

# The Ins and Outs of a Sound Card

The speaker icon in the bottom right corner of your computer screen signifies more than you might think. Its sound card and the computer software written for it have opened the door to a host of new digital modes in Amateur Radio.

A computer used for signal processing and decoding in a ham station is capable of using nearly 100 different Amateur Radio sound card programs with over 20 distinctly different modes of communication. Not only are the traditional modes like CW and RTTY possible, but almost every digital mode is open to operation, as well. It's even possible to use a digital voice keyer that is built into most contest logging programs and thus save your voice in the next contest. State-of-the-art experiments with modes like high definition SSTV and digital voice communication are now possible. Video communication using a new HDSSTV experimental mode can be accomplished with total clarity at signal levels that make conventional SSTV pictures unrecognizable.

## The Possibilities

Amazing examples of what can be done with new digital modes include the communications software developed by Joe Taylor, K1JT.<sup>1</sup> *WSJT* is K1JT's state-of-the-art communication software that offers several modes of operation. *JT44* mode is designed specifically for extreme weak signal communication and it will reliably copy signals that are so weak that they are totally inaudible (barely above the receiver noise floor). This program makes 2 meter moonbounce (EME) contacts possible using only a single small antenna with a relatively low power output (for EME contacts) of only 100 W. Another *WSJT* mode, *FSK441*, will copy a full set of call signs with a meteor ping reflection just 0.1 second long, coming close to making 24/7 VHF meteor scatter communication practical. Pretty amazing stuff...and who knows what's on the horizon?

A sound card opens the door to using all of this software. It can also be used to

link a transceiver to the Internet or even to equalize and process microphone audio. You'll appreciate that the computer in your ham station can be of far more use than just keeping your log! If you don't have a computer, one can usually be found for as little as \$100 at a local hamfest. You'll also need a sound card interface, but that's easy to build or inexpensive to buy. Most of the software is inexpensive or free, written for the Amateur Radio community by talented and dedicated hams.

The concept of a computer with sound being able to communicate through a radio is foreign to many amateurs. It is actually as simple as talking into a microphone and listening to your radio. The computer "listens" and "talks"—that's its input and output. We may try to communicate with another amateur in English, but if that amateur is speaking another language, we might have a problem. If both computers are "speaking" RTTY, the communication

works great; if they are both speaking PSK31, things work even better. If one computer and its radio system are, however, listening and expecting packet and the other is transmitting on AMTOR, things don't work at all. Just think of the different modes that computers speak as communications languages. The information is processed digitally inside the computer, but the "sound" that is coming in and going out is analog audio. The sound card uses a digital to analog converter (DAC) and an analog to digital converter (ADC) to convert and encode the audio for digital processing and, ultimately, to transmit and receive audio to and from the transceiver.

## Making It Work

I will discuss the basics of connecting a sound card but, for the most part, I'll explain sound card operation and point out some pitfalls to be avoided in setup and

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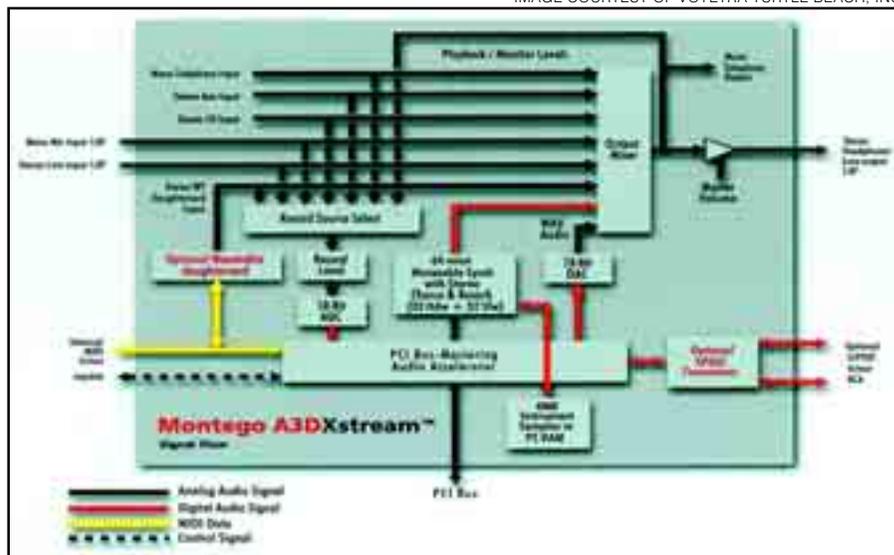


Figure 1—A typical sound card signal flow diagram. The card consists of many circuit blocks, each requiring level adjustments from virtual control panels.

