Technical Data

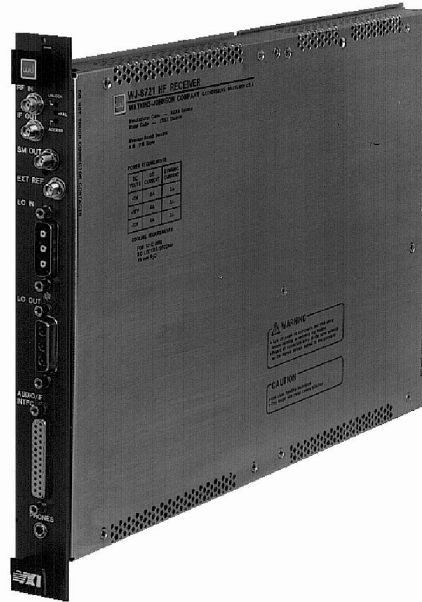**WJ** **WATKINS-JOHNSON**

May 1996

VXI HF Receiver
WJ-8721

The WJ-8721 is a fully synthesized, general-purpose HF receiver for surveillance, monitoring and direction finding for RF communi-cations from 5 kHz to 30 MHz with 1-Hz tuning resolution. The unit is packaged in a single slot *C-size* VXI (VMEbus Extensions for Instrumentation) module measuring 9.2 x 13.4 x 1.2 inches (23.37 x 34.04 x 3.05 cm). The WJ-8721 is ideal for applications requiring high density and the highest degree of integration. Placing the receiver directly on a standard instrumentation and computing bus significantly reduces difficulties in system integration.

Functions such as noise blanking, Tunable Notch Filter, IF filtering, Automatic Gain Control (AGC), demodulation, and Beat Frequency Oscillator (BFO) tuning are accomplished through the use of Digital Signal Processing (DSP) techniques. Filters with superior amplitude and group delay characteristics are achieved with digital stability and repeatability. Sixty-six selectable bandwidths range from 56 Hz to 16 kHz. Available detection modes are AM, FM, CW, USB, LSB, and ISB. A tunable BFO is adjustable in 10-Hz steps over a ± 8000 Hz range. Passband tuning further enhances the reception of available AGC modes. The squelch threshold is adjustable from 0 to -135 dBm, or can be disabled.

Features

❏ *Full HF receiver in a single 6U C size VXI card slot*

❏ *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*

❏ *AM, FM, CW, USB, LSB & ISB detection modes*

❏ *VXI message-based control*

❏ *High-density packaging: up to 12 HF receivers in a single VXI chassis*

❏ *Master/Slave phase-locked LOs when used in multichannel applications*

❏ *Digital IF data available over the VXIbus*

❏ *Built-in self test*

❏ *Suboctave preselector standard*

❏ *Digital outputs standard*
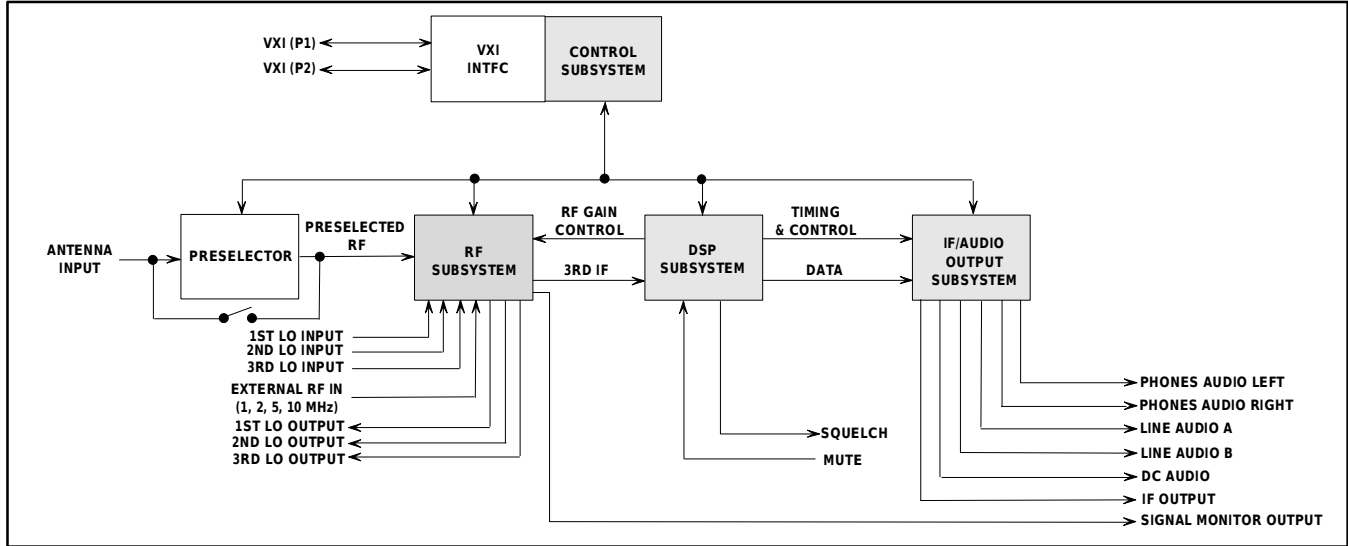
❏ *In-phase & quadrature digital outputs standard*

