

Kenwood TS-2000

HF, VHF and UHF Transceiver

Reviewed by Peter Hart, G3SJX*

IT IS four years since Kenwood last released a new HF transceiver model on to the amateur market and now the recent launch of the TS-2000 multimode HF / VHF / UHF radio has attracted much interest. Covering all 13 bands from 160m - 23cm (the latter band as an optional extra) it adopts the same extensive IF and AF DSP functions first seen in the TS-870 model. It also provides full satellite capability and *DX Cluster* monitoring as well as a host of other goodies, so that this single radio can satisfy virtually all amateur radio communication requirements. The radio is available in two versions, either as a conventional standalone unit (TS-2000) or as a black box minus the control panel (TS-B2000) for use with a personal computer or a remote mobile controller. Functionally, these two versions are identical.

PRINCIPAL FEATURES

THE TS-2000 is 12V operated with a peak current drain of around 21A. It is a middle-sized radio measuring 281 x 107 x 371mm and weighs about 7.6kg. The TS-B2000 remote control version is a little less deep as the front panel is a blank cover but the main body of both units is identical. USB, LSB, CW, FSK, AM and FM modes are selectable with normal or reverse sideband on CW and FSK. Wide or narrow bandwidth FM and AM is selectable, and on FM the deviation is also switched corresponding to 25kHz or 12.5kHz channel requirements.

The main receiver tunes continuously from 30kHz to 60MHz with the transmitter enabled only within the exact amateur band allocations. There are different model variants for Europe and the Americas. On 2m, 70cm, and 23cm where fitted, both receiver and transmitter cover just the amateur bands (the receive coverage can be expanded by



a dealer modification). A second receiver (sub receiver) is provided covering 2m and 70cm on AM and FM modes only and operates simultaneously with the main radio operating on any band or mode, even on transmit providing that the transmit band is not the same as the sub receiver band. Up / Down keys step between bands, returning a single set of last used frequency and mode per band. It is possible to set break points to switch the mode automatically according to frequency, for example the CW and SSB sectors of each band.

The 45mm diameter tuning knob tunes in 10Hz steps at 10kHz per revolution on SSB, CW and FSK with 100Hz steps on FM and AM. A 1Hz step is also selectable for fine tuning.

A click-step rotary provides rapid navigation around the bands in a variety of user-settable step sizes, eg 12.5kHz steps for FM, 5 or 9kHz for broadcast AM, and 5kHz on SSB / CW. 1MHz steps are selected at the push of a button to move rapidly around the general coverage frequencies. The usual twin VFOs are included which are needed for split frequency operation with a button to check and set the transmit frequency. Both frequencies are displayed in split mode. The frequency may be entered directly from a numeric keypad, and RIT or clarifier oper-

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ating on transmit and / or receive covers offsets to ± 20 kHz.

There are 300 memories provided for storing receive and transmit frequencies, modes and tone data. The memories may be tagged with a seven-character label with a very comprehensive character set and may be allocated to one of 10 group numbers. The memory bank can then be selectively searched by one or more group numbers. 10 of the

memory channels are allocated to scan ranges or restricted VFO tuning limits. A quick memory feature allows up to 10 frequencies to be quickly stored and recalled by a simple key press, on the basis of last-in, first-out. The memory management and transfer facilities are very comprehensive but quite complex requiring eight pages of the manual to describe in full.

Various scan modes and selectable scan parameters are provided for VFO scanning, memory scanning, memory group scanning etc. One call channel for rapid access may be set for each band group HF, 6m, 2m, 70cm and 23cm and these can be included within the scan. A novel visual scan mode displays the scan results as a bargraph display of signal strength against frequency or channel. A switchable preamplifier and input attenuator for weak / strong signal situations is provided with of course different preamplifiers and attenuators for the different frequency ranges. The CW pitch is adjustable over the range 400 - 1000Hz to suit personal preferences and an IF noise blanker (non DSP) for pulse interference is also fitted. Receiver functions associated with DSP are described later in this review.

