THE PETER HART REVIEW

IC-736/738 HF Transceiver Family

By G3SJX*

DURING EARLY 1993, Icom introduced the IC-737 HF transceiver as a mid-priced fully featured radio, largely aimed at base station use. This was reviewed in the September 1993 issue of *RadCom*. Early in 1994, Icom released the IC-736, outwardly very similar to the IC-737 but internally completely re-organised. Apart from a number of small enhancements, the IC-736 includes a built-in mains PSU and covers the 6m band at the full 100W power level in addition to the normal HF bands. Later in 1994, the IC-738 appeared, as a lower cost version, omitting 6m coverage and intended for 12V operation without the mains PSU. Apart from these two features, the IC-736 and IC-738 are identical.

PRINCIPAL FEATURES

THE RADIOS COVER USB, LSB, CW, CW narrow, AM and FM. CW narrow selects the narrow IF filter if this option has been fitted. There is no specific provision to cover data modes (RTTY, AMTOR or packet). These modes should use SSB or FM as appropriate with AFSK, unplugging the microphone on transmit to avoid audio modulation.

The receiver tunes from 30kHz to 30MHz and the IC-736 in addition tunes from 45 to 60MHz. Surprisingly, the handbook and short form sales brochure quote a more restricted tuning range of 500kHz minimum and 50 - 54MHz on 6m, probably as the receiver falls out of specification on sensitivity and spurious responses at these wider limits. However, having the wider coverage available on 6m is very useful for monitoring Band 1 TV signals as an indicator of 6m band openings.

The transmitter covers the amateur allocations plus a hundred kHz or so on either side, with 50 - 54MHz in addition for the IC-736. Individual push buttons select the amateur bands, returning the last used frequency and mode on each band. A second press of the band key returns a second frequency and mode for each band. Further key presses toggle between these two settings. This double band stacking register feature is particularly useful when working both CW and SSB modes. A separate key selects general coverage frequencies.

The frequency may be set in a number of different ways. The 50mm diameter main tuning knob tunes in 10Hz steps at 2kHz (200 steps) per revolution or alternatively 20Hz or 50Hz steps at 4kHz or 10kHz per revolution respectively. Extra fine resolution may also be selected, tuning in 1Hz steps (200Hz per revolution). Using the 1Hz, 10Hz or 20Hz step settings, auto speed-up is engaged when the knob is rotated rapidly. A quick tuning step button engages coarser tuning steps of 1 - 10kHz, programmable in 1kHz increments, at 100 steps per revolution. This is useful for larger changes of frequency. UP / DOWN keys step the frequency in increments of 1kHz - 1MHz, programmable in intervals of 1kHz. This is most conveniently left at 1MHz to provide band setting in general coverage mode or at say 20kHz for rapid steering within the amateur bands. The frequency may be entered directly using the numeric keypad which doubles as the band select keys. Last but not least, the frequency may be tuned, albeit rather slowly, using the UP / DOWN keys on the microphone.

The usual A and B VFOs are provided with split frequency capability. These may be

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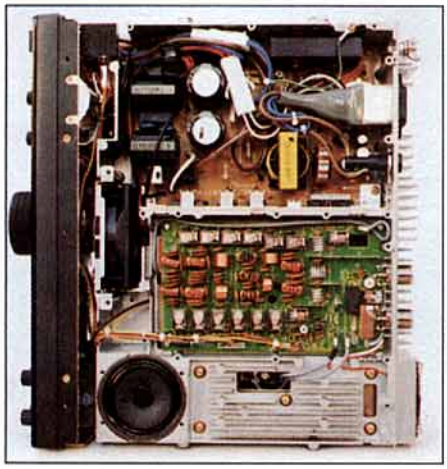
equalised and split operation selected by a single key press. Another button (XFC) allows reception on the transmit frequency and enables this frequency to be tuned from the main tuning knob and other tuning controls. In split operation, the transmit frequency is indicated as a sub frequency on the main display panel. RIT is provided over a range of ±9.99kHz in 1Hz or in 10Hz steps and displayed in the sub display. This is a wider range than on the IC-737. Independent transmit tuning over the same range is also provided.

The IC-736 and IC-738 have 101 memory channels selected by a small click-step rotary control. 89 of these store one frequency and mode, 10 will store two frequencies and modes for split operation and two channels are used to store scan limits. There are the usual read / write operations, including direct tune from any memory location to any frequency, but, as with the IC-737, there is no memory preview. This would have been simple to include as the sub frequency display is already provided for split operation. There is also no provision to partition the memory into smaller units as is done on many radios. In addition to the memories, a memo pad is provided. This is a quick and easy one touch temporary store and recall facility which stores up to 10 frequencies on a stack. This is read out sequentially, last in, first out.

