

ICOM IC-7400 HF/VHF TRANSCEIVER

Reviewed by Peter Hart, G3SJX*

SOME FIVE years or more ago, Icom was busy developing a complete new range of HF transceivers. The IC-746 and IC-756 were introduced as the middle and high end base station models, both also covering 6m and with the IC-746 also covering 2m. Both radios used conventional analogue IF circuitry with crystal filters for the main selectivity and DSP for audio functions. These radios proved very popular, packed with features made easily accessible through large LCD panels and clever software. Since then the IC-756 has been upgraded to the IC-756PRO and more recently the IC-756PROII, both radios using DSP-based IF processing for all channel selectivity functions, eliminating the need for optional extra and expensive IF filters. It is now the turn of the IC-746 to undergo the same treatment. Using the same DSP filtering block developed for the IC-756PRO series and a number of other enhancements, the result is the IC-7400.

Although the outward appearance of the IC-7400 is virtually identical to the IC-746, under the bonnet the IF DSP makes the signal processing architecture very different, with much greater flexibility to the channel filtering, AGC, and extensive transmit audio filtering and processing. There are other enhanced features such as built-in RTTY decoder.

PRINCIPAL FEATURES

THE IC-7400 is a 12V operated radio measuring 287W x 120H x 317Dmm and weighing 9kg. The power lead for the radio incorporates a filter box containing toroidal inductors and capacitors. This is in addition to already extensive filtering on the power line inside the radio. This added filter has obviously been necessary to meet the European CE mark and EMC requirements. In the US, which has less stringent requirements, the IC-746PRO is marketed with reduced performance in this area, but in all other aspects the radios are the same.

The usual modes are covered for LSB, USB, CW, RTTY, AM and FM with reverse sideband selectable on CW and RTTY and data selectable on the voice modes (this mutes the microphone and speeds the T/R switching). The receiver tunes continuously



from 30kHz to 60MHz and 144 to 146MHz with the transmitter enabled only within the amateur bands and a little more on either side. There are slight variants in different countries. Individual buttons select the bands with the usual Icom triple band stacking registers, returning one of three last used frequency / mode combinations for each press of the band key.

The smooth-action tuning knob tunes in 10Hz steps at 6kHz per knob revolution with auto speed-up on fast sustained tuning which can be disabled if desired. Faster tuning rates for rapid frequency changes and a slower rate for precision tuning are also provided. 101 memory channels are provided with direct tune from memory, easily selected by a click-step rotary control. Preview of memory contents together with label tagging up to nine characters is provided, although this needs to be accessed from the menu system which sacrifices other display options. An additional memory channel is assigned as a call channel and accessed directly by a front panel push button. A separate memo pad feature allows up to five (or 10) frequencies to be quickly stored and recalled by a simple key press, on the basis of last in, first out.

A quick split feature enables split fre-



quency operation to a predefined offset by a single key press, and another key selects reception on the transmit frequency and allows it to be independently tuned. Other keys perform the usual memory and VFO transfer and selection functions and allow direct frequency input via the band selection keypad. RIT and transmitter independent tuning operate over a range of ± 9.99 kHz and various scan modes

are implemented. The CW pitch is adjustable over the range 300 - 900Hz to suit personal preferences.

A front panel pushbutton selects between two antenna sockets on HF / 50MHz with a third antenna socket dedicated to VHF / 144MHz. The antenna selections are stored with the band stores. The built-in auto ATU covers HF and 50MHz, matching up to 3:1 VSWR, with tuning settings stored every 100kHz to enable rapid and accurate reselection. The auto ATU is automatically bypassed if an external auto ATU is used. Unfortunately, there is no provision to allow for a separate receiver antenna. To cope with different receive conditions, two preamplifiers are available on HF and 50MHz, one on 144MHz or for exceptionally strong signals a 20dB input attenuator can be selected. No preamp is selectable below 1.6MHz. A combined RF gain / all mode squelch control is provided, now used on most Icom radios. A new feature is voice squelch control. This only opens the squelch when receiving voice signals and is probably of most use during scanning, preventing the scan from stopping on carriers and other non-voice signals.