The transmit power is fully settable from 5W up to 100W on all bands from 160m to 2m with 50W on 70cm and 10W on 23cm. On SSB audio response tailoring is provided with VOX, speech processing and trans-



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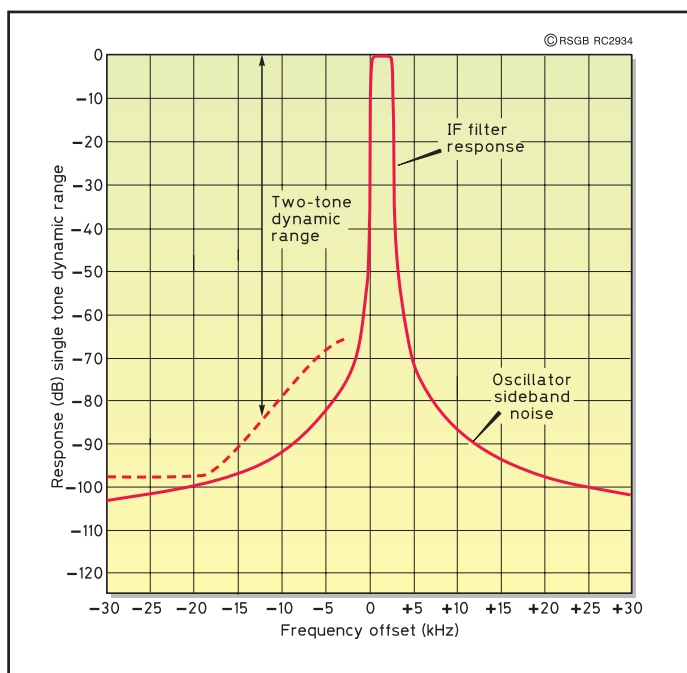


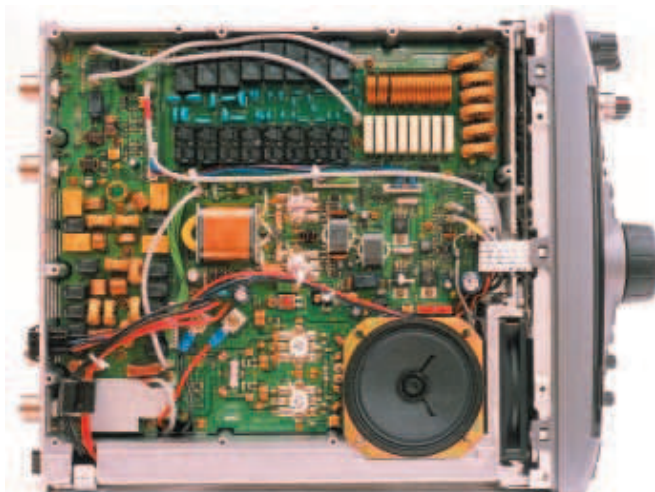
Fig 1: Effective selectivity curve on USB.

mission monitoring, and on CW a full memory keyer with separate key jack is included, and full or semi break-in with adjustable rise and fall time shaping. The keyer accommodates various weighting and keying paddle arrangements, and three 50-character stores. The messages can auto-repeat and also be interrupted for insertion of data such as contest serial numbers. Other features include a TCXO with 0.5ppm accuracy fitted as standard for accurate frequency control, metering of the usual parameters, a transmission timeout timer and auto-power off.

On HF and 6m, a front panel pushbutton selects between two antenna sockets, the setting being stored with the band stores. Also on these bands a separate receive antenna may be used such as a loop or a Beverage although switching is via the user menu set-up. An auto ATU is built-in matching up to 3:1 VSWR and covers all bands including 6m. A 'T' network is used with relays switching capacitor and inductor values in binary sequence to implement a compact and fast tuning ATU. 22 preset tuning settings are stored giving one to three settings per band. Separate antenna sockets are provided for 2m, 70cm and 23cm (when fitted). Separate linear switching and control is provided for HF, 6m, 2m, 70cm and 23cm with selectable delays to accommodate fast or slow switching amplifiers.

