• E-mail: practicalwireless@warnersgroup.co.uk

The Icom IC-7610 HF/6m Software Defined Transceiver

Steve Ireland VK6VZ/G3ZZD was one of the first to get his hands on the eagerly awaited Icom IC-7610. He reports his findings and explains why SDRs make good DX/contest-grade HF transceivers.

The new Icom IC-7610 must be one of the most anticipated new radios in the history of amateur radio. Just as the Elecraft K2 set the scene for an overhaul of the superheterodyne architecture and the release of its bigger brother K3 in 2008 – which went on to dominate HF DXing and contesting for the next decade – the first true 'Software Defined Radio with knobs' the Icom IC-7300 (reviewed in August 2016 *PW*) has raised the curtain for the IC-7610 to challenge the K3 for its crown as arguably the most popular radio for demanding HF operation.

In terms of how successful the IC-7300 has been since its launch in March 2016, the word is that currently about 20,000 have been sold worldwide. In contrast, I understand Elecraft has sold about half this number of K3 and K3S – still a huge amount for an amateur radio transceiver – since sales started [1].

Time will tell how this scenario plays out but as an HF DXer and contester, let me say from the outset that I'm very happy with my IC-7610 and confident that digital architecture transceivers such as those from Icom, Apache Labs and FlexRadio Systems are bringing to a close the days of the superheterodyne transceiver, even those with a digital signal processing back-end.

It's Not Two IC-7300s

Let's start by getting the biggest elephant in the room out of the way by saying that the popular idea of the IC-7610 with its dual receivers being like two IC-7300s in one box is not only misleading but plain wrong.

This comparison is often used to lead into to say that at currently around £3500 in the UK, the IC-7610 is overpriced in comparison to the IC-7300, selling at around £1200.

To start deconstructing 'the elephant', the front-end filtering on each IC-7610 receiver is superior to the IC-7300, with better bandpass filtering and the one-pole Digi-Sel preselector module, which greatly improves the out-of-band rejection of big signals that can cause annoying intermodulation. If you are like me and have a powerful medium wave broadcast station relatively nearby, this is a really important feature.

When it comes to working DX, particular the major 'once every 20 years' DXpeditions such as the recent, sadly-aborted 3Y0Z operation, having two equally good receivers is priceless, because these expeditions will generally use up to a 5 to 10kHz 'split' between their transmit and receive frequencies. In the IC-7300, with its single receiver and dual VFOs, you can toggle back and forward between the receive and transmit frequencies but this is nothing like being able to listen to both frequencies simultaneously, by having one receiver in each ear of your headphones, as you can on the IC-7610.

Dual receivers enable you to know exactly what is happening in the pile-up and on the transmit frequency.

The next point to make is that instead of getting the 14-bit version of the popular LTC2208 analogue-to-digital converter (ADC) that lies at the heart of the IC-7300, it looks though we get the 16-bit version [2] in each of the IC-7610 receivers - more of this later. 16-bit ADCs are used in the vast majority of high-end computer-assisted digital sampling SDRs, such as Apache Labs ANAN series [3] and Flex-Radio's 6000 series [4] and the LTC2208 was originally used in the ground-breaking HPSDR [5].

For those like myself who are keen CW operators or who dislike clicking transmit-receive (TR) relays such as used in the IC-7300, the IC-7610 has solid-state, totally quiet, TR switching.

On the IC-7610, the CW keying waveform generation and shaping is carried out in the radio's RF Field Programmable Gate Array (FPGA) to minimise any latency (the delay between Morse characters being formed by a key/keyer and then actually transmitted).

Unlike the IC-7300, the IC-7610 comes with superb audio peak filtering, adjustable in frequency, width and gain and available on both receivers, which is better than any analogue or digital audio filter that VK6VZ has ever used. This includes the excellent, well-regarded ones on the Elecraft K3, Ten-Tec Orion 2 and Yaesu FT-1000. The IC-7610 filter does an amazing job of cleaning up any CW or digital signal – not just in helping to dig weak ones out of the noise.

The high definition touch screen (7in diagonal) is substantially larger and easier to use than the one on the IC-7300 (4.3in) and you have the additional ability to use an external VGA monitor by plugging a cheap DVD-I to HDMI socket adapter (typically around £5) into the IC-7610, which in turn plugs into a HDMI to VGA converter (usually around £20) into which the screen is plugged, giving you a massive view of the IC-7610 spectrum scope and transceiver functions.

While it is possible to give the IC-7300 an external display by plugging it into a personal computer running the N1MM logging software [6], as most IC-7300 users will know, you cannot simply plug a monitor screen into it.

Other advantages of the IC-7610 over the IC-7300 are its larger physical size, which results in a much more comfortable, spacious and easy to use front panel. It is great, for example, to have a large Independent Receiver Tune control directly adjacent to the main tuning knob. The rear panel offers much better connectivity than the IC-7300, particularly where antennas concerned – you get two PL-259 antenna ports, plus a BNC-format receive antenna input and output.

While the IC-7610 is not a dual IC-7300, the interface of the original software written for controlling the IC-7610 is very similar to that of the IC-7300. What this means in practice is if you have used a IC-7300 and customised its menu settings, in particular the spectrum scope and receiver filtering parameters, setting up the IC-7610 how you want it is a breeze.

Even if you haven't, the super videos on setting up and using the IC-7300 available on YouTube – in particular, my favourite ones by **Steve Ellington N4LQ** [7] – make life very easy for new IC-7610 users.

Design and Construction

The Icom IC-7610 uses a direct sampling SDR architecture, with two identical, independent digital down conversion (DDC) receivers and a digital up conversion (DUC) transmitter. By independent, I mean that the receivers can operate independently on different frequency bands and different modes. As standard, the receivers both share the same main tuning knob but you can buy a second stand-alone tuning knob (Icom RC-28) to tune the second (designated SUB) receiver (UK price to be announced but probably around £250).

