Equipment Review

Yaesu FTDX101D

HF, 50 and 70MHz transceiver

The Yaesu FTDX101D is a base station HF, 50MHz and 70MHz transceiver.

The new FTDX101D is a top-flight DX and contest radio primarily for base station use.

The back panel of the new FTDX101D.

Fifty years ago, the amateur radio HF world was changing. Transceivers were taking over from separate receivers and transmitters, with transistors taking over from valves. Established US manufacturers such as Collins and Heathkit were the norm but newly fledged innovators from Japan were taking an increasing share of the market. In 1970, the Yaesu Musen Company launched the FT-101. Over the years, this was to become probably the most popular and well-known transceiver family of all time. Updated versions were introduced to add features and improve performance, adding WARC band coverage when those bands became available in 1979. Production finally ceased in 1985.

In 1970, fresh out of university and in gainful employment, I now had the money to buy a new radio. I had been using an AR88D receiver and a homebrew G2DAF transmitter on the HF bands but really fancied one of the new transceiver models. I settled on the FT-101, the original version, and it served me well for the next 10 years. So, when Yaesu announced that they were reusing the '101' model number for their latest flagship radio in commemoration of their earlier success and founder of the company, I was keen to review their latest offering.

The FTDX101 is aimed as a top-flight DX and contest radio primarily for base station use on the HF, 50 and 70MHz bands. Incorporating twin independent and identical receivers and a comprehensive real-time scope display, it is available in two versions. The FTDX101D delivers 100W output (50W on 70MHz) and requires the usual nominal 13.8V power supply. The FTDX101MP is a version that delivers 200W transmit power and includes a matching speaker with power supply. The two radios are identical in other respects although some optional filters in the 'D' version are fitted as standard in the 'MP'.

This review was conducted using the FTDX101D.

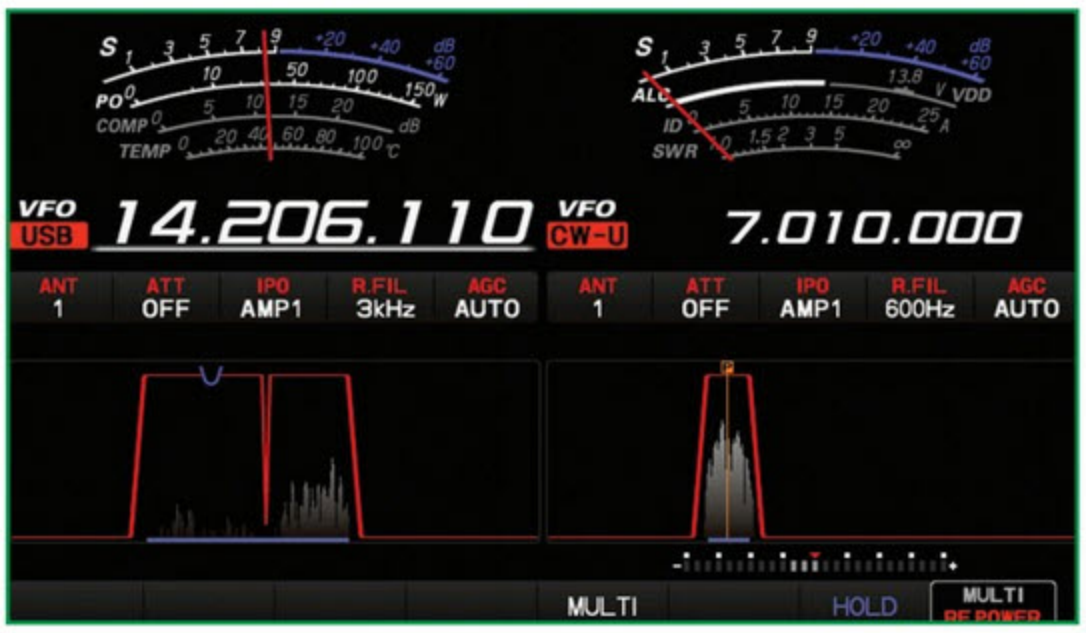
Basic functions

The FTDX101D measures 420mm(w) x 130mm(h) x 322mm(d) and weighs 12kg. This is smaller than the FTDX5000 that it largely replaces and about the same size as the previous FT-1000MP. The receivers (termed MAIN and SUB) both tune from 30kHz to 75MHz and are fully independent from the antenna input to audio output with identical circuitry and duplicate operating controls. The receivers can be synchronised together to provide diversity reception with separate antennas and stereo headphones. The transmitter is enabled on the amateur bands only with full transmit coverage of the 5MHz band (5.250-5.406MHz) as well as 70MHz (70.0-70.5MHz) in the UK. There is no provision for a low-level output to drive transverters or for LF band operation.

