Technical Data

WATKINS-JOHNSON

May 1996

Compact Digital HF Receiver
WJ-8710A

The WJ-8710A 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 blank-front-panel unit is packaged in an enclosure that measures approximately 11.5 x 7.5 x 2.5 inches (29.21 x 19.05 x 6.35 cm), and utilizes the same RF and Digital printed circuit boards as the WJ-8711A. By combining analog and digital signal processing (DSP), the WJ-8710A achieves high performance at low cost.

The WJ-8710A 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-8710A 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, 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 66 IFBWs up to 16 kHz with exceptional shape factor*
- ❏ *Standard AM, SAM, FM, CW, USB, LSB & ISB detection modes*
- ❏ *Fast, flexible scanning with 100 memory channels*
- ❏ *Compact 11.5 x 7.5 x 2.5 in (29.21 x 19.05 x 6.35 cm) configuration*
- ❏ *Noise blanking & passband tuning*
- ❏ *Tunable IF notch filter*
- ❏ *Optional speech enhancement*
- ❏ *Internal switchable Preamplifier & Attenuator*
- ❏ *Internally selectable RS-232 or CSMA remote control (optional multidrop 485)*
- ❏ *Extensive built-in self test*
- ❏ *Optional digital data outputs*

Height	2.5 in (6.35 cm)	**Depth**	11.5 in (29.21 cm)
Width	7.5 in (19.05 cm)	**Weight**	<7 lbs (<3.17 kg)

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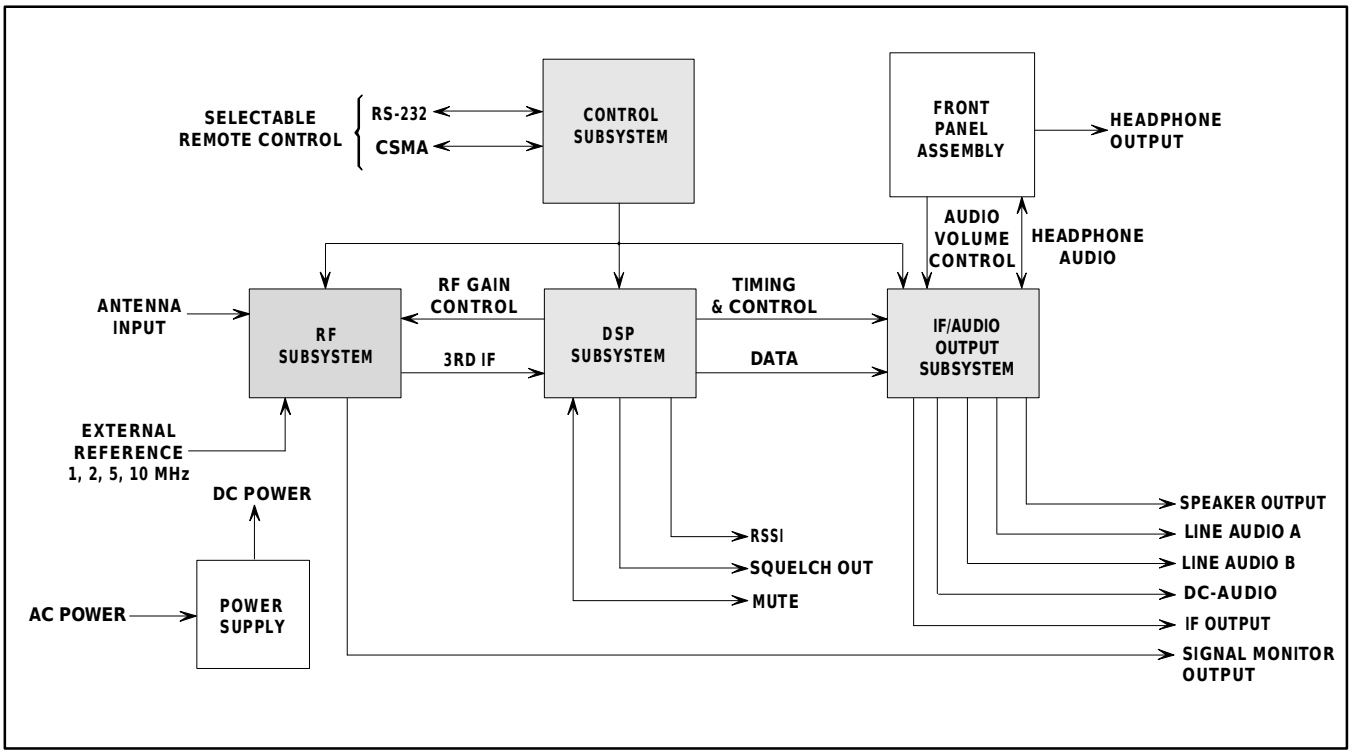