The tuning of the two receivers can be tracked/coupled together, enabling you to carry out diversity reception by, for example, plugging separate horizontal and vertically polarised antennas into each receiver and then listening to one receiver in your left ear and the other in your right ear.

A look at the block diagram and schematics which come on the CD supplied with the IC-7610, **Fig. 2**, shows that each receiver front-end has its own ADC, ADC driver/preamplifier, stepped attenuator, group of bandpass filters and Digi-Sel automatically tracking preselector. If you listen very carefully while tuning one of the receivers, you can faintly hear its associated preselector operating/tuning.

The IC-7610 in use at VK6VZ.

In addition, there are separate digital-to-analogue (DAC) converters, using 14-bit ISL5961 chips, and audio chains on each receiver, enabling binaural reception of signals. The encoding of the analogue transmit audio and the decoding of the receive audio bitstream is carried out by an Ashai-Kasei AK4621EF dual 24-bit 192kHz stereo audio CODEC, which interfaces with the FPGA.

As most who have read about direct sampling receivers will know, it is the ADC that forms the heart of any digital up/down conversion or 'digital sampling' radio, converting RF signals to digital data by rapidly sampling them. The symmetrical data lines coming from the two LTC2208 ADCs go to the main IC-7610 Altera© RF Field Programmable Gate Array (FPGA) which then carries out most of the RF and digital signal processing and frequency management in the IC-7610.

I've recently discovered [8] the FPGA is configured as a digital down converter and delivers a digital 12kHz 'IF' to each of the receiver DACs, which converts the digital signal back to audio. All signal processing functions are performed in the FPGA.

The use of the FPGA after an ADC in this manner is the conventional, time-tested way to deal with the huge amount of data that comes out of an ADC – a crucial and difficult task that takes a huge number of gates and some very special programming ability. My good friend and regular co-writer on SDR **Phil Harman VK6PH** uses the analogy of 'drinking from a fire hose' when it comes to carrying the necessary function of an FPGA.

In the case of a 16-bit LTC2208 ADC that samples analogue signals at the rate of 130 mega samples per second (Msps), the data output stream would be 16 x 130Msps - over two gigabytes per second!

To deal with this huge amount of data and take advantage of the high dynamic range the 16-bit LTC 2208 offers, the FPGA first carries out a specialised form of filtering, known as decimation, using digital filtering formed from gates in the array, before carrying out other processing tasks, using further gates.

In addition to the main FPGA that supports the two ADCs, each IC-7610 receiver has a separate Lattice© common FPGA, which carries signal processing tasks that specifically relate to the associated receiver.

Other separate, independent functions for each receiver include spectrum scope/waterfall displays with 100dB dynamic range, audio and squelch controls and external speaker jacks.

Measurements and On-Air Performance

Just about every radio amateur who is interested in receiver performance and the associated measurements would be aware of the famous receiver test data table [9] published by **Rob Sherwood NC0B**, founder of Sherwood Engineering, which is compiled from equipment testing carried out in Rob's extremely well-equipped laboratory.

Rob's table rates receivers/the receive sections of HF transceivers produced over the last 30 years or so according to their ability to deal with strong signals that are relatively closely spaced (mostly 2kHz apart). He calls this parameter 'Dynamic Range Narrow Spaced' or 'DRNS' and if a radio has a DRNS of 75 to 80dB in his table, my experience is this is good enough for general (DX and ragchewing) operation unless you

The IC-7610 rear panel has plenty of interfaces to antennas and external devices.

are unlucky enough to have a radio amateur who lives a kilometre or two away, runs (at least) the legal UK power limit and is active on a daily basis when you want to go on the air.

If this is the case, then you are likely to need a radio with a DRNS of at least 6dB higher (81 to 86dB) to operate within a kilohertz or two of your high-powered neighbour.

Just before Christmas, Rob put an Icom IC-7610 through its paces in his laboratory [10] and was kind enough to allow me to use the associated measurements in this review. The sample IC-7610 performed very well, displaying a DRNS of 98dB (with the IP+ control switched on) and 90dB (with the IP+ switched off) at 2kHz spacing.

When it comes to Rob's very long and thorough table, this DRNS currently puts the IC-7610 in eleventh place - some five places above the IC-7300, which has a DRNS of 94dB (IP+ on) and 81dB DRNS (IP+ off). However, to put this into context, the leading radio in Rob's table is a FlexRadio 6700 that he measured at 108db DRNS (preamp on) back in 2014. A second Flex 6700 sample measured by him in March 2017 measured 96dB DRNS (preamp on) and 99dB DRNS (preamp off).

As Rob said in a recent interview [11] on the Ham Talk Live internet programme with **Neil Rapp WB9VPG**, the top direct sampling/digital down conversion receivers and transceivers he has tested all have similar, consistently-high DRNS figures. The 2017 Flex 6700 sample measured 99dB, the Apache Labs ANAN 200D 99dB, the Microtelecom Perseus receiver 99dB, the Icom 7610 98dB (IP+ on) and the Icom R-8600 98 dB (IP+ on).

Now I have my own brutal means of on-air testing how well a receiver performs on very strong signals, which is: *"Can I operate within 1kHz of the formidable contesting station of my good friend* ***Kevin Smith VK6LW****, who lives just a couple of kilometres away, whichever way 'Kev' is beaming and whatever band he is operating on?"* To give an idea of his signal strength, on the 160m band where Kev's signal is loudest, he is a true S9+40dB.

To get a feel for how receiver DRNS has improved over time, in the 1990s I used top-of-the line radios for that decade, including the FT-1000MP (68dB DRNS) and FT-1000 (69dB DRNS), neither of which were 'Kev-proof'.

Nowadays DRNS for new top HF radios produced by all the manufacturers are well over the 81 to 86dB milestone and the problems of front-end overloading have, as a result, generally faded into history, at least at my QTH. My IC-7610 was tested out during the 2017 CQ WW CW contest and the 2018 CQ 160 CW Contest and proved totally 'Kev-proof', as did a friend's ANAN 200D (99dB DRNS in Rob's table), which was used alongside the IC-7610.

