

November 1996

# Digital HF Receiver HF-1000A



The HF-1000A is a fully synthesized, general-purpose HF receiver that monitors RF communications from 5 kHz to 30 MHz with 1-Hz tuning resolution. The HF-1000A achieves high performance at low cost, by combining analog and digital signal processing (DSP).

Functions such as noise blanking, IF filtering, AGC, demodulation, Beat Frequency Oscillation (BFO) and passband tuning are accomplished through the use of DSP techniques. Digital stability and repeatability allow filters with superior amplitude and group delay characteristics. Fifty-eight IF bandwidths (IFBW's) allow an operator to optimize filter bandwidth to the signal environment. Filters range from 56 Hz, to monitor CW with exceptional signal-to-noise ratios, all the way up to 8 kHz to monitor AM signals with good fidelity. Available detection modes are AM, synchronous AM, FM, CW, USB, LSB, and ISB. An operator can adjust tunable BFO in 10-Hz steps over a  $\pm 8000$  Hz range. Passband tuning further enhances the reception of CW signals. An operator can achieve gain control manually or automatically, with variable fast, medium, and slow Automatic Gain Control (AGC) modes. The operator can either adjust the squelch threshold from 0 to -135 dBm or disable it. A noise blanking feature effectively eliminates the adverse effects of impulsive noise. The operator can reject undesired signals within the IF passband with the tunable IF notch filter.

In addition to fixed-frequency tuning, the HF-1000A provides a fast, flexible scanning capability. Three scan modes are available: channel scan, F1-F2 scan and F1-F2 scan with lockouts. For all scan modes, the operator can set the dwell

## Features

- Frequency coverage from 5 kHz to 30 MHz in 1-Hz steps
- High dynamic range: +30 dBm 3rd-order intercept typical
- Digital filtering provides 58 IFBW's from 56 Hz to 8.0 kHz with exceptional shape factors
- AM, Synchronous AM, FM, CW, USB, LSB & ISB detection modes standard
- Tunable notch filter
- Fast, flexible scanning with 100 memory channels
- Large readable LED displays & user-friendly controls
- Noise blanking & passband tuning
- Internal switchable preamplifier & attenuator
- Operator-selectable RS-232, RS-485, or RS-422 remote control
- Built-in self test
- Optional Suboctave Preselector, Digital Data Output & Speech Enhancement Unit
- European CE approved for EMC and low voltage safety

HEIGHT 5.25 in (13.36 cm) DEPTH 20.0 in (50.80 cm)  
WIDTH 19.0 in (48.26 cm) WEIGHT 15 lbs (6.78 kg)

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time from 0.5 to 20 seconds or infinite. One hundred programmable memory channels are available in channel scan mode. An operator can specify sectors of memory for individual channel scans, which allows the subdivision of available memory into multiple search scenarios. The operator can skip certain channels without deleting them from memory. He can also manually single-step memory channels. The step size is user-selectable from 1 Hz to 25 kHz in both F1-F2 scan modes. Storage is available for up to 100 independent frequency lockouts.

