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SDR transceivers

FlexRadio FLEX-6700 and Apache Labs ANAN-100D

The FlexRadio FLEX-6700 and Apache Labs ANAN-100D represent the state of the art of amateur radio software defined transceiver technology that you can buy today.

INTRODUCTION. When software defined radios were first proposed, many years ago now, the ultimate goal of attaching an antenna to an analogue to digital converter chip and performing all processing in software seemed just a pipe dream, a gleam in the eye and way beyond the capabilities of technology at that time. The first practical SDR transceivers for the amateur bands appeared about 10 years ago based on down-conversion to a PC sound card and processing by software in a somewhat restricted bandwidth. It wasn't until more recently, with the relentless march of technology, that analogue to digital converters of sufficient resolution and speed have appeared to realise that ultimate goal. Not only that, but with the latest devices performance levels are achieved even surpassing what is possible with the best analogue designs. Two of these latest high performing direct digital designs are the subject of this review.

FlexRadio was the first manufacturer to bring SDR to the amateur market. After several generations of down-conversion based radios, their latest models, the FLEX-6000 series, are a range of state-of-the-art direct digital designs. The FLEX-6700 is their current top of the range model with dual independent receivers, 100W transmit output covering HF and 6m, extended receive coverage together with low level transmit output for the 4m and 2m bands, and Ethernet connectivity for local or remote operation.

The HPSDR (High Performance Software Defined Radio) project started in 2006 as an open sourced activity by a multinational group of SDR enthusiasts exploiting the use of the latest technology in a state-of-the-art modular SDR design. The project has been covered in a number of articles in *RadCom* over the years. As part of this project the Hermes module was developed, a single board combining the key elements of the SDR. Together with front end filtering (Alex module) and a power amplifier this unit has been brought to the market as a fully specified SDR transceiver by Apache Labs based in India, the ANAN-10 and ANAN-100. Further development of the Hermes board resulted in the Angelia board allowing dual independent receivers and marketed by Apache Labs as the ANAN-100D. This unit covers HF to 6m with 100W transmit output and with Ethernet connectivity for local or remote operation.

The features and functions provided by an SDR are determined in part by the hardware but also by the firmware and controlling software; this also provides the user interface. FlexRadio have developed *SmartSDR* as the Windows software package for the FLEX-6000 series and this was used in the review. A number of controlling packages are usable with the ANAN-100D. *PowerSDR* was created by FlexRadio to control their earlier SDR units several years ago and this has matured and expanded greatly in terms of features under open source code development. The *PowerSDRmrx* version has been developed specifically for the HPSDR and Apache radios and was the package used in this review.

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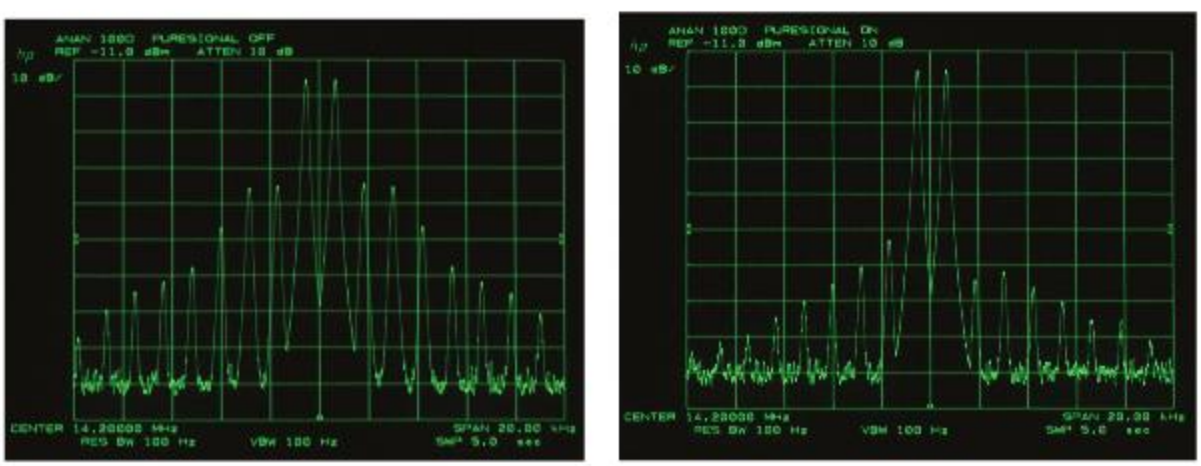
ANAN-100D rear panel.

