The Peter Hart Review

FT-990

Yaesu HF Transceiver

A COUPLE OF YEARS AGO, Yaesu launched the FT-1000. This top of the range HF base transceiver has been highly acclaimed; setting new standards for performance, features and ease of use [reviewed *RadCom*, June 91]. Hard on the heels of the FT-1000 has come the FT-990. Costing around £1000 less than its bigger brother, the FT-990 has most of the same features but omits the second receiver and associated functions. However, some new features are introduced and several advances in both the transmitter and receiver circuitry.

PRINCIPAL FEATURES

THE FT-990 IS AN AC mains powered HF base station transceiver covering LSB, USB, CW, AM, FM, RTTY and packet operation. Extensive support is provided for the digital modes. RTTY can be in either LSB or USB (for inverting the tones) and packet either 300 baud FSK or 1200 baud AFSK. The receiver tunes 100kHz to 30MHz and transmission is limited to the usual segments around the amateur bands. Many of the features of this radio are common with the FT-1000 in the way that they are implemented.

Separate push buttons are provided for each amateur band and these return the last used frequency, mode, IF bandwidth, clarifier setting etc for each band. The tuning knob uses a magnetic rotary encoder to give 1000 steps per revolution of the knob. Tuning is in steps of 10Hz at 10kHz per revolution on CW, SSB, RTTY and FSK packet. On AM, FM and AFSK packet, the tuning is in 100Hz steps at 100kHz per revolution. A FAST button increases all these rates by a factor of ten and UP/DOWN keys give wider steps of 100kHz or 1MHz. The tuning steps can be doubled for any mode by installing internal jumpers. Another method of setting the frequency is to enter directly from the numeric keypad.

Twin VFOs are provided which can be used for split frequency/band/mode operation and a total of ninety memories are available. The VFOs and memories all store frequency, mode, filter bandwidth and clarifier offset and all memories allow a direct VFO feature. The memories are selected by a click-step rotary control and the contents may be simply previewed whilst continuing to receive on a selected VFO frequency. Switching between VFO and memory, and transferring the contents from VFO to memory or memory to VFO, is simply accomplished by push buttons. Memory scanning is provided with a facility to skip any unwanted memory location during the scan.

> **The FT-990 is to be thoroughly recommended**

The clarifier allows for transmitter and/or receiver offsets up to ±9.99kHz and on FM a ±100kHz repeater offset is selectable. The repeater mode also transmits a continuous 88.5Hz sub-audible access tone.

Four IF filter bandwidths are selectable by separate push buttons. 2.4kHz and 500Hz bandwidth filters are fitted as standard with 2.0kHz and 250Hz available as optional extras. An IF shift control is provided and an IF notch filter. There is no variable-bandwidth IF facility but a comprehensive switched-capacitor audio filter is fitted. This gives independent control of the lower and upper limits of the AF passband with a very steep roll-off and makes a highly versatile filter for SSB and CW use.

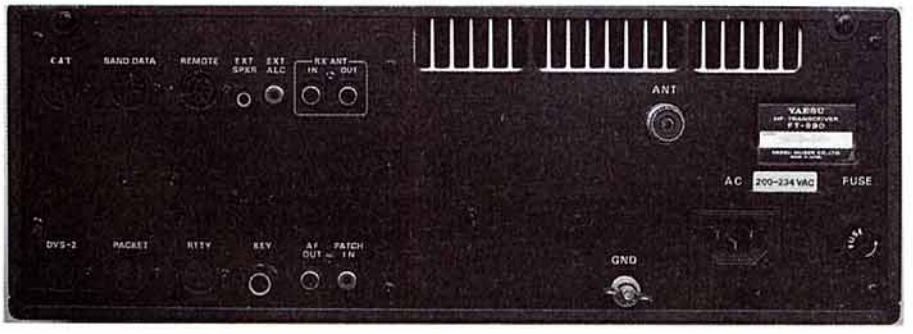
The mode keys also select the last used filter bandwidth and hence it is possible to switch between USB with the 2.4kHz filter and CW with the 500Hz filter by a single key press.