<sup>1</sup>Notes appear on page 36.

operation. Since most radio communication software is written for the *Windows* operating system, this article assumes that system is being used. Connection descriptions should also apply, however, to a Mac or a Linux system. A good understanding of your sound card will make it easier for you to get on the air with it. Even if you have properly interfaced a radio to your computer, that *system* might not work at all if your sound card is not set up properly. Interfacing the sound card to the outside world is not where most hams run into trouble...the problems are usually with the software and the sound card settings. Many of us have spent many frustrating hours checking exterior connections while the solution to a problem was only a mouse click away.

Actually, you don't really need a sound card interface to get on the air and give it a try. A little known secret is that you can put your radio's microphone in front of a computer speaker and your computer's microphone in front of your radio's speaker to make contacts using sound card software. Transmit and receive audio is then acoustically coupled from microphone to speaker and vice versa. Of course, if you do this, you'll need a quiet room, you'll have to operate with voice control (VOX) or manual transmit control (PTT) and you'll have to watch your levels. I do encourage you to try this method; it's an easy way to make your first contact and to start receiving a new mode, although from a practical standpoint, it leaves a lot to be desired.

If you realize what is going on here, the concept of connecting a sound card is simple. Sound comes out of your radio and into your computer to be processed, or decoded, in the receive path. Processed sound comes out of your computer and goes into your radio to be modulated and transmitted. The input to the sound card is the receive (audio) signal and the output is the transmitted (audio) signal. If you understand this, you are ready to operate. Most of the work is done (inside the computer) with the incredible software available to us.

## The Hardware

Sound cards come in lots of flavors... 8 bit, 16 bit, 32 bit, wave table synthesis, ISA, PCI, gold, 128, "surround sound" and so on. I refer to a sound "card," but a computer can, instead, use sound processing chips on the motherboard. That is usually the case with laptops. There are some new external sound adapters that function as a sound card but are connected externally through a USB port. If your computer has sound it will have at least a headphone, microphone or speaker jack. If so, you can use it with your radio to communicate. A

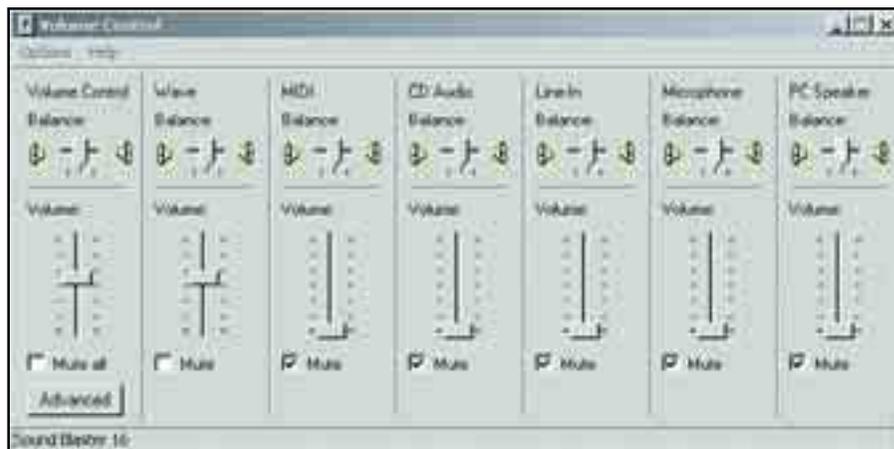


Figure 2—The playback control panel in *Windows*. It serves as a transmit control panel.

complex sound card is not needed—a modern, though inexpensive PCI sound card will work very well and a simple one will be easier to connect and operate. Older, ISA bus cards will work with most Amateur Radio programs but might have limited dynamic range and slower processing.

