# FunkAmateur SDR-Spektrumskop Panadapter

## Introduction.

I have an FT950 which is a great radio in terms of price vs. performance. One of the problems of the FT950 is that it does not have a spectrum scope or a panoramic display (panadapter). A spectrum scope gives you a visual display of your radios IF on a computer. You can be tuned to a particular frequency and the software on your computer displays nearly 100khz (dependent upon soundcard hardware) on either side of where you are tuned. As you turn the dial the view on the display changes in real time. It is very easy to see other stations and even ones that are testing and getting ready to transmit. The Yaseu solution to this is to sell you a DMU2000 which includes a spectrum scope and also a number of other features that I was not personally interested in. They also charge a whole pile of money for the DMU2000 which negated the reason I purchased the FT950 in the first place.

## Softrock Solution

Googling around I eventually found myself at the softrock yahoo group (http://groups.yahoo.com/group/softrock40). A softrock is an extremely inexpensive software defined radio kit that can also act as a panadapter for any type of radio. You just have to access a suitable IF from the radio, select the correct crystal for the softrock, get an inexpensive sound card ,and plug it into a reasonably recent computer to run the many free sdr radio programs.

The problem with the FT950 (also FT2000) was that the first IF of the radio is at 69.450Mhz and the softrock kits did not go that high. The solution to this was to purchase an RFSpace IF2000 at a hefty US200. This card converts the 69.450Mhz IF down to 10.55Mhz, and you it install it into the FT950/2000 into the same position that the add in card that comes with the DMU2000 goes. This means that you cannot have a DMU200 and a IF2000 card in the radio at the same time! I ordered the softrock Lite II (combined) and made it up for 30m. I used the supplied 14.089Mhz crystal that is supposed to be used for 80M, but in the 30m built kit it uses the crystals 3$^{rd}$ overtone. This gave the centre frequency of the softrock as 10.566Mhz. Only 11khz away from 10.55Mhz and was close enough. I purchased an inexpensive Sound Blaster X-Fi 5.1 Surround USB that would give me a 96khz bandwidth , and for around US300 (+computer) I had a pretty good panadapter .

I went onto the softrock site and mentioned my set up and how it was probably the cheapest way I could see to get a panadapter for the FT950/2000 and it works very well. A few days later a European member of the group replied and that yes my solution was good, but not as inexpensive as the SDR-Spectrumskop kit from German magazine called Funk Amatuer. In all my googling and researching I had missed this kit!

## Spektrumskop fur FT950/2000

I went to the Funk Amateur site (http://www.funkamateur.de) and had a look at the kit. The Spektrumskop is basically an IF2000 and Softrock combined on one board. What is really good is the price. I purchased the kit "SDR-Spekrumskop fur FT950/2000, Bausatz #BX-052" and the Housing Kit # BX-055 for the total tax free price of Euro49.07 (~US75.00) delivered to Australia. I purchased the housing kit as the board is too big to fit into the FT950/2000 and the housing kit includes the lead with Ichi Denko plug on one end that gets plugged into the FT950/2000 and a BNC on the other. For purchases to people outside of the EU, it is best to muddle your way through the online shop and add the items to your cart, and generate a correct order with your address etc, but at the final stage before payment send Funk Amateur an email and they will remove EU taxes and work out the shipping costs and generate a Paypal demand. A week or two later the kit arrived.

## The Kit

I unpacked the kit and was pleased with the build quality of the circuit board. Very robust like a Mercedes Benz. All components were supplied and there are no surface mount parts. The board had no mounting holes drilled into it, but did have some copper lands on the edge of the board, maybe for soldering onto the housing kit. The housing kit was just a tin box that you had to solder together. It's a bit like a shielding enclosure you would find inside a radio. It is sufficient, but not sexy ,and easy to put together. The instructions are all in German with a little addendum slip that highlights something about transistor TR2. John, G3PNJ mentioned in the FT950 yahoo group that he also purchased this kit in Oct 2010 and managed to put together some notes for builders in English, which he uploaded to the files section of that group. He had not built the kit at that stage. I managed to get a soft copy of the German article from Funk Amateur and put it though Google translate and fixed up the errors. Like all translations this is in GermEnglish. I will combine all of the sources of information into this paper so that you do not need to go to any other source. I must say that the German article did not add much information about how to build this kit so you don't miss much by not have the literal translation.