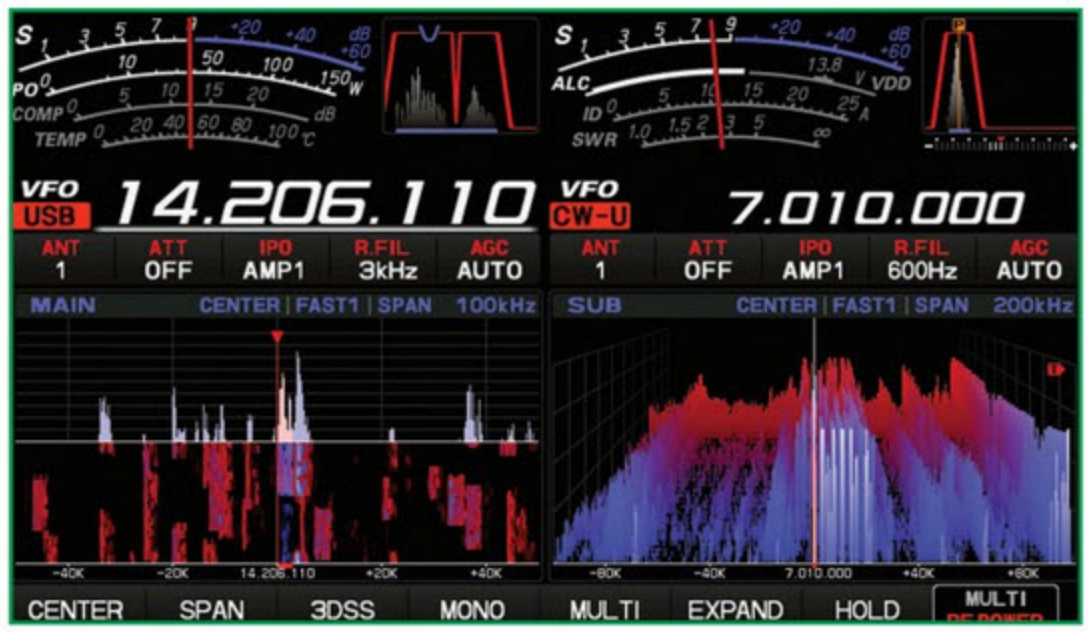
The usual modes are provided; SSB, CW, RTTY (FSK), PSK, AM and FM, with wide or narrow operation on AM and FM, reverse sidebands selectable on SSB, CW and RTTY and with AFSK data on SSB and FM.

The radio is provided with a power cable, accessory plugs and a hand microphone. Instead of the MH-31 microphone that has been supplied with all previous Yaesu radios for the last 20 years or more, the FTDX101 is provided with a new hand microphone, the SSM-75G. As well as up/down keys, this also has an audio mute button and 4 function keys to select between main and sub receive settings and switch the transmitter between main and sub frequencies.

The instruction manual, like most Yaesu manuals, is very comprehensive and well written. It runs to 118 pages. A set of circuit diagrams is also included, although the print size on some sheets is very small.



Display showing channel filters with contour and notch active.



Dual RX display with waterfall on main and 3D spectrum on sub.

Radio design and architecture

The FTDX101 uses what Yaesu terms is a hybrid SDR architecture. The receiver adopts a superhet approach, similar to the earlier FTDX5000 and FTDX3000 radios. After front-end filtering, the signal is mixed down to an IF at 9MHz and passes through a narrow roofing filter. This is then sampled by an 18-bit A/D converter and passes to the FPGA device. This extracts an IF signal at 24kHz by a process of decimation, which feeds the DSP. In the earlier radios, another mixer produces the second IF. The 32-bit DSP operates in a similar way to the FTDX5000, providing all channel filtering, demodulation, noise reduction, audio processing and AGC functions. The spectrum scope operates as a direct digital sampling SDR, taking its input after the front-end filtering immediately prior to the mixer. Processing of the spectrum scope is performed by the FPGA. Three similar DSPs are used, one in each receiver and one for processing the display screens.

The front end has 15 input bandpass filters covering the total frequency range of the receiver and a sharply tuned preselector, VC-Tune. This automatically tracks the tuning using a high-Q LC arrangement where the variable capacitor is driven by a high precision stepper motor. Manual fine-tuning is also provided. The VC-Tune system is an advancement over the VRF and μ-tuning systems used in the earlier FTDX9000 and FTDX5000 radios.

The front end has two switchable preamplifiers for 20dB or 10dB gain and three levels of input attenuation, 6/12/18dB. The mixer uses 8 dual-gate FETs in a D quad double balanced configuration for high dynamic range and an IF output prior to the roofing filter is made available for external use, all similar to the earlier radios. Three roofing filters are fitted as standard with bandwidths of 600Hz, 3kHz and 12kHz and these can be selected manually or automatically according to mode and channel bandwidth. Two further roofing filters can be optionally fitted to both receivers with bandwidths of 300Hz and 1.2kHz although the 300Hz filter is fitted as standard in the 'MP' version.

The SUB receiver is a duplicate of the MAIN with its own set of front end functions, roofing filters and FPGA. The only difference is that the SUB receiver has an IF frequency of 8.9MHz instead of 9.0MHz and the VC-Tune unit is an optional extra in the 'D' version.

The Tx signal is generated directly at final frequency from a 16-bit DAC and not through a mixer. It is then amplified through to the final PA, which uses a pair of RD100HHF1 MOSFETs.

The local oscillator in the FTDX101 uses the same structure as adopted in the FTDX5000. A high resolution direct digital synthesiser is used operating at 400MHz and this is divided down to give the required frequency for the mixers. The oscillator runs high of the signal frequency for bands below 30MHz and low for frequencies above. A 0.1ppm TCXO reference ensures high stability.

The radio is solidly constructed in typical Yaesu style using a substantial and well-shielded diecast frame and integral heatsink with a fan on the rear panel. This is very quiet and only operates when the temperature rises. A 92mm loudspeaker fits in the case top, slightly larger than usual but there is no internal shrouding. Extensible front feet tilt the front panel to improve visibility and operating ease and a wrap-around case completes the unit. There are no carrying handles fitted.