WJ-8710A Functional Block Diagram

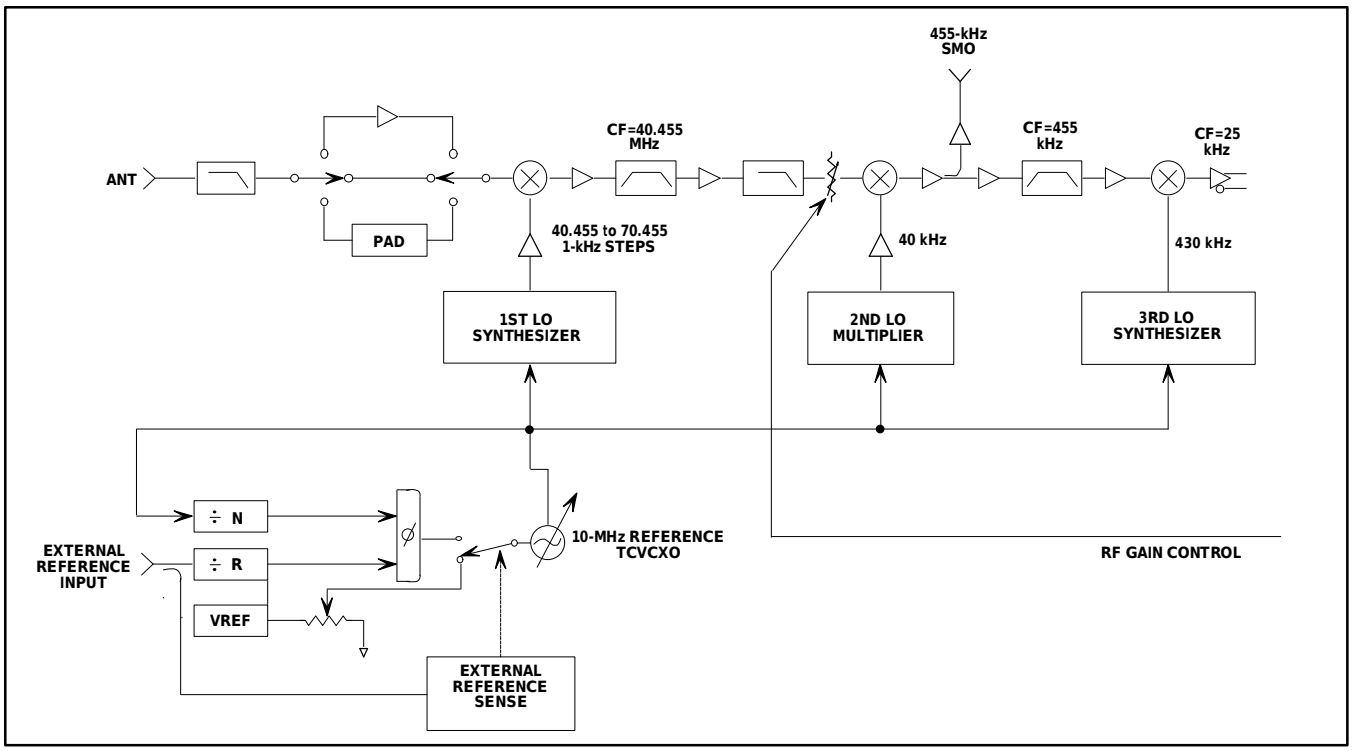
In addition to fixed-frequency tuning, the WJ-8710A provides a fast, flexible scanning capability. Three scan modes are available: channel scan, F1-F2 scan and F1-F2 scan with lockouts. For all scan modes, the dwell time can be set from 0.5 to 20 seconds or infinite. In channel scan mode, 100 programmable memory channels are available.