Three scan modes are provided, scanning between two frequency limits, scanning of all occupied memory channels and scanning of selected memory channels. Scan resume condition and scan speed are selectable.

There is no selectable IF bandwidth setting on SSB, AM or FM but variable bandwidth is available on SSB and CW in the form of passband tuning. On CW, narrow bandwidth filters may be fitted to both the 2nd and 3rd IFs as optional extras with a choice of 250Hz or 500Hz bandwidth available. An audio based notch filter is also fitted.

Receive functions include switchable preamp, switchable 20dB input attenuator, dual speed AGC, single noise blanker and all-mode squelch. There is an RF gain control fitted now, this had been omitted from the IC-737. The CW pitch is fixed at 800Hz.



Top view of IC-736 with cover removed.

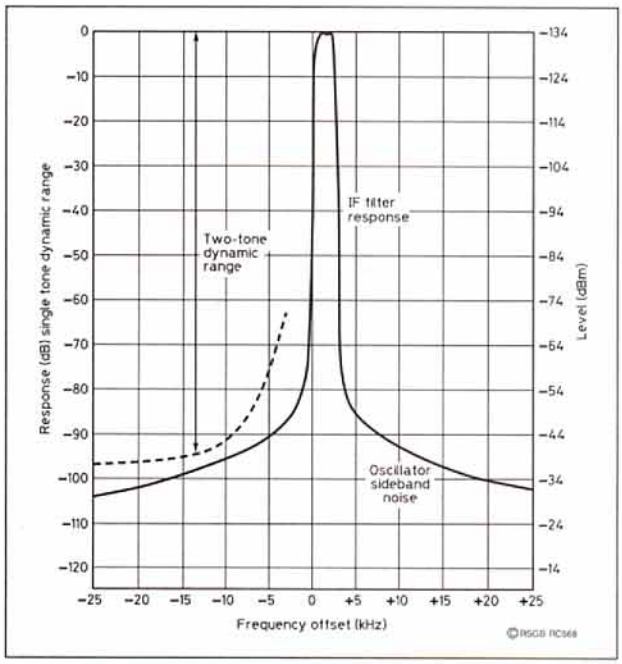


Fig 1: Effective selectivity curve on USB.

Transmit functions include audio based speech processor, built-in CW keyer operating over the range from 7 to 41 words per minute, full and semi break-in on CW, power output variable from a few watts to 100W and VOX. VOX was not provided on the IC-737. Metering on transmit shows relative power output, SWR or ALC level, which is more comprehensive than the IC-737. A sub-audible tone encoder is available as an optional extra for repeater working.

A large backlit LCD panel is used for the display and this is bright, clear and very easy to read. The frequency is indicated to 10Hz resolution with a separate smaller sub display indicating RIT offset or Tx frequency in split operation and the 1Hz resolution digit when selected. The memory channel number is shown and the usual indicators for mode, VFO / memory status etc. When operating on data modes, the displayed frequency needs to be offset to indicate the true operating frequency. A possible solution is to set the RIT to the AFSK offset required.

Both the IC-736 and IC-738 contain an auto-ATU as standard fitment matching antennas up to about 3:1 VSWR, with manually selectable options for handling higher VSWRs. This functions on transmit only and is bypassed on receive. The auto-ATU in the IC-736 also functions on 6m, matching up to about 2.5:1 VSWR. Band stores are provided to give fast tuning by returning to the last used settings when a band is selected. Two separate antennas may be connected and selected from the front panel. Band stores memorise which antenna is used on which band and switch to the appropriate antenna when that band is selected.

Three accessory sockets are provided on the rear panel (see photograph on p43 - the IC - 736 is at the top) to interface to external auto-ATUs, data terminals, Icom linear etc. Relay controlled T / R switching and ALC is also provided for general linear use and these interface connections are common to all Icom HF transceivers. Hence accessories and external connections to other units are all directly interchangeable. The Icom CI-V serial computer control interface is also fitted, fully compatible with other Icom radios. The VOX controls and speech compressor gain setting are provided on the rear panel.

An excellent 62 page instruction manual is included together with a set of circuit diagrams.

DESCRIPTION

THE IC-736 and IC-738 measure 330W x 111H x 285Dmm and fall into the middle size category, ideal for home station use but easily transportable. The IC-738 weighs 8.6kg and the IC-736, with mains PSU, weighs 10.5kg. The transceiver is very sturdily constructed around a diecast main chassis assembly. This supports the upper facing units with integral rear finned heatsink. Two fans are used, to cool the PA and the auto-ATU and these are very quiet in operation. A 6.5cm diameter speaker is mounted facing upward using the diecast assembly as a baffle.

