Terry Fox, WB4JFI

Reprinted with permission from the Sep-Oct 2011 AMRAD Newsletter

SDR Cube – Follow-Up

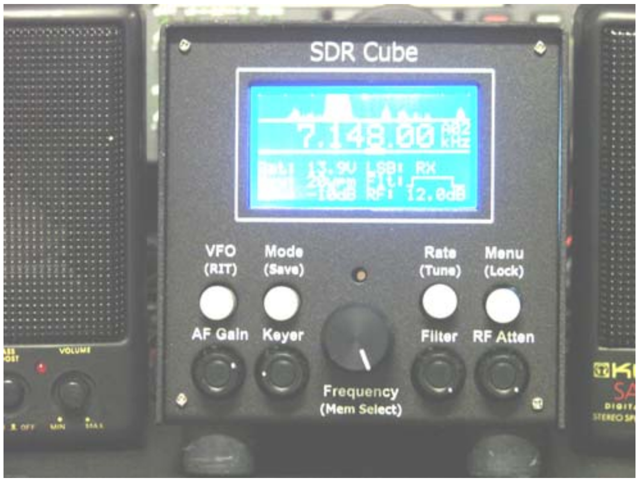
The last newsletter had two articles on stand-alone SDR hardware back-end kits, both of which used the Tony Parks SoftRock decks**(1)** for the RF portion of a complete HF transceiver. The SDR2GO article was a more complete review, as I had built and used my SDR2GO for a few weeks. The article on the SDR Cube was an initial overview, because my SDR Cube kit was not completed at that time, but I had a fully functional demonstration unit, less the case. Since then, my kit (including case) has been built, and used on 40 m. This article has some duplication, but I felt that I rushed the last article to meet a deadline, using a demo unit that I had not built, and had very little experience with. NOTE: This is not meant to be a sales pitch, but a description of an SDR stand-alone option with a well-designed user interface. YMMV.

OVERVIEW

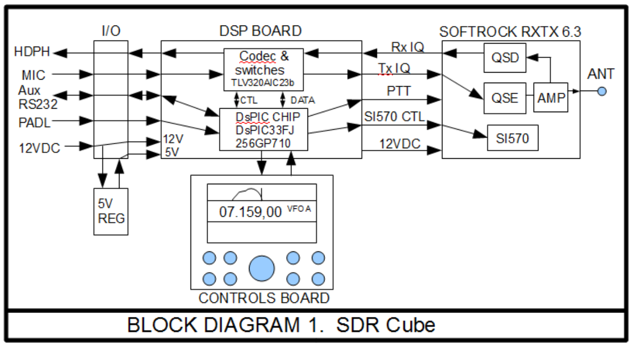
The SDR Cube is designed to provide the back-end DSP and control functions to support a SoftRock, or any other QSD/QSE-based radio. It is specifically designed to support the SoftRock RxTx 6.3 hardware, including the physical layout of that board. If one of those boards is not available, Midnight Design Solutions**(2)** also sells a licensed version of the RxTx 6.3, which is virtually identical to the original Tony Parks' design. Other QSD/QSE-based RF platforms can also be supported, although they might not fit inside the cute SDR Cube case/box. I recommend interested readers check out the features and specifications on the SDR Cube Web site**(3)**.

Technically, the SDR Cube has a single, low-cost dsPIC chip that:

- Demodulates QSD receive analog I/Q signals to audio, with AGC and filtering.
- Also uses the receive I/Q signals to create an 8-kHz visual panadaptor.
- Creates transmit analog I/Q signals, optionally voice modulated, for CW or SSB transmitting using a QSE, with level control for adjustable RF output.
- Creates PTT signal to put RF deck into transmit.
- Has a built-in CW keyer that just needs paddles, with adjustable speed.
- Has frequency control to drive an Si570 or AD9851.
- Creates optional band-switching data following digital or analog standards.
- Creates/controls the user interface (display, controls, pots, etc).



The bottom-line is that any QSD/QSE radio that has analog I/Q outputs for receive, analog I/Q inputs for transmit, and uses an Si570 for tuning, can be used with the cube. In fact, there are options on the Controls board (under the display) to add an Si570 or AD9851 DDS chip to the Cube itself, in case you want to use it with a crystal-based RF deck. In addition to I/Q and tuning signals, a PTT line is generated, and optional drive signals for a receive preamp and attenuator. These last two signals are designed to drive a Midnight Design Solutions preamp board made specifically for the RxTx 6.3, but could probably be modified for other hardware. So while the Cube is designed to wrap around an RxTx 6.3, other QSD/QSE hardware can be used electrically, if not mechanically. The Cube case has a DB-15 to interface these signals to an external RF deck. While SoftRock RxTx boards are typically single-band units, the SDR Cube can be used with a multi-band RF deck as well. The software, including source code, is available on the SDR Cube web site. There is also modified software on the SDR Cube Yahoo Group**(4)** to enable its use as a WSPR rig.