If you are interested in learning more about sound cards there's a very good white paper on the subject written by Jim Barber, N7CXI, of Silicon Pixels.<sup>2</sup> The paper is entitled "ChromaSOUND Technical Supplement" and can be found at [www.barberdsp.com/tech/cs100.pdf](http://www.barberdsp.com/tech/cs100.pdf). It has specific information about sound card differences.

Even the simplest of sound cards can be complicated. They can have as few as two external connections but there may be as many as twelve or more. At the rear of your computer you may find LINE IN, MIC IN, LINE OUT, SPEAKER OUT, PCM OUT, PCM IN, JOYSTICK, FIREWIRE, S/PDIF, REAR CHANNELS or SURROUND jacks, just to name a few. Connections appear not only on the outside, but inside, as well. The main internal connection is to the ISA or PCI bus and this is by edge connection to the board. There may also be CD audio, telephone, daughterboard and PC speaker connections inside and on the board, as well.

The first thing to do is to identify which connection is which, at least at the card edge bracket, outside the board. The jacks are usually poorly marked with nonstandard international symbols or color codes. I mark the jacks clearly with a permanent marker. It seems that the faint cryptic markings are always hidden in the dark, behind my computer and it really helps to identify them clearly.

Depending on your computer, you may be able to choose your receive audio connection from either MIC INPUT or LINE INPUT. Anything else you find is not an audio input. If you do have a choice, use the LINE INPUT for the receive audio from

your radio. Although the MIC INPUT jack can be used, it will have much more gain than you need and you may find adjustment quite critical. The MIC INPUT jack will work better, however, if your sound card has an "advanced" option to select a 20 dB attenuator. You should not need ground isolation for receive audio as it is at a high level and is normally not susceptible to ground loops. You may also be able to choose from several outputs that appear on the radio. Your radio may have SPEAKER, HEADPHONE, LINE OUT, RECORD, PHONE PATCH and DATA OUTPUT jacks available. These may be fixed output or variable output (using the radio's volume control). Be careful with radio's DATA OUTPUT jack—it may not work on all modes and may not have the proper FM de-emphasis requirement.

For the transmit connection, you will have a choice of the computer's HEADPHONE OUTPUT, LINE OUTPUT, SPEAKER OUTPUT or a combination of these. The SPEAKER OUTPUT is usually the best choice as it will drive almost anything you hook to it. The SPEAKER OUTPUT has a very low source impedance making it less susceptible to load current and RF. Any one of these outputs will usually work fine, provided you do not load down a line or headphone output by using very low impedance speakers or headphones to monitor computer-transmitted audio.

The transmit audio connection must have full ground isolation through your interface, especially if it drives the MIC INPUT of the radio. [This usually means a line-coupling transformer of 1:1 ratio and 600  $\Omega$  impedance. RadioShack<sup>3</sup> part no. 273-1374 will work.—Ed.] Again, DATA INPUT jacks may not work the way you expect.

Never use the digital input or output of your sound card. Even though you may wish to operate a digital mode, it will not work. You must use an analog audio connection, not a digital one. These jacks may

be labeled PCM AUDIO and they have a digital data stream coming out of them, but it's not audio. Currently manufactured radios require analog audio.

## Setting Levels

Setting the sound card levels correctly is an area in which you may run into difficulty. Sound cards are much more complex than you might think; most sound cards have more than 35 separate adjustments supported by two major virtual control panels. No two computers are alike, and there are always several different ways to get the same results. To make matters worse, once you adjust your sound card don't expect it to stay adjusted. Running other programs and rebooting your computer may reset your sound card parameters. You may find that you have to readjust your card the next time you need to use it for communications.