The missed opportunity for this kit is that it does not fit into the FT950/2000 like the IF2000. If it did then all that would be visible would be a cable with a 3.5mm stereo jack that goes directly into the computer. Power and RF signals would be supplied by the radio. No messing around with external power supplies and this would have been a better solution. The reason I think that this was not the case was the perception that kits with through hole components are easier to build and are more popular with kit builders . With through hole components the board becomes too big. I would recommend any kit builder to purchase one of the SoftRock kits. These are a mixture of through hole and surface mount and was my introduction to surface mount components. I personally found them very easy to solder, but you do need some extra flux and a magnifying light or goggles.

## Circuit Description

There are 2 halves to this circuit. The RF Stage and the SDR stge.

SDR Stage.

This is a typical SDR circuit (Tayloe Detector) which I will describe briefly. There are a load of articles about how a Tayloe Detector works out on the internet. This stage is the equivalent to the softrock lite II (Combined).

A TTL clock at 22MHz is divided by 4 by 2 flip flops ( IC1 - 74AC74). These flip flops provide 5.5Mhz clocking signals that are 90 degrees out of phase and are fed to 2 analogue switches (IC2, IC3 – Max 4544). The outputs of the switches are sampled by 10nF capacitors (C35,C36, C37 and C38) . Sampled signals that are separated by 180 degrees are summed, and amplified by 10 to form the I and Q stream that is sent to the sound card. The soundcard provides a heap of gain and the Analogue to Digital conversion. The software performs the magic that demodulates the signals into audio.

RF Stage

This stage is equivalent to the IF2000.

The IF input at 69.45Mhz is amplified by a dual gate mosfet (T1- BF961) and is applied to the gate of a mixer (T2 – BF961). The gain of the RF amp can be reduced by 20db by grounding ATT which changes the biasing at Gate 2 of the RF amp. The oscillator is a Kuhne type design that uses both a crystal (Q )and an output tuned circuit (L5) to produce a local oscillator signal at 63.950Mhz to the other gate of the mixer. The mixer output is filtered by a 5.5Mhz filter (Fi1) and buffered (T3- BF245B). The signal then goes into the SDR circuit.

## Construction

Start with building the SDR section on the right had side of the board. Build everything from C19/C20 to the right as shown on the circuit diagram. Do not install the filter Fi1 yet. Note that C28 (100) just below IC4b on the circuit diagram is actually C34. There is a separate bag of components that contain the higher tolerance resistors and capacitors that are some of the more critical components of the tayloe detector, so solder these in first. On the left hand side of the board just construct the power supply components. Double check everything and apply 12V. Check all voltages on the chips and test that the TTL clock is producing a 22MHz signal. Check that Q Bar signals on pins 8 and 6 of the flip flop are present and out of phase. I made a simple coil out of 2 turns of wire which I soldered across C19. I used a grid dip oscillator to inject a 5.5Mhz signal and plugged the I/Q outputs into my soundcard. I ran Rocky (a simple SDR application) and saw the 5.5Mhz signal from my GDO on the screen. By tweaking the GDO I saw the signal move in the spectrum and I deduced that the SDR side of the circuit was working.