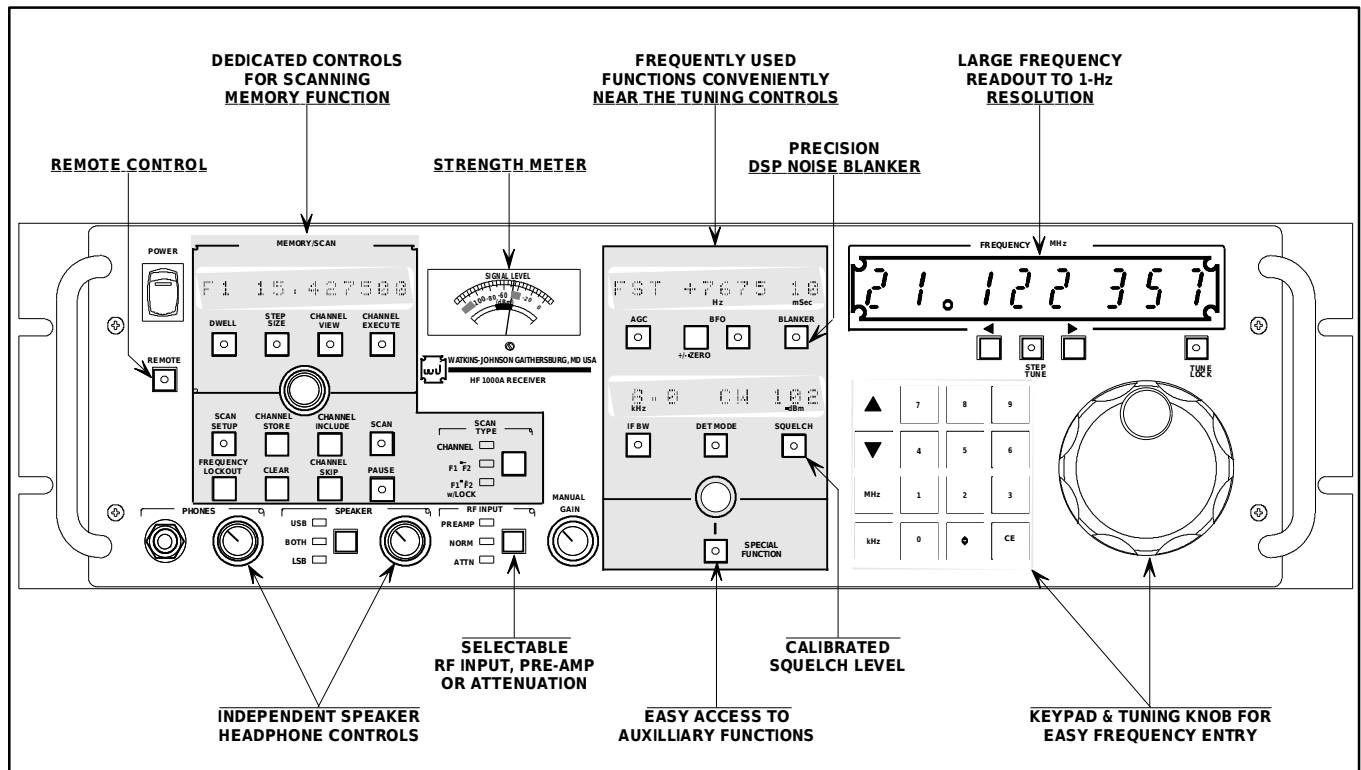
The HF-1000A provides local operation via the front panel or remote operation via one of two selectable serial interfaces. The microprocessor-controlled front panel provides a user-friendly operator interface with dedicated, logically arranged controls and large, easy-to-read LED display.

An operator controls and accesses the majority of the HF-1000A operator-selectable parameters via an RS-232 remote interface. RS-485 and RS-422 are also available. The active interface is selected via an internal switch setting or by front-panel entry.

All receiver inputs and outputs are on the rear panel of the unit with the exception of the front-panel-mounted headphone jack. The antenna and external reference inputs, as well as the signal monitor and predetected IF outputs, are on BNC connectors. Speaker and dual-balanced line audio outputs are on a terminal strip along with dc-coupled audio, RSSI and squelch outputs, and a mute control input. The RS-232 interface is on a 25-pin D-shell connector.

An operator can use the HF-1000A as a tabletop receiver or mounted in a 19-inch (48.26 cm) equipment rack that occupies 5.25 inches (13.34 cm) vertical rack space. The internal power supply accepts 97 to 253 Vac (47 to 63 Hz) line power and automatically adjusts to the input line voltage. Total unit power consumption is less than 35 watts.

The standard HF-1000A is available in a variety of mechanical configurations. Meanwhile, WJ engineers are continuously developing enhancements and options. See the Options table and the WJ-871 Y Option Matrix Data Sheet for details.