Front panel and controls

The front panel layout is a little different from normal and yields a clean layout with most functions accessible in a logical way. Individual buttons select the bands as a linear line across the top of the panel, with the selected band illuminated by a white LED for the MAIN and a blue LED for the SUB. In general, MAIN controls are lettered in white and SUB controls in blue. Band stacking of the three last used combinations of frequency, mode and other settings is returned for each press of the band key. 70MHz is included under the general coverage button and is best stored to memory as it can be overwritten if other general coverage frequencies are later selected. Three mode buttons are provided. CW and SSB modes occupy two of these, the third button accesses all other modes from a short-displayed menu. Subsequent presses of this button reselect the last used mode.

The radio is fitted with a 55mm diameter tuning drive, weighted and smooth in operation. With up to 1000 steps per revolution and 10Hz steps this provides precise tuning with fast frequency navigation. Fine-tuning in 1Hz steps is also selectable. Rapid tuning in a variety of mode dependant channel step sizes is performed by a small click-step rotary control MULTI and this is also used extensively to select memory channels and other settings and functions. Tuning in 1MHz or 1kHz steps is quickly achieved by touching the relevant digits on the display. The frequency may be entered directly from a pop-up numeric keypad.

Surrounding the main tuning knob is a secondary tuning ring (MPVD). This can be used to tune the other receiver to that selected by the main tuning knob or alternatively, the clarifier, VC-tune or a host of other functions. Most of the top-level operating functions are given dedicated controls for both receivers, either rotary controls or buttons, which makes for ease of use. Other functions are accessed via the function menu, quick to access but not quite so convenient. This includes power output, DNR level, NB level and step tuning, but any two functions can be allocated to the MULTI control and the tuning ring.

Perhaps the most striking feature of this radio is the display. The high resolution TFT colour touch-screen LCD measures 7 inches diagonally and is clear, sharp and bright with a good viewing angle. All areas of the screen are touch-sensitive for setting displayed functions, often showing pop-up menus for choice selection. Twin analogue style meters show dual S-meters on receive and a variety of transmit functions. Bargraph meters are not an option provided. The IF filter bandwidth is shown graphically, including notch and contour settings when active, and is

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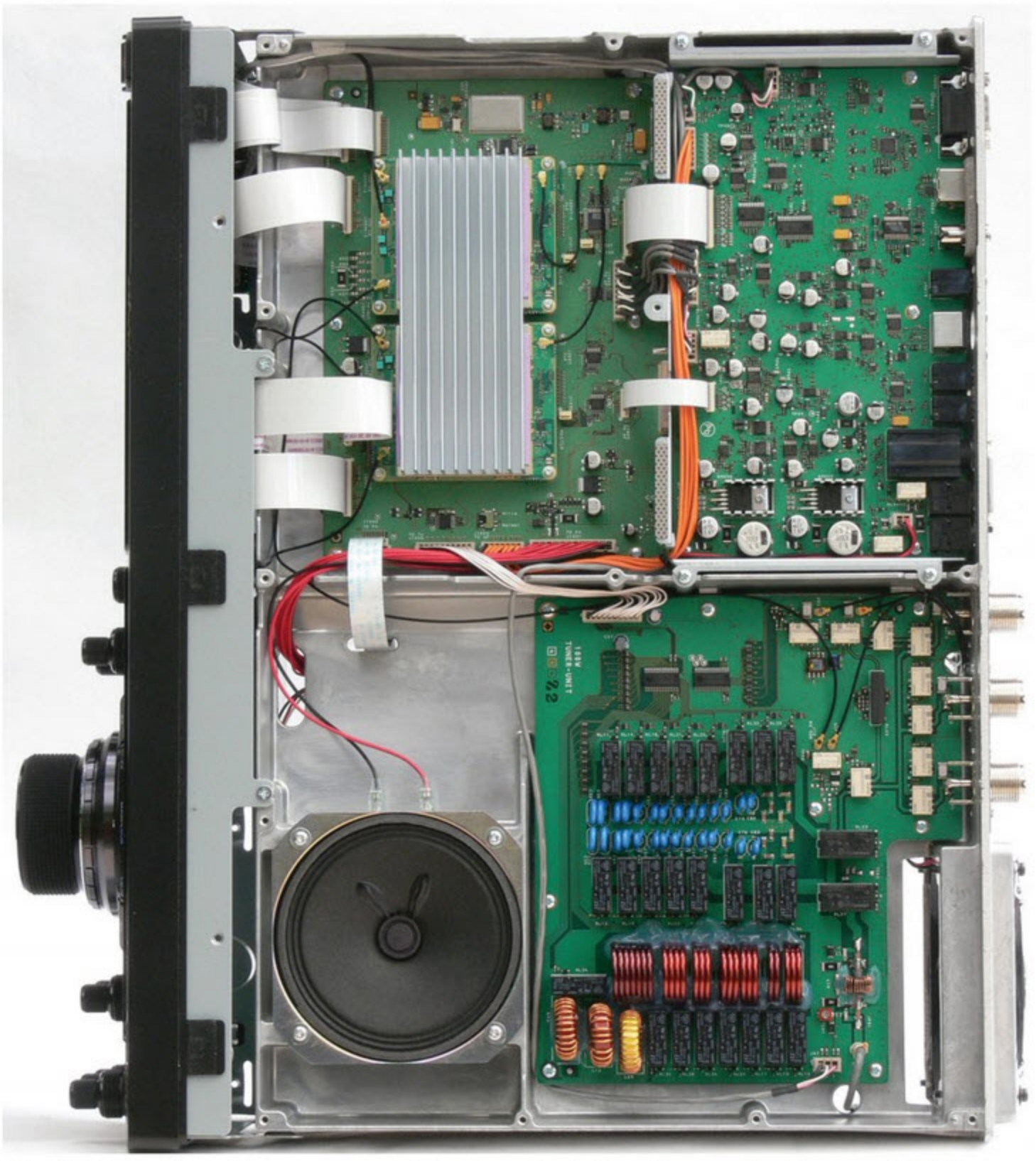


FTDX101D top view with covers removed showing auto ATU, main processing board and FPGA boards (under the heatsink).

overlaid with the passband spectrum. This can be for one receiver or for both.