The receiver is triple conversion with IFs of 69.01MHz, 9.01MHz and 455kHz on all modes. The transmit signal is generated at 9.01MHz and mixed via 69.01MHz to the final frequency. The transceiver uses a common front-end signal path for all bands including 50MHz with dual FETs in the receiver RF amplifier and first mixer and a pair of power MOSFETs in the 100W wideband (1.8 - 54MHz) PA. The frequency synthesiser uses the normal combination of DDS (direct digital synthesis) and PLL (phase locked loop) to give fast tuning and good spurious performance with small step size. A lithium back-up battery, easily accessible on the rear of the front panel unit, is used to preserve the memory contents. This has a five year life.

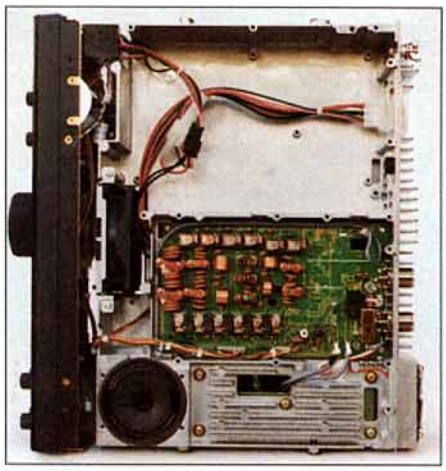
MEASUREMENTS

MEASUREMENTS WERE made using the IC-736, but are applicable to the IC-738 which uses identical circuitry. Details are given in the table with additional comments as follows.

Receiver measurements

S-METER CALIBRATION

The calibration was similar on all modes including FM and shows excellent linearity.



Top view of IC-738 with cover removed.

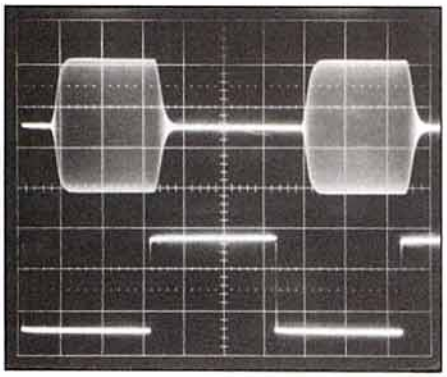


Fig 2: CW Keying waveform at 40WPM in semi break-in mode.

SPURIOUS REJECTION

Rejection of all measured spurious responses including first and second IFs and first mixer image was in excess of 100dB, except on 50MHz where the first IF rejection was 80dB. This is an excellent result.

SELECTIVITY

The review radio was fitted with 500Hz b/w CW filters in both the 9MHz and 455kHz IFs. The measurements show the extremely good skirt selectivity measured on CW which is primarily due to the 455kHz filter. Although this is an expensive filter, it is well worth fitting if CW is of major interest. With both filters fitted, passband tuning is also effective on CW, narrowing the bandwidth still further. This is preferable to fitting 250Hz filters in my opinion. Do not be tempted to economise by fitting only the 455kHz filter and not the 9MHz as the full performance will not be achieved due to dynamic range limitations in the second mixer. The IF bandwidth on SSB was a little narrow for my preference.

STRONG SIGNAL PERFORMANCE

The overall strong signal performance in terms of front-end dynamic range and close-in performance is very good. Although the reciprocal mixing performance is also very good, I measured somewhat better figures for the IC-737 sample reviewed which was exceptionally good. The overall effect of IF filter selectivity and reciprocal mixing is shown in **Fig 1** - an excellent result.

Wideband second order responses measured at 21.1MHz (test signals 11.6 and 9.5MHz) and 14.3MHz (test signals 7.2 and 7.1MHz) showed a response similar to the normal 3rd order 50kHz spacing test.

FREQUENCY CALIBRATION

The receive and transmit frequencies were accurate to within 60Hz. The CW frequency read correctly for a beat note of 800Hz.

Transmitter measurements

POWER OUTPUT

The figures given in the table were measured with the ATU out of circuit. The ATU introduced a loss of about 10 - 15% (0.5 - 0.8dB). The power output was variable smoothly down to 2.5W and the power meter, although calibrated in percentage output, read remarkably close to the true power in watts above 20W. Into a mismatched load, the power output reduced substantially (2:1 VSWR 55W min, 3:1 VSWR 28W min) but the auto-ATU restored output to around the 100W level.