Not only I could tell no difference in Kev-proofness between the two radios, but they performed at least equally well in this regard to their predecessors at VK6VZ, the Ten-Tec Orion 2 and Elecraft K3.

However, for me, using the IC-7610 on-air was more fun and effective than any of its predecessors. As Rob Sherwood said in the Ham Radio Live interview: *"It is crazy to judge a radio by one parameter"* and, to me, it's particularly crazy to do this just on DRNS when all new contest/DX-grade radios work so well on strong signals.

Why SDRs Make Good Radios

One of the reasons why the Elecraft K3S, Icom IC-7851, Yaesu FT-5000D and other superhet-based transceivers are at the top of Rob Sherwood's table is because they use crystal filtering as the first point in their architecture after the antenna to provide signal-width selectivity. Crystal filters placed in this position are known as roofing filters and protect the rest of the receiver from very strong signals outside of the very narrow width of the multi-pole filter.

However, what may seem to be the strongest point of this latest variation of the superhet architecture can also be arguably its 'Achilles' heel' when it comes to producing very clean and clear-sounding audio in your speaker or headphones.

All radio frequencies that radio amateurs use are covered in noise – atmospheric, ionospheric and man-made. When noise spikes or pulses pass through a crystal filter, the phase response of the filter varies, depending of the frequencies of the noise passing through it. However, when the same spikes or pulses pass through an ADC, it responds to them in a linear manner and the phase response stays the same, irrespective of the frequency of the noise.

As a result, noise can sound harsh and grating to our ears from a superhet equipped with a crystal filter(s) but the same noise will sound mellow and easy on the ears when heard on an SDR.

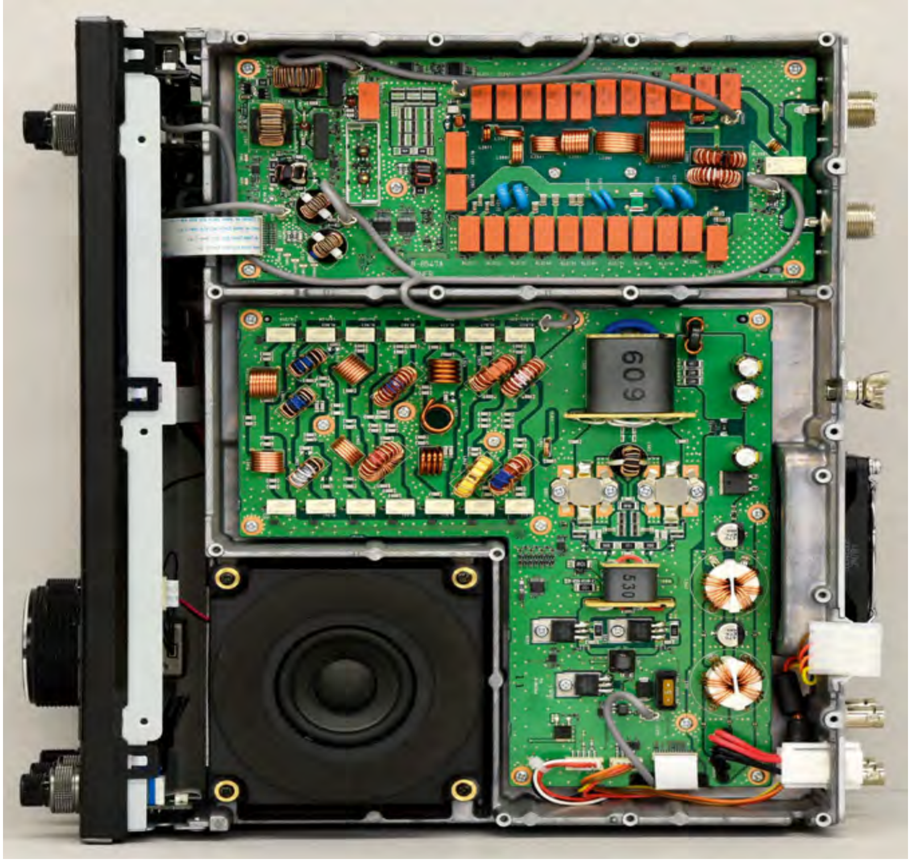
Superhets also generate additional internal noise that gets overlaid onto signals, exacerbating the situation. This is because their architecture makes RF signals audible by stepping down (or sometimes, by temporarily stepping up) the frequency of the desired signal. This means mixing the signals with other signals – and every active superhet stage of mixing adds noise onto the signal.

The Elecraft K3 and other recent top-line superhets cleverly minimise this problem by having only one true intermediate frequency (IF) stage and thus one mixer. However, some superhet transceivers have three IF stages and thus three mixers and sometimes add more crystal filtering to improve the steepness/narrowness of the receiver's selectivity as part of these stages, which all adds additional phase distortion.

To get around this problem of mixers adding noise and to minimise the varying phase responses of crystal filters, modern superhet transceivers reduce the number of mixers and crystal filters and, instead, get more selectivity and noise reduction by turning the analogue signal into a digital one after one IF stage.

The end result is that weak signals on modern superhets can sound highly processed and thus sometimes hard for us to distinguish.

Direct sampling SDRs and their ADCs respond to weak and strong signals in a totally different way to analogue designs using (non-linear) mixers and crystal filters



The rear panel with plenty of interfaces to antennas and external devices.

– they remain linear until the ADC overloads – which takes around +6dBm with the 16-bit LTC2208. To keep the ADC from getting close to overloading and to get the best result on weak signals, we simply switch in the attenuator (all top SDRs have them) if the ADC overflow (OVF) lights starts to flash.