for IF as well as AF based functions. This enables great flexibility to be achieved with the channel filtering without the need for expensive crystal filters. The main receiver is a quadruple superhet with a first IF of 69 or 76MHz on HF / 6m, 42MHz on 2m / 70cm and 135MHz on 23cm, and following IFs of 10.7MHz, 455kHz and 12.0kHz. The sub receiver is double conversion with 58MHz and 455 kHz IFs. IF DSP is implemented at the 12.0kHz IF and provides all channel filtering functions, modulation, demodulation, 20 selectable AGC time constants and IF auto-tuning notch. The default bandwidth on SSB is 300 to 2600Hz but the low frequency cut-off is selectable from 0 to 1000Hz (12 steps) and high frequency cut-off from 1.4kHz to 5kHz (12 steps). Four low and four high frequency cut-offs are available on AM. There are 11 bandwidth selections on CW (50Hz to 2000Hz) and four on FSK (250Hz to 1500Hz) and passband shift is implemented on these modes but not linked to CW pitch. All bandwidth settings are shown graphically on the front panel display.

Audio functions use a separate DSP, although of the same type, and provide an audio notch filter (both auto and manual adjustable), two noise reduction modes (Line Enhancement for SSB and SPAC for CW) and FM receive bandwidth tailoring. On transmit six different audio bandwidth settings are selectable and six profiles to accommo-



Top view with covers removed showing PAs, filters and ATU.

DSP FUNCTIONS

THE TS-2000 is one of a select group of radios which uses DSP

date different microphone characteristics. Speech processing is available on all voice modes and is also handled via the DSP function.

DATA MODES

THE TS-2000 has a number of features for supporting digital modes. For FSK RTTY, the shift, polarity and tone frequency are settable, and AFSK using voice modes is accommodated with suitable interfacing. A packet TNC for 1200 or 9600 baud is built-in which uses a reduced command set (39 commands) not supporting digipeating or some of the enhanced commands. The radio also accommodates interfacing to external TNCs and provides a number of adjustable parameters for TNC set-up. The internal TNC may be used with either the main or sub receiver and interfaces to a PC via the RS-232 COM port on the rear panel. This same interface also provides full remote control of the radio and data transfer to a second radio used for instance to pass data from a spotting radio to the running radio in a contest situation.

The built-in packet TNC is used in conjunction with the sub-receiver to provide *DX Packet Cluster* monitoring. Connecting to a node is not supported but by monitoring cluster channels, incoming 'spots' are displayed on the front-panel LCD one at a time, with the most recent 10 being stored in quick memory format for easy recovery. A single button press will set the main receiver to the spotted frequency and this can even be done automatically. Incoming spots can be announced in Morse code or in voice with the voice synthesiser option fitted.

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VHF / UHF AND SATELLITE

FM REPEATER operation is fully supported with toneburst, CTCSS tone access and automatic offset selection according to the standard band plan (2m only). Automatic simplex check (ASC) periodically monitors the repeater input and flags when direct contact is possible. For general FM use, full CTCSS operation is provided with tone frequency ident, DCS (digital coded squelch) with code ident and DTMF tones can be stored and sent. Different tones and codes can be assigned to the main and sub receivers.

The audio output from the main and sub receivers can be processed in a number ways. Apart from outputting through the internal 7.5cm speaker, the audio signals can be fed separately to twin external speaker sockets or left and right headphone outputs, or mixed in equal or weighted proportions with internal speaker muted or not. The radio also supports transverter operation where the transverted frequency can be directly displayed up to 19.999GHz. Hence direct frequency readout can even be obtained on the 13, 9, 6 and 3cm bands, making this radio a true 'DC to light' controller!

In satellite mode the radio operates in full duplex within band groups HF + 6m, 2m, 70cm and 23cm where the uplink and downlink frequencies lie in different band groups. Any mode can be used and the uplink and downlink frequencies tracked in a forward or reverse direction, fine tuned to allow for Doppler shift and swapped to allow for uplink checking. The various settings can be stored in satellite memory which can be tagged with an eight-character name. Up to 10 satellite settings can be stored. Note that satellite mode could also be used for terrestrial full duplex, a function which can also be achieved on FM using the sub receiver and main transmitter.

