THE SOUND CARD BUDDY

Connecting Your Radio to Your PC for Sending and Receiving Digital Data

Ham Radio and Digital Data

You've passed your FCC examination, bought yourself a Ham radio, and talked to a few people on the air. Now, what else is that license good for? For one thing, it is possible to use your radio for sending more than just voice. Hams first started sending FAX (facsimile) and RTTY (radio teletype) messages decades ago, and the use of "digital modes" by amateurs has been expanding ever since. Today we have a variety of ways to send digital data, text messages, and images over the airwaves.

Before the ready availability of cheap computers, these modes required expensive and specialized equipment. Today all you need is your radio and a PC to operate in any of them. A simple interface connects your radio to your PC's sound card and then specialized software, most of which is either free or shareware, processes the audio to recover the original data. The same software can generally create tones for transmitting data as well, enabling two way communication.

This article discusses how you can build a simple interface to connect your Ham radio with your PC. Although this article is written with VHF/UHF packet radio in mind, the interface can be used with nearly any of the digital mode. At the end of the article there'll be a few pointers to places where you can obtain free software to use with it.

Future articles will discuss a few specific applications. This includes APRS - Automatic Position Reporting System which involves using Packet radio and GPS to track people and vehicles. We'll also explore PACSATs - Packet Satellites, which involves using packet radio to exchange messages with people on the other side of the world through Amateur Radio satellites.

What makes a good interface between your radio and PC?

It is possible to simply connect a patch cord between your radio's headphone jack and your PC's sound card input. This will work to a degree, but it leaves much to be desired. First, the signal levels don't match very well - this is especially true if you true to connect your sound card's output to your radio's microphone input! Improper signal levels cause distortion which will make the data unreadable and, when transmitting, those excessive signal levels can cause over modulation and spurious outputs that interfere with other Hams.

Second, a patch cord doesn't provide any isolation between the radio and the PC. Isolation is desirable to keep digital noise from the PC out of the radio and to prevent ground loops. Ground loops occur because the radio is typically grounded thru its antenna and the PC is grounded by the power cord, and spurious currents can flow between these two grounds that add hum and noise to the audio.

Lastly, a patch cord doesn't provide any way to turn on (or "key") the radio's transmitter. This isn't a problem as long as you only want to receive, but the day will come when you want to transmit your own messages (you did take that FCC test for a reason, after all!) and then you'll need something better. Nearly all the sound card software expects to use a standard PC serial port (a "COM" port) to key the transmitter, and you need a simple circuit to connect the two.

Buying or Building a Sound Card Interface

You can buy a ready made sound card interface from several commercial sources, or you can find any number of plans for building one on the Internet. If you do decide to buy or build one, keep these few pointers in mind. First, be sure that the interface you get provides isolation for all signal paths. There are several inexpensive interfaces that only provide isolation for the radio's microphone input, and it does no good at all to provide isolation here when you still have to connect an ordinary patch cord between the PC and the radio's earphone output!

Also, there are some sound card interfaces that use a VOX circuit to automatically key the transmitter whenever any sound is output from the PC. This may seem attractive, and it saves a COM port, but leads to all sorts of embarrassing situations where you accidentally transmit your MSWindows boot up music, your "You have mail!" announcement, the "error" beep, or worse!

Figure 1 - The Spare Time Gizmos Sound Card Buddy

It's better to have positive control of the transmit function so that you know the transmitter is keyed only when the software has actual data to transmit.

Circuit Description

The circuit described here is about the simplest you can build that solves all the problems just described. It provides complete isolation between the PC and the radio; it provides adjustable level matching for both the receive and transmit audio, and it provides a COM port interface to key the transmitter. When you're reading the schematic, be sure to note the difference between the audio ground and digital ground symbols – audio ground is used on the radio side and digital on the PC side and the two are *never* connected.

The receive audio path starts at J4, pins 4 and 5. If you're using a radio with a dedicated "data" connector (more on that later) then it will generally provide *two* outputs. One, on pin 5, is the post discriminator audio and is used for 1200 bps data rates and slower, and the other, pin 4, is used only for data rates of 9600 bps and above. JP1 allows you to select which of these inputs feeds the PC – normally you'll leave this set in the 1200 bps (pin 5) position.

