

## **Digital HF Receiver** **WJ-8712**



### **Description**

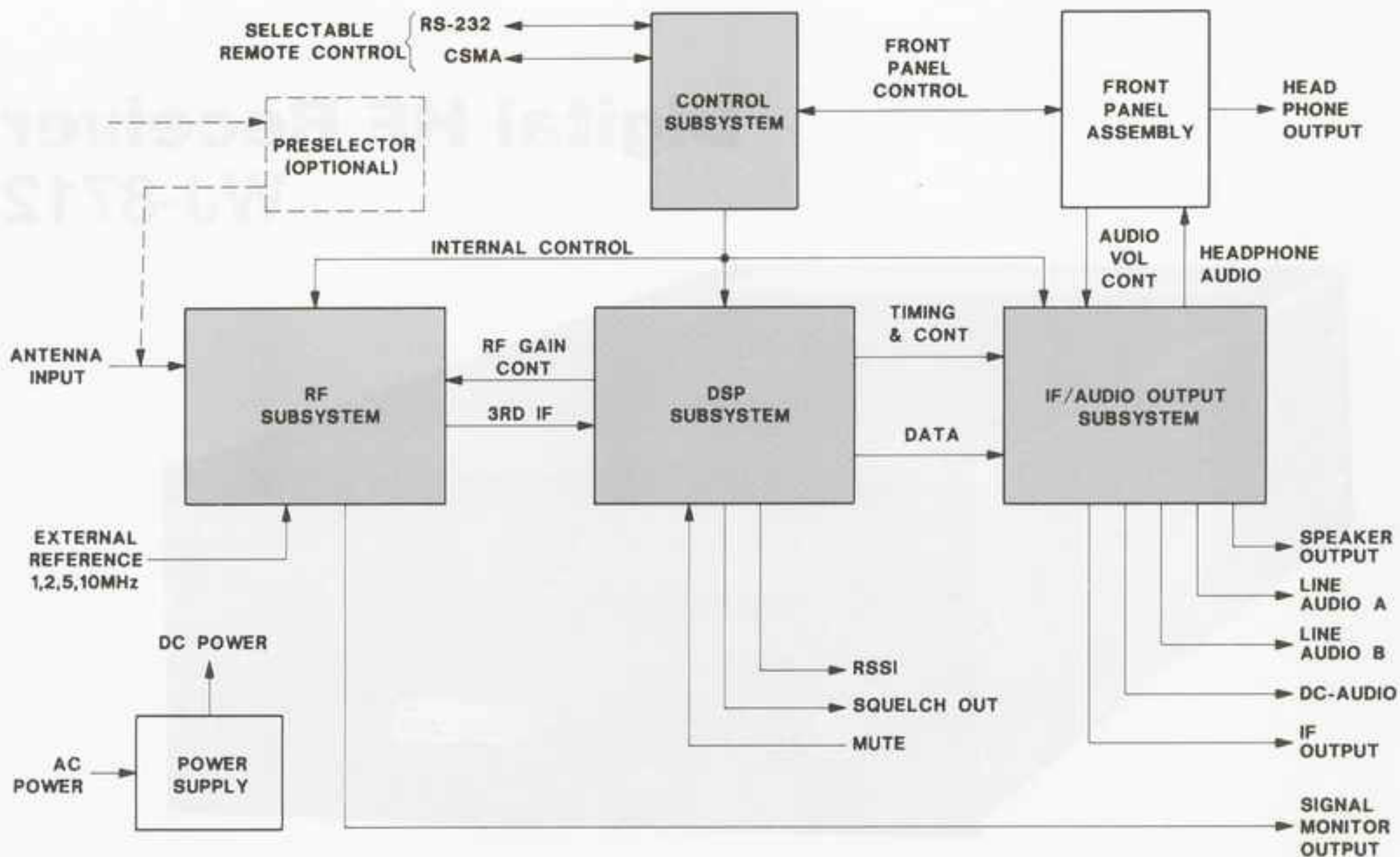
The WJ-8712 is a fully synthesized, general-purpose HF receiver for surveillance and monitoring of RF communications from 5 kHz to 30 MHz with 1-Hz tuning resolution. The unit is packaged in a 3.5 x 8.25 x 20 inch (8.89 x 20.96 x 50.80 cm) half-rack enclosure with a blank front panel, and utilizes the same RF and Digital printed circuit boards as the WJ-8711. By combining analog and digital signal processing (DSP), the WJ-8712 achieves high performance at low cost.