Receive functions include an adjustable noise blanker, switchable 20dB input attenuator, dual speed AGC with automatic speed selection between modes and an all-mode squelch. A front panel push-button allows a separate receive antenna, or a separate receiver, to be selected

The transmitter output power is variable from less than 10W up to 100W and a thermostatic fan is incorporated. On SSB, an RF speech processor is included together with the usual VOX functions. The transmit IF passband may be shifted between -300Hz and +500Hz in much the same way as the receiver IF shift and this enables the transmit passband to be individually tailored to suit the microphone or the operator's voice.

For CW, the pitch is adjustable between 400Hz and 700Hz and a 'SPOT' key allows for accurate netting. Full and semi break-in is provided and a built-in iambic keyer which just requires a keying paddle. The keyer weighting is adjustable via DIP switches buried deep inside the radio to give 16 dot:dash ratios between 1:3 and 1:4.5. A further internal switch allows selection of either iambic mode or 'bug' mode which gives automatic dots with manual dashes. Two parallel keying jacks are provided, one on the front panel and the other on the rear.

A hatch in the top of the case accesses a number of preset modulation and VOX controls together with the RTTY and packet selection options. On RTTY, these options select normal/inverted tones, 170/425/850Hz shift and high tones (2125Hz mark) or low tones (1275Hz mark). For packet, four different tone pairs are selectable to suit different TNCs.



The FT-990 incorporates the same high-speed automatic antenna tuner as used in the FT-1000. This contains 39 memories which automatically store the most recent antenna matching settings for fast recall when the frequency is changed. An analogue meter indicates signal strength on receive and one of six parameters on transmit (ALC, compression, power output, SWR, PA current or voltage). An orange fluorescent display panel indicates the frequency to 10Hz resolution, clarifier offset, memory number and a host of status messages. A 'high SWR' indicator shows when the antenna VSWR is above about 3:1 on transmit.

The rear panel carries six multiway DIN connectors for interfacing to a computer, digital voice recorder, RTTY and packet TNCs and band data for remote switching linear and ATU. The other usual connectors are provided for audio in/out, receive antenna etc, but, as with the FT-1000, no transverter capability. The DVS-2 digital voice system is fully compatible with this transceiver. Although all functions in the radio are powered from 13.8V, only an AC mains input is provided; there is no separate low voltage input.

The computer interface is similar to the FT-1000. Operating at 4800 bit/s, it is very comprehensive and includes digitised meter readout amongst a total of some 25 computer controllable functions and commands.

There is an increasing trend for transceivers to provide more and more personalisation of functions to suit all users. With the FT-990, this is done in two ways. Firstly, there are a number of internal settings which require the case to be removed and in some cases also the PC boards. These settings include mode-specific tuning rates, auto AGC speed, keyer weighting, linear amplifier enable and various output levels for audio, sidetone and beeper. Secondly, a number of functions can be set at power-up or by multiple key presses. These include display options, lock, resetting, beeper pitch etc.

The 45-page operating manual provided with the transceiver is excellent. It is very well written and covers all aspects of use in a very straightforward and highly informative style. Computer programming is fully described, fitting of internal options and user adjustments but no technical or service information other than providing a set of circuit diagrams.

DESCRIPTION

THE FT-990 IS MODERATELY large measuring 368mm(W) by 129mm(H) by 370mm(D) and weighs 13kg. The construction is modular with fully shielded units for the RF PA, ATU and power supply. The bulk of the circuitry is contained on five vertically mounted PC boards which plug into a mother board. This makes them easy to remove for fitting extra IF filters, changing the memory back-up battery etc. The back-up battery is the usual lithium cell with a nominal life of five years. The speaker is 9cm diameter and upward facing through the top of the case as normal.