Once the SDR side is working then this is the test bed to fault find the RF side. Following the circuit diagram build the RF side. Take particular note that T2, the BF961 mixer , is soldered in with the lettering facing the circuit board. Yep when soldered in you see the back of the transistor only. This is what the little addendum slip was all about. The first test is to see that the oscillator (T4) is oscillating. On my kit the oscillator only started up when the tuning slug of L5 was nearly all the way out. I placed a 12pF capacitor across the crystal. There is a spare place on the circuit board for either an inductor (Dr) or capacitor. With this capacitor in I could set the oscillator to 63.950Mhz with the tuning slug flush with the top of the can. I then injected a 69.450Mhz signal at the input by using my GDO and the same coil I knocked up previously to test the sdr and monitored the Rocky for the signal. My luck was in and I got the same response on the computer screen running Rocky as I did by injecting the 5.5Mhz signal at C19. I turned the auto AGC off of Rocky and adjusted the inductors (L1, L2, L3,L4) for maximum clean signal on Rocky. Go backwards and forwards over these adjustment a few times, but to be honest the value turned out to not be too critical. The only critical one is L5 that sets the oscillator frequency. Test the grounding of the ATT signal to reduce the RF gain of T1. I was not too fussed about this but I did see a signal drop though I'm not sure that it was 20dB. This is used to slightly mute the system and could be connected so that pressing the PPT switch during transmit gives a clear representation of the output signal on Rocky without overloading. I wasn't planning to do this as it's a bit fiddly!

I didn't have any problems making up the kit though I am very careful and methodical in my building and have made up quite a few electronic kits and breadboards. It would be an intermediate level kit that most hands on hams should be able to knock up. Appliance operators should stick to the IF2000/LP-Pan ready-made solutions.

## Modifications.

Clive GW0PPO built up the SS at the same time and we shared notes on the construction. He needed only 2 or 3 pf across the crystal to get stable starting and the slug of his core level! He also noticed that the frequency of the oscillator was very dependent upon the supply voltage and decided to add a 9V regulator. I didn't do this as I'm running off of a separate plug pack supply. We both decided that a 1:1 rf input transformer was a good idea to dc isolate the SS from the radio to reduce any ground loops. To do this you need to replace the supplied bnc connector with an earth isolated version and add the transformer. Clive's transformer is three turns bi-filer wound on two FX115 ferrite beads. I didn't have any ferrites handy so used an air wound transformer. My transformer is just 10 turns of .4mm enameled wire using a 4mm drill bit as a mandrel for winding. The wire is bifilar which means that 2 strands of wire are twisted together before the coil is wound. This is just a straight transformer. I chose the wire size for mechanical strength and 10 turns at 70Mhz should be a much larger impedance than the 50Ohm i/p impedance and is the right physical size. Note that when installed the transformer was wired to reverse the phase. This is because the BNC earth and RF input end up being adjacent to each other I didn't want to twist wires around and reduce mechanical stability of the transformer that sort of hangs in mid air ☺. Clive's Ferrite solution looks like a better bet!

## Housing.

The supplied tin plate box needs to be soldered together. I used a 70W equiv gas soldering iron and just tacked the solder around some of the seams of the box, leaving the top free to open. It was pretty easy. I then temporarily installed all of the hardware supplied in the housing kit and worked out the position in the box where the circuit board should go. I could not work out how the circuit board is attached to the box. I'm guessing something to do with the copper lands on the side of the circuit board. Maybe these are also soldered onto the box from below and you sort of self support the board with the hardware in the interim until you solder it. I just found some empty spots on the circuit board and drilled a couple of holes in the board and in the bottom of the box. I mounted the board with some small insulated stand–offs and then wired up all of the connectors. I put some rubber feet on the bottom of the box. The input transformer I made self supports itself off of the 2 pins that are the RF In and RF Ground and the insolated BNC connector that you need to buy separately. The transformer was the last thing soldered in and was supposed to be used as a temporary test of ground loops, but it worked so well that it was left in. Because the housing is all metallic then this transformer is well shielded from outside influences.

## FT950/2000

The supplied coax needs to be fitted to the internals of the FT950/2000. This is a bit cheeky, but go to the RF space website and in the support section you will see the IF2000 installation manual which you can use as a guide to install the coax into your radio. There is one BIG difference however. Because the SS uses a plug rather than a socket at the end of the supplied cable you need to plug the cable into the socket at opposite end of the internal cable as identified on the RFSpace document. On the FT950 this is simple as the internal cable is short and the socket is easily identified. On the FT2000 things are a little tougher. On the FT2000 you have to take off both covers of the radio and the large internal screen plate. Find H Scope J4507 as per the RFSpace manual and with some wiggling and gentle pulling you will find the other end of the cable. It goes into a socket called Scope. It is this socket that you plug the cable to the SS into. Leave the internal cable in place and just insulate it with tape. The end that usually goes to the IF2000 is just a 50Ohm termination. In both radios you just feed the cable out through the rear cooling vents. You will need an hour or two to do this step with an FT2000 and a bit of intestinal fortitude to remove all of the covers. The FT950 should only take 30mins, but you do need to squash the connector a little as per the RFSpace manual for the 950.