HF-1000A Front Panel Features

WPG124

## Functional Description

The Functional Block Diagram demonstrates how the HF-1000A is divided into four functional subsystems: RF, DSP, IF/Audio Output and Control. The RF Subsystem Functional Block Diagram provides a functional block diagram of the RF Subsystem. The 5 kHz to 30 MHz RF signal is applied to the receiver's antenna input, lowpass filtered, and then amplified, attenuated, or routed to the normal through-path based on user selection. The signal is then mixed with the first local oscillator (LO), which tunes from 40.455 MHz to 70.455 MHz in 1-kHz steps, to produce a first IF of 40.455 MHz. The first IF filter limits the bandwidths of the signal to approximately 8 kHz before mixing it with the 40-MHz second LO to produce a second IF at 455 kHz. A sample of this second IF is on a rear panel for connection to a signal display unit. After passing through the second IF filter, the signal is mixed with the 430-kHz third LO to produce the third IF centered at 25 kHz.

All LOs are derived from an internal 10-MHz oscillator that is lockable to an external reference input of 1, 2, 5 or 10 MHz. The HF-1000A automatically senses and switches to the external reference upon application of signal. All critical timing signals used in the DSP and IF/Audio Output Subsystems are also derived from this reference.

The DSP Subsystem performs the majority of the signal processing function within the receiver. The third IF signal from the RF Subsystem is digitized to 16-bits of resolution at a sampling rate of 100 kHz. This digitized IF signal is applied to a programmable