ICOM IC-736 / 738 MEASURED PERFORMANCE

RECEIVER MEASUREMENTS

	SENSITIVITY SSB 10dBs+n:n		INPUT FOR S9	
FREQUENCY	PREAMP IN	PREAMP OUT	PREAMP IN	PREAMP OUT
1.8 MHz	0.14µV (-124dBm)	0.32µV (-117dBm)	20µV	80µV
3.5 MHz	0.14µV (-124dBm)	0.32µV (-117dBm)	20µV	80µV
7 MHz	0.11µV (-126dBm)	0.25µV (-119dBm)	16µV	63µV
10 MHz	0.16µV (-123dBm)	0.32µV (-117dBm)	18µV	71µV
14 MHz	0.13µV (-125dBm)	0.25µV (-119dBm)	18µV	63µV
18 MHz	0.13µV (-125dBm)	0.25µV (-119dBm)	20µV	63µV
21 MHz	0.14µV (-124dBm)	0.25µV (-119dBm)	20µV	63µV
24 MHz	0.14µV (-124dBm)	0.25µV (-119dBm)	22µV	63µV
28 MHz	0.16µV (-123dBm)	0.32µV (-117dBm)	22µV	71µV
50 MHz	0.13µV (-125dBm)	0.16µV (-123dBm)	5.6µV	18µV

S-READING (14MHz)	INPUT LEVEL SSB
S1	0.9µV
S3	1.6µV
S5	2.8µV
S7	6.3µV
S9	18µV
S9+20	200µV
S9+40	2mV
S9+60	18mV

MODE	IF BANDWIDTH -6dB	-60dB
SSB,CW	1970Hz	3320Hz
CW(N)	480Hz	780Hz
AM	8010Hz	13.9kHz
FM	12.6kHz	24.5kHz

AM sensitivity (28MHz): 0.8µV for 10dBs+n:n at 30% mod depth

FM sensitivity (28MHz): 0.18µV for 12dB SINAD 3kHz pk deviation

AGC threshold: 0.6µV

100dB above AGC threshold for +3dB audio output

AGC attack time: 2ms

AGC decay time: 0.2 - 0.4s (fast), 3 - 4s (slow)

Max audio before clipping: 2.1W into 8Ω at 2% distortion

Inband intermodulation products: -30dB

	INTERMODULATION (50kHz Tone Spacing) PREAMP IN		PREAMP OUT	
Frequency	3rd order intercept	2 tone dynamic range	3rd order intercept	2 tone dynamic range
1.8 MHz	+1dBm	90dB	+2dBm	86dB
3.5 MHz	+9dBm	96dB	+17dBm	96dB
7 MHz	+10dBm	98dB	+21dBm	100dB
14 MHz	+11dBm	98dB	+21dBm	100dB
21 MHz	+13dBm	98dB	+24dBm	102dB
28 MHz	+16dBm	100dB	+22dBm	100dB
50 MHz	+2dBm	92dB	+5dBm	92dB

TONE SPACING (7MHz BAND)	3rd ORDER INTERCEPT	2 TONE DYNAMIC RANGE
3 kHz	-31dBm	63dB
5 kHz	-22dBm	76dB
10 kHz	+4dBm	94dB
15 kHz	+8dBm	92dB
20 kHz	+10dBm	98dB
30 kHz	+10dBm	98dB

FREQUENCY OFFSET	RECIPROCAL MIXING FOR 3dB NOISE	BLOCKING	TX NOISE IN 2.5kHz BANDWIDTH
3 kHz	83dB	-22dBm	-76dBC
5 kHz	87dB	-22dBm	-80dBC
10 kHz	94dB	-20dBm	-88dBC
15 kHz	97dB	-14dBm	-91dBC
20 kHz	101dB	-6dBm	-95dBC
30 kHz	106dB	+3dBm	-100dBC
50 kHz	112dB	+3dBm	-103dBC
100 kHz	119dB	+3dBm	-105dBC
200 kHz	123dB	+3dBm	-106dBC

TRANSMITTER MEASUREMENTS

FREQUENCY	CW POWER OUTPUT	SSB(PEP) POWER OUTPUT	HARMONICS	INTERMODULATION PRODUCTS 3rd order	5th order
1.8 MHz	120W	122W	-55dB	-20dB	-35dB
3.5 MHz	117W	122W	-60dB	-28dB	-36dB
7 MHz	115W	120W	-70dB	-26dB	-38dB
10 MHz	114W	120W	-65dB	-28dB	-38dB
14 MHz	113W	120W	-57dB	-26dB	-40dB
18 MHz	112W	117W	-58dB	-21dB	-35dB
21 MHz	111W	115W	-68dB	-20dB	-32dB
24 MHz	112W	119W	-55dB	-22dB	-38dB
28 MHz	112W	118W	-63dB	-20dB	-35dB
50 MHz	108W	112W	-64dB	-16dB	-26dB

Carrier suppression: 55dB. Sideband suppression: 62dB @ 1kHz. Transmitter noise: see table above. Transmitter AF response at -6dB: 450 - 2600Hz. Transmitter AF distortion: 1%. Microphone input sensitivity: 15mV for full output. T/R switching speed (SSB): mute - Tx 7ms, Tx - mute <1ms, mute - Rx 22ms, Rx - mute 1ms Power into load mismatch: see text.