The lower half of the display is devoted to the spectrum scope in its different formats. Eight touch buttons along the bottom of the display select the various options. This provides a spectrum scan and waterfall display centred on the receive frequency or between fixed limits, and an audio waveform scope and spectrum display for both the receiver and the transmitter audio. Both scans may be displayed together or singly in normal or expanded formats for either the MAIN or the SUB receiver or both. The waterfall may be conventional or in pseudo 3-dimensional format and various colours may be selected. There is a huge amount to play with here. The receiver can be tuned to any frequency on the spectrum display by touching the screen.

As with all recent radios the setup menu system is extremely comprehensive with over 200 items split into five categories of every conceivable parameter available for user selection and adjustment. The display makes access very easy, straightforward and unambiguous, probably the easiest of any radio around at this time.

Two USB-A connectors on the front panel allow the connection of a keyboard and mouse. The mouse provides an alternative to touching the screen and is more precise and accurate. The keyboard can be used for inputting text into the message stores, memory labelling, entering frequencies directly and other uses. An SD card slot is also fitted and is used to save various settings, saving memory contents and updating the firmware.

Rear panel

There are three antenna sockets on the rear panel, selectable by band, and one can be allocated as receive only. There are outputs for separate receivers and IF outputs prior to the roofing filters from both receivers. Twin key jacks, one on the rear panel and one on the front, are each configurable for different keying arrangements. A 6-pin mini-DIN connector provides audio and interfacing lines for the Data modes, an 8-pin mini-DIN for the FC-40 external ATU and a 15-pin connector for the VL-1000 linear. A 13-pin jack for specialised accessories is also provided, in particular for the external LAN unit to be available shortly for full remote control via the internet.

Phono jacks provide linear switching, ALC, PTT and a low power 13.8V output but there is no provision for using separate linear amplifiers on the HF and VHF bands. 3.5mm jacks provide separate speaker outlets for each receiver, low-level receiver audio output and connections to the FH-2 remote keypad and an external meter display. A USB-B connector provides the CAT computer interface for logging programs as well as audio lines for data modes. A 9-pin D RS-232 jack is also provided for computer interface. An external display can also be used linked via a DVI-D connector.

Receive features

The usual receive functions are all provided in a similar fashion to most other radios. There are 100 easily accessed and name-labelled memory channels, 10 quick access memories and the usual scan functions. Three mode-dependant AGC speeds are selectable, programmable over wide limits and AGC can also be switched off. RIT and XIT are both provided and an auto-tune feature that fine-tunes the receiver on clear signals to give the correct CW pitch.

The IF channel bandwidth is set by the width and shift controls independently for each mode over quite wide limits and down to 50Hz on CW and data modes. On AM and FM, the bandwidth is fixed. There is no control over the shape or the slope as seen on some radios but the Yaesu contour system is provided, which provides a rolling peak or cut over the passband and this can be effective in some difficult situations. An IF notch filter is provided with adjustable centre frequency. Operating inside the AGC loop, desensitisation with strong carriers is prevented. Implemented at audio is the auto-notch, a beat cancellation filter. This automatically locates and removes multiple tones but does not prevent strong carriers from desensitising the receiver. The numerical values of the bandwidth setting and notch frequency are only displayed for 0.5s (don't blink!) but are graphically displayed most effectively on the display together with their effect on the passband spectrum.

The audio bandwidth can be tailored separately for each mode and on CW an audio peak filter can be enabled. This has three selectable bandwidths and is tuneable across the pitch frequency. Also included are a digital noise reduction system and a noise blanker. Both are adjustable from the menu system.

Transmit features

The transmitter power output is variable on all modes down to about 5W with different levels on the HF, 50 and 70MHz bands. Metering with

dual meters indicates power output, SWR, ALC, compression level, temperature or PA voltage or current. The radio includes a built-in auto ATU covering bands 1.8 to 50MHz and will tune antennas with VSWR up to 3:1.

On voice modes, VOX, speech processor and a transmission monitor are provided. The processor operates in two modes. AMC (Automatic Microphone gain Control) akin to AGC and also known as VOGAD prevents audio overdrive and a conventional compressor raises the average modulation level. The audio bandwidth may be tailored by one of five bandpass filters in conjunction with a three-stage parametric equaliser with separate settings for the processor on or off. On FM, repeater operation on the 29MHz and 50MHz bands is provided with appropriate shifts and CTCSS tone decoders and encoders.

On CW, the usual break-in modes are provided and a full contest message keyer with all the usual options and settings. Five message stores containing up to 50 characters each can be programmed either from the keying paddle or from text entry using an external keyboard or internal pop-up keypad. Messages can be played back from the front panel or more conveniently using the FH-2 remote keypad accessory.

The radio includes a voice store for use in SSB contests. There are 5 message stores, each capable of storing up to 20 seconds of audio and playback is similar to the CW stores, either from the front panel or using the FH-2 remote keypad. The voice store does not record receiver audio.