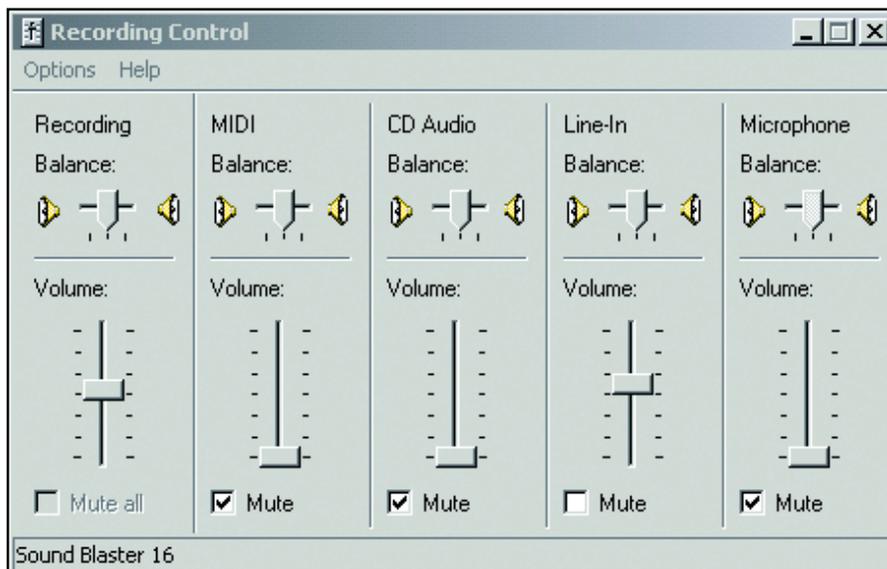
Sound card control is accessed through several virtual control panels. The sound card may also be controlled automatically through the software programs that you use. Take a look at Figure 1 and you'll see there are many analog and digital signal paths in a typical sound card.

You'll see that there are no less than seven inputs to the "Record Source Selector" and eight inputs to the "Output Mixer." Each one of these has on/off, volume (gain), and balance (left/right gain) adjustments on the virtual control panels. Our job is to identify which ones you are connected to and make those connections work.

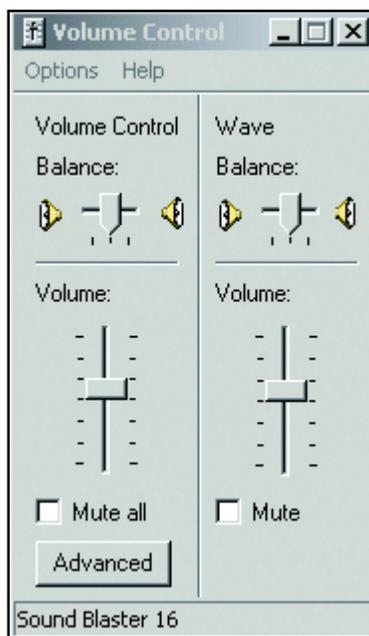
When you single-click (left) the speaker icon in the bottom right corner of your computer screen you get one simple up/down slider with a mute switch. If you double-click that same icon, however, you get a large control panel for playback as shown in Figure 2.

Your control panel may be different. Instead of saying "Volume Control" at the top left corner it may say "Playback" or it may have "Select" instead of "Mute" boxes at the bottom. Each section has a label indicating the control for a single mono or stereo signal path: Volume Control, Wave, MIDI, CD Player, etc. The word Balance that appears to be part of a section label is not; it is just a label for the left/right slider directly beneath it. This is the playback, output or monitor control panel or, as hams would call it, the transmit control panel. This panel's only function is to adjust what comes out of your sound card. The only exception would be if you had an older sound card—the controls might be ganged with the recording control panels; they then could not be adjusted independently.

