Reviewed by Peter Hart, G3SJX

The Willows, Paice Lane,
Medstead, Alton, Hants GU34 5PR

Ten-Tec Orion HF

Ten-Tec has acquired a reputation for making radios with a good RF performance and catering particularly for the needs of the CW operator. Over the years, their top-end flagship models have excelled, particularly when it comes to handling the challenging competitive environment of hectic contest or DX working. The Corsair and Omni series, culminating in the Omni-VI, were developed to provide an impeccable adjacent channel performance at the expense of broadband coverage, whereas other manufacturers had taken the broadband 'bells and whistles' approach.

Ten-Tec has now launched a new top-end radio pushing the state of the art to a higher plateau and combining the very best of both narrow band and broadband approaches. The new Orion is targeted as a home station radio with a 100W transmitter and two independent and fully-featured receivers. One receiver covers amateur bands only and is optimised for highest performance whereas the second receiver provides general coverage operation.

Although the Orion has been available in the USA since early in 2003, it has only recently received CE approval for sales within Europe. It is available in two versions, model 565 without auto ATU and model 565AT with internal auto ATU fitted.

BASIC FUNCTIONS

The Orion is a large table-top sized 12V operated radio measuring 432W x 133H x 476Dmm and weighs about 9.2kg. Although, from the amount of space inside the cabinet, the radio could have been made significantly smaller, the larger format makes for an easy to use and clearly laid out panel with spacious buttons and good-sized controls. The main receiver and transmitter tune the 160m to 10m amateur bands (including the new 60m allocation) with a little overlap. The second or sub receiver tunes from 100kHz to 30MHz, although the sensitivity drops sharply below 1MHz making the receiver unusable at the lower frequencies. Modes covered are USB, LSB, CW (upper and lower sideband), AM, FM and FSK.

In common with the Jupiter transceiver [see review in January 2004 *RadCom - Ed*], the firmware in the Orion may be upgraded from the Ten-Tec website so the transceiver need never be out of date. To support this approach, all controls on the front panel are software addressable, either push buttons or rotary encoders. An array of 27 buttons around the LCD panel provides a high level of customisation and adjustment to suit different operating conditions and preferences. In some cases these are menu selectable and in other cases dependant on mode or other context but all are easy to access; never more than a couple of button presses are needed. Up to five user profiles may be stored and recalled at the press of a button.

The rear panel carries an extensive array of interface connectors. There are two main antenna sockets and a receive-only antenna socket and these may be freely assigned to any receiver / transmitter combination and stored against the band selection settings. There is a transverter output (+15dBm) with control, audio line output, auxiliary interfacing to PC sound cards and for FSK keying, RS-232 serial data port for computer control and firmware upgrading and extensive support for both QSK and non-QSK linears. Control for two separate linears is provided, one associated with each antenna socket, and there are two separate band data output controllers. Linear control is very comprehensive, supporting hardware QSK keying loops and user control of sequencing delays and drop-back times.

The Orion transceiver is provided with various plugs and leads including a full accessory jack lead and a microphone plug, although the microphone is an extra. The radio accommodates most microphone types including electret and Ten-Tec supplies hand and desk models. The radio is shipped with a 60-page operator's manual which covers the set-up and operation of the controls. Circuit schematics are freely downloadable from the Ten-Tec technical support website together

with various application notes, firmware upgrades and a software programmer's guide.

RADIO DESIGN

Both receivers in the Orion use a triple superhet architecture. The main receiver covering just the amateur bands has IFs of 9MHz, 450kHz and 14kHz. Although the main channel selectivity is achieved by DSP at the 14kHz IF, a range of narrow roofing filters is selectable immediately following the first mixer, which ensures the very best close-in dynamic range is achieved. Narrow preselection filters are used in the front end, a separate filter for each band, a switchable bipolar RF amplifier and a quad of four JFETs for the first mixer. The main receiver's synthesiser uses a PLL operating in the 400 - 500MHz region with a DDS driven reference. This is then divided down to the required first mixer local oscillator frequency using high-speed dividers. This technique ensures very low close-in phase noise.