The WJ-8712 is operated remotely via one of two selectable serial interfaces. With the exception of audio output level and remote control mode selection, all receiver parameters are controllable and accessible via an RS-232 remote interface. A Carrier Sense Multiple Access with Collision Detection (CSMA) interface, with a limited instruction set, may be enabled, in lieu of RS-232, to allow the WJ-8712 to be controlled using a command protocol similar to several popular consumer receivers. Selection of the active interface is made via an internal switch setting. The factory should be contacted for a detailed list of remote control commands in order to eliminate any confusion over the extent of the available commands included in each type of interface.

### **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 5 or more IF bandwidths up to 16 kHz with exceptional shape factors*
- *AM, FM, CW, USB, LSB & ISB detection mode standard*
- *Fast, flexible scanning with 100 memory channels*
- *3.5 in. (8.89 cm) high, half-rack configuration*
- *Noise blanking*
- *Internal switchable Preamplifier & Attenuator*
- *Internally-selectable RS-232 or CSMA remote control*
- *Extensive built-in self test*
- *Optional suboctave Preselector*
- *Optional digital data output*





**Figure 1. WJ-8712 Functional Block Diagram**

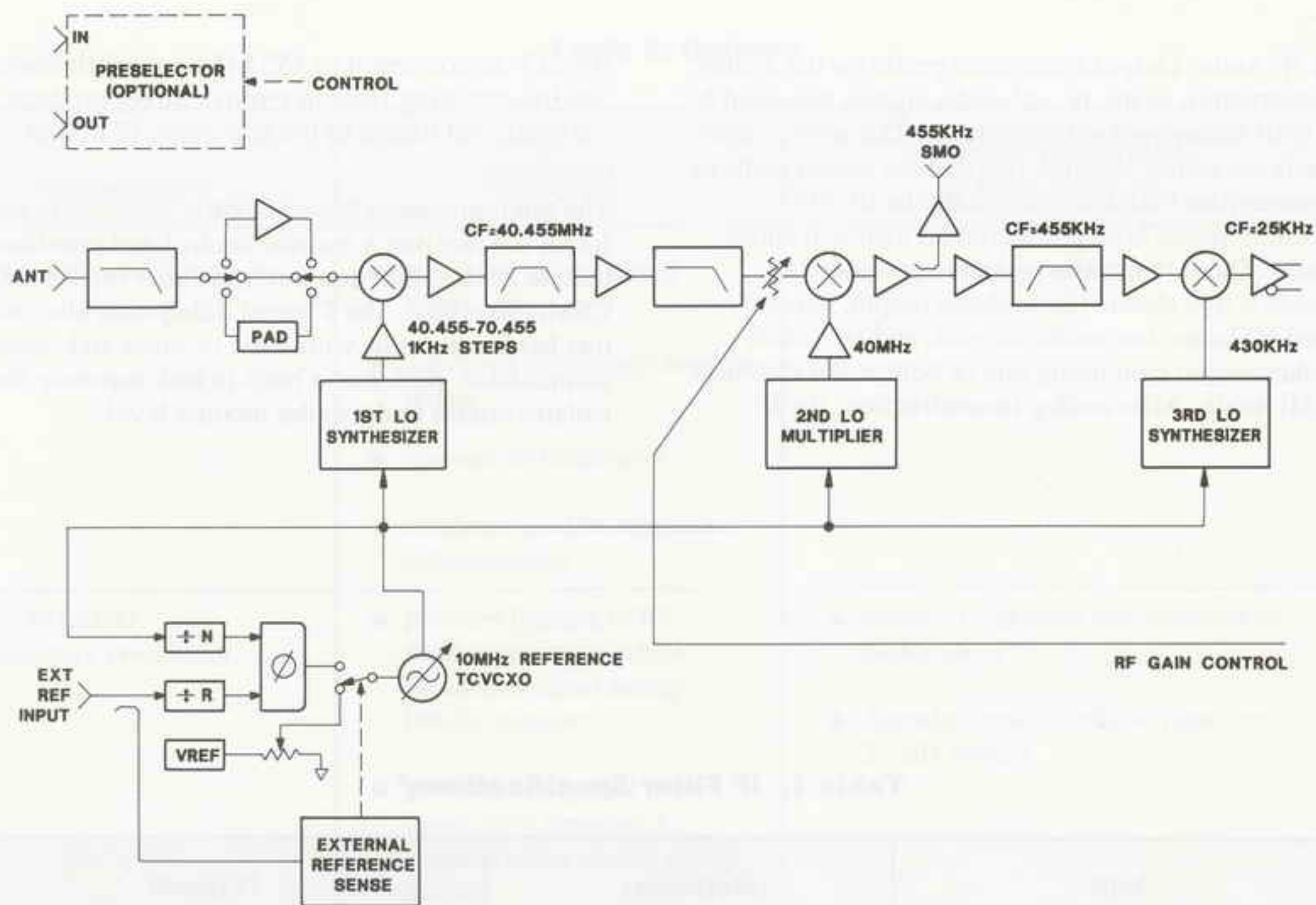
In addition to fixed-frequency tuning, the WJ-8712 provides a fast, flexible scanning capability. Three scan modes are available: channel scan, F1-F2 scan and F1-F2 scan with lockouts. For all scan modes, the dwell time can be set from 0.5 to 20 seconds or infinite. In channel scan mode, 100 programmable memory channels are available.