BLOCK DIAGRAM 1. SDR Cube

SDR CUBE DESIGN

Block Diagram 1 shows the overall SDR Cube, as attached to an RxTx 6.3. I have the Tony Parks versions of this RF deck, which I chose to use within my Cube. There are a few component value changes made to the RxTx 6.3 sold by Midnight Design Solutions, including minor tweaking to the LP filtering on the receive I/Q outputs. This change reduces potential overload by very strong nearby signals, but limits analog I/Q output bandwidth.

There are three main boards used in the SDR Cube, in addition to whatever RF deck it wraps around. The first board is the simplest, the I/O board. It contains the main connections to the outside world, plus the 5-V regulator board. It plugs into the DSP board via a large, 40-conductor ribbon cable.

The second board, the DSP Board, is probably the hardest to build (due to the dsPIC package). It has the dsPIC and codec chips on it, plus some voltage regulators, buffers, EEPROM, and other support components. The SoftRock cables all connect to the underside of this board as well. It connects directly to the Controls board via a 90-degree 40-pin connector. The 16-bit dsPIC is the larger, 100-pin version, with 256k of program flash, and about 30k RAM. Since the dsPIC is the only processor in the Cube, many of the 85 I/O pins are used to interface with the display and various controls, but about 15 random pins are still available. For example, a second SPI port is almost completely available, except for one line. A slight modification to the hardware, and a recompile of the software/firmware would make the second SPI port useable for additional interfacing to the dsPIC chip.

The third board, the Controls Board, is the most complex. The very nice 128x64 blue & white graphics display is mounted on this board, in addition to four other pushbuttons, four pots, and the tuning rotary encoder. If you are going to use the Cube case, make sure all the controls, especially the four pushbuttons are exactly seated and perpendicular to the PC board, otherwise the buttons will rub against the case hole edges, causing them to hang. As mentioned earlier, the Controls board also has spots under the display for an optional Si570 or AD 9851. All these devices interface to the dsPIC on the DSP board.

CONSTRUCTION

Now that my Cube is built, I have a much better idea of how the kit goes together. Rather than using the online assembly instructions, I downloaded and printed out the PDF version for each board or section. The assembly instructions are available to everyone on the SDR Cube web site. Each board (or wiring kit) comes individually packaged, with the non-static-sensitive surface mount parts taped down on paper cards, next to their part numbers. I recommend following the assembly guides, especially the inventory step. In fact, I suggest a complete inventory be done first, on all packages, in case any parts are missing or different. There are pictures of each part in each assembly guide. While these guides may not be exactly "Heathkit" style (separate line and check box for each individual part), they are very close. Common parts share one instruction line. There are also individual pictures for almost every step.

I had construction problems only in two areas. The first was with the internal wiring kit. For some reason, I just could not understand the diagrams on how to make the various ribbon cables. I ended up cheating and looking at the demonstration SDR Cube that had been lent to me. Careful review of the respective board connections on the DSP and RxTx boards also helped a lot.

The other construction problem was related to soldering down the dsPIC chip. My good temperature-controlled soldering iron had completely died, so I was using an older backup iron with thicker tips. Very fine solder, and small solder wick, is included with the kit, which I did not use. While it looked like the pins were all soldered down, some apparently weren't. After the Cube was all together, it became intermittent. I finally got out my embossing tool, and reheated both the dsPIC and the codec. Problem solved.

After my Cube was built, I updated the dsPIC firmware per the instructions. I used a laptop, a USB-to-RS232 adaptor, and a special adaptor cable documented in the SDR Cube Operating Manual. The update went flawlessly. Cube calibration was just as easy.

OPERATION

The SDR Cube is very easy to use, and the display is wonderful. The main tuning knob makes tuning very smooth, and doubles as the menu item selection. The four pushbuttons control VFO/RIT, Mode/Save, Tune Rate/Tx Tune, and Menu/Lock, where the second function shown is selected by holding the button down. The four pots control AF Gain (volume), Keyer Speed, Filter Bandwidth, and RF Atten. My fingers are small enough to use these controls effectively, but larger fingers may cause inadvertent wrong adjustments, such as changing the Keyer Speed while adjusting the volume.

Did I already say that the display is sexy? At the top of the display is a small graphical 8-kHz panadaptor. Since there isn't much vertical room, a menu item allows the sensitivity of the panadaptor to be adjusted. In the center of the display is a large readout of the current operating frequency. Below that are displayed the current input voltage, keyer speed, AF Gain, Mode (LSB/USB/CW/CWR) and Rx or Tx, a small graphical representation of the filter bandwidth, and receive RF Gain.

Many secondary adjustments are available by hitting the Menu button, and then selecting the particular option with the tuning knob. The selection of these adjustments and their modification are easy and obvious.

The "Aux" port on the back of the Cube is used to interface (via RS-232) to a computer. In addition to firmware updates, status information and test/diagnostics can be run via a simple terminal program on a host computer. There is also a PS/2 style connector to interface with a Nue-PSK terminal, but I do not have one of those yet.

