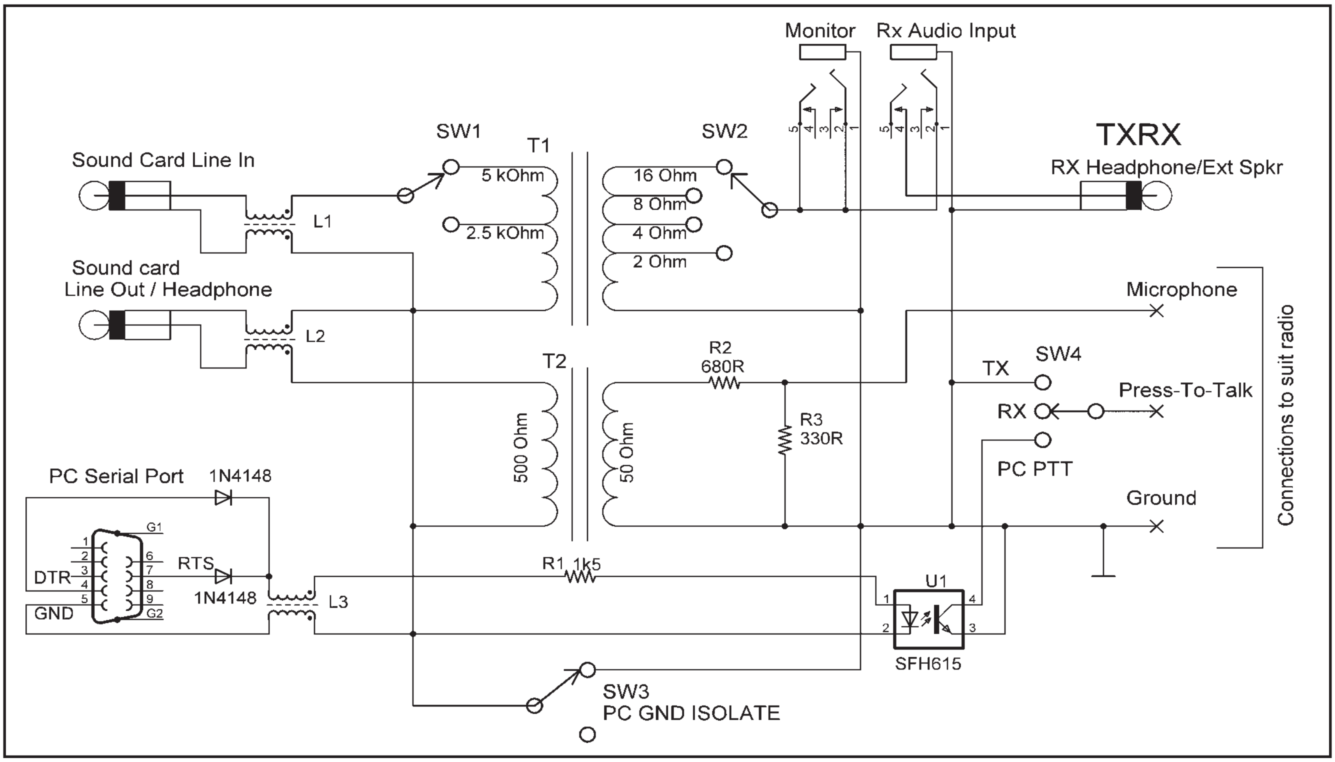

Figure 1: Schematic diagram of interface. Note that the two 1N4148 diodes are mounted in the connector back-shell and that L1, L2 and L3 are common mode chokes made from wrapping the cable through ferrite tubes. The chokes should be as close to the PC as possible.

disconnecting the antenna input. If the noise went away when the antenna was disconnected it was radiated noise, if it did not, it was conducted noise.

The emitted noise appears to be of two types: wide band hash and narrow band 'birdies'; both types are significantly reduced or eliminated if the following steps are taken. Depending on the transmission mode and equipment you are using, one type of noise may be more troublesome than the other.

Reduction of conducted noise: Audio signals

Typical connections between a PC and radio are audio signals from a sound card to the radio's microphone input and speaker (or headphone) output. Data and/or control signals from the computers serial or parallel port may also be used for modulation or Press-To-Talk control.

In both cases a number of techniques can be used to eliminate conducted noise. The solution includes use of galvanic isolation, screening and use of RF chokes. Figure 1 shows the schematic diagram of the interface I use which has successfully reduced RFI in my setup.

