SDR Panadaptors – A Practical Guide

Stop envying that Flex 5000.. add new life and utility to older radios

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One of the coolest things that has been added to modern radios is the panoramic display. Traditionally, we gave ourselves carpal tunnel syndrome tuning back and forth looking for promising signals. Or, if you are a mid-Westerner on UHF bands, any signal. With a panoramic display, you can see all the signals surrounding you at once. Good for band activity, finding stations, seeing pileups, identifying modulation types. A microwave station off frequency? No problem, you can see him and tune to where he is. With the right software, you can even listen to more than one station at a time. And it's terribly addictive. And the best part; modern Software Defined Radio devices and software make it cheap, versatile and powerful, as well as adaptable to almost any radio.

The concept is easy. Use an SDR device to monitor your radio's IF while the radio operates normally. The radio does the preselecting and filtering. The SDR and software looks at the signals in the IF passband. As you tune the radio, signals visibly move across the screen. You don't know there exact frequency, but you know where they are relative to where your radio is tuned. Neat. Since the software demodulates the signals, you can be listening to one signal on the radio, then click on another signal somewhere else in the passband and listen to it, too.

To perform this high magic, you need: 1) an SDR device with software (and a computer to run it on) and 2) an interfacing of the SDR to the IF of your radio.

First: SDR devices. These come in all capabilities and price ranges. There are two common types.

1) An external commutating mixer feeding a computer soundcard. SoftRock is the best known of these. Early FlexRadio worked this way. These use a fixed or variable LO to trigger a multiplexer chip that samples an RF (or your IF) signal in quadrature (every 90 degrees). The result is an audio-frequency signal that is fed to a computer soundcard. Software takes over from there. Because of inexpensive component specs and an LO that usually runs 4X the desired RF frequency, these are generally limited to 30 MHz maximum. So if your IF is below 30 MHz, all is good. An additional limitation is the bits and quality of the soundcard that it feeds. Cheap, built-in soundcards are often limited to 48 kHz, so that is the limit of the RF bandwidth displayable. Better external or add-in soundcards go up to 192 kHz with 24 bit resolution. And much better results.
2) USB "dongles". "Dongle" seems to be a British colloquialism for "USB plug-in". RF in one end, audio through USB out the other. Proprietary. Serious magic inside. A popular and common device is the FunCube Pro+, an absolutely astonishing 1"x3" USB plug-in with a .15-1900 MHz RF range and 192 kHz bandwidth. These even have automatically selected internal RF filters and offer surprisingly good performance. At <$200, quite a bargain. Everybody needs one of these. Note: Sometimes Funcube will not work in a specific USB port. USB3 ports are especially problematic since they are buggy. Simply try a different port. Another popular type is SDRPlay, with similar frequency range and up to 8 MHz bandwidth (way more than you need), and 12 bit signal processing. If you have an IF higher than 25 MHz, a real bargain is the RTL2832U+R820 European TV tuner dongle, with software magic that converts it into a 24-1700 MHz receiver of 2 MHz bandwidth and 8 bit resolution. These have no internal filtering but if applied properly, work OK for IF monitoring. Oh yeh, and they cost ~$20. There are lots of other SDR's, but these are beyond the scope of this application.

Second: this is the harder part. You must interface the SDR device to your radio's IF without desensitizing the radio. Modern radios have low impedance circuitry in the IF. Simply adding a 50 ohm SDR device or amplifier (load) to the existing IF circuitry will be detrimental to stage gain and balance.

Gee, guess how I know this…. An additional problem is that some SDR devices radiate switching noise out of the front ends, which your receiver's IF chain might find a bit disturbing.

There are several ways of sneaking some IF signal out of the radio. Easiest: Some radios have buffered IF outputs built in. These include ICOM R7000 and Elecraft K2 and K3, among others. Very convenient. Simply plug your SDR device into this port and off you go. A note on the R7000 and others: sometimes there is a DC component imposed on the IF output, so either be sure your SDR has a DC blocked input or add a DC blocking capacitor. R7000 has a DC component. Softrock is DC coupled.

On some radios, it may be possible to find a branch in the IF path that is already buffered. This worked well on both a Kenwood TS-430S and a Kenwood TS-700SP. Both had splitters and buffers in the IF path that fed the FM demodulators. Signal was always present at the buffer output, regardless of mode, so I simply tapped out of that point. FM was not my concern, so if it was detrimental to FM performance, it was not significant. The SDR was directly connected to that point (adding a buffer here made no difference) and had no effect on the overall receiver performance.

A method of interfacing that is more widely useful is to tap into the IF with a high impedance buffer amplifier through a small capacitor. One hi-Z amp device uses an AD8007 250 MHz OpAmp. These are available from K8ZOA Clifton Labs. Gain is adjustable but higher gain means lower input impedance. SDR's are quite sensitive, so not much gain is needed.

An even better design utilizes a JFET input device (100K ohm input impedance; that should be high enough) followed by a buffer amplifier and low pass filter. W1GHZ pointed me to the goldmine of devices and information... the G4HUP website. Both of these buffer amps provide reverse isolation to keep SDR noise out of your receiver. Both have the capability to add low pass filters on the circuit board. I have used both of these types on all my radios.