Functions such as noise blanking, IF filtering, AGC, demodulation and Beat Frequency Oscillator (BFO) are accomplished through the use of DSP techniques. Filters with superior amplitude and group delay characteristics are achieved with digital stability and repeatability. Standard selectable IF bandwidths are 0.3, 1.0, 3.2, 6.0 and 16.0 kHz. Available detection modes are AM, FM, CW, USB, LSB and ISB. A tunable BFO can be adjusted in 10-Hz steps over a  $\pm 8000$  Hz range, and passband tuning is available to further enhance the reception of CW signals. Gain control can be accomplished manually or automatically, with fast and slow AGC modes available. The squelch threshold is adjustable from 0 to -135 dBm, or it can be disabled. A noise blanking feature can also be enabled to reduce the adverse effects of impulsive noise.

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

The WJ-8712 can be mounted in a standard 19-inch (48.26 cm) equipment rack occupying 3.5 inches (8.89 cm) of vertical rack space. Two units can be mounted side-by-side (standard configuration), or an optional blank rack (WJ-8712/BR) can be ordered to mount a single unit in the 19-inch (48.26 cm) rack. The internal power supply accepts 97 to 253 Vac (47 to 440 Hz line power) and automatically adjusts to the input line voltage. Total power consumption of the unit is less than 30 watts.





**Figure 2. WJ-8712 RF Subsystem Functional Block Diagram**

## Functional Description

As illustrated in Figure 1, the WJ-8712 can be divided into four functional subsystems: RF, DSP, IF/Audio Output and Control. Figure 2 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 either 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 bandwidth of the signal to approximately 30 kHz before mixing it with the 40-MHz second LO to produce a second IF at 455 kHz. A sample of the second IF is provided 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 can be locked to an external reference input of 1, 2, 5 or 10 MHz. The WJ-8712 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 functions 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 selection of the receiver's parameters:

- Noise blanking
- Fine tuning to 1-Hz resolution
- IF filtering
- Gain control (AGC fast, AGC 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 and provides a remote control function through either the RS-232 or CSMA interface. 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.

**Table 1. IF Filter Specifications\***

3-dB Bandwidth (kHz)**	(Maximum) Shape Factor (3/60 dB)	(Typical) Group Delay Variation (100% of 3-dB Bandwidth)
0.3	1.35:1	50 $\mu$ S
1.0	1.40:1	30 $\mu$ S
3.2	1.25:1	30 $\mu$ S
6.0	1.25:1	40 $\mu$ S
16.0	1.25:1	60 $\mu$ S
USB/LSB/ISB (3.2)	1.25:1	30 $\mu$ S

\* See typical plots in figures 3, 4 & 5

\*\* Consult factory for alternate or additional IF bandwidths



## Specifications

Frequency Range .....	5 kHz to 30 MHz (Tunable to 0 Hz, degraded performance below 500 kHz)
Tuning Resolution .....	1 Hz
Internal Reference Stability .....	Better than 0.7 PPM (0 to 50°C) Better than 0.2 PPM (0 to 50°C) with REF option
External Reference Frequency .....	Accepts 1, 2, 5 or 10 MHz ( $\pm 1$ PPM or better, 200 mV RMS into high impedance load); automatically switches to external reference upon application of signal
Synthesizer Lock Time .....	Less than 10 msec, typical
<b>Antenna Input</b>	
Impedance .....	50 ohms, nominal
VSWR .....	2:1 maximum at receiver's tuned frequency
Maximum Input Signal .....	+30 dBm
Connector .....	BNC, female
3rd-Order Intercept Point .....	+30 dBm typical, +25 dBm, minimum (for signals separated by 50 kHz minimum)
2nd-Order Intercept Point .....	+60 dBm, typical
Noise Figure .....	14 dB, maximum (11 dB maximum with Preamplifier engaged)
Detection Modes .....	AM, FM, CW, USB, LSB & ISB (Consult factory for additional demodulation modes)

