FlexRadio Systems®
Software Defined Radios

White Paper

LEVERAGING SDR FOR BETTER DIGITAL MODE COMMUNICATIONS

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HISTORY AND THE PROBLEM

Digital modes are as old as radio itself. Morse code, the most basic of digital modes, has been around since the 1830s. While Morse Code was more about necessity since the technology to produce more complex modulation types and voice had not yet been invented, it has persevered for several reasons. First, Morse code is very efficient: it uses very narrow bandwidth and as a result enjoys a better signal to noise capability than other modes. In other words, when signals are weak, hearing a CW signal (Morse code) is easier than hearing a Single Side Band (SSB) Signal.

Second, CW has another advantage over sideband—you can send a message exactly as you want it to be received. There are no misunderstood accents or words to get in the way of the message. This has also opened the door for sending codes and encrypted messages as five-letter word groups, a convention that has been frequently used. After receiving the five-letter groups, they can be translated or decrypted into the actual message. This method was used extensively by the US Military and telegraph services. (ITU, 1998)

Radio teletype was one of the first automatic digital modes, often using paper tape as the storage medium and Frequency Shift Keying (FSK) as the modulation scheme. Amateurs often used surplus Teletype Corporation equipment such as the venerable Model 19 and Model 26 teletypes. As the computer became a staple in the modern ham shack, so did equipment to interface the radio. HAL Communications designed a series of devices in the 1980's to decode RTTY and display the FSK signals for turning purposes, for example.

As computers and software grew more advanced, more and more digital modes have been added to the amateur's repertoire. Some of these modes include Olivia, RTTY, Clover, PACTOR, AMTOR, PSK31, MT63 and numerous modes supported by WSJT.[1] Many of these modes are able to be modulated and demodulated in a computer and, as such, do not require an external modem device. A few modes either require complex DSP or are proprietary and still require an external box: PACTOR III and IV, for example. For the modes supported in a computer, numerous software packages have sprung up that do everything from basic mod/demod all the way to complex contest support operations, logging and integrated spotting.

[1] http://physics.princeton.edu/pulsar/K1JT/

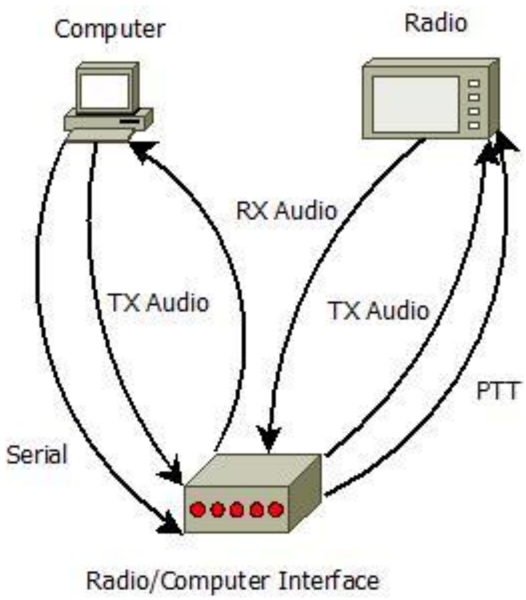

Figure 1, Typical Radio/Soundcard Interface Connections

To use a computer with a conventional (not Software Defined Radio, or SDR) radio requires the use of a PC sound card. The computer sound card is hooked to line-level audio in and audio out jacks on the radio typically through an isolation device, also called a radio/computer interface (see Figure 1). The computer is also generally connected to a PTT line on the radio to support transmitting. This line is typically connected to a COM port (UART) on the computer (shown as "serial" in the diagram). Tigertronics[2] makes a line of these isolation devices called SignaLink™ as does West Mountain Radio with their RIGblaster line.[3] The fundamental problem with all of these schemes is that the digital signal must be converted to audio, piped through an audio interface that is susceptible to RF and other interference and then get converted back to digital in the computer sound card. Unfortunately, while en route between the computer and the radio the analog signals are venerable to RFI, analog losses, coupling effects of any cables, etc. On transmit, the path is the same but reversed.

While all of these systems can ultimately be made to work, they require a significant amount of tweaking and adjusting to ensure that the signal is not degraded in the audio path, the levels are correct in each direction and that the entire system does not suffer from radio frequency interference (RFI). Many stations end up wrapping their audio cables around RF chokes and using optoisolators to prevent ground loop and RFI problems. Figure 2 is a picture of an actual real-world configuration that includes an interface box, toroids for RFI, PTT relay encased in heat shrink, a custom cable for the rig, and a USB-to-serial adapter to connect a PTT line to a computer that does not have a conventional serial port. You can see this picture is actually somewhat more complicated than even the diagram would indicate.

[2] http://www.tigertronics.com/
[3] http://www.westmountainradio.com/content.php?page=RIGblaster

Figure 2, Typical Digital Mode Setup

On top of tweaking the cables and making them work, there is often additional effort to manage the sound card in the PC itself. Some operators use two sound cards or an external sound card because the one built into the PC itself is typically of lower quality. The PC software must be told that digital applications make sounds on one sound card while the PC makes sounds on another. If this is not done correctly, sounds from the PC can end up being transmitted over the air. You may have heard Windows beeps or startup sounds on the air before and wondered how this happens.