One other "good idea" on transceivers is to have the DC to the isolation amp removed during transmit. This prevents some really ugly (not to mention irritating and useless) audio noises and screen displays during transmit. Find a source of DC in the radio that turns off during transmit. The G4HUP website has ideas on this.

Some examples in the real world:

- ICOM R7000: easy. The buffered 10.7 MHz IF is brought out to a jack on the back panel. No buffer amp required. Have used both Funcube and variable frequency SoftRock.
- Kenwood TS-430S: My old workhorse. 8.83 MHz IF accessibility was found in an internally split path with buffer feeding the FM module. Tapped behind the buffer amp. This path is always active regardless of mode the radio is tuned to. External isolation amplifier not required. I built a small receive-only crystal controlled SoftRock Lite SDR receiver; FiveDash had a suitable crystal. This is a specific purpose design but works great. I have also used a SoftRock Ensemble RX, which uses variable frequency VFO. And a FunCube Pro+, too.
- Kenwood TS-700SP: Found a buffered path in the 10.7 MHz IF, similar to that in the TS430S. Used both FunCube and variable frequency SoftRock Ensemble RX.
- Yaesu FT-817: Have used several schemes: 1) 0685 MMIC directly across the 68.33 MHz IF, driving either a Funcube or an RTL2832. Worked but badly desensitized the FT-817 due to IF loading. Abandoned. 2) AD8007 opamp to Funcube or RTL. Worked fine. 3) G4HUP "PAT" high impedance buffer amp with 75 MHz LPF driving Funcube or RTL. There is a version with a 75 MHz low pass filter that removes artifacts before the following SDR. Best of the lot. I prefer Funcube with its higher resolution. You can tap the IF either "in front of (which is physically toward the rear of the radio)" or "behind" the first IF bandpass filter. If you tap behind the filter, you can see +/-10 KHz bandwidth (at -3 dB points) on either side of your center frequency. If you tap in front (before the filter), you can see +/-75 KHz+; just about the entire band! This, with a 192 KHz Funcube, is my current preferred setup.

- Drake R4B: Yup, tubes. Small cap after the first mixer at 5.645 MHz. High impedance buffer amp required. Remember these things have high voltage.

Notes on software for laptops/desktops

Dependent on SDR type and your computer operating system. This is by no means a comprehensive list. Lots of good software out there; most of it free. I've not tried Linux or iOS.

- Rocky from dxatlas.com: For SoftRock (or other IQ type devices) with Windows. Simple. Works well. Has horizontal right to left waterfall mode that gives a really good picture of signals and modulation schemes. Apparently has fast integration time as CW element transitions are very distinct. You can easily read fast CW as it scrolls across the screen. Or let "CW Skimmer" read and decode all the CW signals within the passband at once! Also receives SSB and PSK31.
- SDR Sharp: Windows. Powerful. Easy to use. Works well and has lots of add-ons and customizations. Can display waterfall, power, IF and audio passbands. Supports many hardware platforms, including AirSpy, FunCube, RTL-SDR/USB (this is the RTL 2832), RTL-SDR/TCP, SoftRock (with Si570 VFO), RFSpace SDR-IQ and SDR-IP, NetSDR, HackRF and adaptable to others such as SDRplay. A caution on using SDR Sharp with RTL2832: a port driver called Zadig (included with the distribution) is required. There are specific instructions on how to load SDR# on the RTL-SDR website; you must follow them exactly. Also, Zadig may render a USB port unusable for FunCube. I found out the hard way. Difficult to uninstall if you are not a software guru as there is no uninstall utility. Load it with the RTL2832 in a specific port and use only that port. Install your Funcube in a different port.
- HDSDR: Windows. Powerful, many customizable features. Records RF or AF. Some learning curve. Widely used. Supports numerous hardware platforms.
- SDR Console: Windows. Very powerful, multiple windows. Some learning curve. Numerous hardware platforms. While it appears that you can add numerous platforms for later use, you must have your specific hardware connected for software to find the proper drivers.

For tablets:

"RF Analyzer" and "SDR Touch" for Android. Both designed for use with RTL2832, connected to the Android device by a "USB-to-go" cable. To make either work properly, you have to adjust the RF and IF gain controls in software. RF Analyzer works reasonably well. SDR Touch seemed to have a lot of spurs and wasn't very useful. Good for FM and weather. Since both are powered through the USB-to-go cable, the Android battery gets sucked down in a hurry.

"iSDR" for iOS. Designed for use with Softrock. I have not used it.

Hardware sources:

- Funcube: funcubedongle.com
- RTL2832+R820: Amazon, Nooelec, others
- SoftRock: kits and built, fixed and variable frequency receivers and transceivers. dashfive.com
- JFET buffer amps: G4HUP.com. Great website for all things panadaptor. Stocked by wa5vjb.com.
- AD8007 buffer amps: cliftonlaboratories.com

Software sources (Windows):

- funcubedongle.com. Everything FunCube.
- dxatlas.com. Rocky, CW Skimmer and other interesting stuff.
- rtl-sdr.com: more than you ever dreamed of about RTL2832+R820
- sdrsharp.com. Reroutes you to AirSpy SDR device. Find SDR# software under downloads.
- hdsdr.de: HDSDR
- v2.sdr-radio.com: SDR Console