The Sub receiver has IFs of 45MHz, 455kHz and 14kHz and uses circuitry similar to the Jupiter. The receiver front end uses half octave switchable bandpass filters, a push-pull FET first mixer and three parallel FETs in the RF amplifier. The RF amplifier is in circuit all the time but there is a switchable attenuator for very strong signal situations. Conversion to the second and third IFs uses diode balanced mixers. The local oscillator drive for the first mixer is derived from a single loop PLL tuning in 2.5kHz steps. The smaller tuning step sizes are

"Truly awesome performance" says Peter Hart. Find out what precisely he was enthusing about in this, the first UK full technical review of Ten-Tec's long-awaiting new flagship model, the Orion.

transceiver

accommodated within the DSP. Hence the signals within the IFs move by up to 2.5kHz.

Both receivers use identical DSP IF and back-end circuitry with identical features. 24-bit A/D converters are used to drive the two 32-bit floating point DSPs. AGC is applied mainly within the DSP but a separate second loop around the first and second IFs comes into operation with strong signals. A built-in TCXO reference ensures good frequency accuracy and stability.

The radio is constructed around a sheet aluminium frame with four compartments top and bottom. The PA unit on the rear panel is fitted with a heatsink but no fan. The radio runs sufficiently cool under normal circumstances without a fan. The 4in high quality speaker in the case top is a much larger and more substantial unit than is fitted in most radios.

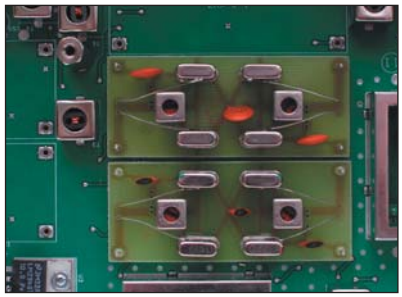
DUAL RECEIVERS

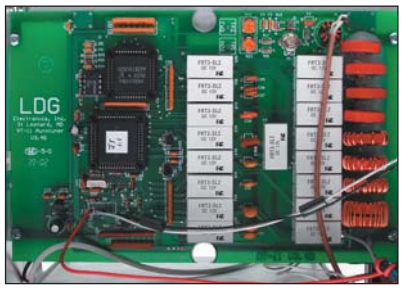
The radio is fitted with two VFOs which may be assigned to either receiver or transmitter in any combination. The two 50mm diameter tuning knobs tune in a variety of step sizes from 1Hz to 100kHz at 62 or 250Hz steps per knob revolution and a button press increases the step size normally by a factor of 10 for rapid band navigation. Individual buttons select the amateur bands, but only for VFO A. Changing bands for VFO B is less convenient, involving swapping back and forth between A and B: this must surely be something for Ten-Tec to address in a future software upgrade. The band buttons scroll through four separate settings per band which can be useful if you operate regularly on several different modes.

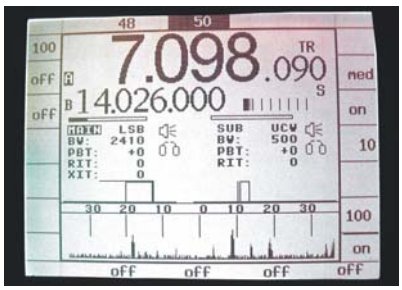
Both VFO frequencies are continuously displayed to 1Hz resolution and both can be entered directly from the band buttons which double as a numeric keypad. 200 simple memories store frequency and mode associated with either of the VFOs and are easy to scroll and select. The main receiver is fitted with a conventional analogue S-meter which indicates power on transmit but the Sub receiver is only provided with a small uncalibrated bargraph on the LCD panel.

Most of the receiver functions can be set independently for the two receivers. This includes all the bandwidth and noise reduction facilities, RIT / XIT, RF gain, switchable input attenuator, squelch and AGC. The AGC has three preset settings of fast, medium and slow and a fully programmable setting. In all cases the decay rate, hang time and threshold level are all adjustable. The threshold level is in effect an IF gain control and can be set as low as 0.37µV. This shows potentially a very high gain in the signal path, sufficient for AGC to act on noise alone. The manual goes into great detail about the importance of setting the AGC parameters to enhance signal readability under extreme conditions. It is true that carefully tweaking the AGC parameters can noticeably enhance readability but I am sceptical about the reasons for this. It seems to me that the AGC can be made to introduce an element of non-linear signal slicing.