HEIGHT	9.2 in (23.37 cm)	**DEPTH**	13.4 in (33.53 cm)
WIDTH	1.2 in (3.05)	**WEIGHT**	<5 lbs (2.26 kg)

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WJ-8721 Functional Block Diagram

In addition to fixed-frequency tuning, the WJ-8721 Receiver provides fast, flexible scanning. 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 5 msec to 20 seconds, or infinite. In channel scan mode, 100 programmable memory-channels are available. Sectors of memory can be specified for individual channel scans, allowing the available memory to be subdivided into multiple search scenarios. The operator can specify certain channels to be skipped without having to delete them from memory. Memory channels can also be single-stepped manually. In both F1-F2 scan modes, the step size is user-selectable from 1 Hz to 25 kHz. Up to 100 independent frequency lockouts can be stored.

The WJ-8721 is operated remotely through a VXI interface. Since there is no front panel control on the WJ-8721 receiver, all receiver functions except power-on/off are accessible over this interface. Data is passed to and from the receiver using the VXI-standard Word Serial Protocol.

Besides being used as a standalone receiver, the VXI HF receiver is designed for applications employing phase-locked local oscillator (LO) configurations such as multichannel Direction Finding. All three LOs are generated internally, and may be locked to an external reference input. In addition, the first, second, and third LO's are provided at the front panel to be routed in a

daisy-chain fashion to slave receivers.

Because the WJ-8721 digitizes the IF signal for internal DSP, this digital data-stream is available for applications where external processors are required to perform high-throughput signal processing such as Fast Fourier Transforms (FFTs). Digital In-Phase and Quadrature-Phase (I&Q) data is available from both the VXIbus, as well as a digital output located on a connector on the front panel.

All receiver inputs and outputs are available on the front panel of the unit. The RF, IF, External Reference and Signal Monitor Output signals are available via SMA connectors on the front panel. The first, second, and third LO inputs and outputs are available via mixed layout D-subminiature connectors for Master/Slave applications. Digital-audio and -IF data is available on a high-speed differential TTL serial interface. Finally, a host of analog audio and control lines, such as mute, are also available on the front panel.