Functions such as noise blanking, tunable notch filtering, 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 (IFBWs) ranging from 50 Hz to 16 kHz (Table C). Available detection modes are-- Synchronous AM (SAM), AM, FM, CW, USB, LSB, and ISB. A tunable BFO is adjustable in 10-Hz steps over a $\pm$8000 Hz range. Passband tuning is available to further enhance the reception of CW signals. Gain control is accomplished manually or automatically, with fast, medium, and slow AGC modes available. A variable AGC threshold can be enabled to force the receiver into manual gain when signal drops below a user-specified level. The squelch threshold is adjustable from 0 to -135 dBm, or it can be disabled. Enabling the noise blanking feature effectively eliminates the adverse effects of impulsive noise. 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 front panel of the unit. 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. The CSMA interface is provided via a miniature phone jack.

The WJ-8710A operates on +12 Volt power input at 1.5 amps typical without options.

As illustrated in the WJ-8710A block diagram the WJ-8710A is divided into four functional subsystems: RF, DSP, IF/Audio Output, and Control. A functional block diagram of the RF Subsystem is provided. 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 to 70.455 MHz in 1-kHz steps, to produce a first IF of 40.455 MHz. The first IF filter limits



WJ-8710A RF Subsystem Functional Block Diagram

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 this 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 1, 2, 5 or 10 MHz. The WJ-8710A 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 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
- Tunable notch filtering
- Gain control (AGC-fast, -medium, -slow, or manual)
- Signal strength & squelch functions
- Signal demodulation & BFO
- Generation of a multiplexed digital data-stream containing one or two 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

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)

External Reference Frequency ..... Accepts 1, 2, 5 or 10 MHz (±1 PPM or better, 200 mVrms into high impedance load); automatically switches to external reference upon application of signal

Synthesizer Lock Time ..... <10 msec, typical

Antenna Input
- **Impedance** ..... 50 ohms, nominal
- **VSWR** ..... 2:1, max (at receiver's tuned frequency)
- **Maximum Input Signal** ..... +30 dBm
- **Connector** ..... BNC, female

3rd-Order Intercept Point ..... +30 dBm, typical
+25 dBm, min (for signals separated by 50 kHz, min)

2nd-Order Intercept Point ..... +60 dBm, typical

Noise Figure ..... 14 dB, max (11 dB, max w/preamplifier engaged)

Detection Modes ..... SAM, 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/(mV)
AM (50% mod. at 400 Hz)	6.0	10	-103/(1.58)
FM (4.8 kHz dev. 400 Hz mode)	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 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 Bandwidths ..... See typical plots on page 8

IF Shape Factors

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

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.

IF Output

Center Frequency ..... **455 kHz (consult factory for additional IF center frequencies)**
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 (-6 dB), min**
Output Level ..... **30 dB above RF input, nominal**
Output Impedance ..... **50 ohms, nominal**
Connector Type ..... **BNC, female**

Gain Control Modes ..... **Manual, AGC-Fast , -Medium, -Slow**
AGC Range ..... **100 dB, min**
AGC Threshold ..... **Variable from -108 dBm (0.9 mV) in 16-kHz bandwidth**
Variable from -125 dBm (0.12 mV) in 300-Hz bandwidth
(Threshold minimum is matched with IFBW & is typically 10 dB above noise floor)
AGC Attack Time ..... **5 msec, typical**
AGC Decay Time ..... **Fast: 0 to 100 msec**
..... **Medium: 100 msec to 1 sec**
..... **Slow: 1 to 5 sec**