## Operation

The construction/installation side of things is complete so now is just the power supply, soundcard and computer to set up.

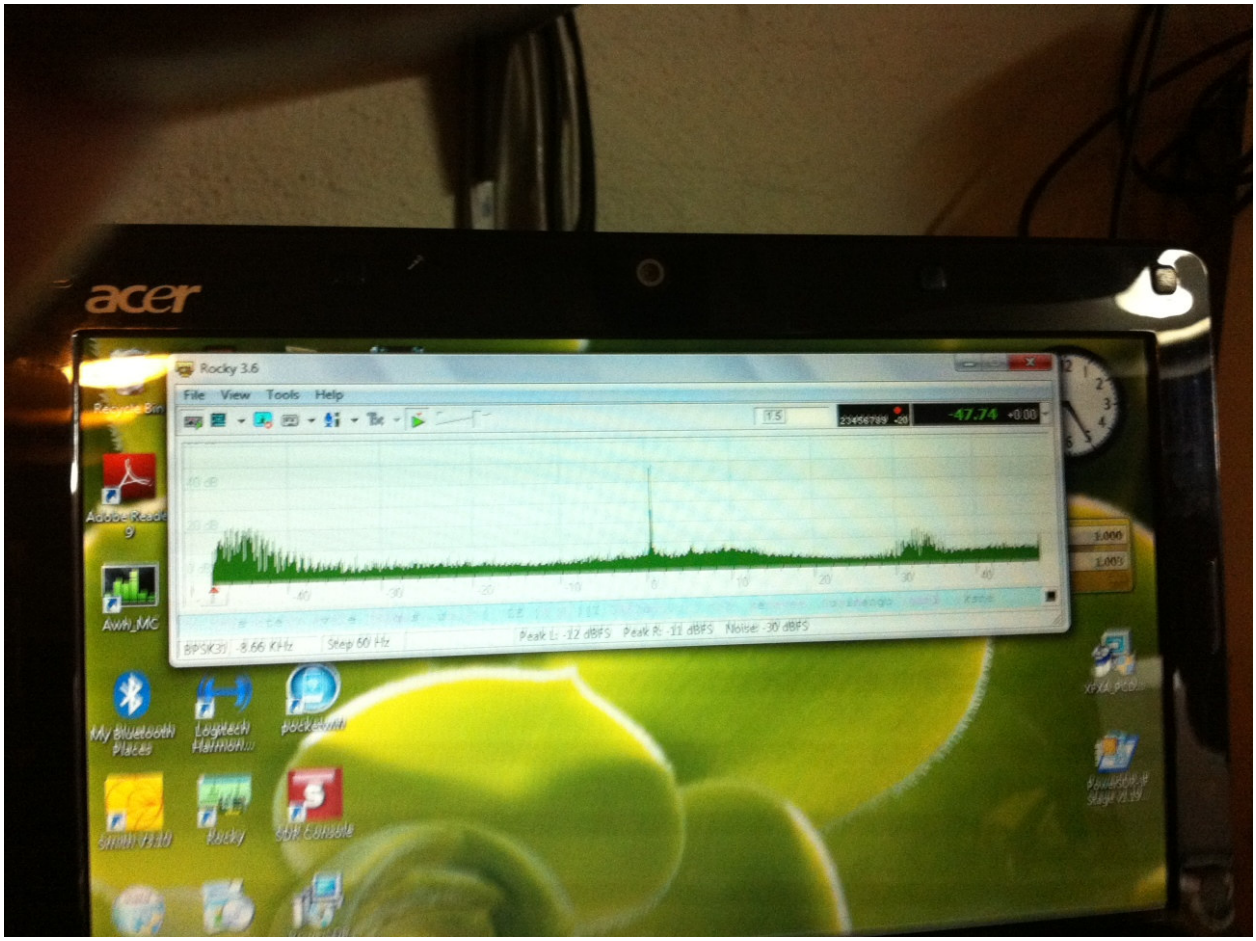
Your initial power supply should be a 9V battery. Buy some clip leads and a dc plug that fits the SS. The centre pin is positive and the board only uses 50-60mA so the battery should last 10 hours. You use a