The receiver is triple conversion with IFs of 47.21 MHz, 10.94MHz and 455kHz. The RF amplifier uses a push-pull pair of FETs and the first mixer uses four FETs in a double balanced configuration. The main selectivity uses crystal filters at the 10.94MHz IF with a single ceramic filter at the 455kHz IF. The

YAESU FT-990 MEASURED PERFORMANCE

RECEIVER MEASUREMENTS

FREQUENCY	SENSITIVITY SSB 10dB s+n:n	INPUT FOR S9
1.8 MHz	0.13µV (-125dBm)	22µV
3.5 MHz	0.13µV (-125dBm)	22µV
7 MHz	0.14µV (-124dBm)	28µV
10 MHz	0.18µV (-122dBm)	32µV
14 MHz	0.18µV (-122dBm)	34µV
18 MHz	0.18µV (-122dBm)	35µV
21 MHz	0.18µV (-122dBm)	35µV
24 MHz	0.18µV (-122dBm)	34µV
28 MHz	0.20µV (-121dBm)	32µV

S-READING (14MHz)	INPUT LEVEL
S1	1.3µV
S3	2.0µV
S5	3.8µV
S7	11µV
S9	34µV
S9+20	420µV
S9+40	4.5mV
S9+60	79mV

	BANDWIDTH	
FILTER	-6dB	-60dB
SSB 2.4kHz	2480Hz	3770Hz
CW 500Hz	510Hz	1140Hz
AM(W), FM	7530Hz	12690Hz

AM sensitivity (28MHz): 1.3µV for 10dBs+n:n at 30% mod depth

FM sensitivity (28MHz): 0.25µV for 12dB SINAD 3kHz pk deviation

AGC threshold: 1.3µV

100dB above AGC threshold for +1dB audio output

AGC attack time: 2ms (see text)

AGC decay time: 0.3-1.0s (fast), 1-2.5s (slow)

Max audio before clipping: 8Ω — 1.2W, 4Ω — 1.7W at 2% distortion

Inband intermodulation products: -30 to -40dB (see text)

	INTERMODULATION (50kHz Tone Spacing)	
FREQUENCY	3rd ORDER INTERCEPT	2 TONE DYNAMIC RANGE
1.8 MHz	+5dBm	94dB
3.5 MHz	+8dBm	96dB
7 MHz	+11dBm	97dB
14 MHz	+14dBm	98dB
21 MHz	+14dBm	98dB
28 MHz	0dBm	88dB

TONE SPACING (7MHz BAND)	3rd ORDER INTERCEPT	2 TONE DYNAMIC RANGE
3 kHz	-29dBm	70dB
5 kHz	-17dBm	78dB
10 kHz	-2dBm	88dB
15 kHz	+4dBm	92dB
20 kHz	+7dBm	94dB
30 kHz	+10dBm	96dB

FREQUENCY OFFSET	RECIPROCAL MIXING FOR 3dB NOISE	BLOCKING	TX NOISE IN 2.5kHz BANDWIDTH
3 kHz	83dB	-23dBm	-74dBC
5 kHz	87dB	-23dBm	-79dBC
10 kHz	93dB	-5dBm	-84dBC
15 kHz	97dB	+3dBm	-86dBC
20 kHz	100dB	+3dBm	-87dBC
30 kHz	105dB	+3dBm	-88dBC
50 kHz	112dB	+3dBm	-89dBC
100 kHz	121dB	+3dBm	-90dBC
200 kHz	128dB	+3dBm	-92dBC

TRANSMITTER MEASUREMENTS

FREQUENCY	CW POWER OUTPUT	SSB(PEP) POWER OUTPUT	HARMONICS	INTERMODULATION PRODUCTS 3rd ORDER	INTERMODULATION PRODUCTS 5th ORDER
1.8 MHz	113W	115W	-62dB	-40dB	-45dB
3.5 MHz	110W	112W	-62dB	-35dB	-44dB
7 MHz	108W	112W	-64dB	-32dB	-38dB
10 MHz	109W	111W	-60dB	-31dB	-38dB
14 MHz	110W	111W	-62dB	-31dB	-38dB
18 MHz	111W	111W	-62dB	-24dB	-36dB
21 MHz	111W	112W	<-70dB	-18dB	-40dB
24 MHz	111W	113W	<-70dB	-16dB	-33dB
28 MHz	113W	116W	-68dB	-18dB	-40dB

Carrier suppression: 55dB. Sideband suppression: 60dB at 1kHz. Transmitter noise: see table above. Transmitter AF response at -6dB: 283-2930Hz. Transmitter AF distortion: <1% at low mic levels. Microphone input sensitivity: 2mV for full output. T/R switching speed (SSB): mute-TX 12ms, TX-mute 4ms, mute-RX 20ms, RX-mute <1ms.