OTHER SPECIAL FEATURES

A VAST AMOUNT of customisation is provided both through the extensive menu set-up and on individual controls. The entire radio can be remotely controlled from a PC and Kenwood provide a Windows driven software package as an option on CD-ROM for this purpose (ARCP-2000). This is the standard supplied user interface for the TS-2000.

Two optional units were provided with the review radio, the VS-3 voice synthesiser and DRU-3A digital recording unit. These are remarkably small in size and easy to install. The voice synthesiser will read out frequencies, memory channel contents and S-meter readings. The digital recording unit functions on transmit only and is useful for repeated contest calls. One 30s and two 15s message stores are provided which

can be linked and cascaded for longer messages and automatically set to repeat.

MEASUREMENTS

THE RADIO SUPPLIED was not fitted with 1.2GHz. Measurements are given in the table when powered from a 13.5V supply with additional comments as follows.

Receiver Measurements

The rejection of images and all IF frequencies was very good, in excess of 90dB and other spurs very low. The filter bandwidths in the table are a representative selection of available bandwidths. The 6:50dB shape factors are excellent but at -60dB somewhat compromised by reciprocal mixing noise and possibly other effects. The front end dynamic range was good at 20kHz offset, but degraded very significantly close-in which is a danger with back-end channel filtering. The reciprocal mixing figures were fairly poor close-in but much better / excellent further out. The combined selectivity plot is shown in Fig 1 opposite.

Transmitter Measurements

The power output figures in the table were measured with the ATU out of circuit. The ATU introduced a fairly high loss of about 10 - 20%, lowest on 50MHz. SSB two-tone distortion levels were rather high but improved significantly at lower powers. The CW keying characteristic was excellent with low distortion and nicely shaped, particularly with 6ms rise / fall times.



ON-THE-AIR PERFORMANCE

THE INITIAL CONFRONTATION with the TS-2000 can be a bit daunting as it is packed with so many features and multifunction buttons that it takes some time with the manual to become fully acquainted with its operation. Fortunately the 143-page manual is very comprehensive, well written and extensively indexed. The radio is nicely styled and largely easy to use, although I found some of the lesser-used functions not so obvious in the short period I had the radio for review. For example memory operations, which I sometimes overwrote by pushing the wrong button, a comment I am sure I would change with greater familiarity. It is fitted with a bright, clear and easy-to-read display with an exceptionally wide viewing angle for an LCD. The tuning speeds were about right and without the need for speedup. There did seem to be a slight roughness to the synthesiser tuning at speed which disappeared on slowing the tuning rate.

The overall performance was good, the filters and notches were excellent and the narrow CW filters gave minimal ringing. The armoury of filters was particularly useful in combating difficult conditions, and at the other extreme it was a pleasure to open up the bandwidth on strong signals and enjoy the improved quality. Providing the preamplifier was not used at LF, there were no real overload problems although the radio seemed slightly noisy in crowded conditions as the close-in measurements might suggest. On transmit, CW break-in was clean and audio reports were excellent. 19 QSOs made on different band / mode combinations with the recent D68C expedition is a good testimonial for this radio. The results on the broadcast AM bands were good and the performance on VLF at 136kHz and lower down on the time and frequency standard transmissions was particularly clean.

Although I did not have a chance to make QSOs in satellite mode, it seemed effective and easy to operate. The *Packet Cluster* mode was novel but with a one-line scrolling display not so effective for serious use. Now that the *Cluster* network is internationally connected, spots arrive too rapidly on a typical weekend - particularly if there is a contest in full swing - for one spot to be fully displayed before the next arrives. Even delving into the memories to retrieve details does not help, as the memory contents are constantly changing. This is where controlling the radio from the ARCP-2000 software really scores. Incoming spots are tabulated and by scrolling down the list, pointing and clicking with the mouse to the selected spot the radio is set on channel. The auto mode setting function can really help here. Unfortunately the sender information is not displayed and the comments field is truncated after 20 characters. In other aspects the ARCP-2000 software also worked well although the VFO tuning was too slow and best handled directly by the radio. Greater advantage could have been taken of the flexibility of a PC display, for example tabulating and scrolling the memories with point and click selection.