T1 provides isolation between the radio and PC for the received audio. R7 is a trim pot that allows you to adjust the signal level fed to your PC, and R5 together with R7 create a voltage divider that reduces the audio level to a typical level for a PC microphone input. Jumper JP3 places R4 in parallel with R5 to increase the signal level if the PC line level input is used instead – ordinarily, R4 will need to be *zero* ohms (i.e. just use a piece of wire!) to provide enough signal for a line level input. J1 connects to the PC's sound card input.

The transmit audio starts at J2, which is connected to the PC's sound card output and transformer T2 provides isolation for this path. Resistors R6 and R9 create an adjustable voltage divider that reduces the signal level to that required by the radio's microphone input, and jumper JP4 allows resistor R8 to be placed in parallel with R6 to increase the signal level if necessary. Generally, you will not need R8 and JP2 and they could be omitted.

Finally, the keying circuit starts with J3, a female DB9 that should be connected to a PC serial (COM) port. The software asserts either the DTR or RTS signal on the serial port when it wants to key the transmitter, and U1 isolates this signal from the radio. LED D3 is used as a visual "on the air" indicator and should be mounted where you can see it.

If you're using a radio with a dedicated "data" connector, then it is keyed by simply grounding pin 3 of the data connector, J4. Handy Talkies, or HTs, however, are generally keyed by a DC path to ground on the microphone audio input so this is provided by R10. Unfortunately this also reduces the transmit audio level, and you may need to experiment with the value of R10 to get the optimum results for your HT. Jumper JP2 allows R10 to be disabled if you switch radios; if you never intend to use an HT, you can eliminate JP2 and R10 altogether.

Construction

This circuit can be constructed on a piece of perf board using point to point wiring, however it's much easier and faster to build with a PC board. A ready made PC board is available from the supplier mentioned in the Parts List. This particular PC board is a perfect fit for the Hammond 1455C802 enclosure (approximately 1" by 2 ¼" by 3 ½") and an enclosure already punched and

drilled to fit this PC board is available from the same source.

All other parts are readily available from common suppliers such as DigiKey, Mouser and Radio Shack. The parts list provides recommended sources and part numbers for each item. Transformers T1 and T2 can be ordered new from the recommended supplier or you can use telephone isolation transformers scrounged from old modem cards. The PC board is designed to accept a couple of different, popular styles for these transformers.

If you do elect to build your interface with point to point wiring, remember that the digital (PC) ground and audio (radio) ground are *separate* and should never connected to each other!

Connecting Your Radio

Most fairly modern mobile radios, including Kenwood, Yaesu and ICOM rigs, already have a 6 pin mini DIN connector marked "data" or "TNC". If you're lucky enough to have a radio with one of these, then all you need is to connect it directly to J4 using a 6 pin mini DIN patch cord. These patch cords are readily available from your local computer store because they're commonly used with PC keyboards and/or mice.

If your radio doesn't have a data or TNC connector, or if it has a different style, or if you're using an HT, then you'll have to make up your own cable. The audio output from your radio, or the earphone output from your HT, should be connected to J4 pins 4 or 5. It doesn't matter which of these pins you use, and you can even connect the audio to both, but be sure jumper JP1 is set accordingly.

The microphone input to your radio should be connected to J4 pin 1 and the key or "push to talk" input – if your radio has a separate one – to J4 pin 3. If you HT doesn't have a separate push to talk input (most don't), then leave J4 pin 3 unconnected and use R10/JP2 instead. See the "Circuit Description" part of this article for more details on R10 and JP2.

Once you have everything connected, you'll need to adjust the signal levels with R7 and R9. The best way to adjust the receive signal level is to find some actual data to monitor – if you have a VHF radio then try monitor 144.390 for APRS traffic. If you do have APRS in your area you'll hear the familiar "BRAAAP! BRRAAAP!" sound (it sounds like an old modem!); if you don't then you'll have to open the squelch on your radio and use background static to adjust the levels.

Use R7 to adjust the receive signal level. An oscilloscope is the best way to adjust it – most PC microphone inputs want to see about 100mV peak-to-peak. If you don't have an oscilloscope then most of the sound card software provides a level adjustment meter, sometimes called a "tuning aid".