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

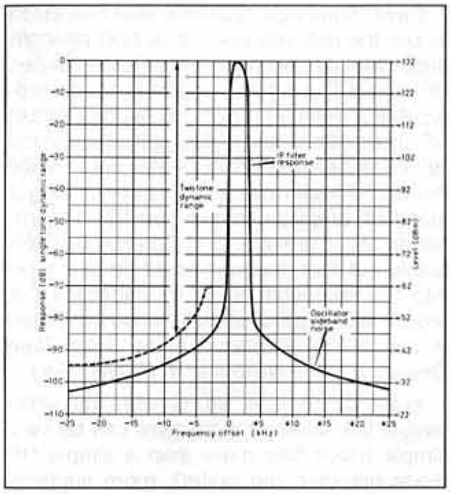


Fig 1: Effective selectivity curve on USB.

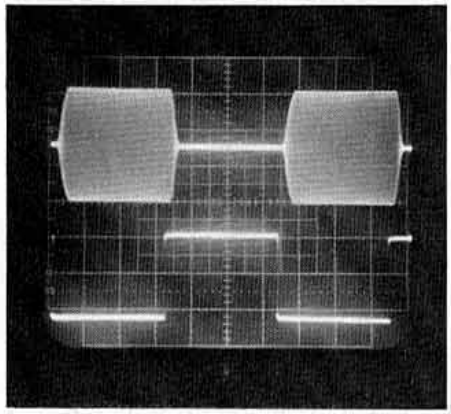


Fig 2: CW keying waveform at 40WPM. Horiz scale 10ms/div.

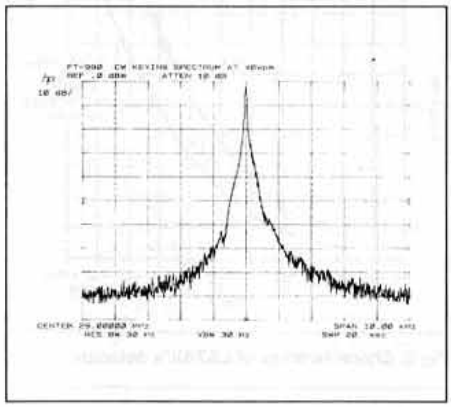
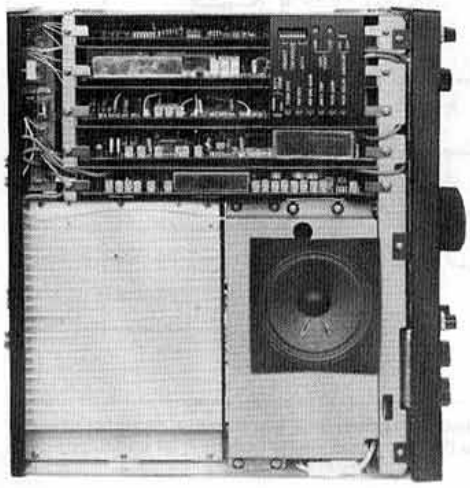


Fig 3: 40WPM keying spectrum. Horiz scale 1kHz/div; vert scale 10dB/div.



optional 250Hz CW filter is a 455kHz crystal filter. On transmit, SSB is generated at 455kHz and mixed through the other IFs to final frequency.

A 10-bit direct digital synthesiser (DDS) generates the VFO in conjunction with phase locked loops to provide the local oscillator source for the first mixers. A second DDS generates the 455kHz carrier oscillator and a total of six microprocessors are used for various control tasks within the radio. The power supply is a switched mode design with no bulky mains transformer and this partly explains why the weight is only half that of the FT-1000.

