particular transmitter. In the old days of tube radios on 6-meter FM, Paul Bohrer, W9DUU, and others would look at a scope across the discriminator output to catch a glimpse of the turn-on of an unidentified transmission.

In 1996 the "Sherlock" system used a homebrew audio amp, followed by an A/D to convert the movement in frequency into a digital representation. The software then converted the digital data into a graph. By comparing the graphed turn-on of an unknown transmitter to the turn-on of a transmitter that was identified, it was possible to determine if the two transmissions came from the same transmitter. Modern rigs that are intended to be used for digital modes may have faster turn-on and therefore less of a "fingerprint," but having the information as to a jammer's turn-on and turn-off characteristics is still helpful, even if only to exclude suspects. The turn-off characteristics should not be ignored, as two transmitters having virtually identical turn-on characteristics may have far different turn-off characteristics.

The Sherlock system software ran under DOS, not Windows®. The hardware required time to build. It is time for a new transmitter fingerprint system.

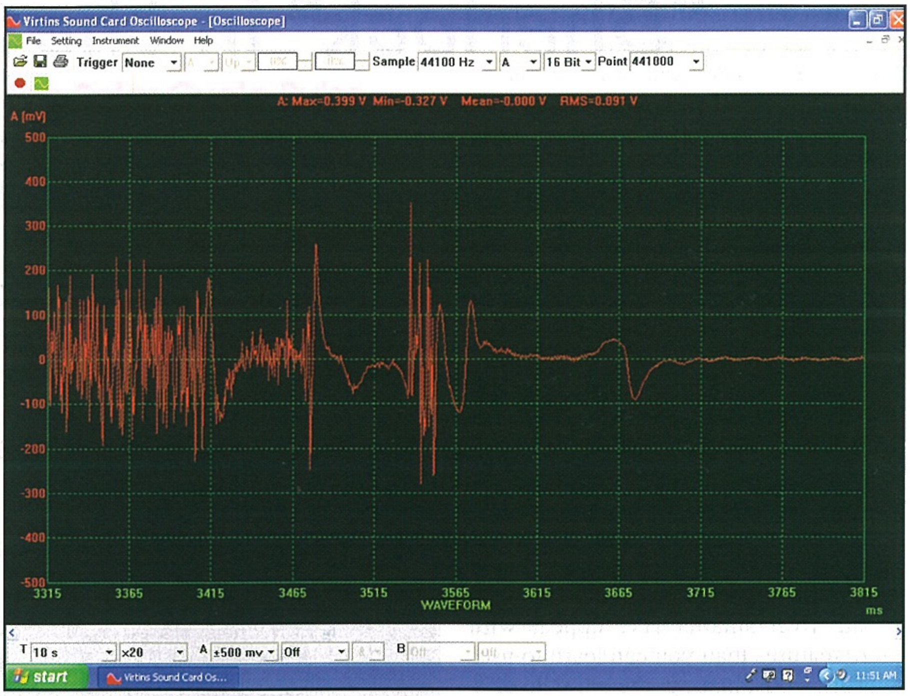

Figure 2. The Virtins Oscilloscope displays the "turn on" signal in figure 1.

The Modern "Sherlock" Transmitter Fingerprint System

The discriminator, ratio detector, or other detector of an FM receiver converts the frequency excursions of a transmitter turning on or off into electrical waves.

Windows® computers have sound cards with standardized computer interfaces. That makes it possible to create software that will run on any XP computer and use the soundcard to change analog electrical waves to digital data. To capture a transmitter's turn-on and turn-off fingerprints, the software must capture the frequency movements of the transmitter in the two-tenths of a second when it turns on or off.

Virtins Oscilloscope Software

Writing complicated software is not necessary if there is commercial software that will do the job. A digital-storage oscilloscope is designed to display electrical waveforms as a graph and save the information. There are various software oscilloscopes that work with computer sound cards. As the frequency movement that makes up the turn-on characteristics is a low-frequency audio wave, a software oscilloscope that stores the data is just what is needed.

The old "Sherlock" system ran until an operator heard a jammer. The operator "hit any key" and the program stopped, displaying a graph of the turn-on. It was impossible to find a software oscilloscope having that exact feature. However Virtins, a software company, has an oscilloscope program available at <http://virtins.com> for only $25 (as this article is being written). There is a free-trial period. The program takes in data for a period of time that is determined by the operator. Then the data is presented on the screen as an oscilloscope graph.