RADIO DESIGN AND ARCHITECTURE. The basic design of a direct digital SDR is now well established and adopts a number of standardised elements. The analogue to digital converter (ADC) is key to achieving performance, with 16-bit resolution necessary for highest performance. The 16-bit Analog Devices AD9467 used in the FLEX-6700 is clocked at a whopping 245.76 million samples per second (Msps, equivalent to sampling rate in MHz), allowing full operation well into the VHF region. The 16-bit Linear Technology LTC2208 is used in the ANAN-100D clocked at 122.88Msps, allowing operation up to 6m. Front end filtering protects against strong out of band signals but can be switched out for wideband operation. The FLEX-6700 uses 10 fairly sharp bandpass filters (BPF) centred on each amateur band (except 60m) and switches automatically to wideband operation outside of the amateur bands. The ANA-100D uses somewhat wider filtering based on automatic or user selectable high-pass filters (HPF) and low-pass filters (LPF) to cover the whole receiver range. There are 5 HPF, 7 LPF and a 6m BPF. The low-pass filters are also used on transmit to filter the PA output. Separate ADCs are used to provide the dual independent receivers in both radios and a second identical set of receiver filters is used in the FLEX-6700. FlexRadio call these receiver front ends spectral capture units (SCUs). The ANAN-100D does not use front end filtering on its second receiver input. Both radios use relay switching and large size inductors in all filters to ensure the best signal handling. The front ends of both radios also include a selection of preamplifiers and attenuators to cater for differing signal level situations.

Both radios use 1000BASE-T / Gigabit Ethernet for the interface to the PC. This has the advantage of being fast, is plug and play needing no drivers or additional software and is directly compatible with routers, networks and remote operation.

The amount of data output from the ADCs is far greater than can be passed to and processed by a controlling PC. With the FLEX-6700 this rate is over 7.8Gbps. High speed on-board processing takes these parallel data streams, 32 lines wide with two ADCs, and produces narrower slices of spectrum that can be passed to the PC in a process termed decimation. The decimation process is performed by field programmable gate array (FPGA) chips, which are large fully programmable devices containing logic blocks, memory, processors and other functions. The FPGA devices in both radios are particularly large with plenty of spare capacity to allow the inclusion of new functions within the radio in future firmware upgrades. Moving functions from the PC to the radio environment can reduce latency or time delays, reducing the Ethernet load and relaxing the demands on the PC. This allows fast QSK on CW which is implemented this way in the FLEX-6700 and also in the ANAN-100D from firmware version 3.1 together with later *PowerSDRmrx* application software.

The FLEX-6700 also uses additional on board processors and digital signal processing (DSP) to support the FPGA and both radios use additional coding/decoding (CODEC) devices coupled to the FPGA to provide analogue audio functions for both receive and transmit. The transmit RF waveform in both radios is generated directly by high speed digital to analogue converter (DAC) devices and then amplified to the 100W power level. There is no ATU in the ANAN-100D but the FLEX-6700 includes an auto ATU, matching up to 3:1 VSWR (2:1 on 6m) although some of the marketing literature quotes higher levels. Both radios require a nominal 13.8V external power supply capable of 25A.



ANAN-100D two-tone Tx spectrum plots. Left: PureSignal off. Right: PureSignal on. The feature makes a visibly significant improvement to the transmitter distortion products when it is switched on.