### Sensitivity (500 kHz to 30 MHz)

Modulation	IFBW (kHz)	S+N/N (dB)	Without Preamp Min dBm/( $\mu$ V)
AM (50% mod. at 400 Hz)	6.0	10	-103/(1.58)
FM (4.8-kHz dev. 400 Hz mod)	16.0	17	-99/(2.50)
USB/LSB/ISB	3.2	10	-112/(0.56)
CW	0.3	16	-116/(0.35)

### CW Sensitivity, 5 kHz to 500 kHz, without Preamp (0.3-kHz IF Bandwidth)

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 mV 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
Output Level .....	-20 dBm, nominal
Output Impedance .....	50 ohms, nominal
Connector Type .....	BNC, female

### Signal Monitor Output

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



<b>Gain Control Modes</b> .....	Manual, AGC Fast & Slow
AGC Range .....	100 dB, minimum
AGC Threshold .....	Approximately -108 dBm (0.9 $\mu$ V) in 16-kHz bandwidth. Approximately -125 dBm (0.12 $\mu$ V) in 300-Hz bandwidth. (Threshold is matched with IF bandwidth & is typically 10 dB above noise floor)
AGC Attack Time .....	15 msec, typical
AGC Decay Time .....	Fast: 25 msec, typical Slow: 4 seconds, typical
<b>Selectable Front End Gain/Attenuation</b>	
Preamplifier Gain .....	10 dB ( $\pm$ 2 dB)
Attenuation .....	15 dB ( $\pm$ 2 dB)
<b>BFO</b>	
Tuning Range .....	$\pm$ 8000 Hz
Tuning Resolution .....	10 Hz
<b>First Image Rejection</b> .....	90 dB, minimum
<b>IF Rejection</b> .....	85 dB minimum, >90 dB typical
<b>LO Phase Noise</b> .....	-110 dBc at 1-kHz offset, typical
(see Figure 6)	
<b>Reciprocal Mixing</b> .....	With a desired signal of 25 $\mu$ V in the 3.2-kHz IF bandwidth, the desired signal-to-noise ratio 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 greater than 50 kHz in the 1-kHz IF bandwidth.
<b>Internal Spurious</b> .....	< -114 dBm referred to the RF input
<b>Blocking</b> .....	An unwanted signal 1 mV separated 20 kHz from a desired signal of 1 $\mu$ V will not cause the IF output to fall by more than 3 dB.
<b>Line Audio Outputs</b>	
Number of Outputs .....	Two center-tapped, balanced outputs. For ISB mode, USB & LSB on separate outputs. For all other modes, audio signal is common to both outputs.
Output Level .....	0 dBm nominal into 600-ohm load
Connector Type .....	Screw terminals
<b>Speaker Output</b>	
Number of Outputs .....	One output. For ISB mode, USB & LSB can be selected individually or combined.
Bandwidth .....	100 Hz to 13 kHz
Output Level .....	Adjustable up to 1 W into 8-ohm load
Total Harmonic Distortion .....	<3% at 1 W
Connector Type .....	Screw terminals



### Headphone Output

Number of Outputs .....	Two unbalanced outputs. For ISB mode, one output contains USB (left channel), the other contains LSB (right channel). In all other modes, the audio signal is common to both outputs.
Output Level .....	Adjustable up to 10 mW into 600-ohm load
Connector Type .....	Standard 1/4" stereo jack
<b>Remote Control</b> .....	RS-232 or CSMA; selectable by internal switch
RS-232 .....	Full duplex, 3-wire serial interface; rear panel 25-pin female D-shell connector
CSMA .....	Half duplex, rear panel miniature phone jack
<b>Baud Rates (Both Interfaces)</b> .....	75, 150, 300, 600, 1200, 2400, 4800 & 9600; selectable by internal switch
<b>Operating Temperature</b> .....	0 to +50°C
<b>Storage Temperature</b> .....	-40 to +70°C
<b>Humidity</b> .....	10 Cyclic days (240 hours); procedure III for continuous exposure to 95% RH (non-condensing)
<b>Altitude</b> .....	50,000 ft. (15,240 meters) non-operating 24,000 ft. (7,315 meters) operating
<b>Shock</b> .....	Bench handling (field service) 8 drops total onto a horizontal hard wooden surface - operating.
<b>MTBF</b> .....	In excess of 13,000 hours; Estimated in accordance with MIL-HDBK 217E for ground fixed; +40°C environment