NOTE: All signal input voltages given as PD across antenna terminal. Unless stated otherwise, all measurements made on SSB with the receiver preamp switched in. All two-tone transmitter intermodulation products quoted with respect to either originating tone.

SSB PERFORMANCE

Although the third and fifth order transmitter distortion products were fairly poor, they are typical of 12V operated PAs. The higher order products were considerably better than most, probably due to the use of power MOSFETs in the PA. The speech processor did not substantially effect the distortion product level.

CW KEYING PERFORMANCE

Fig 2 shows the CW keying waveform with semi break-in at 40WPM and **Fig 3** the equivalent keying spectrum. With full break-in, there was slight character shortening at this speed but overall a very good performance.

TRANSMIT - RECEIVE SWITCHING SPEED

The measured figures should permit satisfactory operation on all data modes.

ON-THE-AIR PERFORMANCE

I USED BOTH RADIOS in place of my normal Icom set-up and in conjunction with my linear. As with other Icom HF rigs, the linear switching contacts are only rated at 16V 2A. I use an additional external relay to switch my Kenwood TL-922 linear which needs a much higher voltage switching capability.

I was quite impressed with the performance of these radios and could find little to fault. The receiver performed well on SSB and CW with adequate sensitivity on the higher bands and good strong signal performance. I could just detect overload on 7MHz during the evenings but this cleared with the preamp switched out. The audio bandwidth seemed a little restricted on SSB, which reflects the rather narrow IF bandwidth on this mode, but was of good communications quality. The AGC performance seemed entirely satisfactory, an improvement over the IC-737 which had a rather short decay time and tended to chop. I found the notch filter disappointing. Although it did not significantly affect the wanted signal, the depth seemed fairly shallow and being an audio based design, it could not prevent a strong carrier from desensitising the receiver.

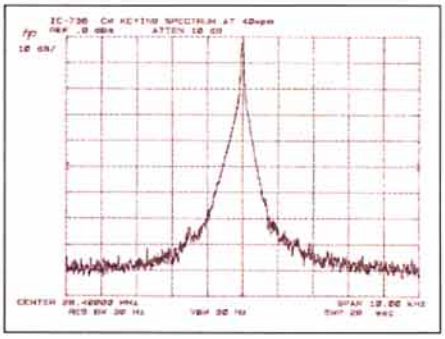


Fig 3: CW keying spectrum at 40WPM. Horizontal 1kHz / division. Vertical 10dB / division.

The transmitter performed very well and good reports were obtained. Full break-in was effective up to quite high speeds and the processor seemed to be clean and provide that extra punch.

The ergonomics were generally good but I continue to dislike the use of auto speed-up which comes into operation at relatively slow tuning speeds. In my opinion, there is really no substitute for a 1000 step per revolution shaft encoder for the main tuning drive (giving 10kHz / revolution with 10Hz step size). Attempts to use cheaper lower resolution encoders together with speed-up and / or switchable step sizes always results in a less friendly system. The tuning is very smooth and is entirely free of clicks or other problems. Split frequency operation is particularly easy to use and the memo pad feature useful. As an equal user of SSB and CW, I am frequently moving between the CW and SSB segments of the bands and I find the use of double band stores for each band a real boon. It seems surprising that this feature has not been included on more radios as it costs virtually nothing to implement.

CONCLUSIONS

OVERALL, I found the IC-736 and IC-738 excellent radios for their price bracket, easy to use with plenty of features, and a very good electrical performance. With full power output available on 6m, the IC-736 will be particularly attractive for the 6m + HF enthusiast. Unfortunately, this band was completely dead during the period of this review.

The current list prices inc VAT are £1649 for the IC-738 and £1969 for the IC-736. The 500Hz bandwidth CW filters cost around £65 for the 9MHz units and £129 for the 455kHz units.

ACKNOWLEDGEMENTS

I WOULD LIKE to thank Icom (UK) of Herne Bay, Kent for the loan of the equipment. ♦