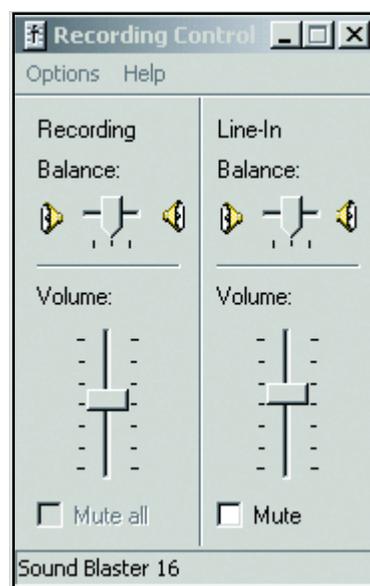
Figure 3 shows a typical "Recording" control panel. This panel is carefully hidden in *Windows* and I bet you didn't know it was there unless you are already operat-



**Figure 3—The recording control panel in *Windows*. This functions as a receive control panel.**



**Figure 4—A customized control panel for setting transmit levels. This is a good starting point.**



**Figure 5—Another custom control panel for setting receive levels. Again, these are good starting point adjustments.**

ing the sound card modes. I don't know why the folks who wrote *Windows* hid it so well but here's how to find it: double click the speaker icon, then "Options," "Properties," "Recording" and finally, "OK." Surprise...another control panel appears! The "Recording Control" panel is used to turn on and adjust the input signals from both analog (audio) and digital inputs and to feed those input signals to the software for processing. This functions as a receive control panel. It does not normally control transmit unless you are transmitting an audio signal that is being fed from your radio, through your computer and software, and processed in real time.

An example would be microphone equalization or speech processing.

Depending on your sound card there may be buttons for "Advanced" settings. Here you can find advanced settings for tone control, microphone gain, recording monitoring, etc. Be careful with the recording monitor settings as they can cause an internal or external feedback loop.

Both of these control panels may be customized to show only the controls that you need for your station. Go to "Options," then "Properties" and select the appropriate check boxes under the "Show the following volume controls" box. By doing this you will end up with simple control panels

customized for operating your station, as shown in Figure 4 and Figure 5.

Figure 4 is all you need to set your transmit level. And, assuming you are using your sound card's line input for the receive function, then Figure 5 is all you need for that, as well. Note that the sliders are up, the balance is centered; and the inputs and outputs are unmuted. I can guarantee that something won't work if you have any one of these sliders all the way down or that input muted. Again, your sound card may be different, but if it says "Select" instead of "Mute" you have to check the box instead of unchecking it. I suppose the folks at Microsoft wanted to see if we were on our toes. Take another look at Figure 1 and see if you can figure out which sliders on the control panels (Figures 2 and 3) correspond to which function.

### Daisy-Chained Transmit Level Controls

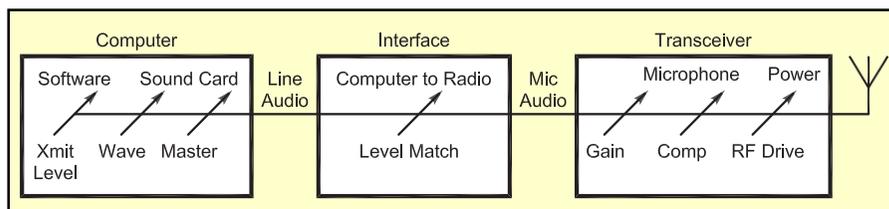
The concept of daisy-chaining may be unclear to many operators, so here's another diagram, Figure 6. All of these adjustments must be set to complement one another. If any level is too high or too low it will affect how the succeeding level reacts and the resultant output level will be improper.

Looking at the left of the drawing (Figure 6), some programs will allow you to set the digital output level of the software itself, independent of the sound card. Some programs will even allow you to set individual modes or tones with respect to others. Generally you can ignore this, but it is best to read the software documentation that comes with your program to find out more.

The next controls (to the right in Figure 6), Wave and Master, set the sound card output via the "Playback" control panel, Figures 2 and 4. Start with an arbitrary setting for both of these at  $\frac{1}{3}$  to  $\frac{2}{3}$  of the way up. Don't forget to select or unmute them. Put the software you are using into the transmit mode and you should be able to hear the transmit tones coming from your computer speakers, if you have speakers connected. If your speakers are too loud turn them down with the actual (hardware) speaker volume knob. Do not set the sound card output too low—that could result in too little audio to transmit. If your computer speakers or headphones are not adjustable you may have to disconnect them.

A properly designed sound card interface will have a level adjustment to match any computer to any radio. That adjustment is typically set last, after setting the computer and radio levels, as you'll see later.