The audio signal lines between the PC and radio are isolated using audio transformers. This means that there is no direct ('metallic' or 'galvanic') coupling between the two units.

The signals are only coupled through magnetic transformer action and this eliminates any common mode signals or coupling of noise through the common earth connection.

Note that the signal earth is isolated, but that a switch (SW3) has been included to connect the common of the radio and PC together if necessary. Chokes are also fitted on the signal lines as they leave the PC; the chokes are 29 mm long ferrite tubes that the audio coaxial cables are wound through. It was possible to wind three or four turns of miniature coaxial cable through the tubes.

Clip-on tubes are also available if it's not possible to fit the connector and cable through the tube. The ferrite tube adds significant inductance on the outside of the cable that reduces any noise that is conducted on the outside of the coax screen.

The ferrite tubes were purchased from Jaycar and the catalogue number is LF1260. As many as necessary can be added to reduce conducted noise.

Although adequate control of audio signal level through the receive and transmit paths can usually be achieved through the 'audio control panel' of the PC; switches SW1, SW2 and resistors R2 and R3 provide (optional) additional control if required.

Jacks and terminals have been included so that the received and transmitted audio signals may be monitored using headphones if required.

Reduction of conducted noise: Press-To-Talk Control

The PTT control line is isolated by using an opto-coupler. The DTR and RTS lines switch to a positive voltage when the PC needs to switch from receive to transmit; the output transistor is then switched on which pulls the PTT input of the transmitter to ground, enabling the transmitter. Again, no direct ground connection is made between the equipment. Manual control of the PTT line is possible via SW4 which can switch between receive and transmit, as well as enabling automatic control from the PC.

Reduction of conducted noise: Power supply

Computer power supplies can be a significant source of noise. In my case the laptop 240 V AC supply was very noisy, so I chose to replace it with a DC-DC converter.

Additional RFI filtering comprising common mode chokes (same as used above) and filter was added. The DC-DC converter was powered by the station battery supply (24 V DC); this also makes it possible to run the PC for an extended period of time when in the field.

The PC required about 13 volts to run correctly, so a Powerbox supply type PBIH-2412J was used (See Reference 2). This converter has an input voltage range of 19 to 32 volts, with a nominal output voltage of 12 volts at 4.3 amps (50 W); but is adjustable over at least +/- 10%.

The supply was mounted in a diecast box with the additional chokes and filter capacitors fitted to the power supply input and output; polarity protection by means of a Schottky diode (D1) was also included. Diode D2 provides limited protection in the event that the output is connected to another power supply.

Figure 2 shows the schematic diagram of the power supply unit. Note that various versions of the power supply exist with different input and output voltages, so other units may be selected

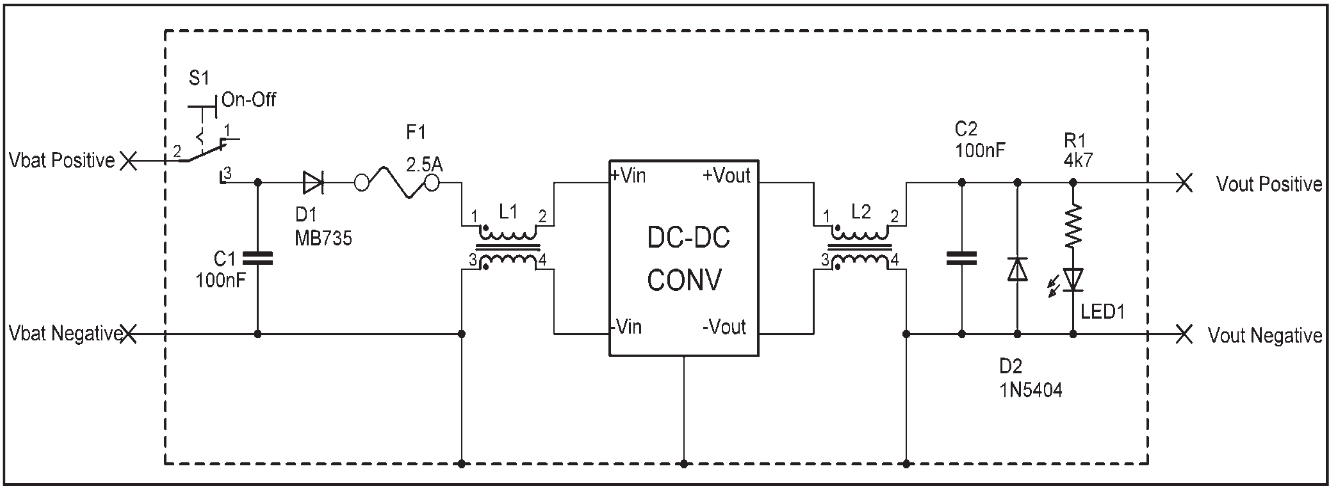

Figure 2: Schematic diagram of power supply.