FLEX-6700 rear panel.

FLEX-6700 HARDWARE. The FLEX-6700 is the larger of the two radios, measuring 330mm(w) x 102mm(h) x 305mm(d) and weighing 5.9kg. The front panel provides connectors for microphone, headphones and CW key jack, the on/off button, a small blue display and associated LED indicator showing status and for troubleshooting. A 4-way navigation keypad is provided for future expansion. Most microphone types can be accommodated, dynamic or electret, and the 8-pin connector is compatible with Yaesu pinning. A balanced input for microphone level or line level is available on the rear panel and uses an XLR/TRS (tip-ring-sleeve) connector.

There are two SO239 antenna connectors on the rear panel and each SCU receiver input has an associated pair of BNC connectors to allow separate receive antennas or inserting extra filters and amplifiers into the receive path. Comprehensive antenna allocation is possible under the control of *SmartSDR*. A transverter socket provides a low level transmit signal at nominally 1mw (0dBm) output and this socket can also be used as yet another receiver antenna input. Three separate relay outputs are provided for switching external equipment such as linear amplifiers and a fourth is available via the accessory connector, all separately configurable with respect to delays etc. Other sockets provide output to external powered stereo speakers, PTT-in, ALC-in, remote power-on provision, transmit inhibit, Ethernet connection and two USB ports. Speaker and headphone outputs can be used simultaneously. A 15-pin accessory connector (of the type used for VGA monitors) provides audio line in and dual audio line out, keying for CW and FSK, duplicates for PTT and transmit inhibit, and serial I^{2}C bus control clock and data for external equipment so equipped.

Both receivers (SCUs) cover the frequency range 30kHz to 72MHz and 135MHz to 165MHz. The transverter output is similar and also provides a source for the LF bands. The transmitter provides 100W output on the HF and 6m bands with no mode limitations. Each receiver is able to open four slice receivers and panadaptors, with a maximum frequency span of 14MHz. A total of eight can be operational at any time. The built-in oven controlled reference oscillator is accurate to within 0.02ppm and can be synchronised against an external 10MHz reference. Even greater accuracy is possible by installing the optional GPS-based GPSDO module.

Removing the top and bottom covers reveals two large circuit boards. The extent and large amount of space allocated to the signal frequency filtering for the receivers, transmitter and ATU is immediately evident. The digital circuitry is fully shielded and cooled by two small on-board fans. Two further fans take air in through the sides of the case and out of the rear, primarily to cool the internal heatsink for the power amplifier. Overall, the fans are very quiet in operation.

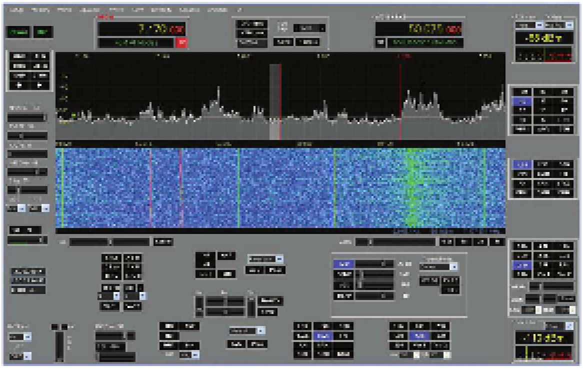
ANAN-100D HARDWARE. The ANAN-100D is contained in a very sturdy fluted extruded aluminium case that also acts as the heatsink for the transmitter. It measures 265mm(w) x 88mm(h) x 230mm(d) and weighs about 4.5kg. Inside, the circuitry is contained on two main PC boards, one for the Angelia SDR functions and the somewhat larger board containing the PA and all the RF filters. An internal fan keeps the unit cool. Limited access to the boards, for example to change microphone jumper settings, is fairly straightforward by removing the front panel but full access is a much bigger job.