battery to again minimize ground loops and have a chance at the best spectrum. When the system is all working then replace this battery with a normal supply or plug pack and see if the spectrum changes. I purchased a cheap modern switching 12V plug pack and this cause no difference, but when I used my main radio 13.8V power supply I had a large earth loop!

The soundcard I use is a SoundBlaster X-FI Surround 5.1 USB. This is a cheap card that will give you a 96Khz wide signal. I choose this card because of its price and it has a line input connector. The line input connector is important and you can't use a Microphone in socket. The soundcard is a little noisy and could have more gain, but for the price it is a good compromise for a panadapter. You may be lucky and have an internal soundcard that has an input socket and a bandwidth of 96Khz. The computer needs to be reasonably recent model made within the 2 to 3 years. An old Pentium laptop will struggle a bit and usually you want to run more than just the panadapter on the shack computer. I used Rocky 3.6 available from http://www.dxatlas.com/Rocky/ on a Windows 7 machine. I set the application to run in Windows XP compatibility mode which stopped it from crashing on exit, and used an external sound card as on Windows 7 Rocky can't see internal cards. STOP PRESS. As I write this the developer of Rocky is upgrading it to be more Windows 7 friendly.

To setup Rocky go to the View-Setting menu and set the I/Q Input device as your soundcard. If you want to listen to the Audio set the Output Device you your preferred soundcard. Set the sampling rate to 96Khz. Everything else on the Audio tab can be left as default. In the DSP section make sure that the local oscillator frequency is set to 0. This is just to set the frequency displayed on the screen to be centred on 0Hz. Remember this is a panadapter used in-conjunction with your radio and not a separate SDR radio so not all parts of Rocky need configuring. Hit the Start Radio button that sits just below the File menu item.

With all the cables in you should see a spectrum on the screen like the following.




This is a picture of a typical spectrum. Sorry that the picture is a little fuzzy. The centre spike is the usual SDR 0 Hz spike and you can see that the spectrum is about 100khz. The big lump on the left is QRM and at +35khz is a signal. You can see more typical spectrums on the site where you downloaded Rocky.