Using the Virtins system, the operator can select the settings of the program, start the program running, and wait for a jammer. When the jammer starts transmitting, the operator can wait until the turn-on is captured, turn the data intake off, and save the turn-on.

How the New "Sherlock" System Works

With the sound card "line" or "microphone" input connected to the output of the detector of the FM receiver to be used (how to do that will be explained below in detail), and no signal being received by the receiver, the Virtins Oscilloscope program will show noise. When the operator hears a transmitter he wants to fingerprint, he waits until the transmission shows up in the data. Figure 1 shows 10 seconds of reception, with typical noise for the first 3 seconds, followed by a few seconds of a received transmission, then noise again.

The operator stops the data input when he sees the turn on (and in this case also the turn off) appear on the screen. The operator then uses the "Time multiplier" function on the program's control panel at the bottom of the screen to spread out the graph 20 times. He then uses the "slider" at the bottom of the screen to scan through the data until he sees the "turn-on" shown in figure 2. The turn-off is figure 3.

The data can be saved as a wave file. The saved data is audio, which can be played back with the *Windows® Media Player*. The operator can open the .wav file with the Virtins Oscilloscope program and see the graph of the turn-on again. The operator can open more than one copy of the program to compare two graphs.

Connecting Things

Download the oscilloscope program from Virtins. Currently there is a free trial period. You can try any oscilloscope program. When the program is installed, run it and look at the oscilloscope screen with audio from any source. When in doubt, read the help file and other instructions.

You have to use a FM receiver. If you want to identify a transmitter that is an

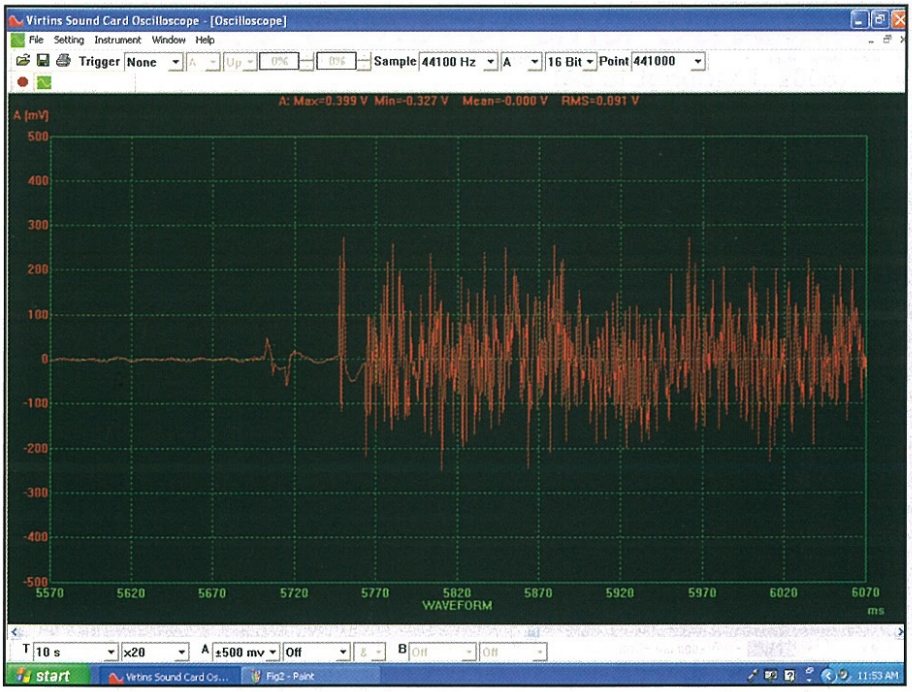

Figure 3. The oscilloscope display of the "turn off" signal in figure 1.

AM transmitter, such as in the commercial aircraft service, you must use an FM receiver to capture the fingerprint at turn-on and turn-off.

Connect the output of the discriminator, ratio detector, or other detector in your FM receiver to the input of your computer's sound card via a shielded cable. A schematic of the FM receiver will be helpful in deciding where to connect the center conductor of the shielded cable. Do not use audio from the speaker or the headphone jack. The receiver has audio circuits that eliminate the sub-audible tones needed to use some repeaters. The circuits that eliminate the sub-audible tones also eliminate the turn-on characteristics. Obtain the direct output of the detector.

Connecting to the Receiver

Since you now have an audio oscilloscope, prepare a shielded cable more than long enough to go from your computer sound card to where you will place the FM receiver. The sound-card end of the shielded cable should have the connector that goes on the line input (or mic input) of your sound card. The center conductor of the shielded cable is attached to either connection on the connector for the A or B channel and the shield is grounded.

