Software Defined Radios
By Murray Niman, G6JYB

Report By Christopher Chapman G0IPU

Murray started his talk by outlining the state of the technology at present and that he would limit the talk to receivers rather than transmitters. The latter could form the basis of another talk later. Describing the equipment he had brought along for demonstration purposes later on, which consisted of two laptop computers and radio related attachments. One was of a more commercial nature but the more relevant one was a Softrock SDR 40 kit on a 1GHz laptop.

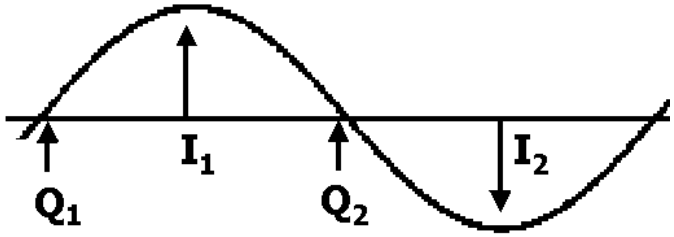
What's SDR all about?

So what is SDR? This is where the computer has taken over and replaced most of the usual analogue functions of the radio. Audio stages, modulation and first up conversions of the radio are now on the computer / soundcard to recover or define the wanted envelope of the signal in the software or hardware. This is not to be confused with tone decoding type software like RTTY, PSK31 etc where DSP is used purely at the audio level - now the DSP is at the IF and Detector stage (RF stages). This means you can use software to replace many of the filters once in hardware, and now use software defined filters with 250 plus virtual taps (not possible in hardware with coils and capacitors). This makes for a very cost effective radio in hardware (around £18 if you import from USA, or £28 from W&S at present), as the software to drive it at present is free.

The modes we use can be controlled from the computer, making changing modes very easy. In addition there is the ability to see on the screen a panoramic view of the band spectrum in use making it easy to see where the activity is on the band (in the demo case, Softrock-40 model – 40m/7MHz). This could clearly be an asset for the contester in the future. Another advantage of less hardware in the front end and IF, is that there is less to go non-linear (within the 100dB range of the sound card) just a simple passive band pass filter, enabling in-band monitoring despite strong adjacent signal.

One key feature of SDR is the use of in-phase and quadrature (I/Q) detection which can be used to overcome interference issues resulting in better overall signal to noise ratios and dynamic range (around 100dB is achievable). As Soundcards have two channels, this enables each of these components (I&Q) to be compared allowing far better performance and functionality compared to tradtional analogue AM/FM detectors. The I/Q channels must be as close to 90 degrees as possible in phasing, and can be adjusted either by the software or manually from within the software, giving as much as an extra 60dB's of image rejection. Murray then highlighted that this reduction in discrete analogue componentry was very attractive to mobile phone makers who already have gone largely digital.

Murray using block diagram explained the hardware, showing the band definition filter, Local oscillator, Quadrature sampler, and two op-amps for the output to the soundcard. There were no RF amplifiers, pre amplifiers, IF amplifiers etc. In fact most of the components on the demo board were for the power supply, keeping the whole thing small.



Quadrature Sampling

Murray then went on to explain the technique that is fundamental to the SDR system. An SDR system samples a waveform at four points per cycle to get pairs of I and Q components (remembering the 90 degree shift). Comparing I and Q in software it is possible to determine for instance whether the result is interference or whatever type of modulation you are receiving. The Softrock-40 samples at 4x the wanted frequency using a 28MHz (LO) that is divided twice to get 7MHz. The dividers have four outputs which drive CMOS sampling gates for the four signal states 0-90°, 90-180°, 180-270° and 270-360° all using simple 7400 TTL series chips. The new model Softrock (v7) simplifies the divider even further.

If this isn't familiar, remember that FM Stereo and Colour TV have been using I/Q signals with analogue detectors for decades.

The Circuit Diagram

Murray then went on to with the aid of the circuit diagram pointing out the bandpass filter, hand-wound transformer for the phasing, and the point where the four sampled signals are combined down to the two outputs for the soundcard. Also present was the LO (28MHz) and the rest of the circuit is for cleaning the power supply from the USB connector. In concluding the diagram section Murray said that you could easily use the SoftRock-40 circuit diagram as a basis for your own design and off the shelf components. It should be possible to produce a bank of SDR receivers to cover your bands of interest. The kit had taken a few hours to solder together with a fine tipped iron

Soundcard Issues

Ordinary Soundcards vary but will be good enough for this type of application. The integrated one used in Murray's laptop whilst not the best on the market is more than capable (AC97). Some Soundblaster cards are better and there are more specialist ones which lower the noise floor down to -130dBm. A nice set of plots of soundcard performance was shown, courtesy of Duncan Munro's Website.