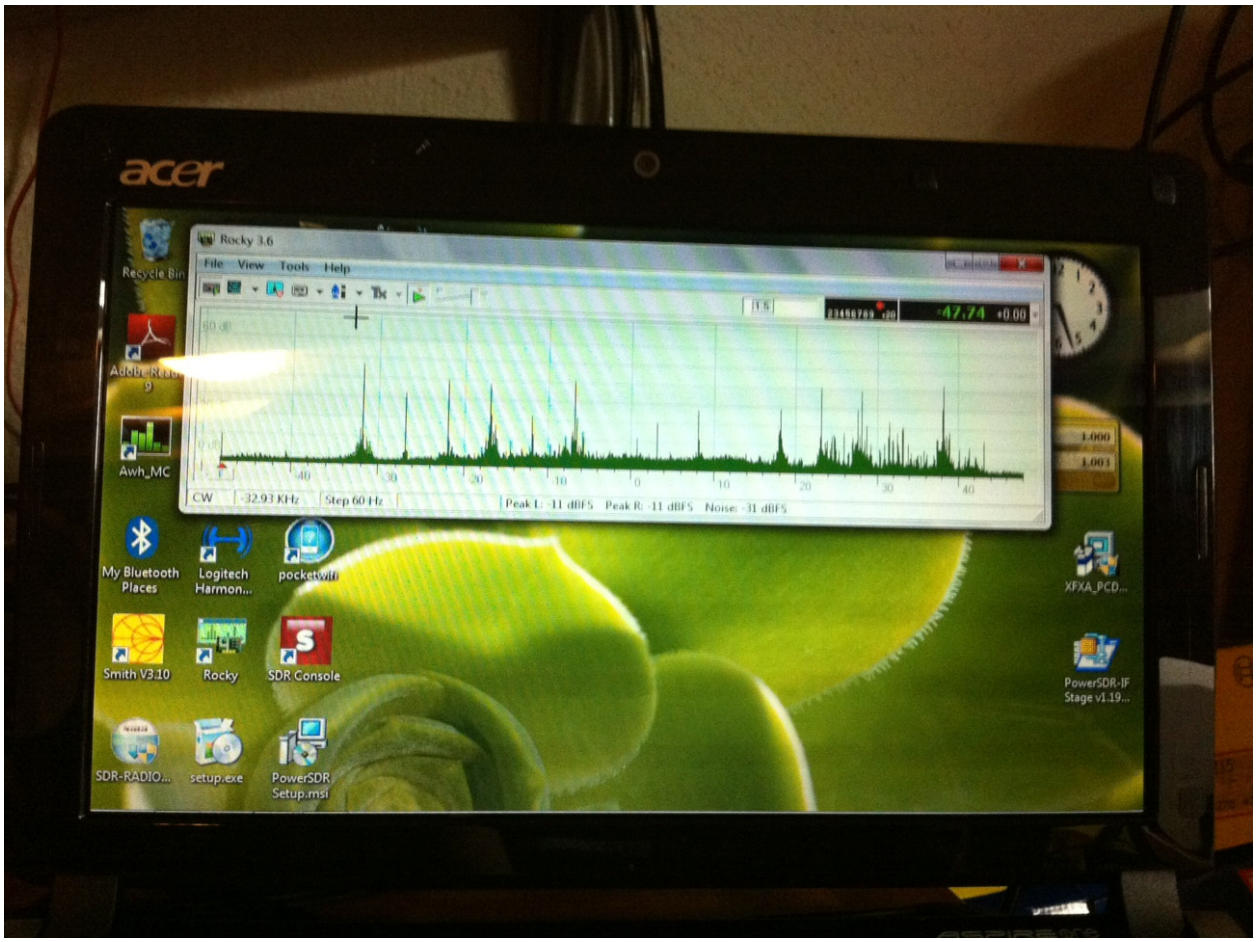
The following picture is of the AM band that starts at 7.2Mhz. It's pretty cool. You can see that the band is pretty full.

If as you tune around the band the spectrum scrolls backwards then you have the RCA connects on the wrong way and you just need to swap them around.

The longer you use Rocky the better the sideband suppression gets as the software works out the phase and gain errors in the I/Q channels as you use the panadapter. Go to the tools- RX I/Q balance menu item to see graphs of the correction factors. You sometimes need to reset the data collected to improve sideband surpression.

Hit the little I button (5$^{th}$ Button along) at the top and change the demodulation mode and then you can move the little window scroll bar at the bottom to listen to any signal displayed in the spectrum. Yet another receiver.

FT2000 Owners. We noticed that with the roofing filters set to be narrow that the spectrum displayed was really distorted. We selected the widest filter and this is what is shown on in the pictures. When a signal is found then by all means narrow up the roofing filter. The FT950 seemed to be impervious to the roofing filter settings. I wonder why?




## Conclusion

I would say that this would be one of the cheapest panadapter for the FT950/2000. There is a bit of construction and tuning but you will be rewarded as once you start using a panadapter you are hooked.

Thanks go to Clive GW0PPO who built the kit at the same time as me but at the other side of the world and worked out the trick of putting a couple of PF across the crystal to shift the frequency a bit and has put a 9V regulator to power the whole thing and get more frequency stability with changing power supply. Also thanks go to John, G3PNJ who put together some useful construction notes.

73's de Steve VK2MD