The front panel provides 3.5mm jack sockets for CW key, microphone, headphones or powered speakers, together with the on/off button, Ethernet connection and two small status LEDs. There are two carrying handles that don't really help and tend to get in the way. Dynamic or electret microphones can be accommodated, selected by internal jumpers. A further jumper enables the PTT function. Apache Labs do not supply a microphone.

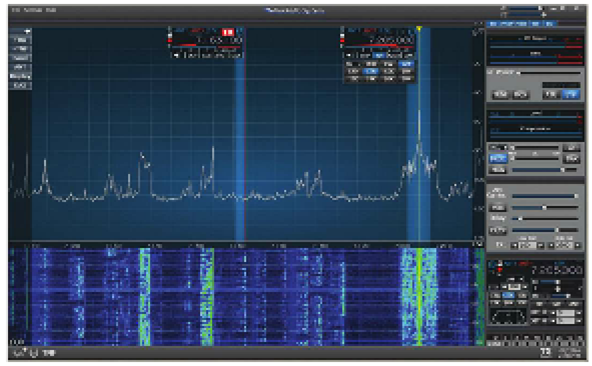
Moving around to the rear panel, an array of eight BNC sockets provides various antenna connection possibilities. There are three user-assignable antenna sockets for transmit or transceive operation and for receiver 1 there are two receive-only inputs that can also be looped through filters or amplifiers and routed to the transmit antenna. There are separate transverter connections for the receive and transmit drive paths. Receiver 2 has a separate antenna input, independent of the routing matrix. An external speaker jack on the rear panel (1W into 8Ω) must only be used with balanced, isolated speaker lines otherwise damage is likely. Apart from a phono PTT output switching line, all other interfaces are provided via a 25 pin D-connector. This includes PTT input and output, left and right outputs for headphones, speakers and line level, general purpose inputs such as for data mode audio in analogue and digital formats and seven user assignable open-collector digital output lines. These lines can be used for communicating band data to external units or switching of external transverters. Different data can even be set for receive and transmit.

Both receivers cover the frequency range 10kHz to 55MHz, each supporting up to seven slice receivers available at any one time with appropriate software. The transmitter provides 100W output on the HF and 6m bands using SSB and CW modes but should be reduced down to 30W for extended operation on FM and data modes. A low level transmit output of nominally 1mW (0dBm) is available in transverter mode across the full frequency range of the receivers. The reference oscillator uses a TCXO accurate to within 0.1ppm and can be synchronised against an external 10MHz reference.

SOFTWARE PACKAGES. The various features and functions are determined primarily by the controlling application software working in partnership with the firmware installed in the radio. Although several software programs are available, particularly for the ANAN-100D, I limited this review to *SmartSDR* for the FLEX-6700 and *PowerSDRmrx* for the ANAN-100D. Both are freely available to download and updates are frequent. Installing or updating is straightforward and relatively trouble free but *PowerSDRmrx* will perform an optimisation routine the first time it is run and this can take 10 minutes or more. If the



PowerSDRmrx screen - dual receivers active.



SmartSDR screen - panadapter + waterfall with 2 slice receivers. Horizontal lines on waterfall are local electric fence ticks.

radio firmware needs updating, the process is largely automatic with the FLEX-6700 as the software is included with *SmartSDR*. With the ANAN-100D the process for firmware updating is more complex. The *HPSDR Programmer* software needs to be installed first and, if upgrading from older versions of firmware, internal jumper links may need to be temporarily moved and alternative bootloader software used. Don't expect the radios to perform satisfactorily with older PCs. Both radios specify a minimum performance of a dual core 2GHz processor with 4GB RAM but a faster PC will reduce time delays (latency) and provide a faster response to control changes. A high-resolution monitor is also desirable. Windows 7 is the recommended operating system but both packages will operate from Windows XP SP3 or later.

Although both the *PowerSDRmrx* and *SmartSDR* software packages largely perform the same basic set of functions, the presentation style and user display interface is significantly different.