The WJ-8721 is mountable in any standard VXI chassis. Up to 12 receivers fit in a single 19-inch (48.26 cm) rack. One slot must be reserved for the slot-0 controller. A variety of system controllers based on Intel, Motorola and Hewlett Packard processors are available. These controllers are able to run UNIX, DOS, and Real-Time Operating Systems.
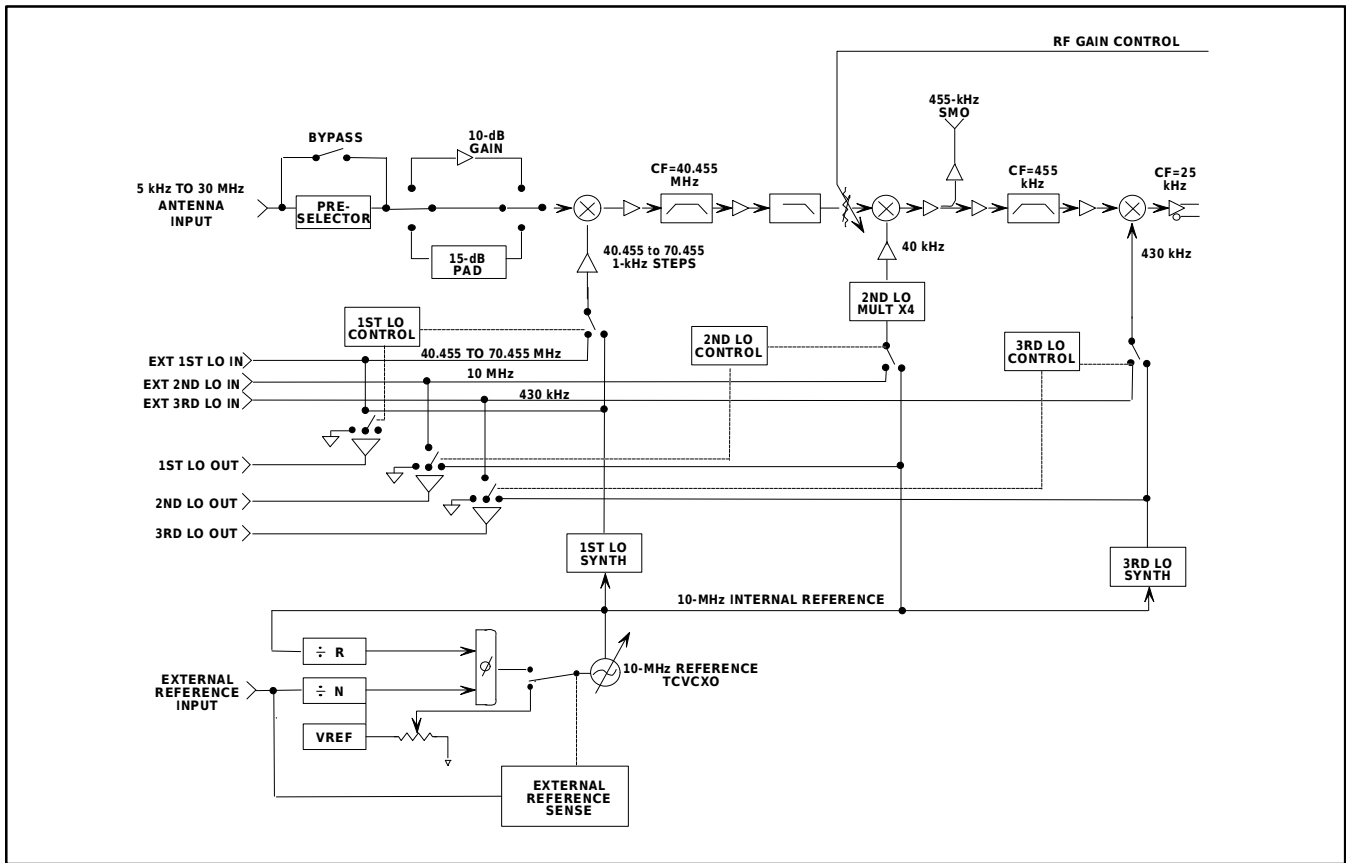
WJ-8721 RF Subsystem Functional Block Diagram

Functional Description

The WJ-8721 can be 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, which is immediately followed by an 11-band suboctave preselector, and then by a lowpass filter. The signal is amplified, attenuated, or routed to the normal through-path, based on user selection. The signal is mixed with the first 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 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 the front 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-8721 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. When the receiver is used in multichannel applications, signals presented at the external first, second, and third LO input connector may be selected by software control.

An 11-band suboctave preselector is standard on the WJ-8721. The preselector filters the RF input spectrum to reduce broadband signal energy into the receiver, and to enhance the second-order

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intermodulation performance. Each of the 11 filter bands cover a segment of the overall tuning range. Preselection can be bypassed, if desired.

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:
- Fine tuning to 1-Hz resolution
- IF filtering
- Tunable notch filtering
- Gain control (AGC Fast, AGC Slow or Manual)
- Signal strength & squelch functions
- 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 and two balanced 600-ohm line audio outputs. 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 front panel IF output connector.

The microprocessor-based Control Subsystem performs the receiver's internal control and provides the interface control with the VXI bus. 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.

