

# Technical Data



WATKINS-JOHNSON

May 1996

## Digital HF Receiver WJ-8712A



The WJ-8712A 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-8711A. By combining analog and digital signal processing (DSP), the WJ-8712A achieves high performance at low cost.

The WJ-8712A 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. In lieu of the RS-232 interface, an operator can enable a Carrier Sense Multiple Access with Collision Detection (CSMA) with a limited instruction set interface. The enabled CSMA controls the WJ-8712A by using a command protocol similar to several popular consumer receivers. Selection of the active interface is via an internal switch setting or by front panel entry. Contact the factory for a detailed list of remote control commands,

### 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 66 IFBWs up to 16 kHz with exceptional shape factors
- ❑ AM, SAM, 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 & passband tuning
- ❑ Tunable IF notch filter
- ❑ Internal switchable Preamplifier & Attenuator
- ❑ Internally-selectable RS-232 or CSMA remote control
- ❑ Extensive built-in self test
- ❑ Numerous options including: IEEE-488 or multidrop RS-485 remote control, suboctave preselector, digital data output, speech enhancement

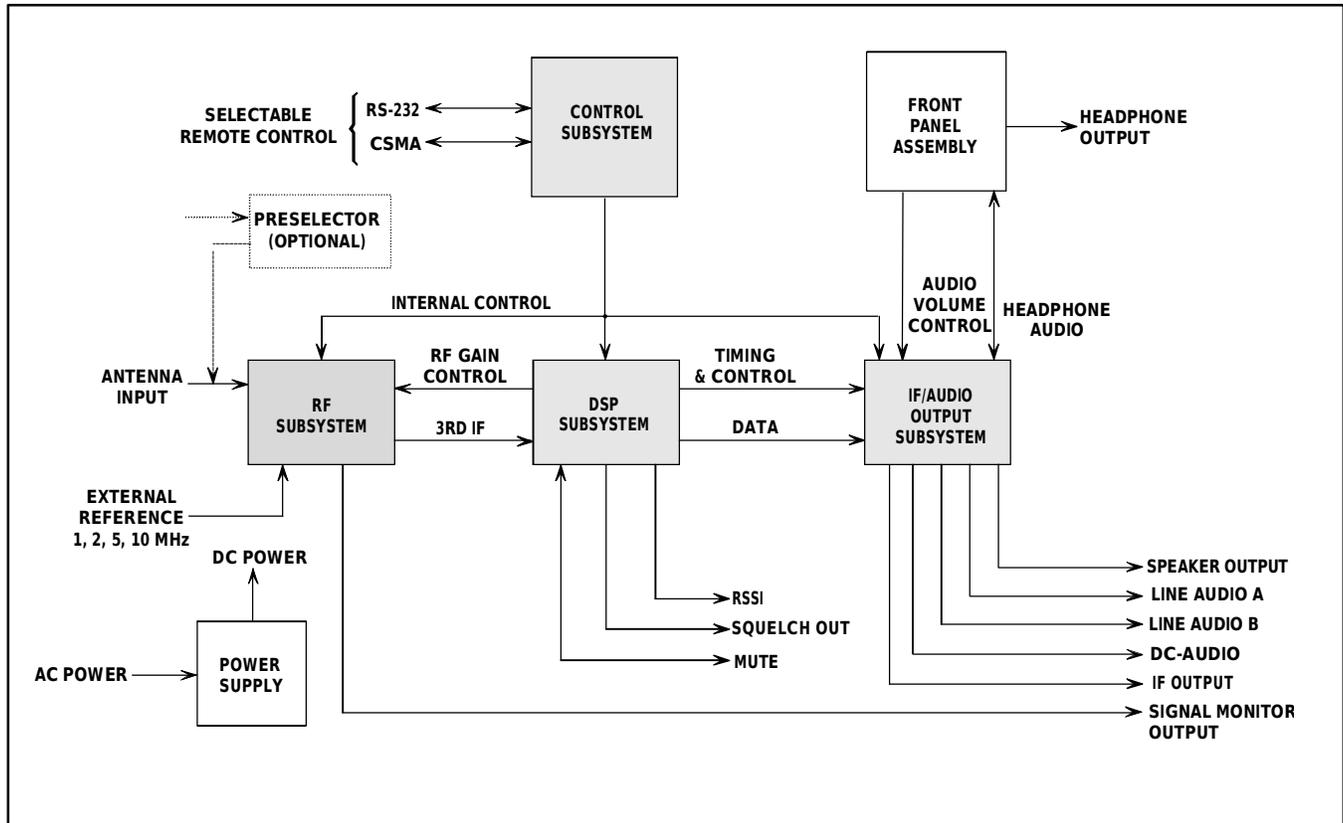
HEIGHT 3.5 in (8.89 cm)      DEPTH 20 in (50.80 cm)  
WIDTH 8.25 in (20.96 cm)      WEIGHT < 12 lbs (5.5 kg)