Available Software

Murray explained that most of the software he was using was free to all and was 'open source'. The software for the FlexRadio SDR1000 can be downloaded for free for use on the Softrock kits, though obviously some functions may not work on the small kit. It is Windows 2000 / XP based and around 17Mb in size. As the software gets better, so your radio does too, without any hardware changes, unlike now where you have to get the next model of radio to get the latest developments. Some software is UK written by Duncan Munro M0KGK, and will work on Widows 98SE and is only a few megs in size making this an international affair. Your PC needs to be a 1GHz plus computer to cope with all the processing, and all background utility software ought to be disabled, or removed on slower PCs to minimise overheads - a dedicated SDR / Shack PC perhaps

Amateur Commercial Equipment

The SDR1000, a full 100W HF transceiver launched about a year ago is equivalent in functionality to the FT9000 plus more and is around $1000 in the USA (or £995 from W&S).

SoftRock Kits

Murray went on to say thanks to the QRP Club in the USA kits have become available for home construction market. Various versions are available at present. The one Murray used was the original Softrock 40 model (now superseded). The Softrock web site has all the detail and circuit diagram, so you can make the thing from scratch. Whilst they are plugged into the USB port, this is used for the power supply only. All the rest is via the soundcard inputs. On later models the USB PSU has been replaced by a more standard method.

The more recent Softrock-5 & 6 models all similar in size and the latter model is a neat dual band model with a small jumper to select between the 7MHz and 14MHz Bands (W&S £29). The next generation Softrock-7 will be 28MHz. The latter or models adapted to 10.7MHz can be excellent as digital IFs for VHF-Microwave receivers.

Questions

Murray then took questions from the floor and some read from those that could not be there for the talk.

***Q**. How is the filtering carried out at RF, If the filtering is too wide, how do you stop cross modulation?*
A. Murray went on to say for instance if sampling 7MHz you must keep out 14Mhz, so the band pass filter will roll of at around 12Mhz avoiding the aliasing of the sampler. This will stop sampling at either the low or over sampling the high end.

***Q**. Can you receive DRM on a SDR?*
A. At present there are DRM capabilities built into the SDR1000 software, so it should be possible when someone releases a software CODEC. However this may overload the PC processor time with the added workload.

Live Demo

Murray's live demo was on the 7MHz Band. Talking us through the display screen (SDR1000 Software) and the various modes the unit would resolve which were all the standard modes to be found an a modern transceiver CW ,AM ,FM, USB, LSB, DSB, plus some more newer ones RTTY, PSK31 and DRM. Selectable filters for the modes above and also variable filters whose widths could all be seen on the central panoramic spectrum. Also catered for were spot frequency memories, AGC, Time UTC/Local and band plan relevant to the frequency band in use. Murray then showed the configuration screen including the 65 pole filter, Noise Blanker, and other DSP / audio settings. It was ever so clear and you would have thought it was a very expensive rig you were listing to. Murray switched between the filter setting and pointing out the not so good aspects of his basic soundcard, but still achieving 90dB image rejection.

Next we were shown the different types of displays that were available for the centre window, panoramic spectrum, waterfall, spectrum analyser, oscilloscope (one audio channel), XY oscilloscope. Another display screen showed the input to the soundcard with all the unwanted interference shown and would be what a standard receiver would resolve. But the DSP cleaned the output up tremendously showing the power of DSP at RF level.

Commercial Equipment

Murray then displayed the professional side of the SDR – a Cognio SDR spectrum analyser card. This had a receive frequency range of 2.4-2.5GHz and 5-6GHz, all in the space of a standard slimline PCMIA card that plugged into the side of a laptop PC. The screen was showing a trace for a movement alarm or microwave oven nearby, then a Bluetooth device

somewhere in the room was activated and displayed on the screen. The analyser could automatically recognise the signal types and could decode the packet information, so it could identify WiFi signals, decoding their data without a user knowing. This is a useful and highly portable device for professionals and Ofcom and it vividly shows how insecure WiFi and other devices could be.

The Future

This little SDR board sparked a lot of interest, and Murray had certainly given a very informative and detailed insight to the future of radio. Only time will tell where this will all end up. Perhaps we will in time see the end of the “Blackbox Radio”, and as with many things, the combination of all the shack into the PC based system (if we can keep the EMC issues to a minimum). Perhaps we will be able to record the entire spectrum (of the band in use) and browse it later – this will make contesting interesting – the one that got away, that DX we missed.

Useful Links

SoftRock-40
http://www.amqrp.org/kits/softrock40/

Duncan Munro M0KGK
http://www.duncanamps.co.uk/amateur/sdr/

Flex Radio SDR-1000
http://www.flex-radio.com/

Yahoo Group Discussion Boards for hints and tips:-
http://groups.yahoo.com/group/softrock40/
http://groups.yahoo.com/group/kgksdr/

Report by Chris Chapman, G0IPU with additional comment by Murray, G6JYB.

Thank you both for your detailed write-up.