Selectable Front-end Gain/Attenuation

Preamplifier Gain ..... **10 dB (±2 dB)**
Attenuation ..... **15 dB (±2 dB)**

BFO

Tuning Range ..... **±8000 Hz**
Tuning Resolution ..... **10 Hz**

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 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.**

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
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.
Line Audio Outputs	
Number of Outputs	2 center-tapped, balanced ISB mode: USB & LSB on separate outputs All other modes: audio signal common to both outputs
Output Level	0 dBm, nominal (into 600-ohm load)
Connector Type	Screw Terminals
Speaker Output	
Number of Outputs	1 ISB mode: USB & LSB selected individually or combined
Bandwidth	100 Hz to 13 kHz
Output Level	750 mW, nominal (into 8-ohm load)
Total Harmonic Distortion	<3%
Connector Type	Screw terminals
Headphone Output	
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 1/8-in stereo jack
Remote Control	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	Carrier Sense Multiple Access with Collision Detection; half-duplex; rear-panel miniature phone jack
Baud Rates (Both Interfaces)	75, 150, 300, 600, 1200, 2400, 4800 & 9600 (selectable by internal switches)
Operating Temperature	0 to +50°C
Storage Temperature	-40 to +70°C
Humidity	10 Cyclic days (240 hours) Procedure III for Continuous Exposure to 95% RH (Non-condensing)
Altitude	50,000 ft (15,240 meters) non-operating 24,000 ft (7,315 meters) operating
Shock	Bench handling (field service) 8 drops total onto a horizontal hard wooden surface - operating
MTBF	In excess of 13,000 hours; estimated in accordance with MIL-HDBK 217E for Ground Fixed; +40°C environment

Environmental Specifications

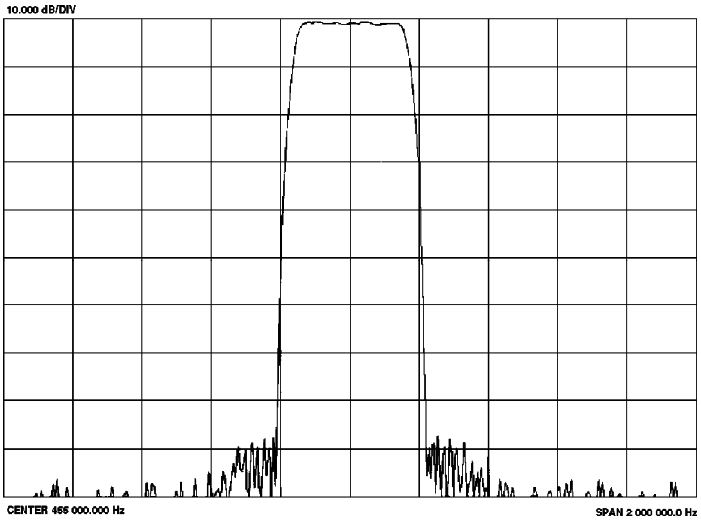
Power Requirements	**+11 to +16 Vdc**
Power Consumption	**<20 W, typical (without options)**

Options

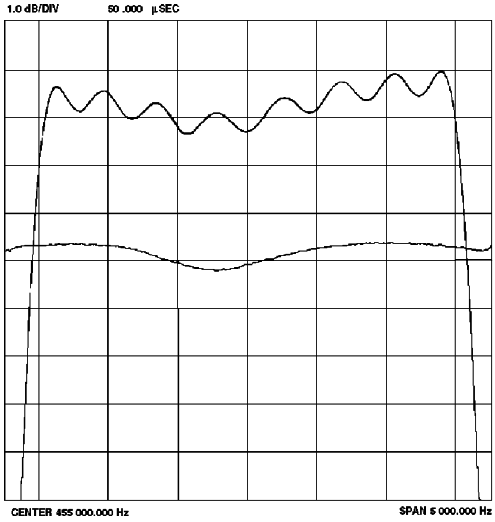
The WJ-8710A Digital HF receiver is available in a variety of configurations. Continuous product improvements have added significant enhancements and a wide array of options to the product line. See the WJ-871Y Option Matrix for current option availability.