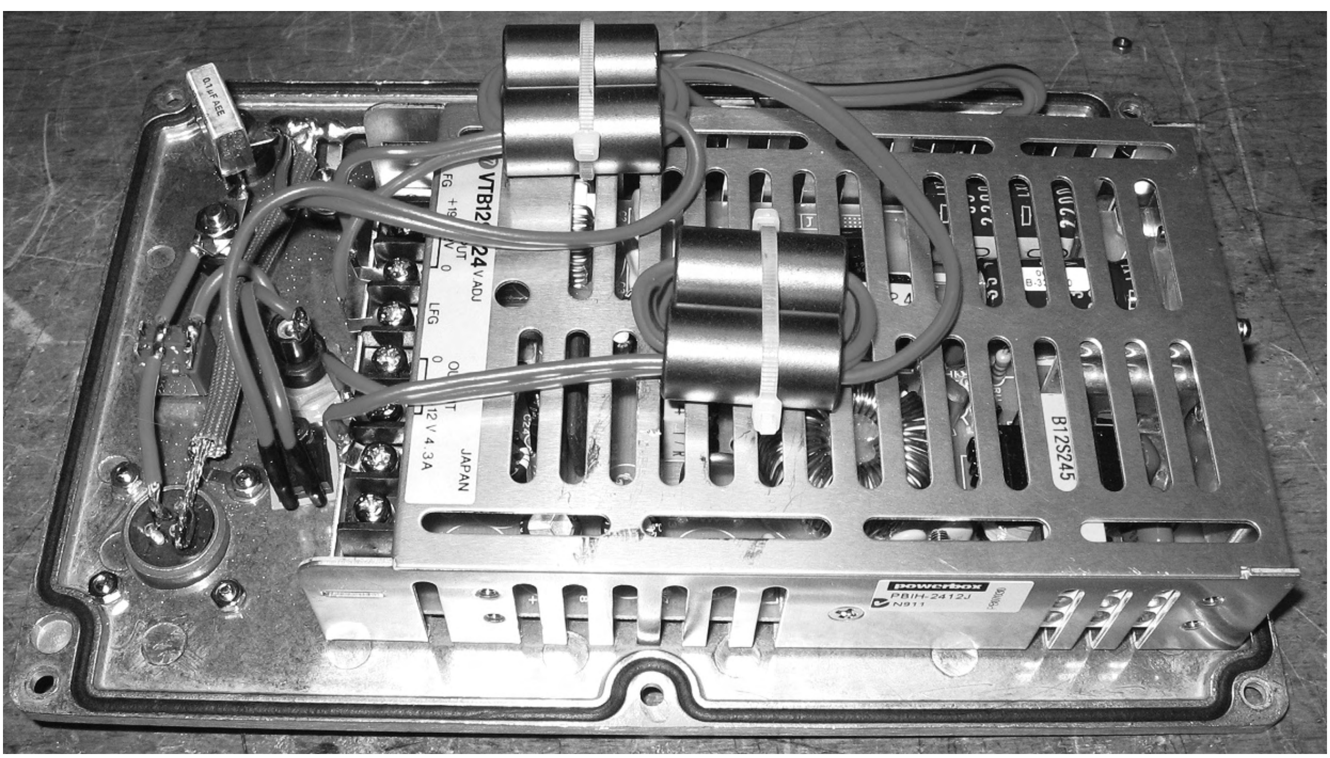

Figure 3: Internal view of power supply showing chokes and DC-DC convertor module.

to suit different battery supplies or computers.

Desktop computers will require a different solution. I have found that using good quality line filters and a 1:1 240 V AC isolation transformer can reduce noise emissions from such computers. In this case - for safety – it is imperative that the PC case is earthed. An additional low impedance connection to an earth stake can reduce noise emission from the PC's circuitry.

Reduction of radiated noise

Noise was found to be radiated from all of the signal lines and the installation of chokes on each of the cables eliminated the problem.

The other significant source of noise was found to be the display, either from the display electronics or from the backlight inverter.