Unlike conventional superhets, the presence of strong in-band and out-of-band signals is not necessarily a concern as long as these do not instantaneously add and overload the ADC (which is a 'once in a blue moon' phenomenon). In fact, lots of signals (and band noise) below this overload level can actually improve the overall performance of the ADC. As my friend, co-writer and SDR expert, Phil Harman VK6PH said at the 2008 Dayton Hamvention on ADC performance: *"As long as all the external signals don't add up so at to overload the ADC, then big signals are your friend."*

Because of the way ADCs work in terms of signal intermodulation, they actually perform better when they have high level inputs (say, made up a majority of strong signals) than at low signal levels (say, made up of lots of weak signals). This aspect of SDR performance is best shown graphically – see **Fig. 1**. While Fig. 1 shows that third-order intermodulation products (IP3) for an analogue radio do not vary with input signal level, they do for an ADC. Note the figure shows IP3 varying linearly with input signal level but in practice there is a more complex relationship, where at some input levels the IP3 increases and at others it decreases.

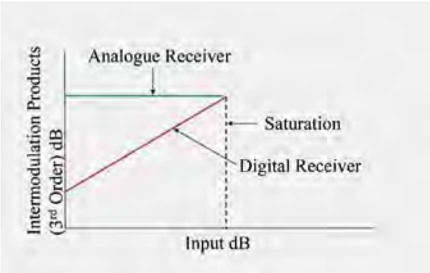


Fig. 1: A comparison between the overload characteristics of analogue and digital receivers.

The reason for this is while an ADC is fundamentally linear in theory, it is less so in practice, which means applying multiple signals to them does not cause intermodulation products. Instead, the signals add together, so a weak signal is carried around the transfer curve of the ADC in the manner of being piggy-backed by a strong signal. What this practically means is the weak signal spends less time close to the graph origin, where most of the non-linearity of the ADC transfer curve occurs.

A band of S9+40dB signals do not all add together to create a resulting massive signal since they all have different phase relationships. Some will add but others will subtract. As long as the resulting sum of all the signals does not cause the ADC to overflow, then, unlike a conventional analogue radio, no harm is done.

This phenomenon/quirk of ADC performance is known as dither and can be created naturally by lots of signals (as explained above) and/or by designing the ADC chip in such a way that dither can also be artificially exploited even if there are not lots of strong signals/noise present. The LTC2208 ADC has been designed in this way and the Icom IC-7610 has a control called IP+ that switches this dither function on – more of this later.

One other crucial aspect where digital sampling radios perform differently and better is filtering. The Fast Fourier Transform digital filters used in digital sampling radios provide steeper sides (better shape factor) than any crystal filter can provide and their steepness and bandwidth is continually variable, down to a few tens of Hertz.

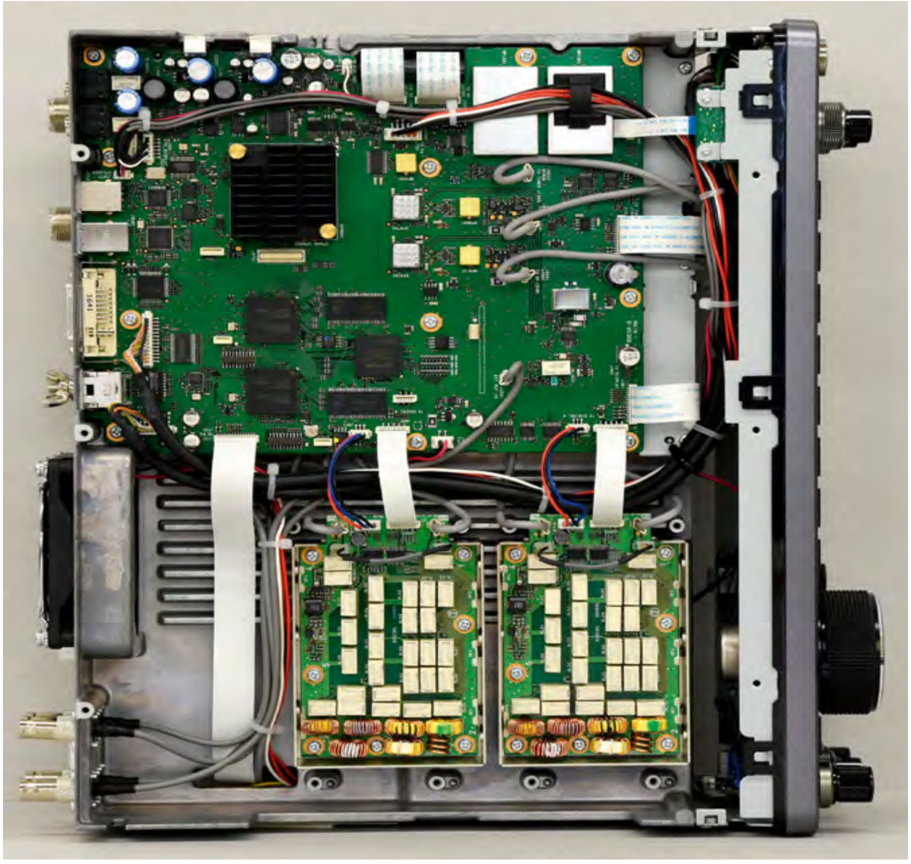
This increased signal clarity that well-designed digital sampling radios can provide over modern superhets is something that is hard to quantify using current radio testing regimes and has to be experienced rather than measured.

Using the IC-7610 On Air

Over the years I've learnt that before putting a radio on the air, the first thing to is to read the manual that comes with it. The IC-7610 comes with a hard-copy version of a 'Basic' manual, plus soft copies of this manual and a further 'Advanced' manual on CD, which I quickly learnt was vital in terms of knowing how to change firmware and getting the most out of the IC-7610's spectrum scope. Familiarise yourself with both manuals right from the start to get the most out of your IC-7610 and avoid frustration.

The first aspect of the IC-7610 you are likely find yourself wanting to explore is the dual - one section for each receiver - spectrum scope. This is a Fast Fourier Transformation (FFT) Type, as is used in direct sampling SDRs, such those from Apache Labs and FlexRadio and their associated software, and is a huge improvement on the swept-type spectrum scope used in the earlier IC-7600.