### Environmental Specifications

Power Requirements .....	97 to 253 Vac, 47 to 440 Hz
Power Consumption .....	<30 W, typical with options

### Weights & Dimensions\*

Height	Width	Depth	Weight
3.5 in. (8.89 cm)	8.25 in. (20.96 cm)	20 in. (50.80 cm)	< 12 lbs. (5.5 kg)

\*excluding connectors & controls

**Table 2. Connectors (Inputs/Outputs)**

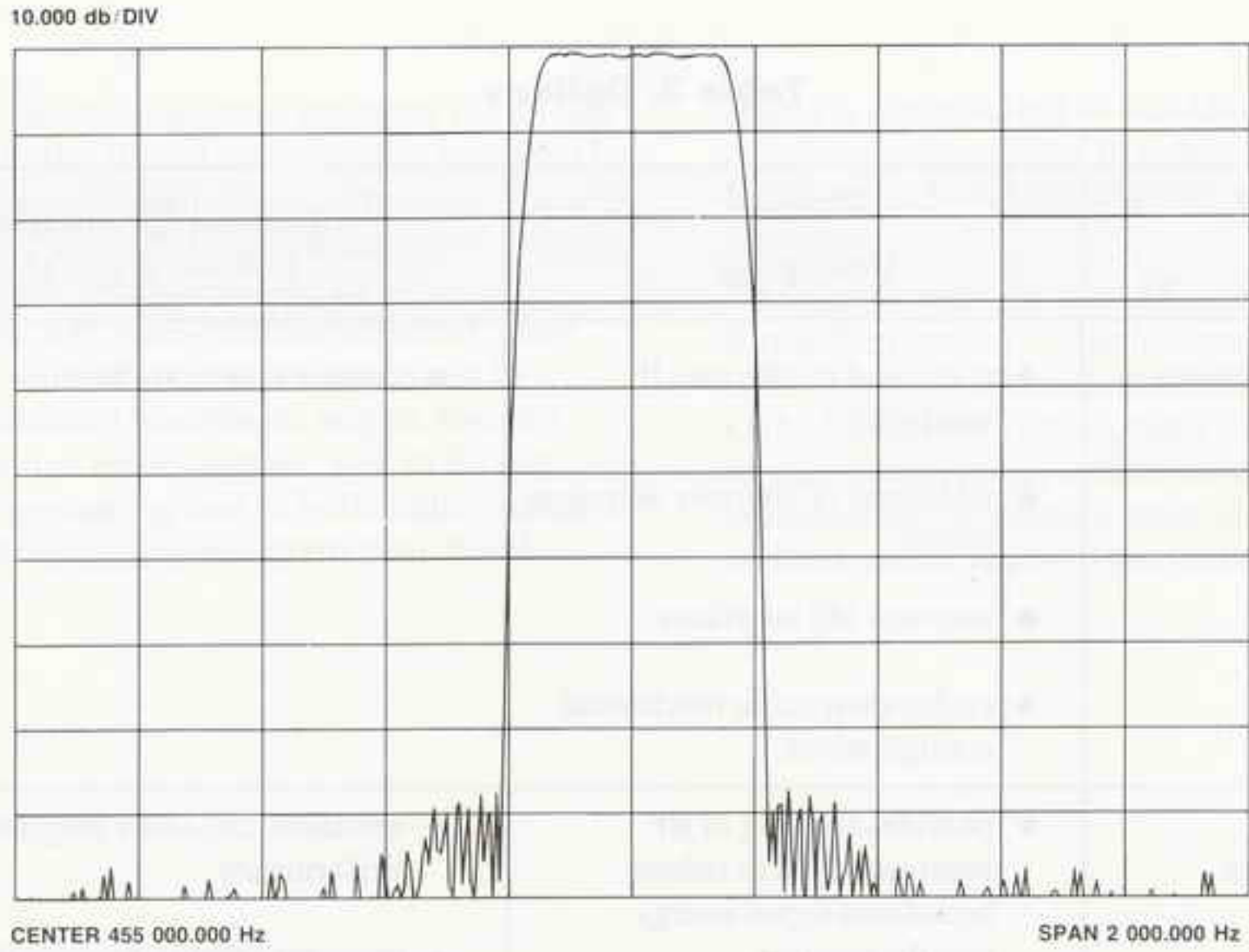
I/O	Function	Type
Input	Antenna External Reference Power Mute	BNC BNC IEC 3-pin Terminal Block
Output	Signal Monitor IF Line Audio Output A Line Audio Output B Speaker DC-coupled Audio Squelch Headphone  Received Signal Strength Indicator	BNC BNC Terminal Block Terminal Block Terminal Block Terminal Block Terminal Block Standard 1/4 in. jack Terminal Block
Both	CSMA Remote Interface  RS-232 Remote Interface Control Interface Test Port	1/8th in. miniature stereo jack 25-pin female D-shell 25-pin D-shell