For FM and repeater use several facilities are provided. Duplex offsets may be set over a wide range, programmed separately for HF, 50 and 145MHz and separate repeater tone access frequencies may be programmed for these different bands. Selective calling may be implemented using CTCSS tone squelch or DTCS which uses a three-digit code to open the squelch and different tones or codes may be preset for the different bands. A scan may be implemented to determine which tone or digital code is being used by the received signal.

For RTTY and data, the IC-7400 provides significantly enhanced capabilities compared with the earlier radio. Extensive filtering (see DSP section), support for FSK and AFSK modes, selectable FSK parameters,

packet data optimisation to 9600 baud or lower rates, a tuning indicator and a simple RTTY decoder / monitor are all built-in.

The transmitter power is variable from about 2 - 100W on all bands including 144MHz. An audio speech compressor is included with VOX, transmit signal monitor and audio response tailoring. Full and semi break-in is available on CW with a built-in message keyer and twin key jacks for the internal or for external keyers. Four message stores are included, each up to 50 characters in length with a provision to send automatically incrementing serial numbers, abbreviated number formats and auto-repeat after a time delay. The message stores are programmed alphanumerically from the front panel push buttons.

The rear panel includes the usual interfaces, common to all Icom radios, for control of linears, ATUs, data terminals etc. The standard Icom C-IV serial computer interface is provided with data transfer rates from 300 to 19,200 baud, allowing several Icom radios to be connected to a common bus. A comprehensive 112-page manual is provided packed with information and circuits are included. Options include voice-synthesised readout of display frequency and mode, and a high stability reference oscillator.

DIGITAL SIGNAL PROCESSING

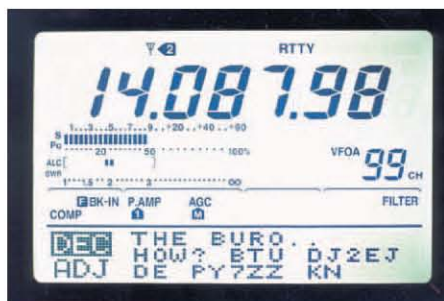
THE IC-7400 architecture and DSP functions are similar to the IC-756PROII. The radio is a triple conversion superhet with a first IF of 64.455MHz, a second IF of 455kHz and a third conversion to 36kHz to feed the DSP. The 32-bit floating point DSP is interfaced to the analogue circuitry through very high resolution 24-bit A/D and D/A converters. The DSP provides the IF filtering, modulation, demodulation and audio processing functions. 41 different passband widths are selectable on CW and SSB from 50Hz to 3600Hz, 32 on RTTY (50 - 2700Hz) and three each on AM (3, 6, 9kHz) and FM (7, 10, 15kHz). Three separate bandwidths are immediately available for each mode selectable by a simple push of a front panel key, from the available menu of bandwidths. In addition, two selectable filter profiles on CW and SSB modes are selectable, a sharp profile with a flat passband for best audio quality or a soft profile with a more rounded passband for weak signal readability. For RTTY a twin peak audio filter may be selected, similar to the IC-756PROII, providing five different bandwidths in addition to the IF filters.

The DSP also provides the passband tuning function, enabling the filter passband to be shifted and narrowed in incremental steps. The AGC is also implemented by the DSP with three separate time constants selectable from the front panel. These three values may

be set from a menu of 13 different values (0.1 to 6s) and are set separately for all modes except FM. Two separate notch functions are provided in this transceiver, both using the DSP. A particularly effective manually tuned IF notch with a depth of 70dB is included within the AGC loop and hence does not result in desensitising with strong carriers. An auto-notch is implemented at AF and will automatically attenuate several beat notes, even if they are moving. An adjustable DSP noise reduction system is included and there is also a conventional (not DSP) IF noise blanker for pulse type interference such as car ignition.

The modulated transmit signal is also generated by the DSP with adjustable bass and treble microphone equalisation and adjustable compressor.

LCD PANEL



MUCH OF THE operation of the IC-7400 centres on the monochrome LCD dot matrix panel and associated five function keys along the bottom, as used in the IC-746. The upper part of the panel displays the frequency, mode, RIT offset, memory, antenna etc and status of all selected functions. A bargraph meter displays signal strength, power output, ALC and SWR with optional peak hold.