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**WJ-8712A**



WJ-8712A Functional Block Diagram

in order to eliminate any confusion over the extent of the available commands included in each type of interface.

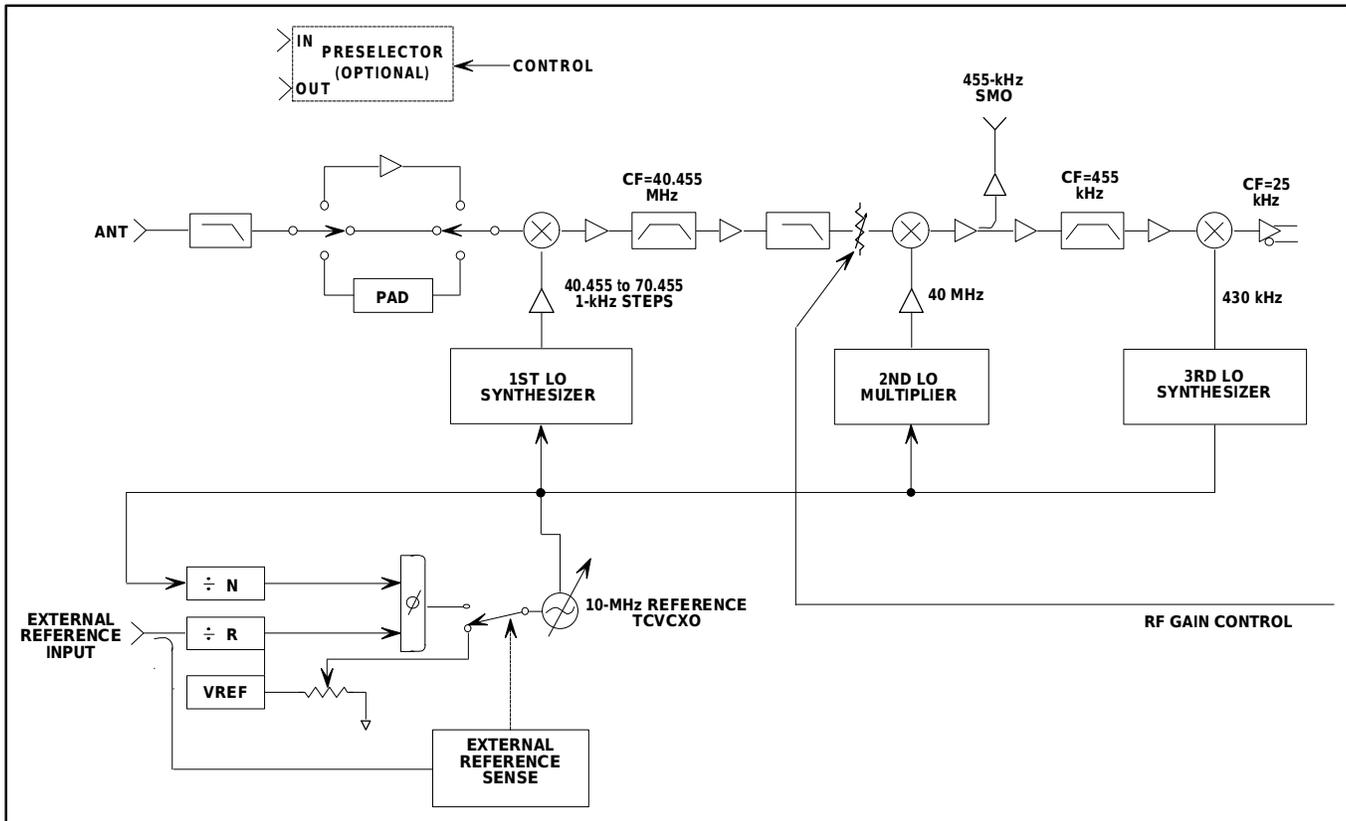
In addition to fixed-frequency tuning, the WJ-8712A provides a fast, flexible scanning capability. Three scan modes are available: channel scan, F1-F2 scan, and F1-F2 scan with lockouts. For all scan modes, the dwell time can be set from 0.5 to 20 seconds or infinite. In channel scan mode, 100 programmable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