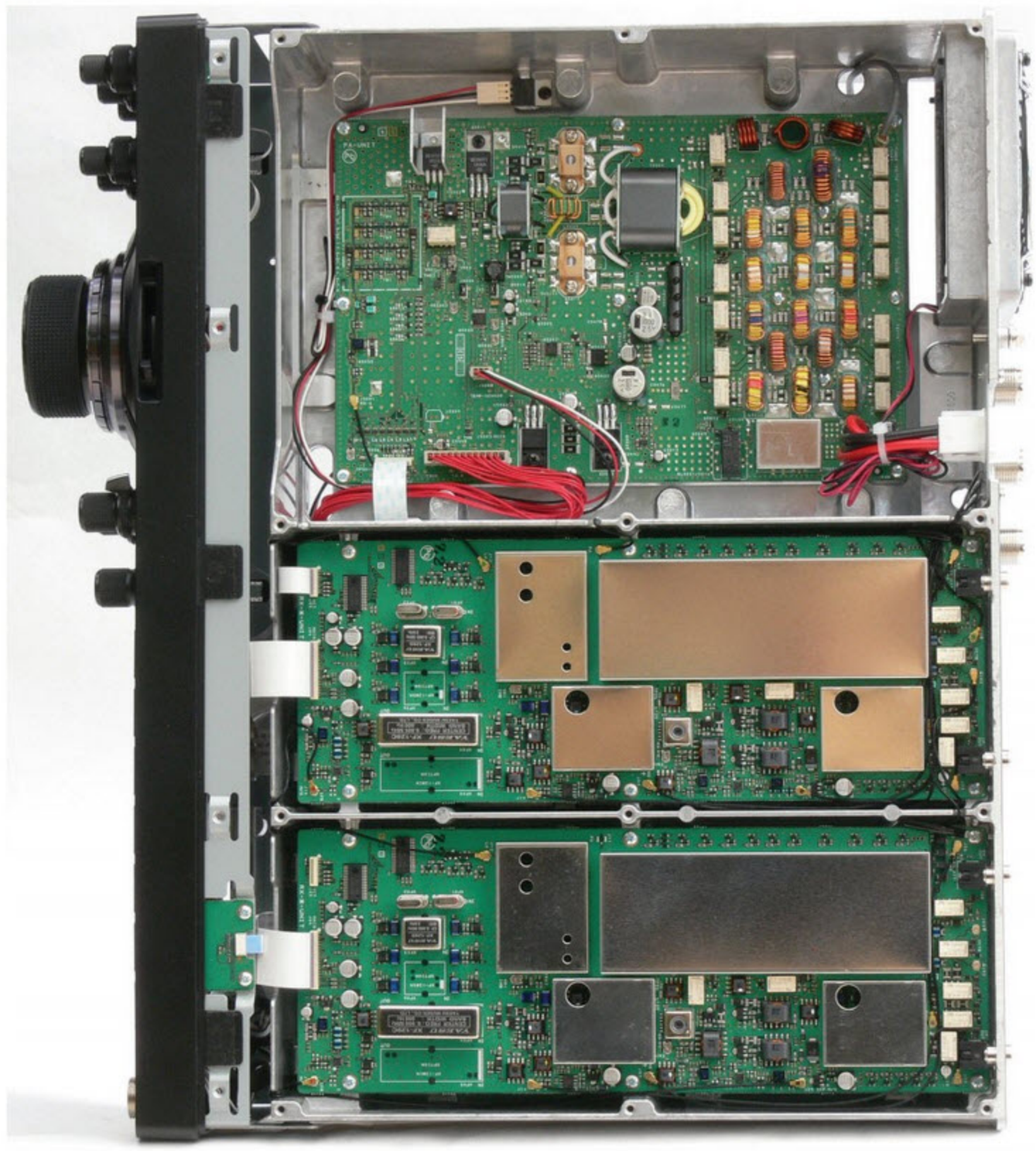
Datamodes

The FTDX101 includes built-in encoders and decoders for RTTY, PSK and also CW operation. The 7-inch display allows a good amount of space for decoded messages with 60 characters per line and 8 lines of received data in standard mode or 11 lines in expanded mode. A single line is allocated to the transmit buffer store.

PSK is limited to 31 baud rate BPSK31 and QPSK31. Both RTTY and PSK have separate transmit message stores, similar in operation to the CW stores. Five message stores are provided containing up to 50 characters each and are programmed using an external keyboard or internal pop-up keypad. Messages can be played back from the front panel or more conveniently using the FH-2 remote keypad accessory. There is no provision to conduct QSOs directly from the keyboard; connection to a PC running appropriate software is required.

Measurements

The full set of measurements is given in the table. The sensitivity figures were excellent and remain flat across the tuning range, only starting to reduce below 100kHz. Full sensitivity is only achieved if the main and sub receivers are allocated to different antenna sockets, even if only one receiver is active. With both allocated to the same antenna input, sensitivity figures are 3dB to 4dB lower and this also affects S-meter readings. The loss introduced by VC-Tune is negligible, 1dB across most of the tuning range, rising to 4dB on 1.8MHz and 28MHz. The S-meter calibration showed about 2.5 to 3dB per S-unit and was very linear across the whole range. All modes were broadly the same, including FM.



FTDX101D underneath with covers removed showing main and sub receiver boards and Tx PA with output filters.

The rejection of the 9MHz IF was over 100dB on most bands. This reduced to lower than 60dB on 7MHz and 10MHz, the bands closest to the IF, but enabling VC-Tune improved this to over 80dB. The image rejection was around 70-80dB but increased to over 90dB with VC-Tune enabled. Other spurious responses and birdies were very low indeed, none of significance. The AGC attack characteristic was clean with no overshoot. DSP-implemented systems usually insert a hole in the signal and this can impair signal copy in noisy situations. With the FTDX101D the hole was about 1ms, somewhat better than most radios.

