

Running PowerSDR for the SDR-1000 Software Definable Radio

By John Catalano

Last month we explored exactly what a Software Definable Radio (SDR) is. We then got our hands on the first commercially available SDR from FlexRadio Systems, the SDR-1000.

This month we take a peek into the inside of the SDR-1000 transceiver. Then we will connect it to a PC and try out FlexRadio's receiver software, PowerSDR. After all, a software definable radio is only as good as its software.

What's Inside?

The blank front panel of the SDR-1000 belies the complexity of the circuitry within. However, given the vast strides in on-chip circuit integration, the SDR-1000 electronics hardware is quite compact. Figure 1 shows the sandwich of printed circuit cards that make up the SDR-1000's hardware. This photo shows the size of the printed circuit board stack relative to a US twenty-five cent piece. The stack only occupies about half of the case, with the remaining half predestined for add-ons, such as a 100 watt amplifier for the now 1 watt transmitter. See Part One for a block diagram of the SDR-1000.

Our first task is to connect the SDR-1000

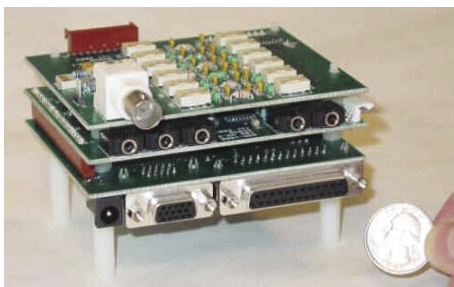


Figure 1- The Printed Circuit Board Sandwich Inside the SDR-1000

to a well-regulated 13.8 volt DC supply. For receive-only a steady 0.6 amp supply will do fine. However, if the transmitter section is to be used, 1.1 amp supply is suggested. In any case, make sure that it is a well-regulated supply. I used a Lambda supply, model LXD-C-152-R, that I found at a radio flea market.

When I heard about the SDR1000, I envisioned it using either a serial or USB port for control. I was very surprised to find that the SDR-1000 utilizes the computer's parallel/printer port. Therefore, you will need a full 25 pin parallel cable (male-male) which is not supplied with the SDR-1000. These are a bit rare these days, but my well-stocked cable box provided one.

The signal output of the SDR-1000 requires a shielded miniature stereo cable (male-male) to connect between the "To Line" connector on the back of the SDR-1000 and the "Line In" of the PC's sound card. See Part One to refresh your memory on the "supported" sound cards. With the addition of an antenna connection, we are ready to go.

PowerSDR and the SDR-1000

I tried PowerSDR on two Windows 98SE PCs with little to no success. Once I moved to an XP machine with the latest SP2 patch, things worked as expected. Experience with the various sound cards and Win98 indicated that these are two *critical* areas that cannot be worked around. I strongly suggest you use XP and try your existing sound card. However, be prepared to install one of FlexRadio's support sound cards if you have problems. Don't waste time, just do it, if you want to use the SDR-1000.

As the FlexRadio website says, "The SDR-Console provides all DSP and control functions for the SDR-1000 transceiver. Source code is available with purchase of the SDR-1000 to encourage amateur SDR research and experimentation."

First, let me say, that the software provided by FlexRadio is in constant flux due to improvements and additions. Remember that this is part of the excitement, with the SDR in its early stages of development. During my time with the SDR-1000 there were four versions of PowerSDR issued. Each one added new features as well as curing teething software issues. Check out their website <http://www.flex-radio.com> for new versions.

We will use PowerSDR version Beta 0.1.6 for this article. This program comes as a 700M zipfile and installs without problems with three mouse clicks. PowerSDR's main screen has a lot going on, as you can see in Figure 2. Clicking on the "Power" button at the top left connects the program to the hardware.

In Figure 2 we are tuned to WWV's time signal on 15 MHz in the SAM (synchronous AM) mode. The large display at the top left of

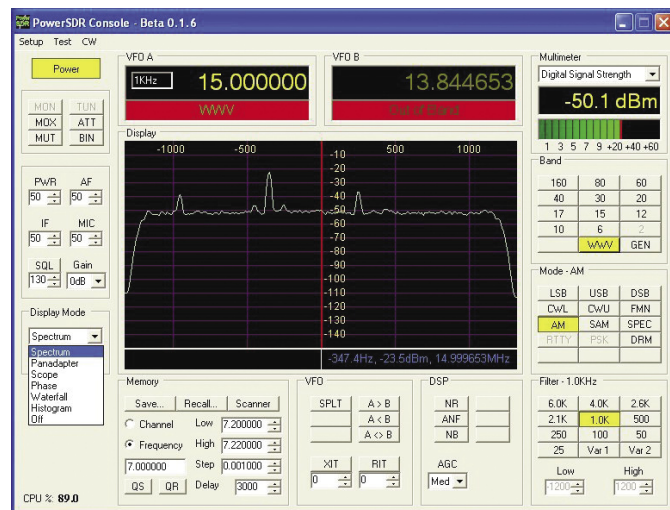


Figure 2- The Main Display of the SDR-1000 Where It's All Happening

the display shows we are tuned to 15.000000 MHz. The out-of-the-box tuning was accurate to a few hundred cycles ... pretty good! But the SDR-1000 is capable of better. More on this subject later.