PowerSDRmrx adopts a conventional dashboard console style layout with separate buttons and sliders for each control, duplicated when both receivers are active. The central area of the screen shows the panadapter spectrum display, waterfall or various scope functions with both RF spectrum and waterfall being displayed for a single receiver active or one function only if both receivers are enabled. *PowerSDRmrx* allows only a single slice per receiver and a maximum span of around 380kHz at the highest sampling rate. Other software packages such as *cuSDR*, which is currently receive-only, can offer more slices and wider spans but software is still evolving. There are a huge number of setup adjustments; tailoring of functions is very comprehensive and there are many extra features. One very interesting recent addition is PureSignal that uses adaptive predistortion to reduce very considerably transmitter distortion products on SSB. Up to 14 separate transverters can be supported with fully configurable independent drive settings and offsets to give display readouts up to 99GHz. Other features include diversity reception support on the dual phase coherent receivers with dual antennas and even support for radio astronomy data collection.

SmartSDR uses the maximum area of the screen for panadapter spectrum and/or waterfall displays with up to eight open at any one time. Up to eight slice receivers may also be opened, with their position indicated by lines on the relevant spectrum. Flags attached to these lines show key parameters for each slice such as frequency and drop-down menu selection for DSP settings, mode, filters, antenna sockets etc. Buttons and sliders for transmit functions are grouped down the right hand side of the screen, together with more detailed access to settings for one selected receiver. The maximum span for panadapter displays is 14MHz. Transverter operation does not provide display offsets.

Both software packages provide all the functions you would expect on a top-flight radio. All the usual operating modes are provided including SSB-based datamodes and synchronous AM, but FM is still to be implemented in a future software release of *SmartSDR* for the FLEX-6000 series. Channel filtering is very comprehensive, widely adjustable with notches, noise reduction modes and much more. *SmartSDR* has a very effective tracking notch filter. Both include extensive audio filtering selection including multi-band audio equalisers on both receive and transmit. For CW, both include iambic keyers and *PowerSDRmrx* includes comprehensive message storage and keyboard sending. Fast QSK is possible with both but needs a fast PC. *PowerSDRmrx* provides largely unlimited memory storage of name-tagged frequencies with many other associated parameters. Comprehensive storage of audio files from the receiver audio or from the microphone is also provided for playback on receive or transmit. The current version of *SmartSDR* does not include these functions.

On datamodes, receive and transmit analogue audio may be passed to and from the PC soundcard in the conventional fashion. Alternatively both software programs allow direct passing of digital audio without the need for physical cables. With *PowerSDRmrx*, two virtual audio cables may be set up with various selectable parameters. With *SmartSDR*, DAX (Digital Audio eXchange) allows eight separate audio channels. In addition, DAX provides up to four channels of wideband I and Q baseband data prior to demodulation for passing to additional client programs such as *CW Skimmer*. Neither radio has a hardware CAT interface. However, both programs provide for the setting up of a virtual COM port that is used to pass data to and from logging programs or other applications.

MEASUREMENTS. The full set of measurements is given in the tables. The sensitivity with preamplifiers in circuit is very good for both radios and reduces by about 10dB at LF. The figures shown for the FLEX-6700 are for wideband operation. With the front end filters in circuit, sensitivity drops by about 2-4dB, depending on band. At VHF the FLEX-6700 is less sensitive and would benefit from an external preamplifier for weak signal working. The S-meter calibration shows about 45µV for S9 with the ANAN-100D and about 70µV for S9 (wideband) with the FLEX-6700 and is independent of the front end gain and attenuator settings. Both radios show 6dB per S-unit and calibration holds well across the frequency range for the S-meter. Spurious responses and birdies are better than 100dB down with one or two minor exceptions.