DSP chip that performs the following functions based on operator-selected parameters:

- Noise blanking
- Fine tuning to 1-Hz resolution
- IF filtering
- Tunable IF notch filtering
- Gain control (AGC-Fast, -Medium, -Slow, or Manual)
- Signal strength and squelch functions
- Signal demodulation and BFO
- Generation of a multiplexed Digital Data Stream containing 1 or 2 demodulated Audio Channels & a post-filtered IF signal

The IF/Audio Output Subsystem performs the analog reconstruction of the IF and audio signals provided by the DSP Subsystem in digital form. The analog audio signals are routed through two distinct signal paths to accommodate ISB detection mode. In all other detection modes, both paths contain identical audio signals. These two audio paths are processed to provide a two-channel headphone output, two balanced 600-ohm line audio outputs and an 8-ohm speaker output containing one or both audio channels in ISB mode. After analog reconstruction, the IF signal is upconverted to 455 kHz, passed through a bandpass roofing filter to remove mixer products, buffered and routed to the rear panel IF output connector.

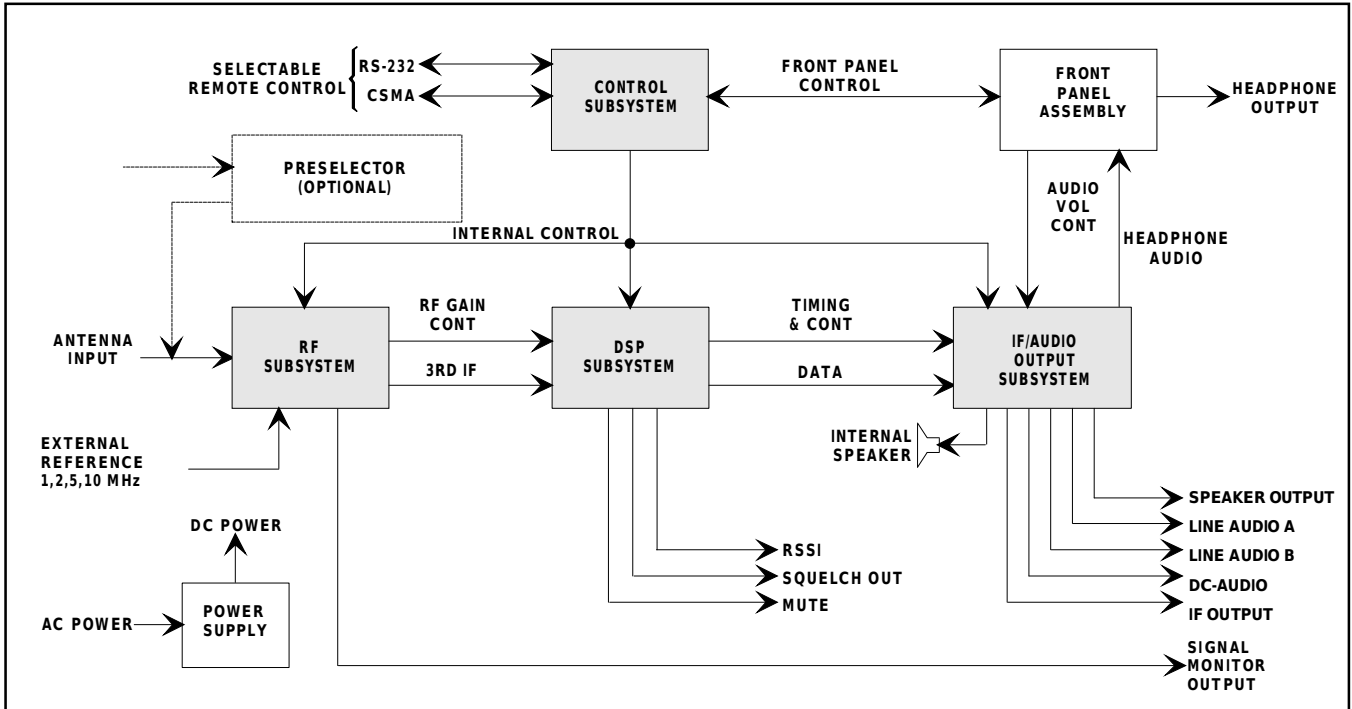
The microprocessor-based Control Subsystem performs the receiver's internal control, acts as an interface with the front panel, and provides a remote control function. The Control Subsystem also monitors hardware status within the receiver and, when commanded, performs a built-in test sequence that isolates circuit faults to the module level.