The lower part of the panel is associated with the function keys and depends on selected mode and other parameters. Two levels of menu and a general settings mode are provided for selecting many of the features. This allows for the setting of a vast number of parameters including the keyer functions, scanning, memory preview, RTTY settings, repeater access and tones and selectable options for all the functions of the radio. A scan can be enabled showing the spectrum on either side of the receive frequency with selectable step

sizes. This provides spans from about ± 15 kHz to ± 750 kHz. The receiver is muted during this process but it can be done just once and stored. This lower part of the panel can also provide a simple two or three line readout for the built-in RTTY decoder. The function key labels cannot be displayed at the same time as the spectrum or RTTY decoder outputs. A novel feature using the lower part of the panel is to plot antenna VSWR against frequency for a number of selectable frequency spans. This handy check is unique to the IC-7400.

MEASUREMENTS

THE FULL SET of measurements is given in the table when powered from a 13.8V supply, with additional comments as follows.

Receiver Measurements

The sensitivity results are very similar to the IC-746. Preamp 1 has a gain of about 10dB and preamp 2 about 17dB. With preamp 2 selected, the receiver shows an improvement in sensitivity over preamp 1 of about 2-3dB. On 144MHz the single preamp has a gain of about 20dB. The S meter calibration is approximate due to the resolution of the bargraph and appears independent of mode. The rejection of images, IFs and spurs is very good, in excess of 100dB in most cases. There were, however, a number of internal 'birdies' audible in the LF region (30-300kHz). Rejection of the first mixer image occurring in the VHF region was a major problem on HF with the IC-746 when a 2m antenna was also connected. This problem has been significantly improved in the IC-7400 and now shows some 70 - 90dB rejection.

The filter bandwidths shown in the table are just a small selection from the filters available. Although the bandwidths available are the same as for the IC-756PROII, the shape

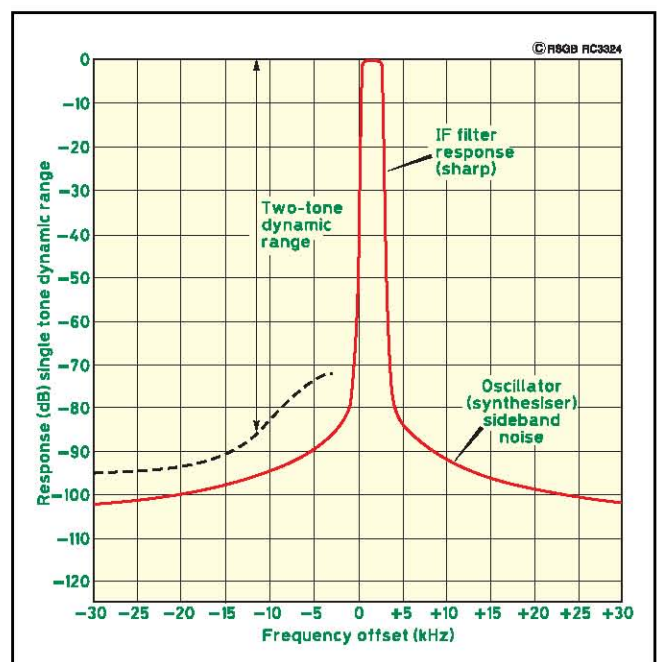


Fig 1: Effective selectivity curve on USB.

factors and skirts are not as steep, particularly for the narrower bandwidths. Presumably the IC-7400 uses a simplified DSP filtering algorithm. The effective selectivity curve on USB is shown in Fig 1.

The reciprocal mixing results are good, slightly better than the IC-746 and virtually identical to the IC-756PROII, suggesting a common synthesiser design is now used. The third order intercept and dynamic range figures are good but the IC-746 measured slightly better.

Transmitter Measurements

The power output figures in the table were measured with the ATU out of circuit. The ATU introduced a loss of about 10%. At full power on SSB, the two-tone intermodulation products measured significantly better than the IC-746 which showed a particularly poor result. The CW rise and fall times were ideal with slight character shortening at higher speeds, perhaps 15% in semi break-in or 30% in full break-in at 40WPM. Transmit-receive switching was clean and very fast in data mode when interfaced via the ACC1 connector. Interfacing via the microphone

connector, it took as much as 80ms for the transmitter to achieve full output. Make sure that data mode is selected and the appropriate data interfaces are used for effective AmTOR and packet operation.