The panadapters of both radios clearly show signals that are nearly inaudible. A signal that gives an audible 10dB signal to noise ratio in the receiver shows up to 30dB above the noise floor on the panadapters at narrow spans. The amplitude calibration linearity across the extensive display range

FLEX-6700 Measured Performance

Sensitivity on SSB 2.4kHz bandwidth for 10dBs+n:n with wideband front end

FREQUENCY	FRONT-END GAIN 0dB	10dB	20dB	30dB
100kHz	2.8µV (-98dBm)	2.0µV (-101dBm)	0.9µV (-108dBm)	-
1.8MHz	1.4µV (-104dBm)	0.5µV (-113dBm)	0.16µV (-123dBm)	0.14µV (-124dBm)
3.5 - 28MHz	1.4µV (-104dBm)	0.56µV (-112dBm)	0.2µV (-121dBm)	0.11µV (-126dBm)
50MHz	1.8µV (-102dBm)	0.8µV (-109dBm)	0.22µV (-120dBm)	0.14µV (-124dBm)
70MHz	2.2µV (-100dBm)	1.0µV (-107dBm)	0.28µV (-118dBm)	0.16µV (-123dBm)
144MHz	4.0µV (-95dBm)	1.4µV (-104dBm)	0.45µV (-114dBm)	0.25µV (-119dBm)

FREQUENCY	NOISE FIGURE
50MHz	9dB
70MHz	10dB
144MHz	13dB

AGC attack time: approx 5ms

AGC decay time: 600ms (fast) 1s (medium) 2s (slow)

Inband intermodulation products: -45dB to -65dB see text

FILTER	BANDWIDTH -6dB	-60dB	-80dB
USB 2400Hz	2400Hz	2472Hz	2485Hz
CW 500Hz	500Hz	645Hz	665Hz
CW 100Hz	100Hz	173Hz	183Hz
CW 50Hz	50Hz	123Hz	132Hz

FREQUENCY OFFSET	RECIPROCAL MIXING DYNAMIC RANGE 500Hz BW CW 7MHz	TRANSMIT NOISE 7MHz 50W O/P
1kHz	113dB (-140dBC/Hz)	-125dBC/Hz
2kHz	117dB (-144dBC/Hz)	-132dBC/Hz
3kHz	118dB (-145dBC/Hz)	-137dBC/Hz
5kHz	118dB (-145dBC/Hz)	-139dBC/Hz
10kHz	119dB (-146dBC/Hz)	-142dBC/Hz
15kHz	122dB (-149dBC/Hz)	-143dBC/Hz
20kHz	125dB (-152dBC/Hz)	-144dBC/Hz
30kHz	see text	-145dBC/Hz
50kHz	see text	-145dBC/Hz
100kHz	see text	-145dBC/Hz

Transmitter Measurements at 100W Output

FREQUENCY	CW POWER OUTPUT	HARMONICS	INTERMODULATION PRODUCTS 3rd order	5th order
1.8MHz	98W	-60dB	-34dB	-50dB
3.5MHz	98W	-65dB	-40dB	-42dB
7MHz	97W	-62dB	-45dB	-40dB
10MHz	94W	-70dB	-45dB	-40dB
14MHz	100W	-70dB	-38dB	-38dB
18MHz	95W	-65dB	-42dB	-40dB
21MHz	98W	-75dB	-40dB	-40dB
24MHz	98W	-55dB	-34dB	-40dB
28MHz	100W	-60dB	-36dB	-43dB
50MHz	91W	-70dB	-38dB	-37dB

Intermodulation product levels are quoted with respect to PEP.

Microphone input sensitivity: <1mV for full output

for both radios is also excellent and within 5dB worst case.

Both radios exhibit a similar AGC characteristic with an exponential decay but have an attack that inserts a hole in the signal path or the audio. This is a familiar characteristic of some DSP based radios and can degrade weak signal performance under noisy conditions.