The strong signal performance of the receiver is really excellent. The front-end IP3 measured around +40dBm on many bands and intermodulation limited dynamic range around 107dB in SSB bandwidths or 111dB in CW bandwidths. These dynamic range figures held at close spacings right down to the skirts of the roofing filter with no degradation, yielding 110dB dynamic range with 1kHz spaced signals. Inband linearity was also excellent, one of the best of any radio I have measured.

The reciprocal mixing phase noise figures were also outstanding and a significant improvement over the FTDX5000 and FTDX9000 that both use a similar synthesiser architecture. The measured figures are equal to and in many ways surpass the best of any radio I have measured before. With both receivers sharing the same antenna connection, slightly lower figures were measured. The low noise performance allowed the IF filter skirts to be measured down to a level of about -90dB with relative ease and the filters exhibited a clean response and excellent shape factor.

On transmit, the power output was well up to specification and the two-tone distortion products were generally quite reasonable. The audio was very clean with low distortion and quite tolerant

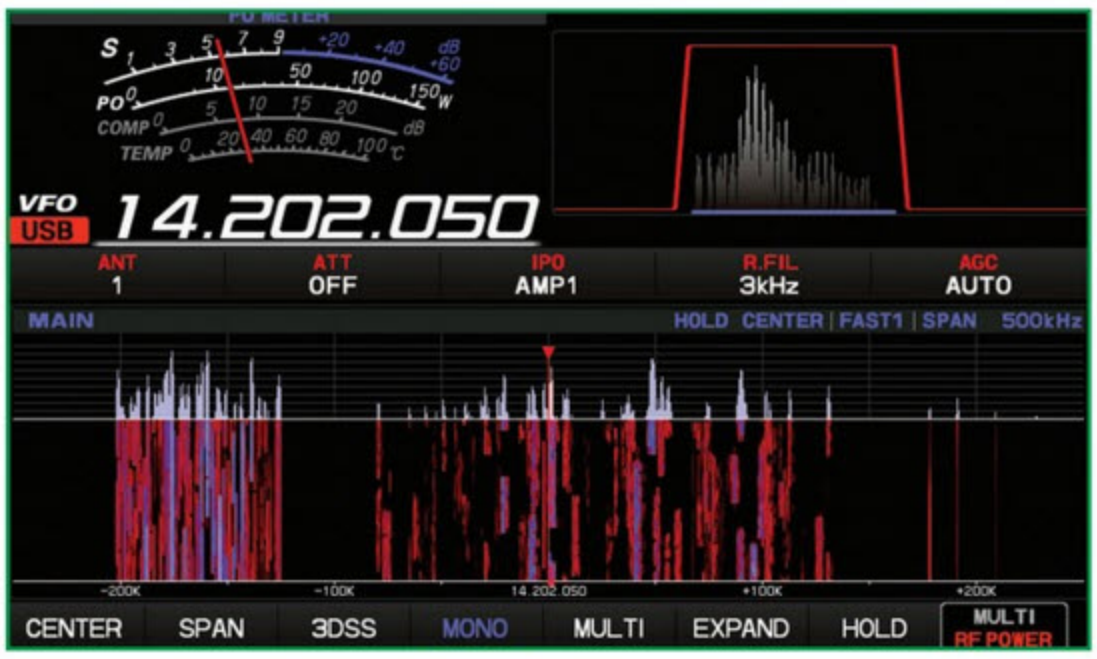


FIGURE 1: Single Rx display showing spectrum scan and waterfall.

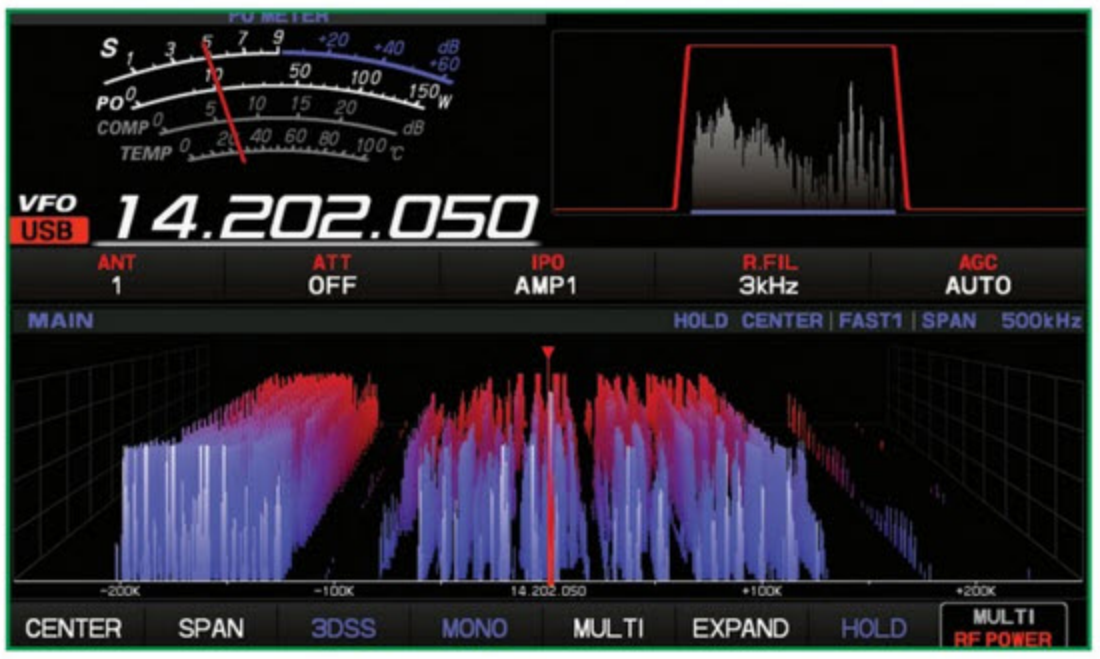


FIGURE 2: Single Rx display showing 3D spectrum scan.

of high ALC levels and overdrive. The processor, similarly, was clean, with negligible effect on wideband products.