In comparison with the latter, the IC-7610 spectrum scope has a dot resolution that is 20 times better, a resolution bandwidth (RBW) of 10Hz (20 times better), a sweep speed of 30 screens per second (over seven times faster) and a display dynamic range of



An internal view from below.

100dB (which is comparable to the overall receiver dynamic range).

After using the Apache ANAN 200D with its associated PowerSDR mRx PS 3.4.2 software for a couple of months prior to the arrival of the IC-7610, I initially found the IC-7610 screen too small so I used the big screen function/output of the IC-7610 with a 17in LG VGA screen. To do this, I plugged a DVI-D to HDMI adapter into the IC-7610 EXT-DISPLAY DVI-D socket on the rear panel of the transceiver and then plugged a HDMI to VGA converter into the adapter.

This display was comparable in readability to the one I had got used to in PowerSDR mRx. You can plug a USB mouse into one of the IC-7610's USB sockets and use this for point-and-click tuning on the spectrum scope. Note that at present, the IC-7610 firmware doesn't allow the mouse to select the menu functions that are shown on both sides of the spectrum scope.

However, after a couple of days using the IC-7610 in this manner, I found my attention was focusing on the IC-7610 LCD touch screen rather than splitting itself between the external monitor and the IC-7610 front panel there. In addition, I had subconsciously started to stop using the mouse for tuning in favour of using the IC-7610 tuning knob.

What I also did during this period was to pay a visit to a local personal computer store and purchase a rubber-tipped stylus to use to select the IC-7610 menu functions, rather than using a rather grubby forefinger.

The reason behind this change of heart was that the IC-7610 spectrum scope screen, with the RBW and Video Band Width (VBW) (MENU 2) both set to narrow, gave a perfectly acceptable display of weak CW and SSB signals - in the case of the former, ones that were actually inaudible.

Not only that but the internal IC-7610 screen scope gave me a nice 'birds eye view' window on the band without dominating my attention, whereas the 17in LG LED screen drew my gaze like a picture window and was a distraction from the well-spaced and laid-out IC-7610 front-panel controls.

I recall listening to several radio amateurs on air who had K3 transceivers and the associated P3 spectrum scope and then bought Elecraft big-screen adapters for their P3, only to discover they ultimately preferred using the P3's smaller, compact screen.

The appearance of signals on the IC-7610 spectrum scope is highly customisable and you can have a lot of fun experimenting with what colour waveform and fills appeal to you most. After trying several different looks, I ended up with a green no-fill waveform appearance that Steve N4LQ uses on his IC-7300 [12].

There are basically two modes of IC-7610 spectrum scope operation – fixed mode screen and centre mode screen, with or without an additional waterfall display. For me, as a primarily CW operator, I love waterfall displays and consider them the most important part of any spectrum scope. However, an SSB operator may prefer not to have the waterfall engaged.

In the CENTRE mode (pressing the CENT/FIX button toggles between two modes), the signal to which the receiver in use is tuned is shown at the centre of the screen and the associated SPAN function selects one of eight spans, ranging from ±2.5kHz to ±250kHz. In the FIXED mode, the signal to which the receiver in use is tuned is shown on one of three configurable, fixed frequency spans and the associated EDGE function selects the edge frequencies of each of these separate, individually fixed frequency spans.

For example, using the FIXED mode for the 7MHz band I have configured my IC-7610 spectrum scope to the following three fixed frequency spans: 7.000 to 7.030, 7.030 to 7.060 and 7.000 to 7.300MHz. An SSB operator would likely to configure these fixed mode frequencies differently.

Now the fact that I have 7.030 to 7.060MHz fixed span showing on my spectrum scope does not stop me from tuning/receiving/transmitting above or below this. To some considerable extent, the spectrum scope and transceiver IC-7610 functions operate independently, which can be quite useful. For example, you could listen to a local net on 7.075MHz while at same time monitoring 7.125MHz with the spectrum scope (using a fixed span from 7.100 to 7.200MHz) where a major DXpedition is expected to appear.

Balancing the Gain

The best way to think about the receiver and spectrum scope operations is as separate functions that are linked in one particular vital regard – that of RF gain.

In operation, in my experience what you need to do is to first adjust the gain of the IC-7610 receiver to suit the particular band you wish to operate on and its prevalent conditions so that the band noise is just audible – just below AGC threshold. Next, adjust the spectrum scope gain of the scope using its REF menu function (MENU 2), using the main tuning dial to actually change the gain level, so that the scope is just sensitive enough to show signals on the band.

The Digisel module.

Carrying out this balancing act is what lies at the heart of making the best of the IC-7610 receive operation – and you will need to get used to adjusting the gain of both the receiver and the spectrum scope as you move from band to band.

As an illustration of this, when using 1.8MHz – usually the noisiest of the amateur bands – I need to switch off the preamps and engage Digi-Sel (remember I have a Medium Wave BC station nearby) and, with the RF Gain at maximum, use between 12 to 18dB of attenuation. The REF spectrum scope gain is then adjusted – usually to a similar level of negative gain/attenuation. On 40m, the preamps are also switched off, the Digi-Sel engaged and the attenuation in the front end is running from 0 to 6dB, depending on band noise.

As a result, Icom has paid a lot of attention to preamplification and attenuation in the IC-7610, putting in two preamps – a wide dynamic range 12dB preamplifier for the lower HF bands and a 20dB preamplifier for the higher HF bands. Unless you have a relatively small or low-gain antenna for the lower HF bands, such as a magnetic loop or a Beverage, you are not going to need to switch a preamp on at all there.

When it comes to attenuation, the default settings are off, −6dB, −12dB and −18dB, but you can adjust the attenuation in 3dB steps by depressing the attenuator touch button for a few seconds and adjusting the level using the MULTI knob.