The two receivers have separate audio gain controls and the audio outputs can be routed in a number of ways, either combined or kept separate to headphone or auxiliary outputs. One interesting feature is the binaural panoramic stereo feature when used with stereo headphones. This can be used with either receiver and helps in a CW pileup by presenting a spatial separation of signals within the audio passband. Diversity reception is also possible by setting the two receivers on the same frequency, eg using a common VFO, and having separate antennas for the







The Orion's IF roofing filters.

The LDG automatic ATU board.

The LCD panel showing the spectrum display.

Orion LCD panel showing the receiver menu.

A plethora of sockets on the rear panel.

TEN-TEC ORION MEASURED PERFORMANCE

RECEIVER MEASUREMENTS

	SENSITIVITY SSB 10dBs+n:n			INPUT FOR S9	
FREQUENCY	PREAMP IN	PREAMP OUT	SUB RX	PREAMP IN	PREAMP OUT
1.8MHz	0.35µV (-116dBm)	0.90µV (-108dBm)	0.70µV (-110dBm)	25µV	100µV
3.5MHz	0.28µV (-118dBm)	0.70µV (-110dBm)	0.40µV (-115dBm)	18µV	80µV
5.4MHz	0.25µV (-119dBm)	0.70µV (-110dBm)	0.45µV (-114dBm)	20µV	80µV
7MHz	0.32µV (-117dBm)	0.90µV (-108dBm)	0.35µV (-116dBm)	20µV	90µV
10MHz	0.35µV (-116dBm)	0.90µV (-108dBm)	0.45µV (-114dBm)	22µV	90µV
14MHz	0.28µV (-118dBm)	0.70µV (-110dBm)	0.40µV (-115dBm)	20µV	90µV
18MHz	0.32µV (-117dBm)	0.90µV (-108dBm)	0.45µV (-114dBm)	25µV	100µV
21MHz	0.40µV (-115dBm)	1.3µV (-105dBm)	0.45µV (-114dBm)	32µV	125µV
24MHz	0.50µV (-113dBm)	1.6µV (-103dBm)	0.50µV (-113dBm)	28µV	125µV
28MHz	0.50µV (-113dBm)	1.8µV (-102dBm)	0.45µV (-114dBm)	22µV	100µV

AM sensitivity (28MHz): 3.5µV for 10dBs+n:n at 30% mod depth
FM sensitivity (28MHz): 1.8µV for 12dB SINAD 3kHz pk deviation
AGC attack time: 2 - 3ms
AGC decay time: 250ms (fast), 500ms (med), 1.5s (slow) + variable
Max audio at 10% distortion: 2.0W into 4Ω
Inband intermodulation products: -35dB to -50dB

S-READING	INPUT LEVEL SSB	
(7MHz)	PREAMP IN	PREAMP OUT
S3	0.8µV	3.2µV
S5	2.2µV	10µV
S7	7.0µV	28µV
S9	20µV	90µV
S9+20	125µV	560µV
S9+40	1.4mV	5.6mV

BANDWIDTH	IF BANDWIDTH			
SET TO	-6dB	-60dB	-70dB	-80dB
6000Hz	5236Hz	6322Hz	6363Hz	8491Hz
4000Hz	3974Hz	4362Hz	see text	see text
2400Hz	2364Hz	2746Hz	2773Hz	3023Hz
1800Hz	1766Hz	2151Hz	2545Hz	2640Hz
1000Hz	965Hz	1338Hz	1365Hz	1403Hz
500Hz	444Hz	843Hz	1162Hz	1237Hz
250Hz	225Hz	682Hz	883Hz	1281Hz
100Hz	131Hz	623Hz	1262Hz	1337Hz

receivers. However, the effectiveness was marred by a slow beat (about 1Hz) when both receivers were set to the same frequency.

FILTERS

Two DSP circuits provide identical and separately controllable filtering and noise reduction facilities for the two receivers. A front panel rotary control allows the channel bandwidth to be set from 100Hz to 6kHz in 10Hz steps. The upper and lower passband edges can also be individually set and passband tuning allows the entire passband to be moved up or down in frequency.