CW rise and fall shapes were clean with negligible distortion or character shortening at 40wpm even in full break-in mode. The default setting of 4ms for rise and fall time is fine but 6ms is even better and there was no power overshoot at any power levels. There is a menu-settable delay on keying (15-30ms) to allow for linear amplifier switching. The RF is correctly sequenced even for slow linears. AM transmit was clean with fairly low distortion but modulation was prominently in the downward direction. This resulted in overall power reduction with modulation.

The transmit noise output at full power is a big improvement over virtually all other radios currently available, only equalled by the Elecraft K3S. The noise at lower power and even key-up on CW does not reduce significantly and this is fairly normal with most radios. The key-up noise on CW measured -98dBm/Hz.

The top half-dozen or so high performing radios available all have a similar high level of measured performance. Some excel in terms of close-in noise, some in close-in intermodulation dynamic range but few when it comes to transmit noise. The FTDX101D excels in all areas.

On-the-air performance

The initial impact of this radio is very positive with its eye-catching display and intuitive layout. The controls are well grouped, logically laid out and easy on the fingers with nothing too small and fiddly. The tuning is smooth and positive and I quite liked the secondary tuning ring. The band selection method is excellent. Nothing is perfect and personal preferences come into play but I would prefer certain menu-accessed functions to be on the front panel – DNR level and RF power, for example. However, I appreciate it is best not to over-clutter the front panel.

As with all modern radios, the performance cannot be faulted. It handled strong signals well in the IARU HF Championship and weak signals in the UKAC VHF contests. The audio from the internal speaker had excellent quality with good volume and frequency response and no rattles. Performance in the AM broadcast band and down to the LF time-code transmissions was very clean, one of the best radios I have used in this area. The filters and notches were excellent and the DNR digital noise reduction system effective. I have always found the DNR in the FTDX5000 to work well in lifting weak CW signals from the noise and the DNR in the FTDX101 comes from the same stable. Also, the noise blanker worked well in removing electric fence and ignition noise.

On transmit, the audio quality was good using the supplied SSM-75G hand microphone. The processor was clean and added extra punch. On CW, the keying and the sidetone were clean and with full break-in it was possible to listen between characters up to around 18 WPM. The process for setting the microphone gain and AMC levels as described in the manual is rather ambiguous, but setting these to give a moderate degree of compression (10dB max) with the ALC in the lower half of the meter display gave good results.

FTDX101D menu display.

The various display options were well presented and very helpful with a huge selection to choose from. I found the 3D spectrum display really was effective and gives a good impression of band activity and clear spaces. **Figure 1** and **Figure 2** show the spectrum plus waterfall display compared with the 3D spectrum display under similar conditions. The touch screen worked well and tuning the radio from the spectrum display gave reasonably accurate results providing the span was kept fairly low. Using a mouse for this purpose is much more precise than using fat fingers.

On data modes, the decoder worked well even with weak and noisy signals. The CW decoder also seemed quite effective, rather better than most, but as always intolerant of QRM or poorly sent code. Most decoders don't have any user adjustment but the speed tracking control in the FTDX101 results in much less gibberish being displayed.

During the period that I had the radio for review, a software upgrade became available. I downloaded and installed the upgrade easily with no problems.

Conclusions

Of all the top-end radios currently available, the FTDX101D is my current favourite. It is the only radio that excels in all performance areas and has an excellent balance of features, functions and user ergonomics. The display and the presentation of information on the display is first class and the price is very reasonable for a radio in this category. It is currently priced around £3149 from the usual Yaesu stockists, with the FTDX101MP priced at around £4199.

Acknowledgements

I would like to express my gratitude to Yaesu UK for the loan of this radio and also to Martin Lynch & Sons who also offered a radio for review.

Yaesu FTDX101D Measured Performance

Receiver Measurements

	Sensitivity SSB 10dBs+n:n			Input FOR S9		
Frequency	Preamp Off	Preamp 1	Preamp 2	Pre Off	Preamp1	Preamp 2
1.8MHz	0.56μV (-112dBm)	0.18μV (-122dBm)	0.13μV (-125dBm)	90μV	32μV	11μV
3.5MHz	0.5μV (-113dBm)	0.16μV (-123dBm)	0.11μV (-126dBm)	90μV	32μV	11μV
7MHz	0.5μV (-113dBm)	0.18μV (-122dBm)	0.13μV (-125dBm)	90μV	32μV	11μV
10MHz	0.56μV (-112dBm)	0.2μV (-121dBm)	0.13μV (-125dBm)	100μV	35μV	13μV
14MHz	0.5μV (-113dBm)	0.18μV (-122dBm)	0.11μV (-126dBm)	90μV	32μV	11μV
18MHz	0.56μV (-112dBm)	0.2μV (-121dBm)	0.11μV (-126dBm)	71μV	25μV	9μV
21MHz	0.63μV (-111dBm)	0.22μV (-120dBm)	0.14μV (-124dBm)	80μV	28μV	10μV
24MHz	0.35μV (-116dBm)	0.11μV (-126dBm)	0.1μV (-127dBm)	56μV	20μV	9μV
28MHz	0.35μV (-116dBm)	0.11μV (-126dBm)	0.11μV (-126dBm)	56μV	20μV	9μV
50MHz	0.35μV (-116dBm)	0.13μV (-125dBm)	0.11μV (-126dBm)	80μV	28μV	11μV
70MHz	0.4μV (-115dBm)	0.13μV (-125dBm)	0.13μV (-125dBm)	90μV	32μV	10μV