SDR receivers using direct digital conversion respond to strong signals in a totally different way from conventional analogue designs. They remain linear up until the point that ADC overload or clipping occurs, at which point the receiver performance totally collapses. This point occurs at about +9dBm input for the ANAN-100D or +6dBm for the FLEX-6700 with no front end amplifiers or attenuators in circuit. No blocking occurs up to this point. With multiple strong signals intermodulation can occur at a low level, even for signals less than S9, but then intermodulation levels do not worsen until close to the ADC overload point. This is due (I think) to the quantisation steps introduced by the ADC and the greatest dynamic range is achieved if the full range of the ADC is used for processing signals. This low level intermodulation can cause problems on quiet bands such as 6m and in this situation it might be desirable to increase front end gain so that band noise significantly masks the receiver noise floor. This is completely opposite to the normal advice given for optimising strong signal performance with conventional analogue receivers! With the ANAN-100D, intermodulation products appear about 10dB above the noise floor with input signals around -65dBm but remain around this level as input signals increase to within about 2dB of ADC overload. At this level it corresponds to an intermodulation limited dynamic range of 105 to 110dB and is independent of spacing down to very close spacings. Referencing to the -65dBm level is a rather pessimistic approach yielding around 65dB dynamic range. The FLEX-6700 did not exhibit appreciable low level intermodulation until within about 5dB of ADC overload. This corresponds to a dynamic range of around 105dB. For both radios, inband intermodulation measured with two tones 200Hz apart was significantly better with high level input signals than with low level.

Both radios use low noise reference oscillators and as a consequence the reciprocal mixing figures due to phase noise are excellent. I have only ever measured one radio with a better performance, the Elecraft KX3. At spacings greater than 20kHz the limit is ADC overload. Transmit noise is also very low, a welcome departure from some recent introductions. Measurements of channel filter selectivity showed superb narrow skirts even at the narrowest settings.

Both radios use a similar transmitter power amplifier structure with the popular RD100HHF1 MOSFETs and two-tone distortion products are generally very good. With PureSignal adaptive pre-distortion enabled on the ANAN-100D, distortion products are reduced by some 15 to 20dB, making it by far the cleanest amateur transmitter available. PureSignal is quite easy to set up but the levels need to be adjusted.

On CW transmit, the characters were nicely shaped with around 3ms rise and fall times for both radios. Fast QSK requires a fast PC and my 2GHz dual core unit did not do this justice but semi break-in functioned satisfactorily. Latency in the receiver path is the key factor here. Maximum transverter output was +13dBm for the ANAN-100D and +15dBm for the FLEX-6700 with very clean spectrum and reducible down to quite low levels.

ON-THE-AIR PERFORMANCE. Both radios are in general easy to use and operate but, as is the nature of SDR, they are not quite the instant use, straight out of the box units characterised by standalone analogue radios. They both require installation of software and a degree of setting up before they are ready to use, which in itself is quite straightforward. Both radios are provided with software and manuals on CDROM but this is a fast moving world and they become rapidly out of date. However, the latest versions are readily available from the FlexRadio and Apache websites. Hardware is reasonably well covered by manuals and the *SmartSDR User Guide* is regularly updated but there is no manual yet covering the use of *PowerSDRmrx*. Searching on the web reveals bits of information but no comprehensive user guide. Fortunately the software is well structured and although there are a huge number of setups and features they are fairly intuitive and time spent playing around will reveal its many delights.

The panadapter display is central to the use of the radio and tuning the receiver can be accomplished in a number of ways. Dragging the receiver display line, dragging the background, clicking on a displayed signal and mouse wheel tuning are all fundamental to the use of both radios. With *PowerSDRmrx*, hovering the cursor over any of the frequency digits allows mouse wheel scrolling in this particular step size and provides a convenient method of fast tuning, but is not implemented on *SmartSDR*. Direct keyboard entering of frequency is also allowed and if you prefer analogue-style round knob tuning, FlexRadio have a useful USB accessory – FlexControl – that operates with *SmartSDR* and *PowerSDR*. This contains a smooth operating round knob with finger indent and three assignable push buttons. The WoodBox Radio Tmate-2 [1] also provides a similar function but software for *SmartSDR* is still in progress.