IF Filters (Nominal 3-dB Bandwidth in Hz)

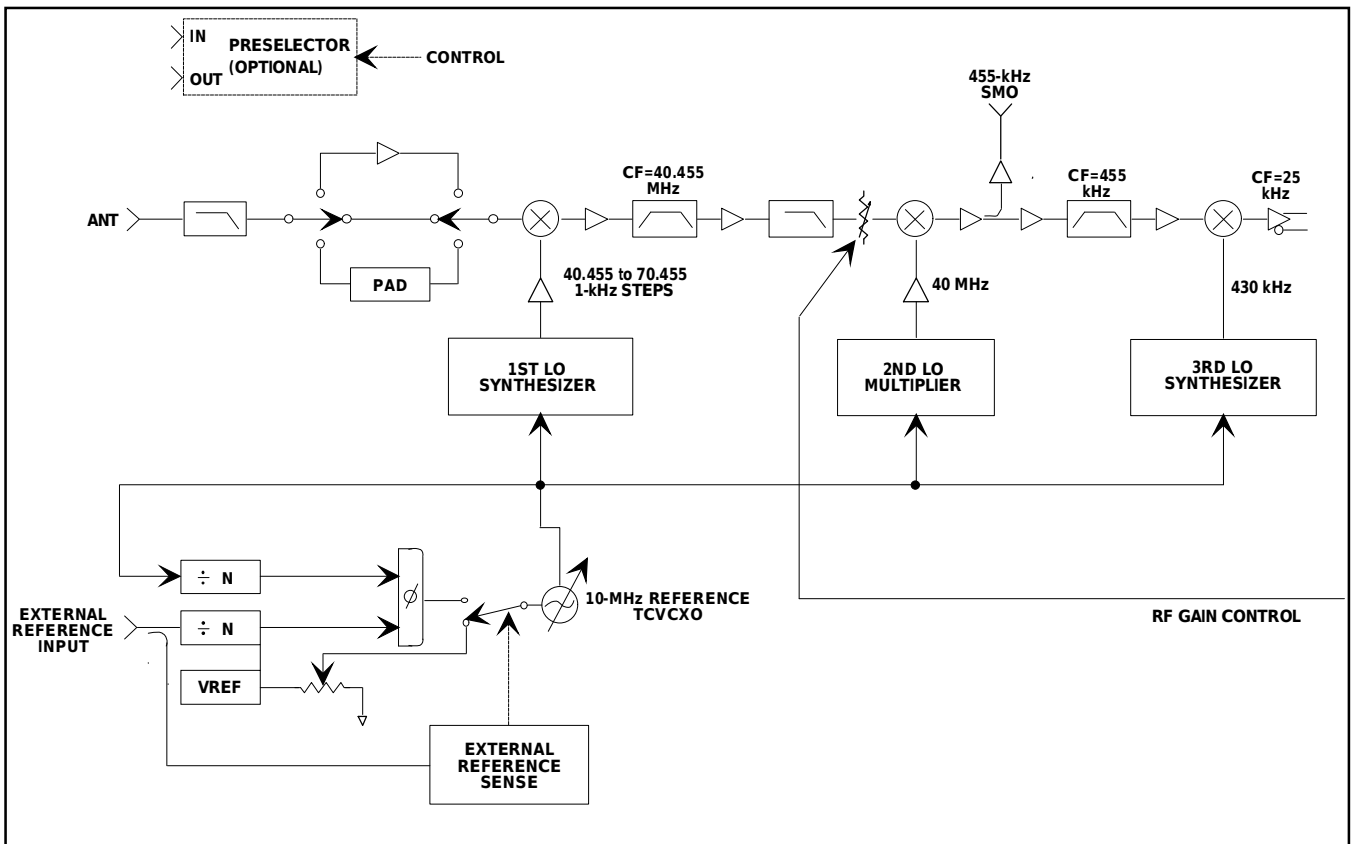
<b>56</b>	<b>113</b>	<b>225</b>	<b>450</b>	<b>900</b>	<b>1800</b>	<b>3600</b>	<b>7200</b>
<b>63</b>	<b>125</b>	<b>250</b>	<b>500</b>	<b>1000</b>	<b>2000</b>	<b>4000</b>	<b>8000</b>
<b>69</b>	<b>138</b>	<b>275</b>	<b>550</b>	<b>1100</b>	<b>2200</b>	<b>4400</b>	
<b>75</b>	<b>150</b>	<b>300</b>	<b>600</b>	<b>1200</b>	<b>2400</b>	<b>4800</b>	
<b>81</b>	<b>163</b>	<b>325</b>	<b>650</b>	<b>1300</b>	<b>2600</b>	<b>5200</b>	
<b>88</b>	<b>175</b>	<b>350</b>	<b>700</b>	<b>1400</b>	<b>2800</b>	<b>5600</b>	
<b>94</b>	<b>188</b>	<b>375</b>	<b>750</b>	<b>1500</b>	<b>3000</b>	<b>6000</b>	
<b>100</b>	<b>200</b>	<b>400</b>	<b>800</b>	<b>1600</b>	<b>3200</b>	<b>6400</b>	

The 900 through 4000 Hz bandwidths are available in SSB detection mode  
See typical plots on page 5 of this data sheet