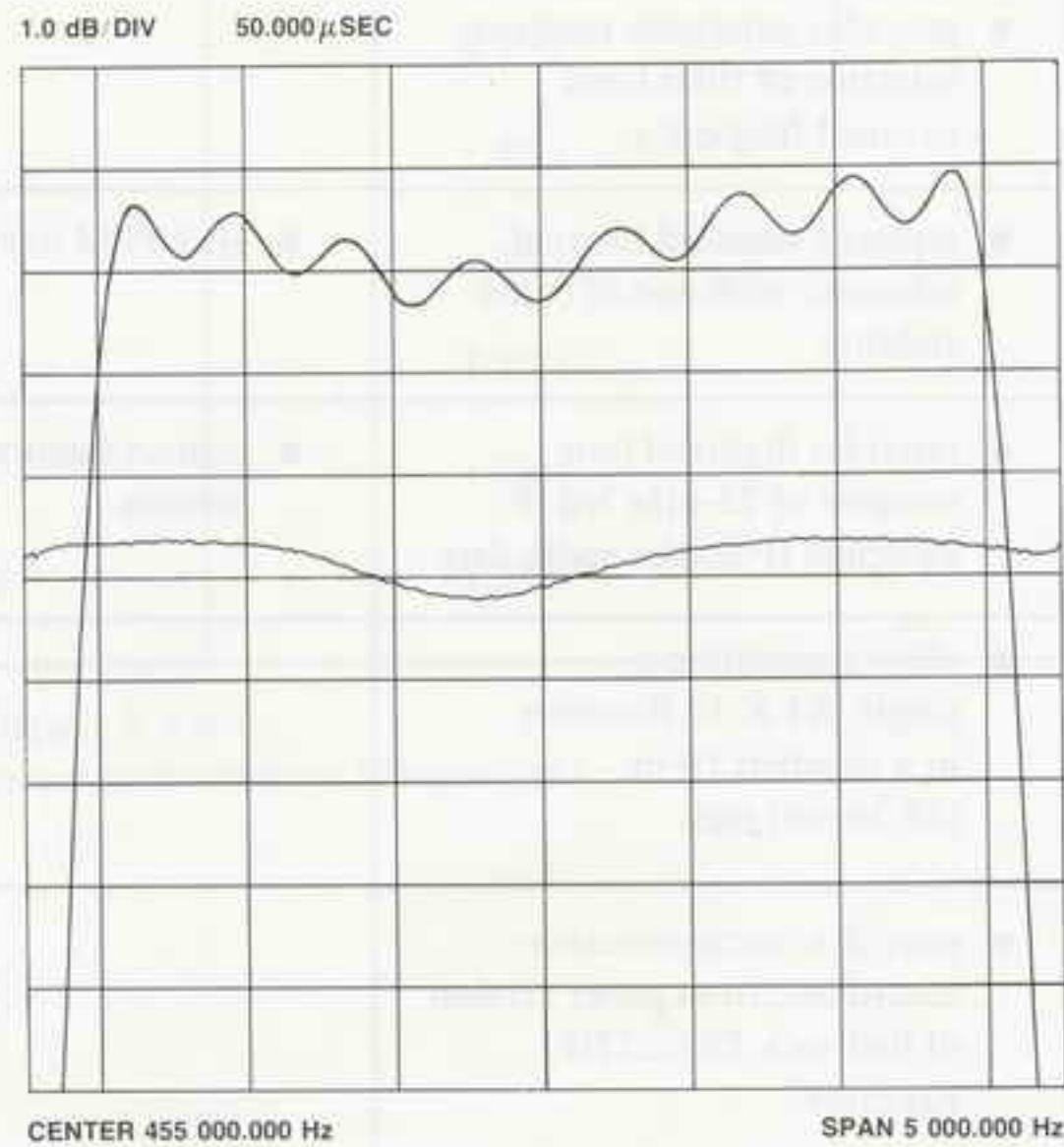
**Table 3. Options**

Nomenclature	Description	Additional Specifications to Basic WJ-8712
Customer-specific options	<ul style="list-style-type: none"> <li>● additional or alternate IF bandwidths</li> <li>● additional or alternate detection modes</li> <li>● alternate I/O interfaces</li> <li>● customer-specific mechanical configurations</li> </ul>	<ul style="list-style-type: none"> <li>● contact factory for details</li> </ul>
WJ-8712/PRE 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 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>
WJ-871Y/REF Frequency Reference	<ul style="list-style-type: none"> <li>● replaces standard internal reference with one of better stability</li> </ul>	<ul style="list-style-type: none"> <li>● <math>\pm 0.2</math> PPM over temperature</li> </ul>
WJ-871Y/DSO1 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>● contact factory for details &amp; alternate formats</li> </ul>
WJ-8712/BR Blank Rack	<ul style="list-style-type: none"> <li>● allows mounting a single WJ-8712 Receiver in a standard 19-in. (48.26 cm) rack</li> </ul>	
Front Panel Version	<ul style="list-style-type: none"> <li>● provides microprocessor-controlled, front panel version of half-rack Digital HF Receiver</li> </ul>	