AGC threshold PREAMP1: 2.0μV
100dB above AGC threshold for <1dB audio output increase
AGC attack time: 1-2ms
AGC decay time: adjustable 20ms to 4s
Max audio at 1% distortion: 1.6W into 8Ω, 2.7W into 4Ω
Inband intermodulation products: better than -60dB see text

S-Reading	Input Level USB		
(7MHz)	Pre Off	Preamp 1	Preamp 2
S1	8μV	2.8μV	1μV
S3	14μV	5μV	1.8μV
S5	25μV	8.9μV	3.2μV
S7	45μV	16μV	5.6μV
S9	90μV	32μV	11μV
S9+20	900μV	320μV	110μV
S9+40	9mV	3.2mV	1.1mV
S9+60	90mV	32mV	11mV

Bandwidth/Roof	Bandwidth				
SET TO	-6dB	-60dB	-70dB	-80dB	-90dB
USB 2.4kHz/3kHz	2418Hz	3220Hz	3316Hz	3405Hz	3497Hz
CW 500Hz/600Hz	495Hz	707Hz	736Hz	767Hz	816Hz

Intermodulation (50kHz Tone Spacing) on USB. 2.4kHz bandwidth with 3kHz roofing filter

	Preamp Off		Preamp 1		Preamp 2	
Frequency	3rd order intercept	2 tone dynamic range	3rd order intercept	2 tone dynamic range	3rd order intercept	2 tone dynamic range
1.8MHz	+29dBm	99dB	+19dBm	99dB	+19dBm	101dB
3.5MHz	+36.5dBm	104dB	+28dBm	105dB	+20.5dBm	102dB
7MHz	+42dBm	108dB	+33dBm	108dB	+24dBm	104dB
14MHz	+41dBm	107dB	+32.5dBm	108dB	+22dBm	103dB
21MHz	+43.5dBm	108dB	+36dBm	109dB	+24.5dBm	104dB
28MHz	+29.5dBm	102dB	+20dBm	101dB	+13dBm	97dB
50MHz	+25dBm	99dB	+16dBm	99dB	+8.5dBm	94dB
70MHz	+21dBm	93dB	+13dBm	95dB	+2.5dBm	88dB

Frequency Offset	Reciprocal Mixing Dynamic Range 500Hz BW 7MHz	Intermodulation Dynamic Range 500Hz BW 14MHz	Transmit Noise 7MHz 100W O/P
1kHz	123dB (-150dBc/Hz)	110dB	-87dBm/Hz (-137dBc/Hz)
2kHz	128dB (-155dBc/Hz)	110dB	-89dBm/Hz (-139dBc/Hz)
3kHz	129dB (-156dBc/Hz)	110dB	-88dBm/Hz (-138dBc/Hz)
4kHz	130dB (-157dBc/Hz)	111dB	-90dBm/Hz (-140dBc/Hz)
5kHz	130dB (-157dBc/Hz)	111dB	-91dBm/Hz (-141dBc/Hz)
10kHz	131dB (-158dBc/Hz)	111dB	-93dBm/Hz (-143dBc/Hz)
15kHz	131dB (-158dBc/Hz)	111dB	-94dBm/Hz (-144dBc/Hz)
20kHz	131dB (-158dBc/Hz)	111dB	-94dBm/Hz (-144dBc/Hz)
30kHz	131dB (-158dBc/Hz)	111dB	-95dBm/Hz (-145dBc/Hz)
50kHz	132dB (-159dBc/Hz)	111dB	-96dBm/Hz (-146dBc/Hz)
100kHz	132dB (-159dBc/Hz)	111dB	-97dBm/Hz (-147dBc/Hz)

Transmitter Measurements

	CW Power		Intermodulation Products	
Frequency	Output	Harmonics	3rd order	5th order
1.8MHz	104W	-65dB	-22dB	-43dB
3.5MHz	107W	-62dB	-35dB	-50dB
7MHz	106W	-70dB	-37dB	-40dB
10MHz	106W	-60dB	-45dB	-40dB
14MHz	108W	-70dB	-50dB	-40dB
18MHz	108W	-66dB	-42dB	-37dB
21MHz	107W	-72dB	-40dB	-40dB
24MHz	107W	<-75dB	-33dB	-38dB
28MHz	107W	-70dB	-35dB	-41dB
50MHz	107W	-72dB	-26dB	-38dB
70MHz	54W	<-80dB	-37dB	-40dB

Intermodulation product levels are quoted with respect to PEP.

Microphone input sensitivity: 0.2mV for full output
Transmitter AF distortion: generally less than 0.1%
FM deviation: 2.0kHz narrow / 4.0kHz wide
SSB Data T/R switch speed: mute-TX 22ms, TX-mute 20ms, mute-RX 60ms, RX-mute 1ms

NOTE: All signal input voltages given as PD across antenna terminal. Unless stated otherwise, all measurements made with receiver preamp switched out (IPO), on USB with 2.4kHz bandwidth and 3kHz roofing filter and on CW with 500Hz bandwidth and 600Hz roofing filter. All measurements made on the MAIN receiver using ANT1, with the SUB receiver switched off and allocated to ANT2.