Two notch filters are provided. A manual notch with adjustable centre frequency and width is particularly effective and deep. An auto-notch for voice modes will track and notch out multiple carriers and is also very effective. Both notches operate at IF up-front of the DSP AGC circuitry and prevent the receiver AGC being captured by strong carriers.

Adjustable DSP noise reduction is also provided and this can be effective in lowering background noise but does impart a synthetic sound to the audio. Adjustable DSP noise blanking is also included and for the main receiver only an additional hardware noise blanker of the traditional type operating at the 9MHz IF.

Adjustable audio equalisation is also provided for both receivers and transmitter. This can tailor the audio response by boosting or cutting the bass and treble frequencies.

The main receiver is fitted with a selection of roofing filters at the 9MHz IF and careful use of these filters is key to achieving the very best in adjacent channel performance. 20, 6, 2.4 and 1kHz bandwidth filters are provided as standard but additional filters of 1.8kHz, 500Hz and 250Hz bandwidth are available as options. All filters can be fitted at the same time and may be selected manually or automatically according to the setting of the bandwidth control.

OTHER GOODIES

Transmit features include variable output power (5 - 100W), VOX and a speech processor. The transmit filter bandwidth is adjustable from 900 to 3900Hz as well as for equalisation and low frequency roll off allowing for different microphone characteristics, hi-fi audio, DX punch etc. On CW the rise and fall characteristic of the keying envelope is adjustable and a keyer is built in with adjustable weighting and speed range of 10 to 60WPM. Three memory stores are provided for both CW and voice modes, easy to access via dedicated front panel buttons. The CW stores operate only in conjunction with the built-in keyer and seem to hold quite long messages but the manual does not cover their capacity. Two of the voice stores hold only 4.54 seconds maximum of audio and the third 28.1 seconds but this third store is not saved on power down.

The Orion also provides a spectrum sweep showing signals up to ±36kHz on either side of the main receiver frequency. This is displayed on the lower part of the LCD and unlike other implementations of this feature it is continuous and does not interrupt the operation of the receiver.

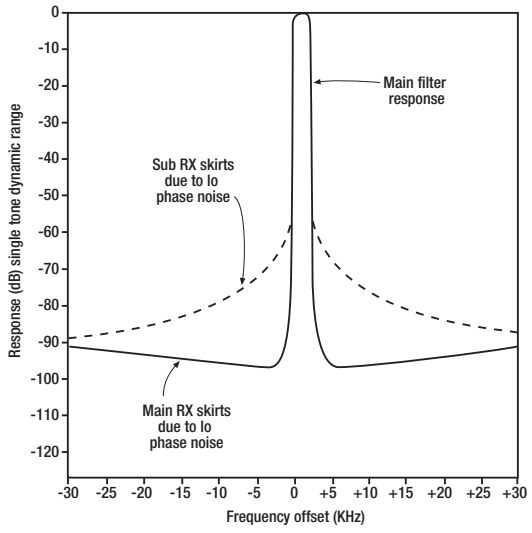
The optional tuner fitted into the Orion, which can be retrofitted at a later date, is an LDG design using an LC ladder network with latching relays and with a particularly wide impedance matching range of 6 to 800Ω (up to 10:1 VSWR). There are no frequency stores so changing bands requires a retune but this only takes a second or two.

MEASUREMENTS

Measurements shown in the table were made with the review radio powered from a 13.8V supply and in most cases with the receiver bandwidth set to 2400Hz. Close-in dynamic range measurements were made with a 500Hz receive bandwidth. Receiver measurements relate to the main receiver unless sub-receiver is stated.

The measured figures for third order intercept and dynamic range of the main receiver are very good but lower than the Orion published specification. The sub-receiver, however, has a rather better performance than the specification. Intermodulation within the test equipment is often the limitation in measuring the dynamic range of high performance radios. My measurement set-up has been carefully evaluated in this area and is capable of measuring receivers to at least +45dBm third order intercept so I have a good degree of confidence in the accuracy of the dynamic range results. The close-in results with the

FIG 1 © RADCOM 169



WEB SEARCH

Ten-Tec	www.tentec.com
Ten-Tec technical support	www.rfsquared.com
Ten-Tec Direct (UK)	www.aoruk.com/tentec