Gain Control Panel

The area on the center left side of Figure 2 has six different gain settings. The default values worked fine for all except "Gain". For my location/antenna the gain setting had to be set to 0dB (from the default value of 26dB) in order to eliminate overloading and all the problems it brings. This change made a world of difference to the performance of the SDR-1000.

The "IF" gain adjusts the Record Line In level and effects the dynamic range of the receiver. It seemed to work best in a range from 36 to 60. But this value is a function of the sound card being used. Volume "AF" and squelch "SQL" are other often used settings found in this panel.

Tuning the SDR

There are many methods of tuning the SDR-1000. These include using: the mouse wheel, the numeric keypad, Shift/arrow keys, the "Band" buttons and spectrum display, to name a few. I found the easiest method was a two-step approach. First, the approximate frequency is keyed in via the number keys or the "Band" buttons on the right of the screen. These buttons store the last four frequency, mode, and band pass selections. Pressing the Band button multiple times, scrolls through the stored selections. For SWLers, a five memory General Coverage

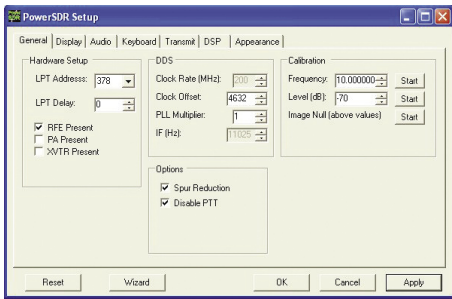


Figure 3- SDR-1000's Setup Menu with Seven Tabbed Sub-menus

Band button is provided.

Then, for fine-tuning, the spectrum display can be used. Here a right mouse click brings up crosshairs. They are placed over a signal of interest, and then a click of the left mouse button will accurately tune to the signal. The mouse/trackball wheel tuning also works very conveniently. Under the "Keyboard" tab in the "Setup" menu, the user can customize keystrokes for tuning functions.

Two VFO (a throwback to the old days of Variable Frequency Oscillators) memories are provided. The "A" and "B" frequency memories can be easily manipulated and swapped using the VFO box shown at the lower center of Figure 2. Tuning to a resolution of 1 Hz is possible, especially after careful calibration, as we shall see.

Filters Are Us

Operating in the digital domain allows for IF filtering that can only be dreamed about in the analog world. PowerSDR has ten fixed filters and two user defined filters which allow setting the high and low frequency filter parameters from 1 Hz to 9999 Hz.

These filters range from 6 kHz down to 25 Hz in 1 Hz steps (not a typo!). These filters, shown on the lower right of Figure 2, have a shape factor of <1.05:1 at 500Hz bandwidth. Not too shabby. In addition, three selectable noise filters are available at the lower right of the screen.

Multi-Talented Displays

Another great feature of an all digital receiver is the flexibility of its displays. Coupled with the SDR's hardware flexibility, just about

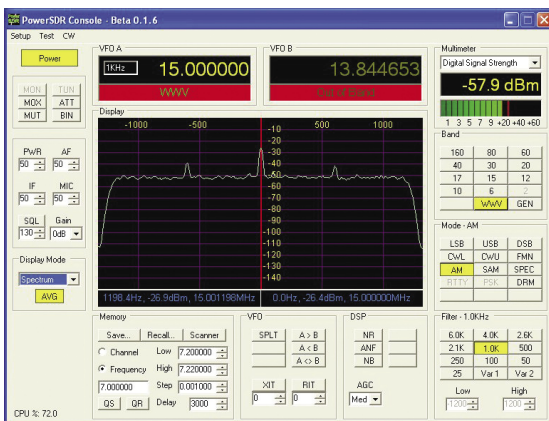


Figure 4- A Calibrated SDR-1000. Compare It To the Un-Calibrated in Figure 2.

anything can be displayed. In Figure 2 we have purposely left the pull down menu on the lower left side expanded to show all signal display modes. What is being displayed in Figure 2 is the Spectrum in the averaging mode. Similarly, the signal strength meter, labeled "Multimeter" at the top right, can be configured in one of ten ways.