R9 adjusts the transmit audio level to your radio. If your radio has some kind of audio level meter built in then you're all set, but most VHF and UHF rigs do not. If you have an oscilloscope then try adjusting R9 for approximately 30mV peak-to-peak on J4 pin 1, but if you don't you'll have to experiment. Put a dummy load on your HT and use another radio nearby to monitor its output while you test, and then adjust R9 so that the volume of the transmitted data sounds about the same as your voice does when you speak into the HT's microphone. If you're unsure, then err on the low side – that's generally better than too high.

Finally, if you just can't get the right signal level, then remember that you can always change the values of R4/R5 or R6/R8 if necessary.

Software

The AGW Packet Engine, written by George Rossopoulos, SV2AGW, is free Windows software for sending and receiving 9600, 1200 and 300 baud UHF, VHF and HF packet. So far as I can tell, AGWPE is *the* defacto standard for hams doing packet radio with their sound cards. The free version of AGWPE includes a terminal program (for doing keyboard to keyboard packet), and is directly supported by WinAPRS and many other ham radio programs. George also offers a professional version, AGW Packet Engine Pro, which is not free but adds support for TCP/IP networking in addition to AX.25. You can download either AGWPE or AGWPE Pro, along with many utility programs, from the web site http://www.elcom.gr/sv2agw/inst.htm.

Although WinAPRS is not actually sound card software, I will mention it here because it can be used with the AGW Packet Engine to map and track APRS stations. You can find WinAPRS at http://www.winaprs.org/.

Although you can use AGWPE for HF packet at 300 baud, this is rarely done any more. The current standard for HF digital communications is PSK31, and there are several PSK31 implementations for a PC and sound card. Just a few of the more popular programs are WinPSK, http://www.qsl.net/ae4jy/winpsk.htm, DigiPan, http://www.nvbb.net/~jaffejim/digipan.htm, and HamScope, http://www.qsl.net/hamscope/. The latter program, HamScope, also decodes several other modes including RTTY and CW!

SSTV (Slow Scan Televsion) is still alive on HF, and you can try out MMSSTV, http://www.qsl.net/mmhamsoft/mmsstv/, or WinPix32, http://homepage.ntlworld.com/winpix/, if you want to experience it for yourself.

Finally, although it isn't exactly a Ham radio application, you can also use your sound card interface to receive images from weather satellites. These images are transmitted using facsimile (better known as FAX) and several programs exist to decode them. You might want to try HF-FAX (which also decodes HF FAX and SSTV), http://www.hffax.de/, or MeteoPro, http://www.mscanmeteo.com/products.html.