Receiver Connectors

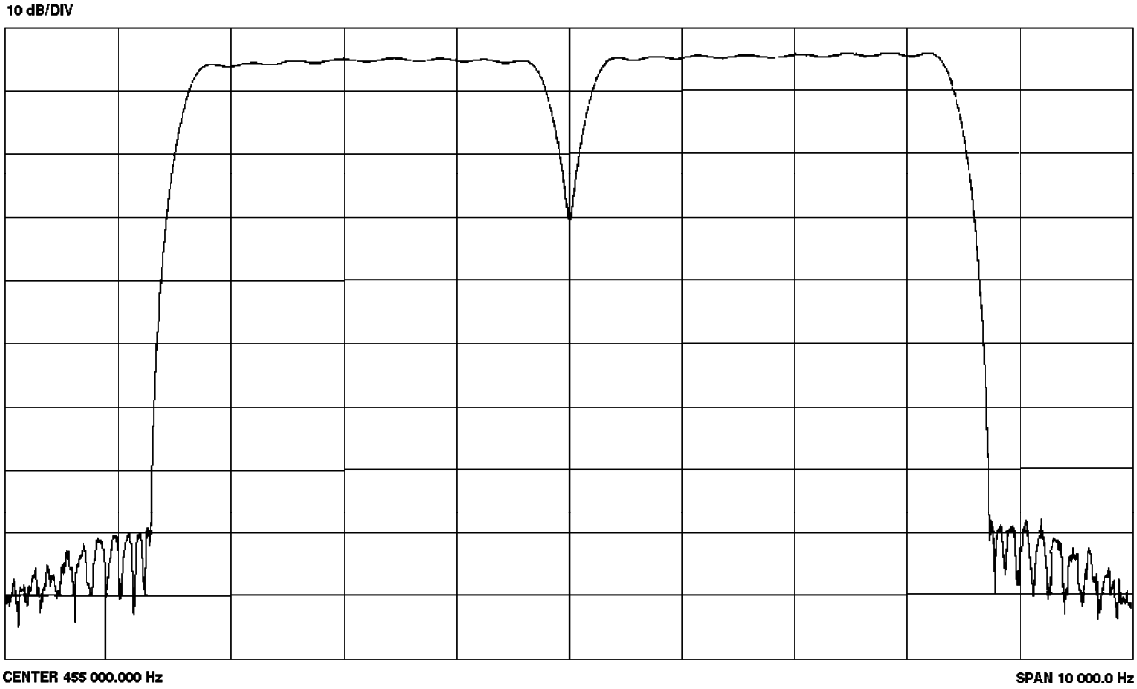
I/O	Function	Type
Inputs	**Antenna**	**BNC**
	External Reference	**BNC**
	Power	**3-pin LEMO**
	Mute	**Terminal Block**
Outputs	**Signal Monitor**	**BNC**
	IF	**BNC**
	Line Audio Output A	**Terminal Block**
	Line Audio Output B	**Terminal Block**
	Speaker	**Terminal Block**
	dc-coupled Audio	**Terminal Block**
	Squelch	**Terminal Block**
	Headphone	**Standard 1/8-in stereo jack**
	Received Signal Strength Indicator	**Terminal Block**
Bidirectional	**CSMA Remote Interface**	**1/8-in miniature stereo jack**
	RS-232 Remote Interface	**25-pin female D-shell**



WJ-8710A Typical 300-Hz IF Filter Amplitude Response



WJ-8710A Typical SSB IF Filter Group Delay & Passband Ripple



WJ-8710A Typical ISB (USB/LSB) IF Filter Amplitude Response