The spectrum display takes lots of computer horsepower to run and taxed the outdated Pentium III to the limit. In fact, you can see at the bottom left that the CPU is working at 89% of its capacity, at times reaching 100%. When the Display Mode is shut off, this drops to around 50%, which is indicative of what it takes to actually run the signal manipulation algorithms.

We could shut down the spectrum display to ease the work of the CPU. Alternatively, we could reduce its refresh rate. This is found in the Setup menu under the "Display" tab. A Main Display FPS (frame per second) value of 8 is a nice compromise for a PC running at less than 1 GHz. With this FPS value and the spectrum display running, the CPU utilization drops to around 70%. This reduces the lag between initiating a command and seeing the result on the display.

Calibration

Three important parameters – oscillator adjustment, image rejection and spectrum analyzer/S-meter – can be adjusted to each user's system. I did not do any when I first operated the SDR-1000. I suggest that a frequency calibration is performed. This does not require any test equipment and can be done in a minute.

Why do it? It is clear from the spectrum display in Figure 2 that the signal for WWV peak (the major peak) is not tuned to the center of the spectrum. However, the digital display reads 15.000000 MHz. Now look at the number at the lower right of the spectrum display. The first number automatically gives the frequency offset between the major signal peak and the tuned frequency. Here we read 347.4 Hz, not bad for most receivers. But, as we said, the SDR-1000 can do much better.

First we need to click on the "Setup" at the top left of the Figure 2. This brings up a screen with seven tabbed menus, see Figure 3. Here we have chosen the "General" menu tab. To calibrate the SDR's tuning we must change the setting of Clock Offset under the DDS box. But what number should we use? A simple formula provides the answer.

$$\text{Frequency Offset X [200MHz / Actual Frequency]} = \text{Clock Offset}$$

$$\text{For our case: } 347.4 \text{ X [200/15]} = 4632$$

By entering 4632 into the Clock Offset as seen in Figure 3, and then clicking "Apply" we have calibrated the SDR-1000 to within a few hertz! This can be seen in the numbers below the display in Figure 4 and the fact that the peak has now moved under the center vertical axis.

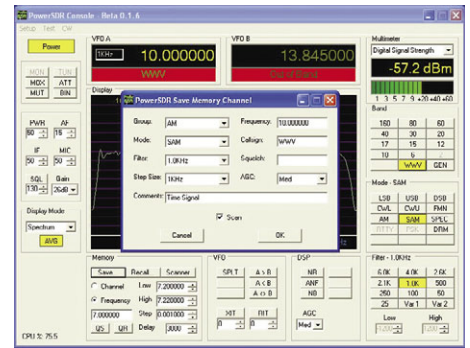


Figure 5- "Save Memory Channel" Screen Showing the Stored Fields.

Also note at the bottom left, that the CPU usage has dropped to 72% as a result of reducing the Main Display FPS value. I used the SDR-1000 without further adjustments, since test equipment is required to set the image rejection and calibrate the spectrum analyzer/S-meter.

Scan/Storing/Search

The section labeled "Memory" on the bottom left of Figure 4 provides scanning, searching and on-disk storage functions. Scan between two pre-set frequencies, entered in the High and Low boxes. Or scan the stored channel list using the "Scan" button.

Selecting "Save" brings up the Save Memory Channel screen seen in Figure 5. The frequency, mode, band-pass filter, squelch value, memory scan lock settings, call sign (or broadcast station ID) and comments of the current tuned station can all be stored. Each memory can be linked with groups for memory scanning. The number of stored memories is essentially only limited by hard drive space. Saved frequencies are retrieved by using the "Recall" button which displays a listed of stored channels. Select the channel you wish to recall by clicking on the arrowhead on the left of the screen.

Temporary storage of the current radio settings is possible using the Quick Memory buttons; QS (Quick Storage) and QR (Quick Recall). But remember, when the program is shut down this information is lost.

The first time the list of stored channels was displayed and any item selected by a click, a Windows error message appeared and the application needed to be closed. However, the second time the list was recalled, an arrowhead appeared on the left and the problem disappeared. I'm sure this will be corrected in future versions of PowerSDR.

Next Time

The SDR-1000 does it all! Using the MK 1 Ear standard, this receiver sounds pretty good in the shortwave bands hooked up to a tuned multi-band dipole. It pulls in weak ham stations and does a great job on strong broadcast powerhouses.

Next time, we will do A-B-C listening tests using the SDR-1000, a PCR1000 and an FRG-100, all switched to the same antenna. Stay tuned: We will see if the SDR technology can live up to being called "the most important development in radio for the past 75 years."