INTERMODULATION

(50kHz Tone Spacing) 2400Hz bandwidth USB

	PREAMP IN		PREAMP OUT		SUB RX	
FREQUENCY	3rd order intercept	2 tone dynamic range	3rd order intercept	2 tone dynamic range	3rd order intercept	2 tone dynamic range
1.8MHz	+9dBm	90dB	+16.5dBm	90dB	+14dB	89dB
3.5MHz	+9.5dBm	92dB	+20.5dBm	94dB	+12.5dB	92dB
7MHz	+9dBm	91dB	+19.5dBm	92dB	+14dB	93dB
14MHz	+9dBm	91dB	+20dBm	93dB	+18dB	95dB
21MHz	+11dBm	91dB	+22.5dBm	92dB	+18dB	95dB
28MHz	+8dBm	87dB	+20dBm	88dB	+7.5dB	88dB

CLOSE-IN TWO TONE DYNAMIC RANGE

ON 7MHz BAND 500Hz bandwidth CW

FREQUENCY SPACING	SUB RX	MAIN RX ROOFING FILTER BANDWIDTH 20kHz	6kHz	2.4kHz	1kHz
1kHz	not meas	78dB	79dB	83dB	77dB
2kHz	not meas	79dB	83dB	89dB	83dB
3kHz	70dB	78dB	89dB	92dB	86dB
4kHz	72dB	80dB	88dB	94dB	89dB
5kHz	74dB	80dB	89dB	94dB	91dB
7kHz	77dB	78dB	90dB	94dB	93dB
10kHz	82dB	83dB	90dB	94dB	93dB
15kHz	90dB	89dB	91dB	94dB	93dB
20kHz	92dB	92dB	91dB	94dB	93dB
25kHz	92dB	94dB	93dB	93dB	93dB
30kHz	92dB	94dB	94dB	93dB	93dB

	MAIN RX			SUB RX	
FREQUENCY OFFSET	RECIPROCAL MIXING FOR 3dB NOISE	BLOCKING PREAMP IN	BLOCKING PREAMP OUT	RECIPROCAL MIXING FOR 3dB NOISE	BLOCKING
2kHz	97dB	-18dBm	-6dBm	not meas	-24dBm
3kHz	97dB	-9dBm	>0dBm	65dB	-24dBm
5kHz	96dB	>0dBm	>0dBm	72dB	-24dBm
10kHz	95dB	>0dBm	>0dBm	77dB	-13dBm
15kHz	94dB	>0dBm	>0dBm	81dB	-11dBm
20kHz	93dB	>0dBm	>0dBm	83dB	-4dBm
30kHz	90dB	>0dBm	>0dBm	87dB	0dBm
50kHz	88dB	>0dBm	>0dBm	92dB	0dBm
100kHz	96dB	>0dBm	>0dBm	98dB	0dBm
200kHz	104dB	>0dBm	>0dBm	104dB	0dBm

TRANSMITTER MEASUREMENTS

			INTERMODULATION PRODUCTS	
FREQUENCY	CW POWER OUTPUT	HARMONICS	3rd order	5th order
1.8MHz	104W	-64dB	-40dB	-48dB
3.5MHz	105W	-64dB	-40dB	-44dB
5.4MHz	100W	-64dB	-38dB	-42dB
7MHz	101W	-56dB	-36dB	-42dB
10MHz	102W	-60dB	-38dB	-42dB
14MHz	102W	-65dB	-34dB	-40dB
18MHz	103W	-52dB	-30dB	-44dB
21MHz	103W	-60dB	-22dB	-38dB
24MHz	104W	-66dB	-22dB	-36dB
28MHz	105W	-60dB	-26dB	-41dB

Two-tone transmitter intermodulation product levels are quoted with respect to PEP.

Carrier suppression: 35dB approx
Sideband suppression: >80dB @ 1kHz
Transmitter AF distortion: 2%
Microphone input sensitivity: 15mV
FM deviation: 5kHz
SSB data T/R switch speed: mute-TX 26ms, TX-mute 10ms, mute-RX 36ms, RX-mute 14ms

NOTE: All signal input voltages given as PD across antenna terminal. Unless stated otherwise, all measurements made on USB, preamp switched out, 2400Hz bandwidth, 6kHz roofing filter and with a 13.5V supply.

narrower roofing filters are very impressive indeed, results with the 2.4kHz filter being significantly better than with the 1kHz filter.