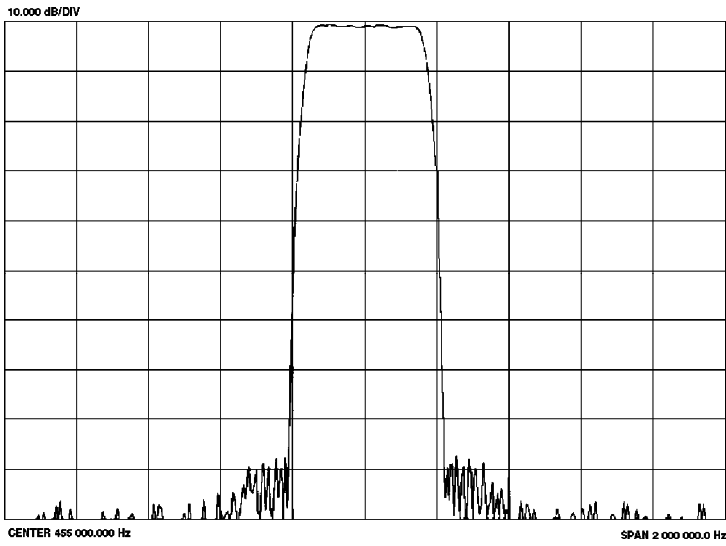
HF-1000A



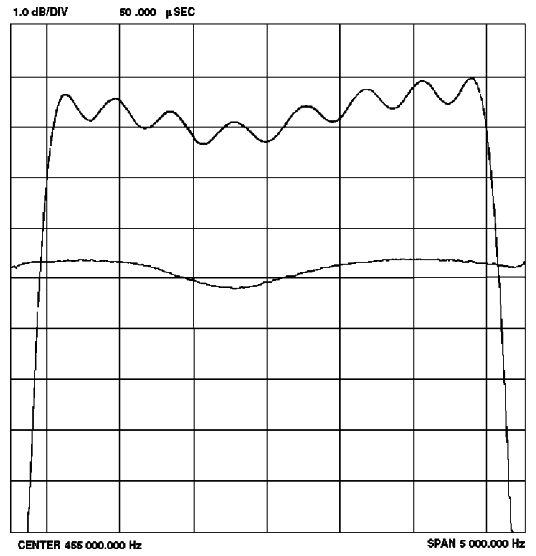
Functional Block Diagram



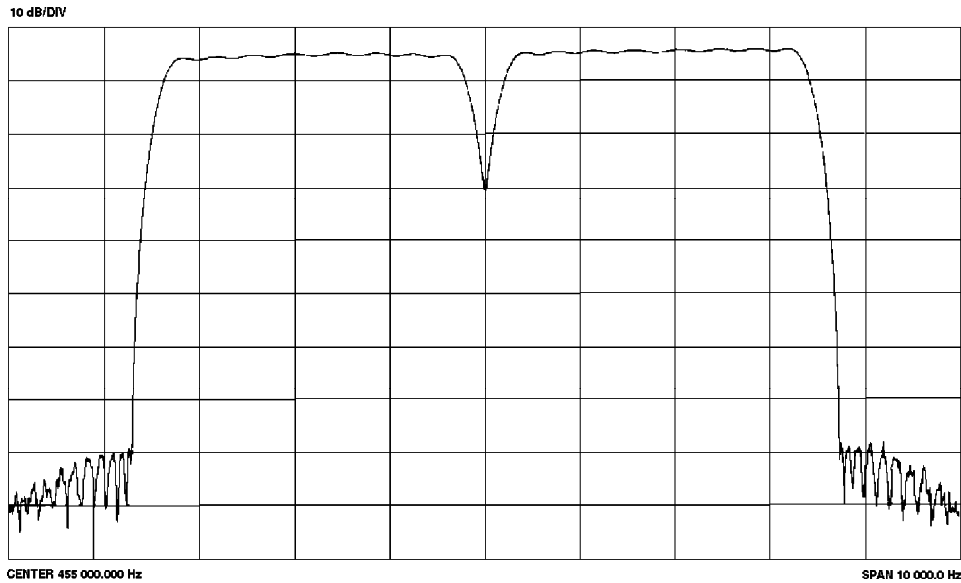
RF Subsystem Functional Block Diagram



Typical 300-Hz IF Filter Amplitude Response



Typical SSB IF Filter Group-delay & Passband Ripple



Typical ISB (USB/LSB) IF Filter Amplitude Response

Specifications

<b>Frequency Range</b> .....	5 kHz to 30 MHz (tunable to 0 Hz, degraded performance below 500 kHz)
<b>Tuning Resolution</b> .....	1 Hz
<b>Internal Reference Stability</b> .....	Better than 1.0 PPM
<b>External Reference Frequency</b> .....	Accepts 1, 2, 5 or 10 MHz (+1 PPM or better, 200 mv rms into high impedance load); automatically switches to external reference upon application of signal
<b>Tuning Time</b> .....	25 msec typical from receipt of terminating character to within 1 kHz (measured at IF out, 6 kHz IFBW selected)
<b>Scan Rate</b> .....	Memory Channel scan 20 CH/sec F1-F2 sweep 50 CH/sec
<b>Antenna Input</b>	
Impedance .....	50 ohms, nominal
VSWR .....	2:1, max at receiver's tuned frequency
Maximum Input Signal .....	+30 dBm
Connector .....	BNC, female
<b>3rd-Order Intercept Point</b> .....	+30 dBm, typical + 25 dBm, min (for signals separated by 20 kHz, minimum)
<b>2nd-Order Intercept Point</b> .....	+60 dBm, typical
<b>Noise Figure</b> .....	14 dB, max (11 dB, max with preamplifier engaged)
<b>Detection Modes</b> .....	AM, Synchronous AM, FM, CW, USB, LSB & ISB (Consult factory for additional modes)