MEASUREMENTS

THE MEASURED PERFORMANCE of the radio is summarised in the table with additional comments as follows:

RECEIVER MEASUREMENTS

S-METER CALIBRATION

The range and linearity were reasonable and the calibration was the same on all modes.

SPURIOUS REJECTION

The rejection of the first mixer image was in excess of 87dB and rejection of all IFs well in excess of 100dB. There were very few other spurious responses and generally this is an excellent result.

AGC

In the fast position only, the attack time suffered considerable overshoot. This characteristic was also observed with the FT-1000.

STRONG SIGNAL PERFORMANCE

Very good figures were measured for the third order intercept, close-in dynamic range and reciprocal mixing performance. Indeed, all these figures measured a few dB better than the FT-1000 sample reviewed last June. In particular, the close-in dynamic range was noticeably better.

The inband intermodulation performance improved markedly with the RF gain control reduced.

SELECTIVITY

The optional filters were not fitted to the review transceiver. The receiver gain, as indicated by the S-meter reading, dropped about 5dB when the 500Hz filter was selected. Although the 'digital' audio filter was not measured, its performance seemed very good.

Fig1 shows the effective selectivity curve on USB.

TRANSMITTER MEASUREMENTS

POWER OUTPUT

The figures given in the table are measured at maximum output but the power was variable down to about 8W. With the ATU in circuit, power levels were about 15% less. Into a mismatched load, 80-100W was produced into a 2:1 VSWR and 40-50W into a 3:1 VSWR. Into these mismatches, the ATU restored the power to about 80-90W output. The power output reading on the front panel meter was generally about 5-10% low.

SPURIOUS OUTPUTS

The second harmonic was around 10dB worse than the third harmonic which is given in the table. Non-harmonic spurious outputs were generally -70 to -80dB although somewhat worse on some bands (-52dB on 24MHz)

SSB PERFORMANCE

The distortion figures on the higher bands could be improved substantially by reducing power to 80W output. The speech processor degraded the 3rd order products but not the wideband products.

CW KEYING PERFORMANCE

Fig 2 shows the keying waveform on semi break-in and **Fig 3** the equivalent keying spectrum, both at 40WPM. There was a slight shortening of the characters on full break-in.

ON-THE-AIR PERFORMANCE

I WAS VERY PLEASED with the performance of this radio during on-air tests. This included the 80m AFS contest when some 215 QSOs were made during the four hour event running 'barefoot' to a dipole at 12-15ft(4-5m) height. The receiver functioned faultlessly in all situations with good sensitivity and no observed strong signal problems.

Switched mode power supplies can be notorious for generating spurious signals but there was no trace of noise or spurii on any frequency, even at LF. There was, however, a very slight buzz on the speaker or headphones, audible only at minimum volume and unnoticeable during normal operation. The 'digital' audio filter was excellent with a very steep roll-off and, having full control over the upper and lower passband limits, is usable for both SSB and CW. It is one of the most useful audio filters I have used on any radio.

Good quality transmit reports were received on both SSB with the MH-1B8 hand microphone and on CW. QSK was effective to quite high speeds and the internal keyer has a speed range from about 12WPM up to in excess of 50WPM.

The ergonomics were superb and I cannot find fault with the way that any of the functions have been implemented. Every function was quick and easy to select, well positioned on the front panel, and the tuning drive was 'silky smooth'. There were no audible clicks on the synthesiser and the fast tuning characteristic was excellent. The fan is rather noisier than most but only comes on rather infrequently except during prolonged transmit periods.

CONCLUSIONS

THE FT-990 CAN BE thoroughly recommended. It has an excellent electrical performance and ergonomically every function is very easy to use. It is basically the FT-1000 but without the second receiver and without the extra transmit power. The current list price is £1895 inc VAT with the additional IF filters costing £42 for the 2kHz narrow SSB filter and £76 for the 250Hz narrow CW filter. Perhaps this is my only criticism: the price is rather high for a rig without a dual receiver.

ACKNOWLEDGEMENTS

I WOULD LIKE TO THANK South Midlands Communications Ltd of Eastleigh, Hants for the loan of the equipment.

Peter Hart, G3SJX