The reciprocal mixing results are very interesting (see **Fig1**). At 50kHz offset the results for the main receiver are uninspiring and indeed somewhat bettered by the sub-receiver. However, the performance improves markedly closer to the carrier and at 2kHz offset surpasses any other radio measured previously, with the possible exception of the Ten-Tec Corsair. These results equate to an oscillator phase noise of -131dBC/Hz at 2kHz offset, but still a little short of the Orion published specification of -136dBC/Hz. The sub-receiver reciprocal mixing results are rather mediocre for a high performance radio and identical to the Jupiter results.

The very low phase noise in the main receiver made it possible to measure 80dB down the IF filter skirts with excellent results. Filter bandwidths below about 300Hz started to exhibit wider skirts and ripples in the stopband which limited their ultimate performance. A weak spurious signal limited measurements of the higher bandwidth filters. Rejection of IFs and images was better than 75dB for the main receiver but only better than 60dB for the sub receiver. The main receiver exhibited a spurious response 6KHz off tune about 60dB down but only on SSB modes and only with the 6kHz roofing filter selected. If this proves a problem, select a different roofing filter.

The blocking results shown in the table were measured with the 6kHz roofing filter. With the 2.4 and 1kHz filters it is possible to get even closer to the carrier before any desensitisation occurs. With the 1kHz filter, measurements showed that it was possible to copy an S1 signal with an interfering signal 90dB greater only 500Hz away. This is truly awesome performance.

Transmit SSB intermodulation products were generally quite reasonable but were degraded by the speech processor. CW keying had well-shaped edges but exhibited some character shortening and delay only of real significance at high keying speeds. The auto ATU matched well and exhibited very low loss of only 1 - 2W at the 100W level. Occasionally a second attempt was needed as the first try gave an erroneous match. The front panel power meter was rather inaccurate at mid range, reading significantly on the high side.

ON THE AIR

It takes a little time to get the best out of the Orion and become fully acquainted and at home with all its facets. However, as you use the radio, understand its philosophy and tweak its many adjustable features to match best your operating style you will find that the radio grows on you more and more. The RF performance is really excellent and unsurpassed in crowded band conditions. The ease of varying the bandwidth is a real boon, the quality of the filters, notches and audio is excellent and similarly the AM broadcast performance. However, being able to receive very close to strong stations is only possible if the strong station itself has a clean signal. In a transceiver, the phase noise characteristic of the transmitter largely mirrors that of the receiver and unless the strong signal is also an Orion, the strong signal is likely to be the limiting factor.

Audio quality reports were excellent. My first QSO with the Orion was with a VK2 station who immediately gave an unsolicited report of excellent audio quality. CW also generally performed well both on the internal and external keyers. The receiver QSK drop back delay and the linear drop back delay are totally separate adjustments. I had some difficulty with my non-QSK linear achieving a suitable balance between the two. On CW you do not want the linear dropping back to receive between words but on SSB when you release the PTT you want the linear to drop back to receive immediately. The linear drop back delay is applied to all modes but on CW should really only take effect after the receiver delay has finished. (A possible candidate for a software update maybe?)

The control ergonomics are generally very good. One minor comment, however, is that rapid frequency navigation is generally better implemented on many Japanese radios. Some roughness on fast tuning was resolved when I upgraded the firmware from version 1.367 to version 1.369. The upgrade file from the website was 877kB which installed the Flash Update Utility on my PC. Connecting the radio to the PC COM port then installed the upgraded code in about five minutes.

CONCLUSIONS

The Orion lives up to its claim as a high performance radio with exceptional close-in dynamic range. It is likely to appeal particularly to the serious and technically-minded DX chaser or contest operator or someone who desires the very best in terms of performance. With its large format panel, clearly laid out controls, well-implemented features and internet upgradeable software it is a truly excellent radio.

The Orion is available in the UK from Ten-Tec Direct, 4E East Mill, Belper, Derbyshire DE56 2UA; tel: 01773 880788, with a list price of £2499, or £2799 if fitted with the auto antenna tuner. My thanks to Ten-Tec Direct for the loan of the review radio. ♦