CONCLUSIONS

THE TS-2000 IS A most interesting and effective radio, providing in one unit all the communication needs for the amateur with the widest of interests. It is the only radio on the market covering 160m to 23cm, with all modes including satellite and packet. At around £1700 with £300 extra for 23cm, it is excellent value with a high level of features and performance. When available, the 'black box' version will be a little less.

My thanks to Kenwood Electronics UK for the loan of the radio. ♦

KENWOOD TS-2000 MEASURED PERFORMANCE OVER PAGE

KENWOOD TS-2000 MEASURED PERFORMANCE

RECEIVER MEASUREMENTS

FREQ	SENSITIVITY SSB 10dBs+n:n		INPUT FOR S9	
	PREAMP IN	PREAMP OUT	PREAMP IN	PREAMP OUT
136 kHz	2.0µV (-101dBm)	4.0µV (-95dBm)	350µV	1.1mV
1.8MHz	0.20µV (-121dBm)	0.56µV (-112dBm)	45µV	180µV
3.5MHz	0.18µV (-122dBm)	0.50µV (-113dBm)	40µV	180µV
7MHz	0.16µV (-123dBm)	0.50µV (-113dBm)	35µV	160µV
10MHz	0.16µV (-123dBm)	0.50µV (-113dBm)	32µV	160µV
14MHz	0.16µV (-123dBm)	0.50µV (-113dBm)	35µV	160µV
18MHz	0.13µV (-125dBm)	0.45µV (-114dBm)	28µV	160µV
21MHz	0.14µV (-124dBm)	0.45µV (-114dBm)	28µV	160µV
24MHz	0.11µV (-126dBm)	0.40µV (-115dBm)	22µV	130µV
28MHz	0.10µV (-127dBm)	0.40µV (-115dBm)	22µV	140µV
50MHz	0.10µV (-127dBm)	0.63µV (-111dBm)	20µV	250µV
144MHz	0.10µV (-127dBm)	0.90µV (-108dBm)	7µV	130µV
432MHz	0.10µV (-127dBm)	0.56µV (-112dBm)	6.3µV	90µV

Spacing	CLOSE-IN INTERMODULATION ON 7MHz BAND			
	PREAMP IN		PREAMP OUT	
	3rd order intercept	2 tone dynamic range	3rd order intercept	2 tone dynamic range
3kHz	-35dBm	65dB	-23dBm	66dB
5kHz	-32dBm	67dB	-20dBm	68dB
7kHz	-28dBm	70dB	-15dBm	72dB
10kHz	-17dBm	77dB	-4dBm	79dB
15kHz	+2dBm	89dB	+14dBm	91dB
20kHz	+8dBm	94dB	+24dBm	98dB
30kHz	+11dBm	95dB	+24dBm	98dB
40kHz	+11dBm	95dB	+24dBm	98dB
50kHz	+11dBm	95dB	+24dBm	98dB

FILTER	IF BANDWIDTH		
	-6dB	-50dB	-60dB
SSB 2.3kHz	2370Hz	3200Hz	5390Hz*
AM 5kHz	12.1kHz	15.3kHz	16.5kHz
AM-narrow	2700Hz	3760Hz	4810Hz
FM	16.8kHz	24.2kHz	25.7kHz
FM-narrow	11.9kHz	18.3kHz	19.8kHz
CW 600Hz	645Hz	1340Hz	1660Hz
CW 400Hz	430Hz	890Hz	1340Hz
CW 200Hz	215Hz	505Hz	735Hz
CW100Hz	130Hz	310Hz*	310Hz*
CW 50Hz	65Hz	265Hz*	265Hz*