ON-THE-AIR PERFORMANCE

WHEN I REVIEWED the IC-746 four years ago, I found this radio performed extremely well and was a delight to use. These same comments also apply to the IC-7400 and even more so with the extra flexibility provided by the DSP filters and added RTTY features. With the clear, bright LCD, the radio is easy to use and access to the various features fairly intuitive. The tuning rate and feel is ideal and auto speed-up just about right. Quick-split and XFC (transmit frequency monitor and tune) makes split frequency operation very simple and a nice touch is the ability to lock the receive frequency and still be able to vary the transmit frequency. This is particularly useful in the heat of a split frequency pile-up. The filters were excellent, I generally preferred the sharp setting in all cases.

The strong signal performance appears excellent and no particular intermodulation problems were experienced. The receiver was very good on all modes with excellent AM broadcast quality and clean VLF performance, an indication of good synthesiser noise. The transmitter performed well with clean break-in on CW and good audio reports.

The RTTY decoder was effective and functioned well on weak signals but it is limited to 45 baud / 170Hz shift. The radio also performed effectively on 2m on CW/SSB and on FM. The repeater access features were straightforward to use.

CONCLUSIONS

THE IC-7400 provides an entire HF / VHF station in one box. With an excellent performance, 100W output on all bands and packed with features it should prove a popular choice. Available for around £1499, it is excellent value with the added bonus that no additional filters need be fitted.

I would like to thank Martin Lynch & Sons for the loan of the equipment. ♦

FREQ	SENSITIVITY SSB 10dBs+n:n		INPUT FOR S9	
	PREAMP1 IN	PREAMP OUT	PREAMP1 IN	PREAMP OUT
136kHz	-	1.6µV (-103dBm)	-	250µV
1.8MHz	0.13µV (-125dBm)	0.28µV (-118dBm)	16µV	50µV
3.5MHz	0.11µV (-126dBm)	0.28µV (-118dBm)	13µV	56µV
7MHz	0.11µV (-126dBm)	0.25µV (-119dBm)	14µV	50µV
10MHz	0.13µV (-125dBm)	0.28µV (-118dBm)	16µV	56µV
14MHz	0.13µV (-125dBm)	0.28µV (-118dBm)	16µV	56µV
18MHz	0.13µV (-125dBm)	0.28µV (-118dBm)	18µV	56µV
21MHz	0.13µV (-125dBm)	0.28µV (-118dBm)	16µV	56µV
24MHz	0.13µV (-125dBm)	0.28µV (-118dBm)	14µV	63µV
28MHz	0.14µV (-124dBm)	0.28µV (-118dBm)	16µV	63µV
50MHz	0.16µV (-123dBm)	0.45µV (-114dBm)	22µV	100µV
144MHz	0.1µV (-127dBm)	0.25µV (-119dBm)	4.5µV	40µV

ICOM IC-7400 MEASURED PERFORMANCE

All signal input voltages given as PD across antenna terminal. Unless stated otherwise, all measurements made on SSB with receiver preamp 1 switched in and with 2.4kHz bandwidth sharp filter selected.

Freq	INTERMODULATION (50kHz Tone Spacing)			
	PREAMP1 IN		PREAMP OUT	
	3rd order intercept	2 tone dynamic range	3rd order intercept	2 tone dynamic range
136kHz	-	-	+14dBm	85dB
1.8MHz	+4dBm	93dB	+15.5dBm	96dB
3.5MHz	+4.5dBm	94dB	+16dBm	96dB
7MHz	+4.5dBm	94dB	+16dBm	97dB
14MHz	+6dBm	94dB	+18dBm	97dB
21MHz	+7dBm	95dB	+19dBm	98dB
28MHz	+7dBm	94dB	+19dBm	98dB
50MHz	+8dBm	94dB	+22dBm	97dB
144MHz	-12dBm	83dB	-7dBm	81dB

AM sensitivity (28MHz): 1µV for 10dBs+n:n at 30% mod depth
 FM sensitivity (28MHz): 0.2µV for 12dB SINAD 3kHz pk deviation
 AGC threshold: 0.9µV
 100dB above AGC threshold for +0.5dB audio output
 Max audio before clipping: 1.6V into 8 ohm, 1.9V at 10% distortion
 Inband intermodulation products: better than -55dB