Noise emission was significantly reduced by fitting conductive screens to the back of the display (that is, the top of the laptop) as well as underneath the PC base. I used thin un-etched printed circuit laminate attached using small squares of Velcro tape. Earth straps were soldered to the PCB screens which were then connected to the PC common via a convenient connector.

This significantly reduced RFI radiated by the screen. A final factor to consider is proximity; simply moving the PC further away from the radio may reduce interference.

Components and construction

None of the components used in the interface are critical and components sourced from the junk box, or purchased new can be used.

Transformer T1 is a speaker transformer used in public address installations, the ability to change taps is useful but not essential; T2 is a small audio transformer with 500 to 50 Ohm windings.

For either T1 or T2, transformers with other turns ratios can be used if they are available; in which case the audio levels to and from the sound card may need adjustment using the PC control panel or by changing the values of R2 and R3.

For example, Jaycar catalogue items MM-2530 or MM-2532 audio output transformers appear suitable and are relatively inexpensive. Other published designs have used 600:600 ohm telephone isolation transformers in similar applications.

Again, possible examples appear in the current Jaycar catalogue. Remember, it is the isolation feature of the transformer's function we are seeking to exploit here rather than any changes to voltage levels, so be prepared to experiment with what you can find.

The opto-coupler is a low current device, but the more common 4N26 device should also work if the value of

Figure 4: View of PC interface.

R1 is decreased so that more current will flow through the emitter diode.

Screened cable was used for all connections between the PC, interface, power supply and transceiver. For ease of connection, the audio and control connections were made through 5-pin DIN connectors. Figure 4 shows the completed interface unit.

Serial Port Options

The standard RS232 serial port that has been supplied on virtually all computers until recently appears to be becoming obsolete.

Modern laptop PCs, particularly the smaller units that would be especially attractive for field use, frequently only have Universal Serial Bus (USB) ports and no standard serial ports. This makes the PTT interface a bit more difficult.

A number of options exist, including the use of Voice Operated Transmit (VOX) and with care, particularly to avoid unwanted transmissions via a ‘hot microphone’; this will work in most circumstances.

Other designs sample the audio output from the PC soundcard and process it to produce a signal that can drive the PTT control; see Reference 3 for details.

A simple solution can be to use an inexpensive USB-to-serial convertor cable which converts the USB port to a standard 9-pin serial port, complete with handshaking lines, which can be used to control the transceiver PTT line.

I have tested a number of Windows PSK packages and all have worked well when using my convertor cable instead of a standard serial port. I may have been lucky though, as it appears that not all USB-Serial Port adaptors are created equal.

The various internet discussion groups carry lots of messages to the effect that some applications do not work with various brands of convertors. It appears that those designed around the Prolific chipset are the least likely to suffer from incompatibility problems.

It may be that our use of the USB port for PTT switching purposes is so rudimentary that it avoids such problems but I have not been able to test a wider range of convertors. If you strike problems in using one in your interface, I suggest you try borrowing a few different brand convertors from your friends to see if you can find one that works for you.

Noise from the PC has been significantly reduced but not entirely eliminated. However, the remaining noise is at a very low level and does not interfere with the reception of even the weakest signals.

Results and conclusion

Noise from the PC has been significantly reduced but not entirely eliminated. However, the remaining noise is at a very low level and does not interfere with the reception of even the weakest signals. The wideband noise emissions from the PC no longer cause any problems and the remaining noise appears to be specific frequencies that can be avoided if necessary.

Some or all of the techniques described above may be necessary depending on the particular installation and severity of the problem. After applying the above in a sequence of steps the effectiveness of each step can be assessed and a decision made about whether more work is required to solve the problem.

Software packages such as Digipan, WinPSK or Winwarbler include a spectral display and this is very useful in observing and assessing the magnitude of the emitted noise as well as providing an excellent way of assessing the effectiveness of mitigation steps you undertake. General purpose spectral analysis programs such as Spectrogram will allow accurate measurements of the frequency and amplitude of noise components which may be helpful in identifying sources of noise.

I wish to thank Bill Maxwell VK7MX for his helpful suggestions during the writing of this article.

References

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See www.powerbox.com.au for various power supplies.

ARRL Handbook, 2008, Page 19.47, *An Improved Digital Communication Interface*, circuit attributed to Larry Coyle K1QWand first published QST, April 2005.

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Figure 5: A view of the ferrite chokes and external PC screening.