The PowerSDR™ Advantage

So how does an SDR help out with all of these problems? To understand this, we need to review the architecture of a SDR system. In Figure 3, the black line represents the digital spectrum data *and* the radio control signals that are passed between the radio and PowerSDR. This data is digital since the SDR radio works directly with data rather than analog audio signals. A single cable between the radio carries both the PTT signal for transmitting as well as receive and transmit data. Since the data is digital, it cannot suffer the same degradation that an analog signal travelling down an analog cable is likely to experience. Both digital interface chips (one in the radio and one in the computer) are designed to reject interference on the cable itself. This means your audio is ultra clean and cannot be degraded once it leaves the radio.

Once the data is in the computer, it is demodulated to a sideband signal (lower or upper) and then passed over the Virtual Audio Cable[4] (VAC) pair or blue line in the display to the software inside of the computer. Virtual Audio Cable was designed to be a "pass-through" that connects two digital sound programs as if each is seeing a sound card rather than another piece of software (one as a send cable, the other as a receive cable). This software is immune to all of the problems that exist in the analog world shown in Figure 1 and Figure 2. Since we are just moving buffers of audio data in the computer with VAC, there exists no chance of analog drop-outs, level issues, RFI or the like causing a problem. So with an SDR there are no additional cables and interface boxes to purchase, configure and potentially be a source of interference for the digital signals. In addition, the receive signals are converted from analog to digital only once

The second blue line is a virtual COM port which is used by the digital mode software to simulate the PTT line. Again, instead of being a real adaptor and cable, this is software that runs inside of the computer and carries the PTT signal from the digital mode software to PowerSDR where it is then sent down the FireWire or USB cable to enable transmit on the radio.

At the other end of the VAC pair is a digital mode software program such as Fldigi[5] or MixW[6]. Fldigi fully supports the native PowerSDR CAT interface via rigCAT where you can select all of the preset filters and all of the PowerSDR modes as well as asserting PTT and polling / setting the VFO.

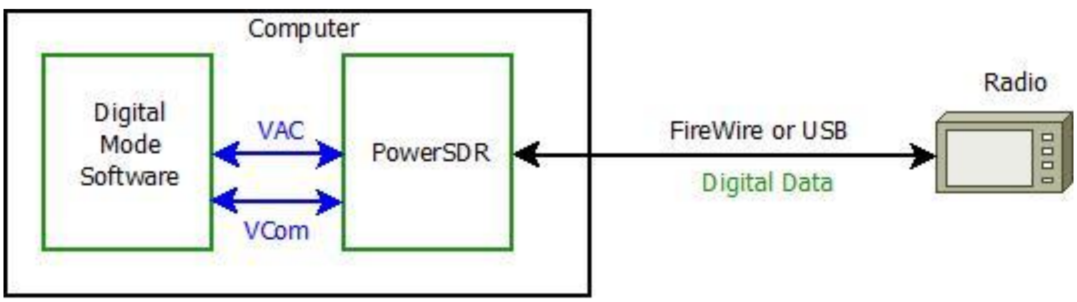

Figure 3, PowerSDR Digital Mode Connections

The SDR (a FlexRadio radio) has been designed as a system to ensure that the analog signal off-air is accurately digitized as a faithful representation of the on-air signal before transmitting to the computer. Further, this requires no work on the operator's part -- he does not have to adjust levels, protect the system from RFI, etc.

[4] http://software.muzychenko.net/eng/vac.htm
[5] http://www.w1hkj.com/Fldigi.html
[6] http://mixw.net

ADVANCED DIGITAL APPLICATIONS

Many newer applications require both in-phase and quadrature signals (I/Q) in order to perform demodulation. WSPR[7] from K1JT and CW Skimmer[8] both have these options. FlexRadio products and PowerSDR are already configured to work with I/Q data internally, so interfacing to these two and any future applications that use I/Q rather than "real" signals is a snap. PowerSDR can transmit the I signal on one audio channel (Left) and the Q signal on the other (Right) by convention.

SUMMARY

Amateurs have come to recognize that SDR systems provide superior audio and filtering capabilities, but few are aware of the key advantages that an SDR brings to digital modulation schemes. These advantages include:

1. No additional wiring between the computer and radio
2. No 3rd party interfaces to connect the computer and radio
3. No additional sound cards are required
4. Because all data is already digital when it leaves the radio, all signals are protected from degradation and interference typically encountered with traditional analog audio interfaces
5. True SDR radios are already equipped with I/Q data to support leading edge and future digital mode programs
6. PowerSDR includes additional digital modes that support fixed offset RX filters and "on the fly" adjustable transmit filters defined specifically for digital modes

FOR MORE INFORMATION

For more information visit FlexRadio Systems at www.flexradio.com or call sales at 512-535-4713.

[7] http://physics.princeton.edu/pulsar/K1JT/wspr.html
[8] http://www.dxatlas.com/CwSkimmer/