RECEIVER MEASUREMENTS

Spacing	CLOSE-IN INTERMODULATION ON 7MHz BAND		PREAMP1 IN		PREAMP OUT	
	3rd order intercept	2 tone dynamic range	3rd order intercept	2 tone dynamic range	3rd order intercept	2 tone dynamic range
3kHz	-33dBm	69dB	-21dBm	72dB	-21dBm	72dB
5kHz	-31dBm	70dB	-19dBm	73dB	-19dBm	73dB
7kHz	-25dBm	74dB	-13dBm	77dB	-13dBm	77dB
10kHz	-16dBm	80dB	-5dBm	83dB	-5dBm	83dB
15kHz	-5dBm	87dB	+7dBm	91dB	+7dBm	91dB
20kHz	-1dBm	90dB	+11dBm	93dB	+11dBm	93dB
30kHz	+1dBm	91dB	+13dBm	95dB	+13dBm	95dB
40kHz	+1.5dBm	92dB	+14dBm	95dB	+14dBm	95dB
50kHz	+4.5dBm	94dB	+16dBm	97dB	+16dBm	97dB

FREQ OFFSET	RECIPROCAL		
	MIXING FOR 3dB NOISE	BLOCKING PREAMP1 IN	BLOCKING PREAMP OUT
3kHz	83dB	-40dBm	-30dBm
5kHz	87dB	-40dBm	-30dBm
10kHz	93dB	-36dBm	-27dBm
15kHz	96dB	-21dBm	-13dBm
20kHz	99dB	-9dBm	+1dBm
30kHz	102dB	-3dBm	+7dBm
50kHz	106dB	-3dBm	+7dBm
100kHz	111dB	-3dBm	+7dBm
200kHz	119dB	-3dBm	+7dBm

FILTER	SHARP		SOFT	
	IF BANDWIDTH	IF BANDWIDTH	IF BANDWIDTH	IF BANDWIDTH
	-6dB	-60dB	-6dB	-60dB
10kHz	10.9kHz	17.2kHz	-	-
6kHz	6.6kHz	11.0kHz	-	-
2.4kHz	2525Hz	3750Hz	2400Hz	3650Hz
500Hz	517Hz	1458Hz	546Hz	1482Hz
250Hz	255Hz	1055Hz	264Hz	1081Hz
100Hz	107Hz	817Hz	113Hz	787Hz
50Hz	64Hz	668Hz	65Hz	661Hz

S-READING (7MHz)	INPUT LEVEL	SSB PREAMP1 IN	PREAMP OUT
S1	1.0µV	4µV	
S3	1.8µV	7µV	
S5	4µV	14µV	
S7	8µV	28µV	
S9	14µV	50µV	
S9+20	250µV	1mV	
S9+40	2mV	7mV	
S9+60	13mV	45mV	

TRANSMITTER MEASUREMENTS

Carrier suppression: >70dB
 Sideband suppression: >80dB @ 1kHz
 Transmitter AF distortion: <1%
 Microphone input sensitivity: 2mV for full output
 SSB T/R switch speed: mute-TX 15ms, TX-mute 1ms, mute-RX 15ms, RX-mute 1ms

FREQ	CW POWER	SSB(PEP) POWER	INTERMODULATION PRODUCTS		
	OUT	OUT	HARMONICS	3rd order	5th order
1.8MHz	110W	105W	-68dB	-30 (-24)dB	-46 (-40)dB
3.5MHz	106W	105W	-62dB	-36 (-30)dB	-51 (-45)dB
7MHz	105W	104W	-70dB	-32 (-26)dB	-51 (-45)dB
10MHz	104W	104W	-60dB	-34 (-28)dB	-44 (-38)dB
14MHz	104W	103W	-65dB	-34 (-28)dB	-50 (-44)dB
18MHz	103W	102W	-63dB	-28 (-22)dB	-50 (-44)dB
21MHz	100W	102W	-64dB	-30 (-24)dB	-50 (-44)dB
24MHz	103W	102W	-70dB	-30 (-24)dB	-50 (-44)dB
28MHz	103W	101W	-70dB	-24 (-18)dB	-40 (-34)dB
50MHz	98W	96W	-70dB	-30 (-24)dB	-42 (-36)dB
144MHz	97W	83W	-75dB	-26 (-20)dB	-44 (-38)dB

Intermodulation product levels are quoted with respect to PEP, figures in brackets are with respect to either tone.