I have used my SDR Cube on 40 meters, both CW and SSB. Trying to make SSB contacts with about ¾ watt can be a challenge. The built-in keyer is nice, just hook up a set of paddles. The four filter bandwidths are also very nice to have. The tuning is in increments of 100 kHz, 1 kHz, or 10 Hz, having additional tuning steps would be most welcome.

In a recent SDR demo, I took the Cube to a local restaurant, and hooked it up to a portable vertical antenna. As soon as it was turned on, some strong Russian signals came through on 40 m SSB. That instigated a few comments on how sensitive it was. I use a set of small black speakers, an MFJ paddle, and a cheap black computer microphone for these demos, and run the rig on a single 1.2-Ah SLA battery.

SOFTWARE MODS

Midnight Design Solutions created a "Software Development Kit" document for those of you wishing to play with the firmware guts. I have installed Microchip's MPLAB and C30 compiler, and downloaded the SDR Cube source code, but I have not actually recompiled it yet. Most of the source code is in C, with a small amount of specialized code in dsPIC assembly language (mostly filters). There are some simple software mods that I would like to do, so experimenting with the code is coming soon. The SDK document mentions the use of the Microchip ICD-2 In-Circuit Debugger, but that device is not necessary to upload new firmware, just the RS-232 connection and a simple terminal program.

ONE COOL EXPERIMENT

I was planning to give a demonstration of the SDR Cube to the "Low Country Contest Club" (LCCC)**(5)** here in Charleston. This is an informal club that meets monthly, and seems to be the most technically advanced amateur radio group here. Before the meeting, I had the silly idea of widening out the panadaptor display, by using iSDR**(6)** running on my iPad2. I carefully build a splitter for the receive analog I/Q signals, and fed the second copy out the DB-15 on the back of the Cube. Another cable outside the Cube then connected to a Griffin "iMic"**(7)**, which then plugged into the iPad2 via USB with the Apple "Camera Adaptor". After hooking all this up, I was able to see the 8-kHz spectrum on the Cube (and hear its demodulated signals), while simultaneously seeing 44 kHz of spectrum (and hearing more demodulated audio) on the iPad2. Very cool, and completely portable! This is when I found out that the Midnight Design RxTx 6.3 has narrower I/Q filtering however. I mentioned my experiment on the SDR Cube Yahoo group, and was told that not all SDR Cubes could do this, due to the narrower analog filtering. Too bad, their loss! BTW, the iMic will not work with my iPhone 3GS, but I also have a Belkin TuneTalk**(8)** that works fine with iSDR on that device.

THE FUTURE?

One of my prime motivations to get the SDR Cube was to see if it could be interfaced to the Charleston SDR Receiver, either directly (preferred) or via an FPGA. It turns out that while the Cube's codec is not needed for analog I/Q processing anymore, it is still necessary to digitize the analog *mic* input, and drive speaker outputs. The codec chip uses the only high-speed interface on the dsPIC chip, so getting the Charleston Receiver's digitized I/Q samples into the dsPIC is a challenge. I've thought of using a software UART inside the dsPIC (too much overhead), hardware shift registers (more hardware???), or moving the Cube's codec to another dsPIC port (since it only needs to do 8kHz now). I'm still trying to work out the best way to handle this. The Charleston SDR Receiver makes a great, inexpensive, multi-band receiver, and since it's a "Digital DownConverter" (DDC), it does not have I/Q imbalance issues that the typical QSD suffers from. More on this if it is successful.

Continued on next page

Continued from previous page.

COST?

The SDR Cube is more sophisticated than other stand-alone SDR back-ends, and therefore costs more. As seen on the SDR Cube web site, there are many purchase options, depending on kit versus assembled, with or without SoftRock, and single boards to complete Cube. The three options that I liked are:

1. 3-PCB set, kit @ $245, plus internal cable kit @ $12. For use without the Cube case, including with RF decks other than the RxTx 6.3.
2. Full kit, without SoftRock @ $293, for those with an RxTx 6.3, or other SoftRock that will fit inside the SDR Cube case. My final purchase.
3. Full kit, with SoftRock @ $424, for a complete, single-band rig.

With options 2 and 3, you might also consider the RXAMP kit @ $24 if you are using the RxTx 6.3, as it provides additional preamp gain and/or attenuation, for a better dynamic range on receive.

REFERENCES

1. Softrocks
2. Midnight Design Solutions web site: http://midnightdesignsolutions.com/
3. SDR Cube web site: www.sdr-cube.com
4. SDR Cube Yahoo Group: http://groups.yahoo.com/group/sdr-cube/
5. Low Country Contest club: http://www.nu4sc.com/
6. iSDR program for iPhone/iPad: http://www.digitalconfections.com/ and on iTunes (free app)
7. Griffin iMic: http://store.griffintechnology.com/catalogsearch/result/?q=iMic
8. Belkin TuneTalk: http://www.belkin.com/IWCatProductPage.process?Product_Id=277661