Functions such as noise blanking, tunable notch filter, IF filtering, Automatic-Gain Control (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. There are 66 selectable IF bandwidths (IFBW) ranging from 60 Hz to 16 kHz (Table 2). Available detection modes are AM, synchronous AM (SAM), FM, CW, USB, LSB, and ISB. A tunable BFO can be adjusted in 10-Hz steps over a  $\pm 8000$  Hz range. Passband tuning further enhances the reception of CW signals. Gain

control can be accomplished manually or automatically, with variable fast, medium, and slow AGC modes. When the signal drops below a user-specified level, enabling the variable AGC threshold forces the receiver into manual gain. The squelch threshold is adjustable from 0 to -135 dBm, or it can be disabled.

A tunable IF notch allows an operator to tune a Digital Notch Filter through the selected IFBW, in order to eliminate undesired signals within the IF passband. Typical notch 3-dB bandwidth is 10 to 20 percent of the selected IFBW and provides 50-dB of rejection (typical). The notch filter is a nonlinear phase IIR Filter and should not be used when flat group-delay response is required. The notch filter is not available in CW detection mode.

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



WJ-8712A RF Subsystem Functional Block Diagram

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-8712A is mountable in a standard 19-inch (48.26 cm) equipment rack occupying 3.5 inches (8.89 cm) of vertical rack space. The standard configuration is two units mounted side-by-side. Using an optional blank rack (WJ-8712/BR) allows the mounting of 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.

## Functional Description

As illustrated in WJ-8712A functional block diagram, the WJ-8712A is divided into four functional subsystems: RF, DSP, IF/Audio Output and Control. The WJ-8712A RF Subsystem functional block diagram provides a 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 is lockable to an external reference input of 1, 2, 5 or 10 MHz. The WJ-8712A 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

**WJ-8712A**

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
- Tunable notch filtering
- IF 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 one or two demodulated audio channels and 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.

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 μS
1.0	1.40:1	30 μS
3.2	1.25:1	30 μS
6.0	1.25:1	40 μS
16.0	1.25:1	60 μS
USB/LSB/ISB (3.2)	1.25:1	30 μS

See typical plots on pages 7 & 8.

IF Filter Set (Nominal 3-dB Bandwidth in Hz)

56	113	225	450	900	1800	3600	7200	14400
63	125	250	500	1000	2000	4000	8000	16000
69	138	275	550	1100	2200	4400	8800	
75	150	300	600	1200	2400	4800	9600	
81	163	325	650	1300	2600	5200	10400	
88	175	350	700	1400	2800	5600	11200	
94	188	375	750	1500	3000	6000	12000	
100	200	400	800	1600	3200	6400	12800	

The 900 through 3200 Hz bandwidths are available in SSB detection mode.