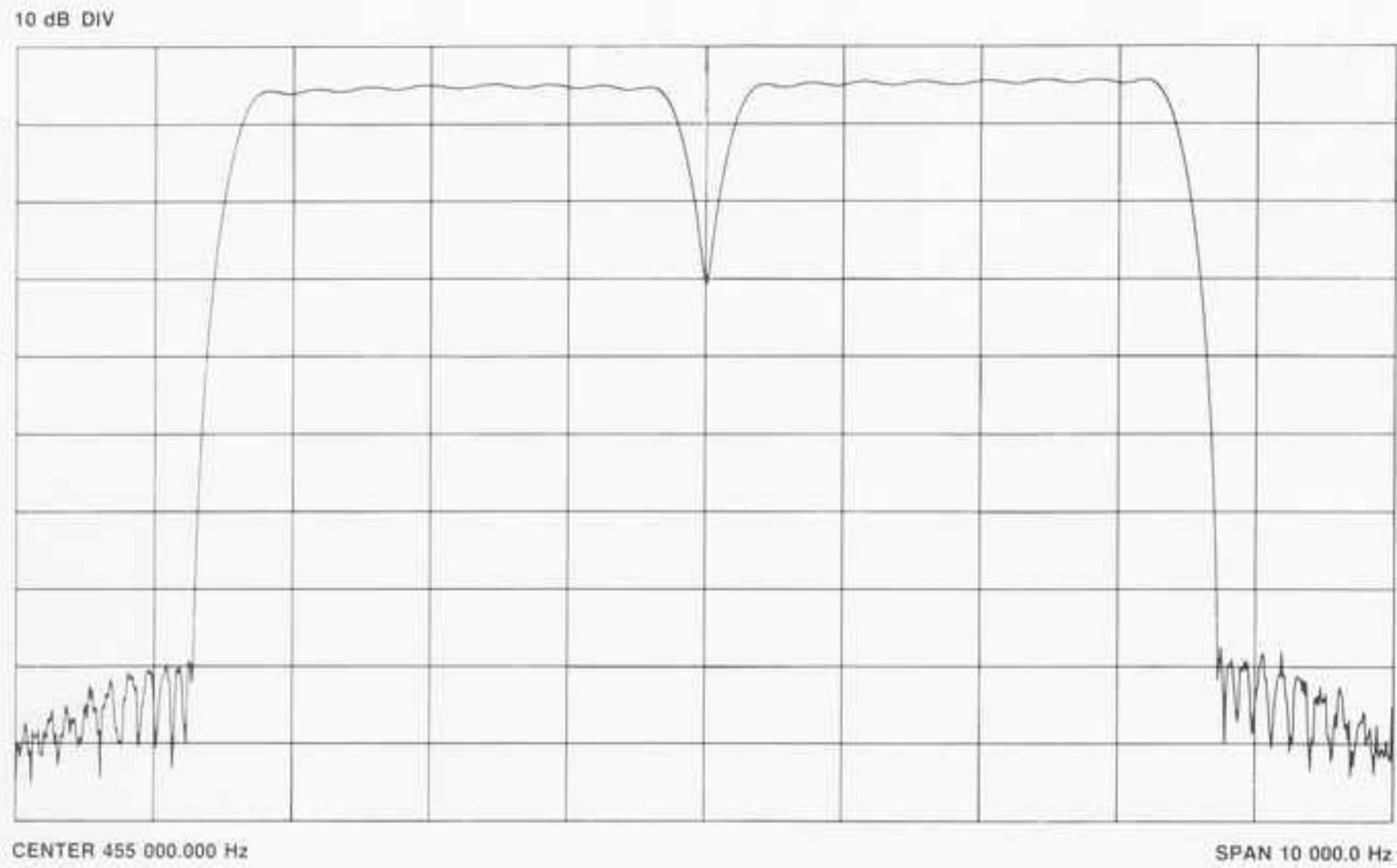


**Figure 3. WJ-8712 Typical 300 Hz IF Filter Amplitude Response**

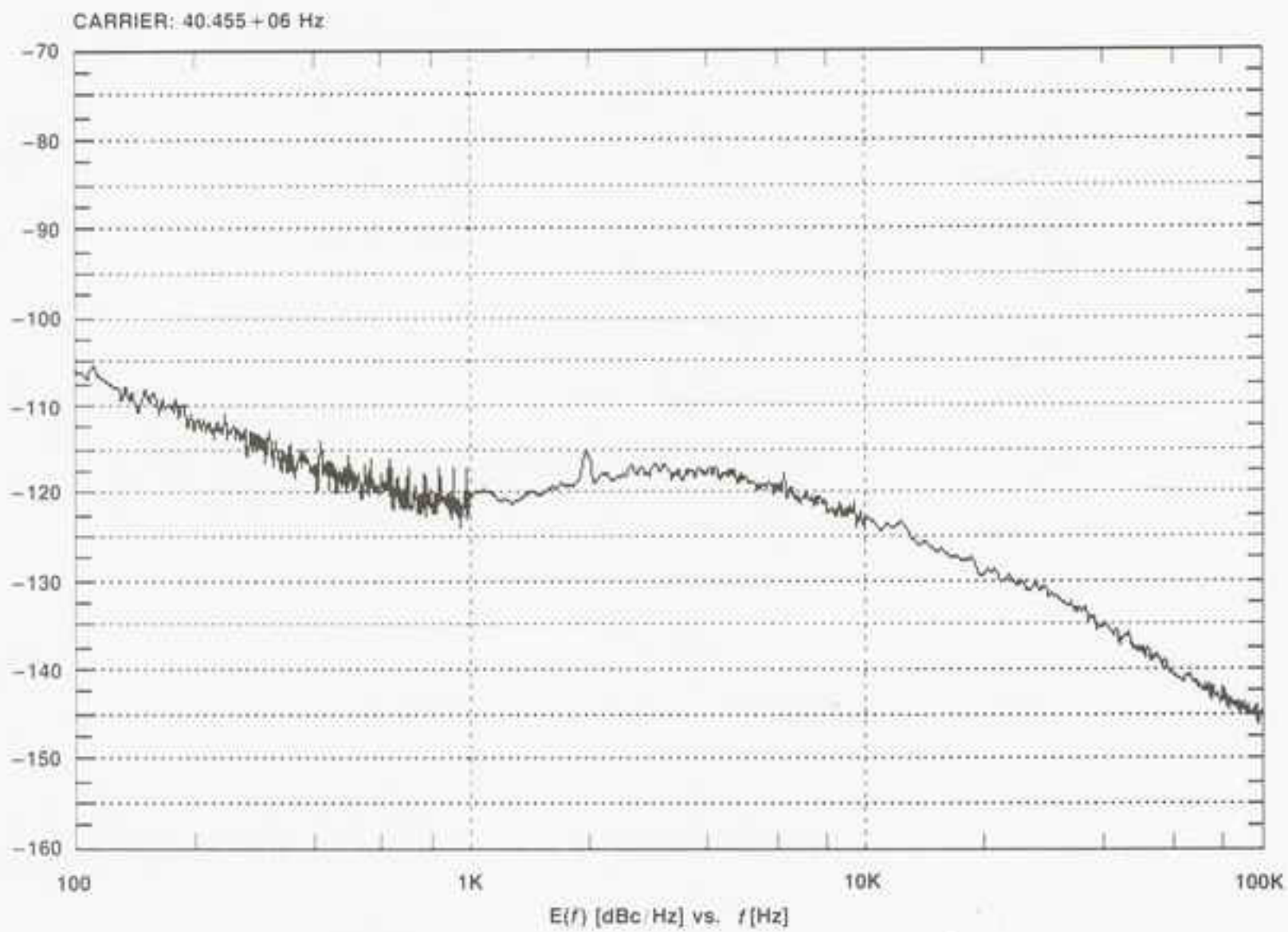


**Figure 4. WJ-8712 Typical SSB IF Filter Group Delay & Passband Ripple**





**Figure 5. WJ-8712 Typical ISB (USB/LSB) IF Filter Amplitude Response**



**Figure 6. WJ-8712 Typical Phase Noise**