At the receiver there may be an output from the detector to use for high-speed data. If there is, try that source. If not, solder one lead of a .1-mFd ceramic capacitor to the center lead of the cable and use a clip lead to ground the shield to the receiver chassis. With the receiver not connected to an antenna, you can use your new audio oscilloscope to look for the detector output, which will consist of noise. The noise will not look quiet like the noise in figure 1, as you will not be using the long sampling period of 10 seconds used to produce the graph in figure 1. You are using the free capacitor lead as a probe to find the detector output. Obviously, look near the detector circuit. Do not short out anything.

When you find the audio noise, turn the audio on the receiver up and down. The level of the audio on the oscilloscope screen should not vary, as you are sampling the audio before the audio-amplifier and volume-control stages. If the amplitude on the screen does vary, you are not connected to the detector output.

When you find the detector output, disconnect the cable from the sound card, turn off the receiver, and remove capacitor lead that is attached to the cable. Being careful when soldering, solder one lead of the .1-mFd capacitor to the component lead or printed circuit trace where you found the audio noise from the detector. Solder the other lead of the capacitor to any type of connector you prefer that you can mount on the receiver case. An RCA audio connector is fine. Be certain that the outside part of the connector is grounded and the inside part is connected to the capacitor lead. Install the appropriate plug, such as RCA, on the end of the shielded cable.

Put the cabinet back on, plug the cable into the sound card and the other end into the new connector on the receiver (or the high-speed data output), and check things out. When the receiver is turned on, audio should appear on the oscilloscope screen.

Operating the System

Run the Virtins oscilloscope software. At the top of the screen there are various options. For "Trigger" select "None." For "Sample" you can use the default rate if you have a new, fast computer, such as a 3-Gig Pentium 4. You may have to change the "Sample" rate to 8000 or 4000 if you have a slower computer to avoid excessive time while the data is being computed and no data is being taken in. Choose "A" or "B" as the channel input, depending on how you wired the sound-card plug.

At the bottom of the screen, "T" for time should be set to *10 seconds*. With that setting the computer will take in data for about 10 seconds, do the computations, and place the entire 10 seconds on the screen. For the time being, leave the time multiplier at "1." The "A" or "B," depending on which audio channel of the sound card you are using, is the gain setting. Set it so that the noise from an unused frequency is about one half of the screen.

Try things out using your HT to generate a turn-on and turn-off. With no antenna on the receiver, put the HT in low-power position and connect it to a dummy load. Turn off the sub-audible tone transmission on the HT. The HT must be transmitting on the frequency the receiver is receiving.

Start the data intake. Nothing will appear on the screen for about 10 seconds. Then you should see noise across the screen. Turn off the data intake. Turn the data intake back on and wait two seconds or so. Make a two-second transmission with the HT. Wait for the data to appear on the screen. It should be similar to figure 1.

Stop the data intake as soon as you see the transmission on the screen. You have now captured the turn-on. As the transmission was short, you have the turn-off also. Go to the bottom of the screen. Change the time multiplier to "X20." Use the slider that will appear at the bottom of the screen to move back and forth through the data until you can see the turn on. Figure 2 is a sample turn-on. Figure 3 is a sample turn-off. Your HT's turn-on and turn-off will be different.

The data can be saved using the save function of the program. As the data is saved as a wave file, it can be played so you can hear what was said, as well as reloaded into the program and displayed.

If the station transmitting is using a sub-audible tone (tone squelch transmission), the sub-audible tone will appear. Figure 4 is a transmission with a sub-audible tone. Figure 5 is a turn-on with a sub-audible tone, using the same transmitter that generated the turn-on and turn-off in figures 2 and 3 when its sub-audible tone was turned off.

Finally, this system produces data that is based on the turn-on and turn-off characteristics of the transmitter being received. However, the receiver being used influences the result. The sound-card performance influences the result. Therefore, the same transmitter may produce different data when received by a different receiver and when a different sound card is used. Only compare samples taken with the same receiver and the same computer/sound card. In addition, it is possible that two transmitters might have the same turn-on and/or turn-off characteristics.