As with the IC-7300, Icom has included a function on the IC-7610 that it calls 'IP+' and is described on page 9 of the Advanced manual where it says its engagement *"improves the intermodulation distortion quality by optimising the direct sampling system performance".* The manual goes onto say: *"This function optimises the ADC against distortion when you receive a strong input signal."*

Rob Sherwood has commented [14]: *"IP+ implies it raises the overload point, which it does not. IP+ is 'dither'… it can take the low distortion products that are fairly weak – and probably below the band noise on 160, 80 and 40 – and turns the distortion products into noise. If the radio is done right, which the IC-7610 is… it doesn't degrade the noise floor much."*

Rob added: *"People should experiment with IP+ [on their IC-7610] in situations where they think their receiver is getting stressed."*

I've spent some time switching the IP+ in and out while operating when there have been very strong signals on the band and, generally speaking, haven't noticed any difference when the function is engaged. However, on one occasion, when I was trying on an almost dead 28MHz band to work a very weak signal immediately adjacent to the huge signal from my neighbour VK6LW, engaging the IP+ helped me to read the weak signal. There appear to be benefits in using it under some circumstances.

When it comes to the digital FFT filtering used for governing the passband of the IC-7610 receiver, there are three preset bandwidths for each of the five reception modes. These have been decided based on conventional use – for example, the SSB bandwidths are 3.0kHz, 2.4kHz and 1.8kHz, while the CW, digital (SSB-D) and PSK bandwidths are 1.2kHz, 500Hz and 250Hz.

You can independently set the filter shape to either SHARP or SOFT for each operating mode. As Icom say, the SHARP filter has *"an almost ideal shape factor"* with very steep sides. On CW I was constantly torn between using the SHARP filter, which in a pile-up situation is so sharp that while it can give you single signal reception, it is easy to miss very closely adjacent signals if you don't keep moving your RIT, and the SOFT shape, which has shallower sides more like a conventional crystal filter.

On SSB, I loved the SHARP filter shape, which really separated out received signals if a band was packed.

Transmit Performance

In regard to the IC-7610 transmit performance, my brief experience with SSB on air was that it was uniformly excellent, with the supplied Icom HM19 microphone providing nice well-rounded, full audio with the default settings. However, when it came to CW transmission, Rob Sherwood's laboratory tests have revealed that there are couple of transmit settings where some careful adjustment is vital.

The default rise time of the IC-7610 transmitted CW envelope is very fast (2ms) and, as Rob Sherwood noted in his laboratory report [14], this magnitude of rise time can be a *"key-click special."* Rob suggests increasing the rise time to 6 or 8ms and I took his advice, using page 16 of the Advanced manual to set a 6ms rise time.

Rob also found that for a clean first 'dit' to be transmitted on CW, the ALC/drive level needs to be set to one-third of the red ALC scale. The ALC level is adjusted by pressing the QUICK button and then selecting DRIVE on the front panel display. Press the TRANSMIT button, key your CW paddle or key and adjust the ALC/drive level using the MULTI rotary control.

Rob has observed interaction between the IC-7610 power output setting and the drive setting, so you may need to go back and forth between these two controls.

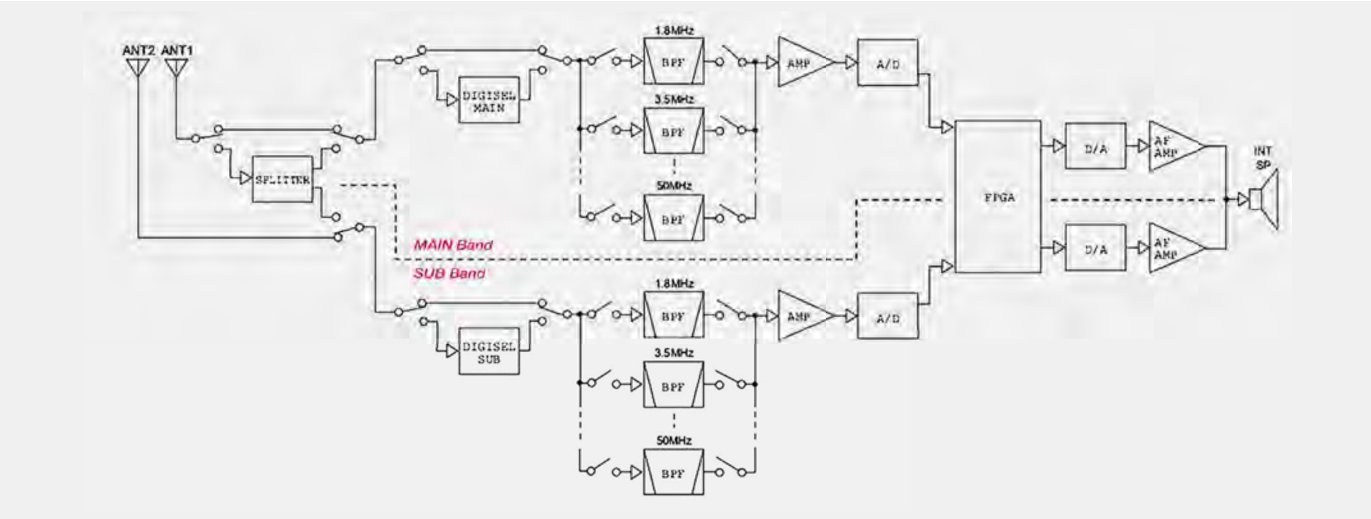


Fig. 2: IC-7610 block diagram.

Note the drive setting seems band-dependent so you will need to check it when you change bands. If the drive level is not around one-third of the red ALC scale, the power output of the radio will be lower than it should be (i.e. 25% cent power output will not correspond to 25W RF).

The latter is important if you are using a high-gain RF linear amplifier and want to drive it consistently with the correct power level. In addition, if you are driving a linear amplifier with your IC-7610, consider changing the default key-down delay (in BK-IN/BK-IN SEMI) from OFF to a higher level. Rob writes in his lab report: *"OFF provides only a 6 or 7ms delay, which will 'hot-switch' any amplifier. An amp with PIN diode TR switching may not hot-switch at 10ms, but I run mine at 15ms for both an Acom 1000 vacuum TR relay and an Alpha 89 PIN diode TR switch."*

I use semi break-in keying (BK-IN SEMI) and, to avoid the possibility of hot keying as much as possible, have increased the key-down delay to the maximum possible of '13d' for use with my OM Power linear.