**Sensitivity (500 kHz to 30 MHz)**

Modulation	IFBW (kHz)	(Minimum) S+N/N (dB)	Without Preamp Min dBm/(mV)
AM (50% mod. at 400 Hz)	6.0	10	-103/(1.58)
USB/LSB/ISB	3.2	10	-112/(0.56)
CW	0.3	16	-116/(0.35)

**CW Sensitivity, 5 to 500 kHz, without Preamp**

**(0.3-kHz IFBW)**

50 to 500 kHz .....	-113 dBm/0.5 $\mu$ V typical for 16 dB S+N/N
20 to 50 kHz .....	-105 dBm/1.27 $\mu$ V typical for 16 dB S+N/N
5 to 20 kHz .....	-78 dBm/28 $\mu$ V typical for 16 dB S+N/N

**IF Output**

Center Frequency .....	455 kHz, nominal
Output Level .....	-20 dBm, nominal
Output Impedance .....	50 ohms, nominal
Connector Type .....	BNC, female

**Signal Monitor Output**

Center Frequency .....	455 kHz, nominal; inverted; 1-kHz steps
Bandwidth .....	8 kHz (-6dB), nominal
Output Level .....	30 dB above RF input, nominal
Output Impedance .....	50 ohms, nominal
Connector Type .....	BNC, female

**Gain Control Modes** .....

AGC Range .....	Manual, or AGC Fast, Med & Slow
AGC Threshold .....	100 dB, min
	Approximately -112 dBm (0.56 $\mu$ V) in 6-kHz bandwidth
	Approximately -125 dBm (0.12 $\mu$ V) in 300-Hz bandwidth
	(Threshold matched with IFBW, typically 10 dB above noise floor)

<b>AGC Attack Time</b> .....	5 msec, typical
<b>AGC Decay Time</b> .....	Fast: 10 to 100 ms, variable Med: 100 ms to 1s, variable Slow: 1s to 5s, variable
<b>Manual Gain Control Range</b> .....	>100 dB
<b>Selectable Front-End Gain/Attenuation</b>	
<b>Preamplifier Gain</b> .....	10 dB ( $\pm 2$ dB)
<b>Attenuation</b> .....	15 dB ( $\pm 2$ dB)
<b>BFO</b>	
<b>Tuning Range</b> .....	$\pm 8000$ Hz
<b>Tuning Resolution</b> .....	10 Hz
<b>First Image Rejection</b> .....	90 dB, min
<b>IF Rejection</b> .....	85 dB, min (>90 dB, typical)
<b>LO Phase Noise</b> .....	-110 dBc at 1-kHz offset, typical
<b>Reciprocal Mixing</b> .....	With a desired signal of 25 $\mu$ V in the 3.2-kHz IFBW, the desired signal-to-noise ratio (SNR) is >20 dB, when an undesired signal 70-dB higher in amplitude and 35-kHz removed in frequency is present.
<b>Cross Modulation</b> .....	With a desired signal of 10 $\mu$ V, an undesired signal 86-dB higher, 30% AM modulated produces <10% cross modulation for frequency separation of >50 kHz in the 1-kHz IF IFBW.
<b>Internal Spurious</b> .....	<-114 dBm referred to the RF input
<b>Blocking</b> .....	An unwanted signal 1 $\mu$ V separated 20 kHz from a desired signal of 1 $\mu$ V does not cause the IF output to fall by more than 3 dB.
<b>Line Audio Outputs</b>	
<b>Number of Outputs</b> .....	2 (center-tapped, balanced) ISB mode: USB & LSB on separate outputs All other modes: audio signal common to both outputs
<b>Output Level</b> .....	0 dBm, nominal into 600-ohm load
<b>Connector Type</b> .....	Screw terminals
<b>Speaker Output</b>	
<b>Number of Outputs</b> .....	1 ISB mode: USB & LSB selected individually or combined Internal speaker optional
<b>Bandwidth</b> .....	100 Hz to 13 kHz
<b>Output Level</b> .....	Adjustable up to 1 W into 8-ohm load
<b>Total Harmonic Distortion</b> .....	<3% at 1 W
<b>Connector Type</b> .....	Screw terminals
<b>Headphone Output</b>	
<b>Number of Outputs</b> .....	2 (unbalanced) ISB mode: 1 contains USB (left channel), 1 contains LSB (right channel) All other modes: audio signal common to both outputs
<b>Output Level</b> .....	Adjustable up to 10 mW into 600-ohm load
<b>Connector Type</b> .....	Standard 1/4-in stereo jack
<b>Control</b> .....	RS-232, RS-485, or RS-422 selectable by internal switch or front-panel entry
<b>RS-232 (Remote)</b> .....	Full-duplex 3-wire serial interface; rear-panel 25-pin female D-shell connector
<b>RS-485</b> .....	Half-duplex, 2-wire serial interface Rear-panel 25-pin female D-shell connector
<b>RS-422</b> .....	Full-duplex 4-wire serial interface Rear-panel 25-pin female D-shell connector
<b>Baud Rates</b> .....	75, 150, 300, 600, 1200, 2400, 4800 & 9600;