It is a good idea to practice capturing turn-on and turn-off characteristics off the air using a good (high) antenna before any serious use of this system. Note that you can lose a turn-off or turn-on if the computer has completed taking a 10-second sample and is computing the result while the turn-on occurs. Given the price, the fact that the audio being transmitted can be saved as well as the fingerprint, and the fact that there is no hardware to build, this system may be the answer to your jammer identification problems. ■

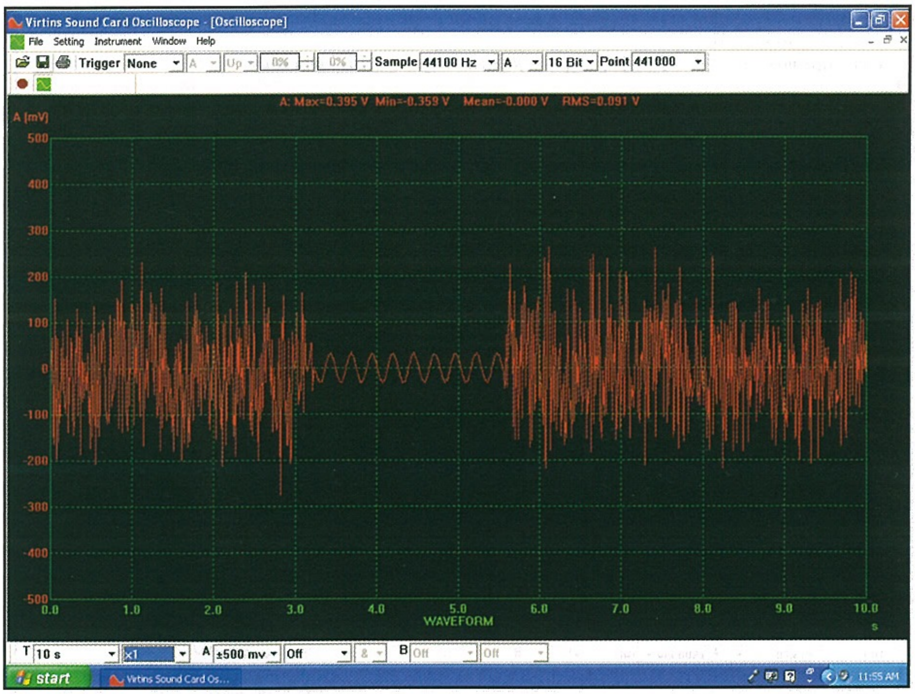

Figure 4. The oscilloscope display of a transmission with a sub-audible tone.

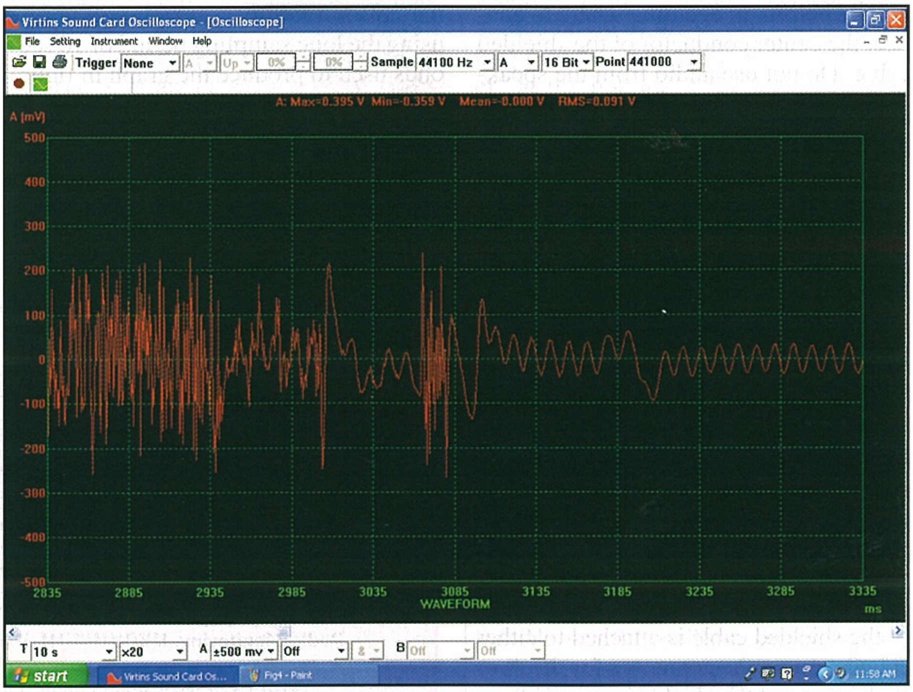

Figure 5. The Virtins Oscilloscope displays the "turn on" signal of the transmission signal in figure 4.