Digital and Audio IF are standard outputs, provided via the front panel interface connector. Due to the modular design of the WJ-8721, and the inherent flexibility of DSP techniques, WJ can support multireceiver subsystems and many other specific customer requirements. Contact factory to discuss additional or alternative IF bandwidths, detection modes, I/O Control, digital I & Q outputs, etc.

Receiver Connectors

I/O	Function	Type
Input	Antenna External Reference Mute	SMA SMA Multipin D
Output	Signal Monitor IF dc-coupled Audio Squelch Headphone Line Audio A Line Audio B Digital IF Digital Audio	SMA SMA Multipin D Multipin D 3.5-mm stereo jack Multipin D Multipin D Multipin D Multipin D
Bidirectional	1st, 2nd & 3rd LO	D-subminiature mixed

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 mV p-p into high-impedance load); automatically switches to external reference upon application of signal

Synthesizer Lock Time .... < 5 msec, typical

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

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

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

Noise Figure .... 14 dB, max
   11 dB, max 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)	(Minimum) 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 (SINAD)	-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 500 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
   Center Frequency .... 455 kHz, nominal (Consult factory for alternate IF center frequencies)
   Output Level .... -20 dBm, nominal
   Output Impedance .... 50 ohms, nominal
   Connector Type .... SMA 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 .... SMA female

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Specifications

Standard IF Bandwidths (kHz)*

3 dB Bandwidth	Maximum Shape Factor (3/60 dB)	Typical Group Delay 100% of 3-dB BW (µs)
0.3	1.35:1	50
1.0	1.40:1	30
3.2	1.25:1	30
6.0	1.25:1	40
16	1.25:1	60
USB/LSB/ISB	1.25:1	30

*See typical plots in Figures 4, & 5

IF Filter Set (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.

Gain Control Modes .... Manual, AGC, Fast & Slow
   AGC Range .... 100 dB, min
   AGC Threshold .... Approximately -108 dBm (0.9 mV) in 16-kHz bandwidth
                                                          Approximately -125 dBm (0.12 mV) in 300-Hz bandwidth
                                                           Threshold is matched with IF bandwidth & is typically
                                                           10 dB above noise floor
   AGC Attack Time .... 5 msec, typical
   AGC Decay Time .... Fast: 25 msec, typical
                                                          Slow: 4 seconds, typical

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 @ 1-kHz offset, typical
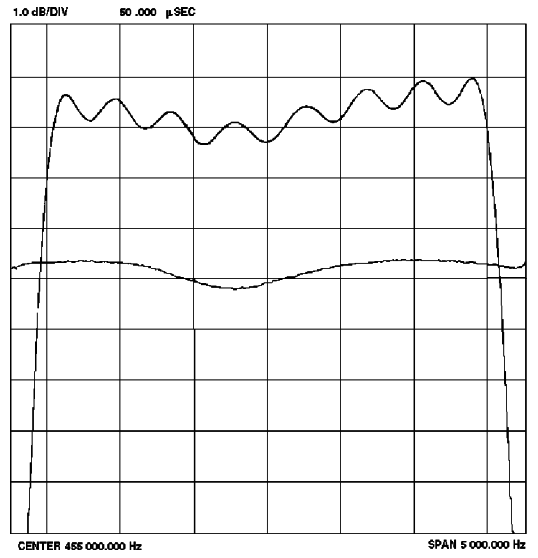
Specifications

Reciprocal Mixing	With a desired signal of 25 mV 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.
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	A 1 W signal produces <5% distortion at the Line Audio & IF outputs

Line Audio Outputs

Number of Outputs	2 center-tapped, balanced outputs 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 (programmable)	-20 to +10 dBm into 600-ohm load
Connector Type	Multipin D

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 (programmable)	-20 to +10 dBm into 600-ohm load
Connector Type	Standard 3.5-mm stereo jack

VXI Interface

Protocol Supported	Word-Serial Protocol, IEEE-488.2
Device Type	Message-based device, VXI servant
Card Size	VXIbus C-size module
Slots Used	1 Slot
Data Transfer Handshake	Normal Transfer Mode
Data Transfer Capability	A24, D16 circuitry provided
EMI Shielding	Completely enclosed module