Adjust your radio's microphone gain



**Figure 6—An example of daisy-chained transmit level controls. Note that the controls are in series and the resultant output is affected by each of the prior control settings.**

control for normal voice operation. Normal microphone settings *will* work with a sound card; you should not change them. Do not turn down the RF drive/power and expect the sound card audio to drive your radio. Leave the RF drive set to maximum or full power. For most sound card operating modes turn your speech compressor off, although a few modes, especially pure FSK, may work better with the speech compressor on. Read the help files and documentation that came with the software.

After your computer and your radio are set, you should adjust your sound card interface audio level to drive the transmitter to 50 percent power output or less. There are two reasons for doing this—to eliminate production of a wide and distorted signal and to prevent overheating of the transmitter's power amplifier. Less than full power output ensures that you won't overdrive the transmitter, cause distortion and overtax the amplifier. Most digital mode duty cycles are continuous and full power operation for an extended time can overheat the transmitter. According to K1JT, the *WSJT* software modes contain only single tones at any instant and cannot easily produce intermodulation distortion (IMD), although IMD is possible with other digital modes if drive levels are excessive.

Most sound card modes, even CW and RTTY, require that your radio be in USB. For FM operation with packet, SSTV or Internet linking, you will usually not be able to determine the exact modulation level. Set your transmit audio for correct FM deviation using proper test equipment or simply monitor your signal with another receiver to compare your modulation level to that of other stations. For Internet linking, all users connected via the Web will have to be correct as far as level is concerned. *EchoLink* by K1RFD<sup>4</sup> has a test server, 9999, that echoes back audio so that modulation levels can be set correctly.

### Finally

Now that you know everything you need to know about using your sound card for communications, proper operation should be simple. But...what if you don't have a speaker icon in the lower right corner of your computer screen? Go to

"Start," then "Settings," and "Control Panel." Look at the listings under Control Panel and choose "Sound and Audio Devices Properties." Select the "Volume" tab. You should see a check box entitled, "Place volume icon in the taskbar." Check it. While you're at it, you should select, under the "Sounds" tab, the box titled "Sound scheme," then "No Sounds." That will eliminate annoying beeps, clicks and melodies from being transmitted. Sound card control panels may also be available from the menus within most radio software. Again, there are usually several ways to get the same result.

While this discussion has centered on adjusting your sound card using the *Windows* control panels, you should also read any help files and/or manuals that come with the radio software you want to use. Those authors probably spent almost as much time writing that documentation as they did coding the program. The help files and manuals will usually contain the answers to most of your questions.

Amateur Radio is a technical hobby and computers are a part of it. They are wonderful tools that can be coupled with marvelous communication software. Together, they can manage signal processing and facilitate communication modes that were never dreamed possible 20 years ago. Put your computer on the air! Make it work for you and take part in the amazing synergy of the digital world and Amateur Radio.

### Notes

<sup>1</sup>[www.vhfdx.de/wsjt](http://www.vhfdx.de/wsjt).

<sup>2</sup>Silicon Pixels, PO Box 579, 681 Wenas View Dr, Selah, WA 98942; tel 509-961-3780; [www.barberdsp.com](http://www.barberdsp.com).

<sup>3</sup>[www.radioshack.com](http://www.radioshack.com).

<sup>4</sup>[www.echolink.org](http://www.echolink.org). See also S. Ford, "VoIP and Amateur Radio," *QST*, Feb 2003, pp 44-47.

*Del Schier, K1UHF, was first licensed in 1961 and holds an Amateur Extra class license. Del operates from the top of West Mountain in Ridgefield, Connecticut and is active on all bands, from 1.8 MHz to 10 GHz, including 2 meter EME. He says his favorite band is 10 GHz. The designer of the RIGblaster and RIGrunner products, he works at West Mountain Radio. He also enjoys flying R/C electric and glider models. You can contact him at 126 Old West Mountain Rd, Ridgefield, CT 06877 or at [k1uhf@westmountainradio.com](mailto:k1uhf@westmountainradio.com). QST*