The panadapter and waterfall displays are most impressive, particularly so in the FLEX-6700. They are excellent for monitoring weak beacons on 6m and it is surprising what can be 'seen' even under fairly flat conditions. Both receivers sound very clean across the whole tuning range and filters, notches and noise reduction are very effective. The transmit audio quality was also reported as excellent and highly adjustable.

ANAN-100D Measured Performance

Sensitivity on SSB 2.4kHz bandwidth for 10dBs+n:n

FREQUENCY	FRONT END GAIN: 20dB preamp on	FRONT END GAIN: 20dB preamp off
100kHz	0.63µV (-111dBm)	3.2µV (-97dBm)
1.8 – 28MHz	0.2µV (-121dBm)	2µV (-101dBm)
50MHz	0.11µV (-126dBm)	0.4µV (-115dBm)

AGC attack time: approx 7ms

AGC decay time: 300ms (fast) 1.5s (medium) 1.7s (slow) 2.5s (long)

Inband intermodulation products: -50dB to -70dB see text

FILTER	BANDWIDTH (16384 buffer) -6dB	-60dB	-70dB
USB 2400Hz	2400Hz	2503Hz	2564Hz
CW 500Hz	500Hz	602Hz	623Hz

FREQUENCY OFFSET	RECIPROCAL MIXING DYNAMIC RANGE 500Hz BW CW 7MHz	TRANSMIT NOISE 7MHz 50W O/P
1kHz	114dB (-141dBC/Hz)	-133dBC/Hz
2kHz	115dB (-142dBC/Hz)	-137dBC/Hz
3kHz	116dB (-143dBC/Hz)	-137dBC/Hz
5kHz	118dB (-145dBC/Hz)	-138dBC/Hz
10kHz	121dB (-148dBC/Hz)	-138dBC/Hz
15kHz	124dB (-151dBC/Hz)	-139dBC/Hz
20kHz	126dB (-154dBC/Hz)	-140dBC/Hz
30kHz	see text	-141dBC/Hz
50kHz	see text	-141dBC/Hz
100kHz	see text	-142dBC/Hz

TRANSMITTER MEASUREMENTS AT 100W OUTPUT

		INTERMODULATION PRODUCTS			
		PURESIGNAL OFF		PURESIGNAL ON	
FREQUENCY	HARMONICS	3rd order	5th order	3rd order	5th order
1.8MHz	-60dB	-37dB	-40dB	-56dB	-60dB
3.5MHz	-60dB	-39dB	-36dB	-56dB	-62dB
7MHz	-54dB	-35dB	-45dB	-60dB	-64dB
10MHz	-53dB	-40dB	-36dB		
14MHz	-50dB	-39dB	-37dB	-54dB	-65dB
18MHz	-54dB	-40dB	-36dB	-55dB	-66dB
21MHz	-54dB	-38dB	-36dB	-56dB	-60dB
24MHz	-51dB	-38dB	-36dB	-56dB	-62dB
28MHz	-52dB	-30dB	-35dB	-55dB	-66dB
50MHz	-60dB	-41dB	-37dB	-55dB	-64dB

Intermodulation product levels are quoted with respect to PEP.

Microphone input sensitivity: <1mV for full output

CONCLUSIONS. The FLEX-6700 and ANAN-100D are both excellent fully-featured and high performing SDR transceivers at the top end of a growing range of models from FlexRadio and Apache Labs. Supported by software packages that are continuing to evolve adding more and more functions, both bring a new dimension to operation on the amateur bands. The ANAN-100D is priced at £2999 (RRP) with the FLEX-6700 at £5799 (RRP) but the latter also includes coverage of the 4m and 2m bands, has extra front end filtering and a built-in ATU.

ACKNOWLEDGEMENTS. I would like to express my gratitude to Waters and Stanton for the loan of these radios.

REFERENCE

[1] Reviewed in *RadCom* April 2014, p33