Shared Memory Configuration	32 kwords, static
Operating Temperature	0 to 50°C
Storage Temperature	-40 to +70°C
Humidity	10 Cyclic days (240 Hrs) Procedure III for Continuous Exposure to 95% RH
Altitude	50,000 ft (1525 meters) non-operating 24,000 ft (730 meters) operating
Shock	Bench Handling (Field Service) 8 drops total onto a horizontal hard wooden surface (non-operating)
MTBF	In excess of 14,000 hrs (Estimated in accordance with MIL-HDBK 217E for Ground Fixed; +40°C environment)

Power Requirements

+5V	+12V	-12V	-5.2V	-2V
11 W	7.2 W	5.16 W	0.89 W	0.05 W

Power Consumption	21 W, typical

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10.000 dB/DIV

CENTER 455 000.000 Hz   SPAN 2 000 000.0 Hz
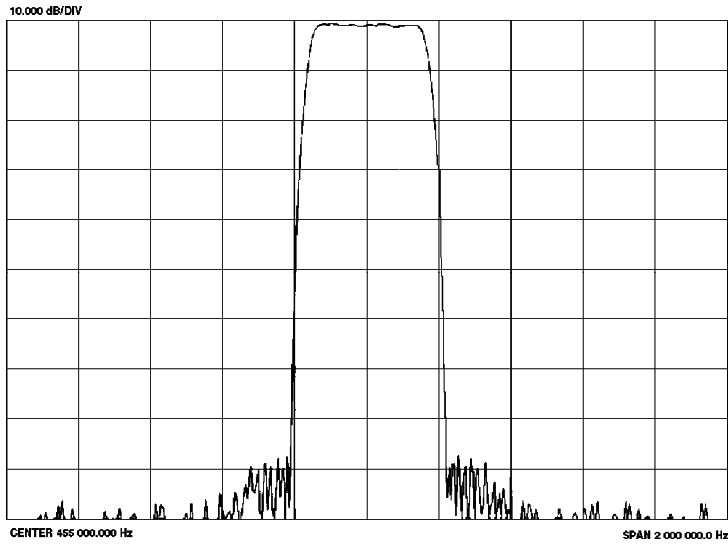
Typical 300-Hz IF Filter Amplitude Response

1.0 dB/DIV   80 .000 μSEC

CENTER 455 000.000 Hz   SPAN 5 000.000 Hz

Typical SSB IF Filter Group-delay &
Passband Ripple

10 dB/DIV

CENTER 455 000.000 Hz   SPAN 10 000.0 Hz
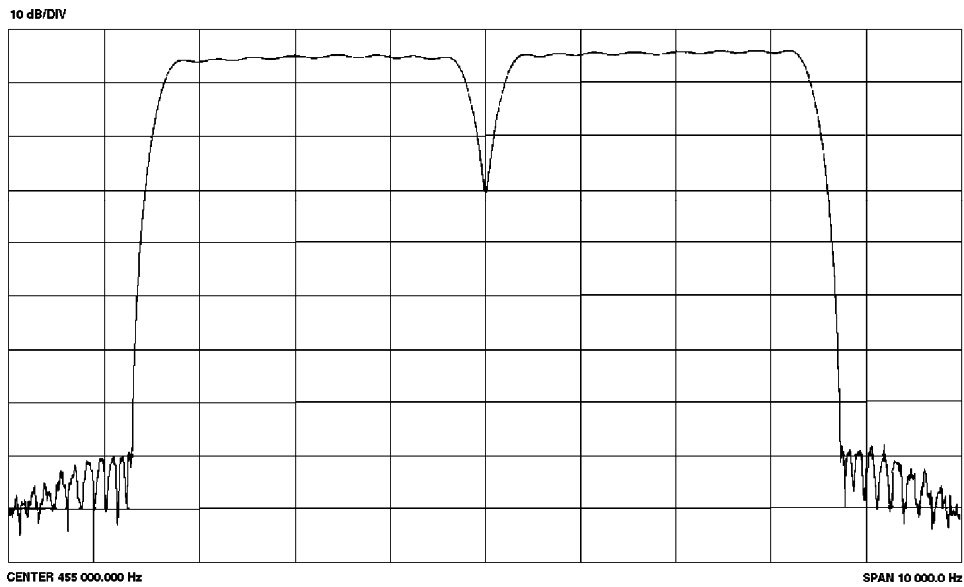
Typical ISB (USB/LSB) IF Filter Amplitude Response

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VXI HF Receiver
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