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 0.7 PPM (0 to 50°C) Better than 0.2 PPM (0 to 50°C) with REF option
<b>External Reference Frequency</b> .....	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
<b>Synthesizer Lock Time</b> .....	>10 msec, typical
<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 50 kHz, min)
<b>2nd-Order Intercept Point</b> .....	+60 dBm, typical
<b>Noise Figure</b> .....	14 dB, max (11 dB, max with Preamp engaged)
<b>Detection Modes</b> .....	SAM, AM, FM, CW, USB, LSB & ISB (Consult factory for additional modes)

Sensitivity (500 kHz to 30 MHz)

Modulation	IFBW (kHz)	S+N/N (dB)	Without Preamp Min dBm/(mV)
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 mV 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 mV typical for 16 dB S+N/N

**IF Output**

<b>Center Frequency</b> .....	455 kHz (consult factory for additional IF center frequencies)
<b>Output Level</b> .....	-20 dBm, nominal
<b>Output Impedance</b> .....	50 ohms, nominal
<b>Connector Type</b> .....	BNC, female

**Signal Monitor Output**

<b>Center Frequency</b> .....	455 kHz, nominal (inverted)
<b>Bandwidth</b> .....	30 kHz (-6dB), min
<b>Output Level</b> .....	30 dB above RF input, nominal
<b>Output Impedance</b> .....	50 ohms, nominal
<b>Connector Type</b> .....	BNC, female

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

Manual, AGC-Fast, -Medium & -Slow	
<b>AGC Range</b> .....	100 dB, min
<b>AGC Threshold</b> .....	Variable from -108 dBm (0.9 mV) in 16-kHz bandwidth Variable from -125 dBm (0.12 mV) in 300-Hz bandwidth (Threshold minimum matched with IFBW & is typically 10 dB above noise floor)

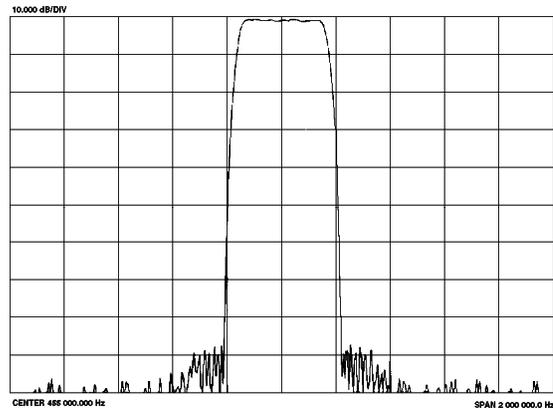
AGC Attack Time .....	5 msec, typical
AGC Decay Time .....	Fast: 10 to 100 msec Med: 100 msec to 1 sec Slow: 1 to 5 sec
<b>Selectable Front-End Gain/Attenuation</b>	
Preamplifier Gain .....	10 dB ( $\pm 2$ dB)
Attenuation .....	15 dB ( $\pm 2$ dB)
<b>BFO</b>	
Tuning Range .....	$\pm 8000$ Hz
Tuning Resolution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

Environmental Specifications

<b>Baud Rates (Both Interfaces)</b> .....	75, 150, 300, 600, 1200, 2400, 4800 & 9600 (selectable by internal switches)
<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
<b>Power Requirements</b> .....	97 to 253 Vac, 47 to 440 Hz
<b>Power Consumption</b> .....	<30 W, typical with options

Options

The WJ-8712A Digital HF Receiver is available in a variety of configurations. Continuous product improvements have produced significant enhancements and a wide array of options for the product line. See the WJ-871Y Option Matrix for current option availability.