<b>Operating Temperature</b> .....	0 to +50°C
<b>Storage Temperature</b> .....	-40 to +70°C
<b>Humidity</b> .....	95%, non-condensing
<b>Shock</b> .....	Bench handling (field service) 8 drops total onto a horizontal hard wooden surface, operating
<b>CE Approval - GMC Directive</b> .....	89/336/EEC (19 March 1996)
<b>CE Approval - Low Voltage Directive</b> .....	72/23/EEC (19 March 1996)
<b>MTBF</b> .....	>10,000 hours
<b>Power Requirements</b> .....	97 to 253 Vac (47 to 440 Hz)
<b>Power Consumption</b> .....	35 W, typical with options

Receiver Connectors

I/O	Function	Type
Input	Antenna External Reference Power Mute	BNC BNC IEC 3-pin Terminal Block
Output	Signal Monitor IF Line Audio Output A Line Audio Output B Speaker DC-coupled Audio Squelch Headphone  Received Signal Strength Indicator	BNC BNC Terminal Block Terminal Block Terminal Block Terminal Block Terminal Block Standard 1/4-in (0.63 cm) stereo jack  Terminal Block
Bi-Directional	RS-232 Remote Interface	25-pin female D-shell

Options

Nomenclature	Functions	Physical Characteristics
<b>HF-1000/PRE</b> Suboctave Preselector	<ul style="list-style-type: none"> <li>• Provides filtering of RF input spectrum to reduce broadband signal energy into the receiver</li> <li>• Provides 11 separate filter bands, each covering a segment of the overall tuning range</li> <li>• Option can be bypassed if preselection is not desired</li> <li>• Provides automatic receiver-selection of filter band appropriate to tuned frequency</li> </ul>	<ul style="list-style-type: none"> <li>• Enhances 2nd-order intermodulation performance</li> <li>• Degrades sensitivity/noise figure by 2.5 dB, typical</li> </ul>
<b>HF-1000/DSO1</b> Digital Signal Output	<ul style="list-style-type: none"> <li>• Provides digitized time samples of 25-kHz 3rd IF, switched IF and/or audio data</li> </ul>	<ul style="list-style-type: none"> <li>• See WJ-871Y/DSO1 Technical Data Sheet for details of output data formats</li> </ul>
<b>HF-1000/SEU</b> Speech Enhancement Unit	<ul style="list-style-type: none"> <li>• Provides wideband noise reduction &amp; automatic notch filtering using adaptive filters</li> </ul>	<ul style="list-style-type: none"> <li>• Digital expansion card installed internally</li> </ul>