On the basis of leaving the best till last, there are couple of absolutely stand-out features on the IC-7610, which for me make the purchase of the IC-7610 worth it just for them.

The first of these is the noise reduction (NR) feature, which I run on the '3' setting at all times on CW. The drop in noise level by up to several 'S units' without any noticeable effect on signal strength/reproduction simply astounded me.

I'm lucky enough to live in a semi-rural village that is only 'semi-noisy' so it is impossible to know how effective the NR would be in a highly urban location, but I'd be racing out to borrow and try out an IC-7610 from my home if I was in this situation.

The second jaw dropper for me was the audio peaking filter APF/TPF. Initially I set it to 80Hz WIDTH, SHARP and an AF LEVEL of 2dB and found it made weak, almost-buried-in noise signals literally pop out of the mud. Then, as Rob has suggested, for general operation, I set the width to WIDE, the type to SOFT and the AF level to 4dB and this does a brilliant job of making CW signals stand out in 'single signal fashion'.

Final Thoughts

The Icom IC-7610 is a very new radio, with shipments to Japan/Australia only really starting in October/November and the UK only now receiving its first supplies. As you would expect, the radio's firmware has undergone a number of revisions (five at the time of completing this article in early February) as the firmware is fine-tuned as more and more radio amateurs use the radio and discover operational scenarios and possibilities that the developers could not necessarily have anticipated.

Reading **Adam Farson VA7OJ/AB4OJ's** brilliant IC-7610 Yahoo reflector, essential reading for all users, some appear to have found the odd software bug, which have been reported to Icom, but in my case the IC-7610 has performed flawlessly since its purchase. My only issues have come because of a lack of understanding that, in my particular station, some default settings potentially needed checking/tweaking; in particular checking the adjustment of the transmit drive level when a band change and/or power level change has been made.

This review could not have been written without the co-operation and assistance of Rob Sherwood NC0B and Adam VA7OJ/AB4OJ. Rob is a regular contributor to both the IC-7610 and IC-7300 Yahoo reflectors that Adam oversees and runs and whatever Rob and Adam write on these radios – and about radios of any kind – is always worth reading.

Just as this article was undergoing the publishing process, Adam published his 48-page *IC-7610 User Evaluation and Test Report*. If you have read this article, Rob's lab report and Adam's report – both referenced below – you will have a very solid grounding in the IC-7610.

Rob and Adam's enthusiasm is infectious and their knowledge is great – and this has meant that I rewrote several sections of this review after realising I needed to include their latest insights. Thanks blokes for consistently sharing what you know with IC-7610 users – and for making me think hard. A huge thank you also goes to my great friend Phil Harman VK6PH for his advice in the preparation of this article

The IC-7610 is now available from the major UK amateur radio retailers for around £3500.

References

[1], [10], [13] The interview with famous HF receiver and transceiver reviewer/tester Rob Sherwood NC0B by Neil Rapp WB9VPG on the Ham Radio Live channel (Episode 99) covers the IC-7610 and other high-performance HF transceivers – and gives an excellent tutorial on how to best use direct sampling transceivers – see:
https://tinyurl.com/y8rvcyhn

[2] E-mail from Adam VA7OJ/AB4OJ to VK6VZ/G3ZZD on December 5th 2017. *"I have examined the block diagram and schematics of the IC-7610. The ADCs are indeed LTC2208s. There are two FPGAs, an RF FPGA supporting the ADCs and a*

Table: Icom IC-7610 Measured Performance by Rob Sherwood NC0B, Sherwood Engineering
Icom IC-7610 Serial # 12001056, Test Date: 22/12/2017

Bandwidth set to 2.4kHz (6/–60)	**Ultimate rejection**
2.525/3.430kHz	> 110dB

Bandwidth set to 500Hz (6/–60)	**Ultimate rejection**
517/658Hz	> 110dB

DYNAMIC RANGE, BLOCKING, PHASE NOISE AND RECIPROCAL MIXING DYNAMIC RANGE (RMDR)	
Configuration: Front End Selectivity (using A – F preselector selection) Half-Octave Band Pass plus first-order Tracking Preselector A.The following Dynamic Range measurements were made on 14MHz band. The DigiSel filter is set to OFF unless listed.	
1. Dynamic Range of radio, Preamp OFF, IP+ OFF	
Dynamic Range 100kHz, DigiSel ON	95dB
Dynamic Range 20kHz	90dB
Dynamic Range 10kHz	90dB
Dynamic Range 5kHz	90dB
Dynamic Range 2kHz	90dB
2. Dynamic Range of radio, Preamp OFF, IP+ ON	
Dynamic Range 100kHz, DigiSel ON	105dB
Dynamic Range 20kHz	98dB
Dynamic Range 10kHz	98dB
Dynamic Range 5kHz	98dB
Dynamic Range 2kHz	98dB
3. Blocking	
Blocking above noise floor, 1µV signal @ 100 kHz, AGC ON. Blocking refers to OVF (overflow) indicator ON	
DigiSel OFF IP+ OFF	122dB
DigiSel OFF IP+ ON	119dB
DigiSel ON IP+ OFF	124dB
DigiSel ON IP+ ON	121dB
4. Phase noise	
Phase noise (normalised) at 2.5kHz spacing	–139 dBc/Hz
Phase noise (normalised) at 5kHz spacing	–142dBc/Hz
Phase noise (normalised) at 10kHz spacing	–146dBc/Hz
Phase noise (normalised) at 15kHz spacing	–148dBc/Hz
Phase noise (normalised) at 20kHz spacing OVF	> –149dBc/Hz
5. Reciprocal Mixing Dynamic Range (RMDR)	
RMDR at 2.5kHz spacing	112dB
RMDR at 5kHz spacing	115dB
RMDR at 10kHz spacing	119dB
RMDR at 15kHz spacing	121dB
RMDR at 20kHz spacing:	OVF (Overflow) > 122dB