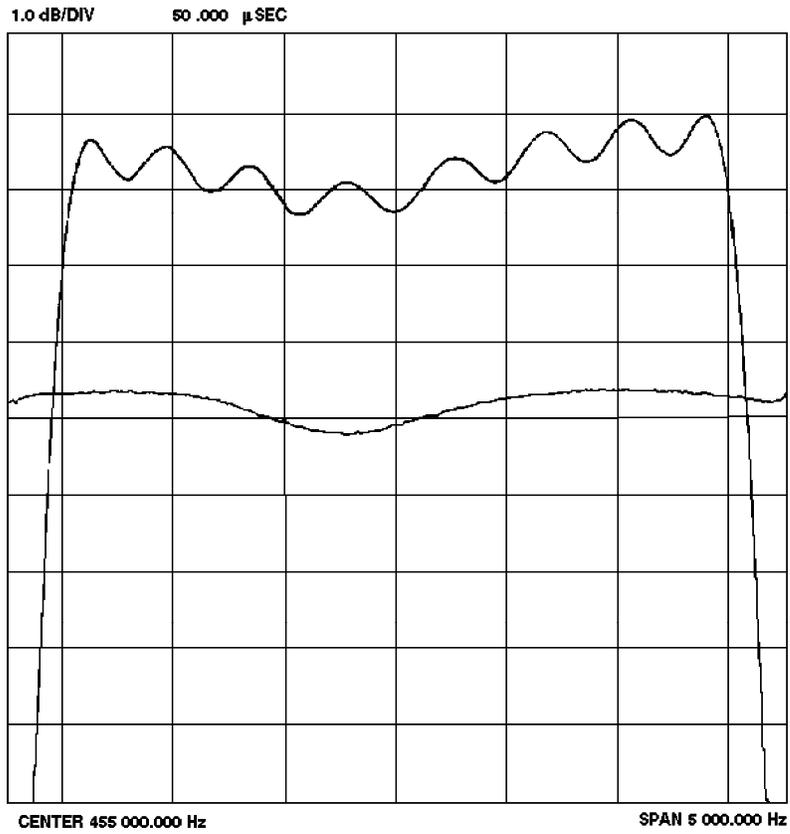


WJ-8712A Typical SSB IF Filter Group-Delay & Passband Ripple

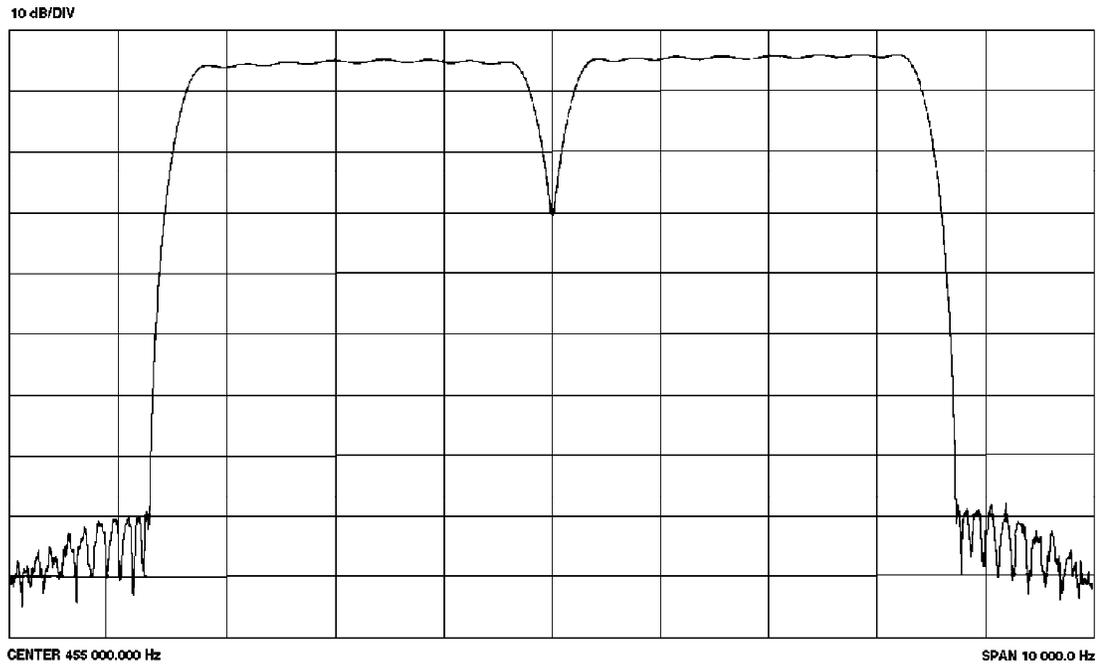
Receiver Connectors

I/O	Function	Type
<b>Input</b>	Antenna External Reference Power Mute	BNC BNC IEC 3-pin Terminal Block
<b>Output</b>	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
<b>Bidirectional</b>	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

**WJ-8712A**



WJ-8712A Typical 300-Hz IF Filter Amplitude Response



WJ-8712A Typical ISB (USB/LSB) IF Filter Amplitude Response