* see text

Freq	INTERMODULATION (50kHz Tone Spacing)			
	PREAMP IN		PREAMP OUT	
	3rd order intercept	2 tone dynamic range	3rd order intercept	2 tone dynamic range
136kHz	+14dBm	83dB	+15dBm	79dB
1.8MHz	+9dBm	93dB	+13dBm	90dB
3.5MHz	+9dBm	93dB	+15dBm	91dB
7MHz	+11dBm	95dB	+24dBm	98dB
14MHz	+5dBm	92dB	+19dBm	94dB
21MHz	+7dBm	94dB	+23dBm	98dB
28MHz	+1dBm	92dB	+22dBm	98dB
50MHz	-4dBm	88dB	+20dBm	94dB
144MHz	-20dBm	78dB	+6dBm	82dB
432MHz	-15dBm	81dB	+9dBm	87dB

FREQUENCY OFFSET	RECIPROCAL MIXING FOR		
	3dB NOISE	BLOCKING PREAMP IN	BLOCKING PREAMP OUT
3kHz	71dB	-38dBm	-22dBm
5kHz	78dB	-38dBm	-22dBm
10kHz	90dB	-35dBm	-19dBm
15kHz	96dB	-23dBm	-7dBm
20kHz	99dB	-13dBm	+3dBm
30kHz	103dB	-4dBm	>+6dBm
50kHz	108dB	-4dBm	>+6dBm
100kHz	114dB	-4dBm	>+6dBm
200kHz	120dB	-4dBm	>+6dBm

S-METER READING (7MHz)	INPUT LEVEL SSB	
	PREAMP IN	PREAMP OUT
S1	1.4µV	6µV
S3	2.2µV	10µV
S5	4µV	18µV
S7	10µV	45µV
S9	35µV	160µV
S9+20	400µV	1.8mV
S9+40	4.5mV	20mV
S9+60	32mV	140mV

AM sensitivity (28MHz): 0.5µV for 10dBs+n:n at 30% mod depth
 FM sensitivity for 12dB SINAD 3kHz pk deviation:
 Main RX 144MHz: 0.16µV
 Sub RX 144MHz: 0.16µV
 Main RX 432MHz: 0.16µV
 Sub RX 432MHz: 0.16µV
 AGC threshold: 0.9µV
 100dB above AGC threshold for +0.5dB audio output
 AGC attack time: 2 - 4ms
 AGC decay time: 0.1 - 3s (variable)
 Max audio before clipping: 1.7W into 8Ω, 2W at 10% distortion
 Inband intermodulation products: -30 to -45dB

FREQ	CW POWER OUTPUT	SSB(PEP) POWER OUTPUT	HARMONICS	INTERMODULATION PRODUCTS	
				3rd order	5th order
1.8MHz	96W	100W	-74dB	-26 (-20)dB	-36 (-30)dB
3.5MHz	100W	104W	-70dB	-30 (-24)dB	-42 (-36)dB
7MHz	101W	105W	-60dB	-31 (-25)dB	-46 (-40)dB
10MHz	101W	104W	-70dB	-28 (-22)dB	-44 (-38)dB
14MHz	101W	104W	-76dB	-27 (-21)dB	-42 (-36)dB
18MHz	101W	104W	-62dB	-28 (-22)dB	-44 (-38)dB
21MHz	101W	104W	-70dB	-28 (-22)dB	-42 (-36)dB
24MHz	101W	104W	-65dB	-26 (-20)dB	-50 (-44)dB
28MHz	101W	104W	-74dB	-28 (-22)dB	-46 (-40)dB
50MHz	101W	104W	-74dB	-21 (-15)dB	-31 (-25)dB
144MHz	104W	108W	-75dB	-24 (-18)dB	-36 (-30)dB
432MHz	51W	52W	-72dB	-22 (-16)dB	-36 (-30)dB

Two-tone transmitter intermodulation product levels are quoted with respect to PEP, figures in brackets are with respect to either tone.

TRANSMITTER MEASUREMENTS

Carrier suppression: <-60dB
 Sideband suppression: <-75dB @ 1kHz
 Microphone input sensitivity: 0.3mV for full output
 SSB T/R switch speed: mute-TX 12ms, TX-mute 3ms, mute-RX 25ms, RX-mute 2ms

NOTE: All signal input voltages given as PD across antenna terminal. Unless stated otherwise, all measurements made on SSB with receiver preamp switched in.