NOISE FLOOR AND SENSITIVITY (14 MHz)		
Measurements with IP+ OFF and IP+ ON	**IP+ OFF**	**IP+ ON**
Noise floor, SSB [2.4 kHz] bandwidth 14 MHz, Preamp OFF	–125dBm	–122.5dBm
Noise floor, SSB [2.4kHz] bandwidth 14 MHz, Preamp 1 ON	–134dBm	–131.5dBm
Noise floor, SSB [2.4kHz] bandwidth 14 MHz, Preamp 2 ON	–135dBm	–134.5dBm
Sensitivity SSB at 14 MHz, Preamp OFF	1.13µV	1.65µV
Sensitivity SSB at 14 MHz, Preamp 1 ON	0.45µV	0.56µV
Sensitivity SSB at 14 MHz, Preamp 2 ON	0.37µV	0.39µV
Noise floor, 500 Hz [CW] bandwidth, 14.2 MHz, Preamp OFF	–132dBm	–129dBm
Noise floor, 500 Hz [CW] bandwidth, 14.2 MHz, Preamp 1 ON	–140dBm	–138dBm
Noise floor, 500 Hz [CW] bandwidth, 14.2 MHz, Preamp 2 ON	–142dBm	–141dBm

NOISE FLOOR AND SENSITIVITY (50 MHz)	
Noise floor, SSB, 50.125 MHz, Preamp OFF	–124dBm
Noise floor, SSB, 50.125 MHz, Preamp 1 ON	–133.5dBm
Noise floor, SSB, 50.125 MHz, Preamp 2 ON	–135.5dBm
Sensitivity, SSB, 50.125 MHz, Preamp OFF	1.33µV
Sensitivity, SSB, 50.125 MHz, Preamp 1 ON	0.46µV
Sensitivity, SSB, 50.125 MHz, Preamp 2 ON	0.37µV
Noise floor, 500 Hz [CW] bandwidth, 50.125 MHz, Preamp OFF	–130dBm
Noise floor, 500 Hz [CW] bandwidth, 50.125 MHz, Preamp 1 ON	–139dBm
Noise floor, 500 Hz [CW] bandwidth, 50.125 MHz, Preamp 2 ON	–140.5dBm
Signal for S9, no preamp	–73 dBm (50µV)
Signal for S9, Preamp 1 ON	–80 dBm (23µV)
Signal for S9, Preamp 2 ON	–80 dBm (23µV)

GAINS OF IC-7610 PREAMPLIFIERS	
Preamp 1	12dB
Preamp 2	16dB
NOTE: Gains are estimates. Receiver gain is adjusted along with preamp settings. See additional information under Table Notes below.	

AUTOMATIC GAIN CONTROL OPERATION/SENSITIVITY	
AGC threshold at 3 dB, Preamp OFF	2.7µV
AGC threshold at 3 dB, Preamp 1 ON	1.20µV
AGC threshold at 3 dB, Preamp 2 ON	1.16µV

NC0B TABLE NOTES

When the preamplifiers are enabled, the receiver noise at the speaker goes down 1dB for Preamp 1 and 2.5dB for Preamp 2. This keeps the volume of a signal near the noise floor of the receiver relatively constant, regardless of preamp selection.

Enabling IP+ on the IC-7610 with no preamplifier turned on results in noise at the speaker increasing by 3.5dB. This increased noise from IP+ (which is dither) has less effect with each increment [of gain] of the preamp.

Dither (IP+) reduces low-level ADC distortion products, which on the lower HF bands are likely covered up by band noise. On the higher HF bands the likelihood of needing IP+ to reduce low level distortion may be minimal. Note that IP+ does not affect the level at which the OVF (Overflow) indicator comes on.

Occasionally while making [noise floor] measurements, some spurious noise, as from a switching power supply, would drift through the passband. The spurious noise was relatively weak, and I [NC0B] simply moved the signal generator to a different frequency 10kHz away.

When something appears in parentheses (i.e. [ ]) in the table, this has been added by VK6VZ.

common FPGA running the other functions (including DSP-type functionality). I noticed 16 symmetrical data lines from each of the two ADC's to the RF FPGA. This leads me to surmise that the ADCs are LTC2208-16s".

[3] See the ANAN pages on the Apache Labs website at:
https://apache-labs.com/1001/Ham-Radio-Products.html

[4] See the 6000 series web pages on the Flex-Radio website at:
www.flexradio.com/amateur-products/flex-6000-signature-series

[5] See the HPSDR pages at:
https://openhpsdr.org

I used a computer-controlled HPSDR transceiver for a number of years.

[6] See Steve Ellington's You Tube video 'IC-7300 External Monitor N1MM software' at:
www.youtube.com/watch?v=BvmbGY4uQWs&t=183s

[7] Visit Steve N4LQ's You Tube channel 'Steve Ellington' at:
www.youtube.com/channel/UC8yv24rjknvixn1KIAcwzoQ
and click on uploads. He has uploaded at least half a dozen videos on optimising the IC-7300 settings for ease of use and maximum performance – I'd recommend watching them all.

[8] See Adam Farson VA7OJ/AB4OJ's excellent and newly published IC-7610 User Evaluation and Test Report at:
www.ab4oj.com/icom/ic7610/7610notes.pdf

[9] Rob NC0B's famous 'Receiver Test Data' table is at:
www.sherweng.com/table.html

[10], [14] You can view the full laboratory report (currently at Rev. H) on the IC-7610 at:
www.dj0ip.de/sherwood-forest/sherwood-xcvr-tests/icom-ic-7610

[12] See *IC-7300 with No-fill Spectrum* at:
www.youtube.com/watch?v=wY3T91AHQko