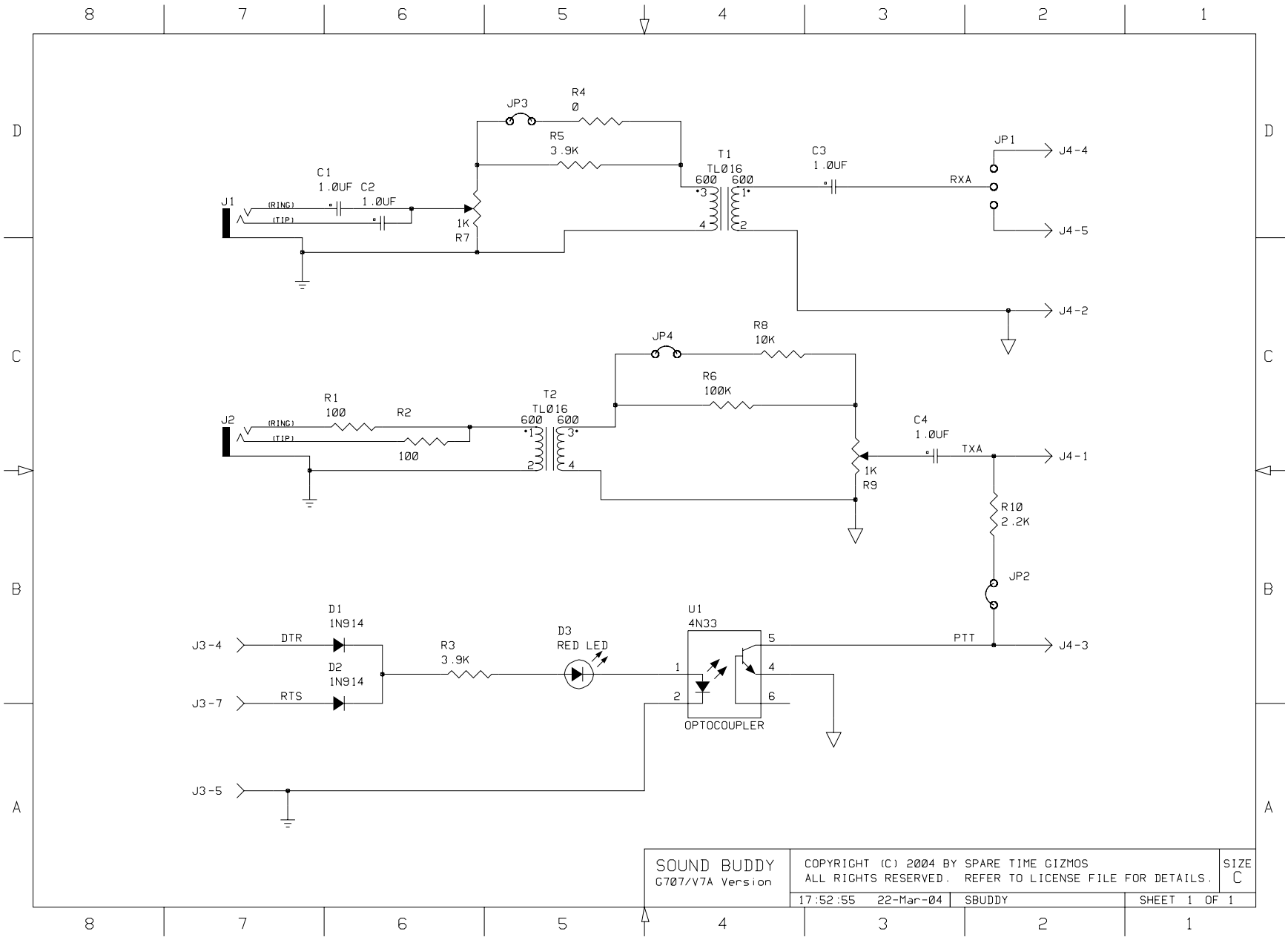

Figure 2 - Sound Card Buddy Schematic

LOC	MANUFACTURER	P/N	SUPPLIER	STOCK	QTY	DESCRIPTION
U1		4N33	Anchor		1	Optoisolator
D1, D2		1N914 or 1N4148	Anchor		2	Small signal switching diodes
D3			Anchor		1	Red T-1 3/4 LED
R1, R2			Anchor		2	100 ohm 1/8W 5% carbon composition resistor
R3, R5			Anchor		2	3.9K 1/8W 5% carbon composition resistor
R4			Anchor		1	0 ohm resistor (use a wire jumper!)
R6			Anchor		1	100K 1/8W 5% carbon composition resistor
R7, R9			Anchor		2	4.7K ohm 3/8" trimmer resistor
R8			Anchor		1	10K 1/8W 5% carbon composition resistor
R10			Anchor		1	2.2K 1/8W 5% carbon composition resistor
C1, C2, C3, C4			Anchor		4	1.0uF 50 WVDC Mylar Capacitor (0.3")
T1, T2	Xicon		Mouser	42TL016	2	600:600 Ohm Matching Transformer
J1, J2	Cui Stack	SJ-3533N	DigiKey	CP-3533N	2	3.5mm Stereo Audio Jack (PCB Mount)
J3		DE-9S			1	9 pin right angle PCB mount female D connector
J4	Cui Stack	MD-60SM	DigiKey	CP-2260	1	6 pin female right angle PCB mount DIN connector
JP1			Jameco		1	3 pin header (jumper)
JP2, JP3, JP4			Jameco	SMH02	3	2 pin header (jumper)
	Spare Time Gizmos[1]	SBUDDY-1A			1	Printed Circuit Board
	Hammond	1455C802			1	Aluminum enclosure[2]

Table 1 - Sound Card Buddy Parts List[3]

[1] A blank, double sided silk screened and solder masked PC board is available from Spare Time Gizmos for $15 plus tax and shipping.
[2] A machined and drilled Hammond enclosure is available from Spare Time Gizmos for $18 plus tax and shipping as P/N SBUDDY-ENC.
[3] A complete kit of all parts, including the PC board and a machined and drilled enclosure, is available from Spare Time Gizmos. Ask for part number SBUDDY-KIT.