Technical Data Sheet
C E T Division

WATKINS-JOHNSON

Microwave Receiver System
WJ-8809A/SYS

Description

The WJ-8809A/SYS is a complete microwave receiving system in a miniaturized package. It provides continuous tuning in the 0.1 to 18.5 GHz frequency range, tunable in 100-Hz increments. Its key features include high dynamic range, low noise figure, and low phase noise for effective reception and demodulation of known signals of interest.

The microwave receiver provides the selection of AM, FM, and Pulse detection modes, with up to five selectable IF bandwidths ranging from 2 to 40 MHz having good group delay characteristics. Its flexible operational capabilities provide complete operator control in the manual mode. Using the receiver's 100-channel non-volatile memory, automatic SWEEP or STEP operations may be programmed and initiated as required. Total control over the WJ-8809A/SYS is provided via the standard RS-232, RS-422 or RS-485 interfaces, using desktop or laptop computers. If desired, the WJ-8809A/SYS can be factory-configured for Hewlett-Packard Interface Loop (HPIL) operation.

The standard configuration of the WJ-8809A/SYS Microwave Receiver System consists of the

Features

- *Continuous tuning from 0.1 to 18.5 GHz*
- *Synthesized in 100-Hz steps*
- *Low power: 35 W*
- *Small size: 11.25 x 6.5 x 3.2 in (28.58 x 16.51 x 8.13 cm)*
- *Remote microwave converter*
- *Five selectable IF bandwidths: 0.5 to 40 MHz*
- *Low group delay filters*
- *Low phase noise: 88 dBc/Hz @ 10 kHz*
- *Remote control: RS-232, RS-422, RS-485 or HPIL*
- *Low cost*

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WJ-8809A/MC Microwave Converter, and a WJ-8809/RX Receiver. These units are normally shipped attached in a single unit, measuring 11.5 inches (28.58 cm) long by 6.5 inches (16.51 cm) wide by 3.2 inches (8.13 cm) high. The combined weight is approximately 13.5 pounds (6.11 kg). The electrical interconnections between the receiver and microwave converter consists of RF, DC power, and a control interface cable that are factory-provided. If desired, the units may be separated to permit the WJ 8809A/MC to be remotely located, up to 500 feet (152.4 meters) from the receiver. Remote location is provided with one optional coaxial IF interface (100 to 512 MHz) and one control cable. An approximate IF line driver, dependent on cable type, is required for extended locations. WJ-8809A/MC power of +12 Vdc is also required at the remote location.

Surveillance applications that require high dynamic range, low power, and portability are easily addressed using the WJ-8809A/SYS. The small size and low weight are particularly attractive when configuring manportable systems. This receiver system is also particularly well-suited for applications where low EMI/RFI emissions are important.

Functional Description

The WJ-8809A/MC block diagram and frequency plan are shown in Figure 1 and Table 1, respectively. RF input frequencies between 2 and 18.5 GHz are downconverted to a common 0.5 to 2 GHz frequency band in twelve frequency bands. Within the 2 to 8 GHz input frequency range, the input signal is first filtered, and then amplified with the selection of the appropriate suboctave bandpass filter and amplifier combination. Prior to amplification, the signal is filtered with a five to seven six-pole combline filter. Insertion loss of each filter over the specified frequency range is less than 1 dB with rejection at image, IF and local oscillator (LO) frequencies of greater than 80 dB. Selection of the required filter and amplifier is accomplished with pin diode switches at the input and output of the filter combination.

Following input preselection, the input signal is applied to a selectable attenuator that provides 0 or 20 dB of control for attenuating large in-band signals prior to mixing. Control for this attenuator is provided from AGC circuitry in the associated WJ-8809/RX (Figure 2).

Over the frequency range of 2 to 8 GHz, the selected 1.5-GHz frequency band is upconverted to a 9.5 to 11 GHz signal. This upconversion is accomplished with a low-side LO signal derived in an associated LO subassembly. After conversion, the signal is filtered, amplified, and filtered again prior to being applied to the second mixer for downconversion to the 500 to 2000 MHz frequency band. Filtering of the 9.5 to 11 GHz IF signal is provided with a six-pole filter, before and after the IF amplifier.

Following the second conversion, the 0.5 to 2 GHz output is amplified and filtered with a 2-GHz lowpass filter. This output is then coupled to the input of the Frequency Extender (FE), shown in Figure 3, which downconverts the 0.5 to 2 GHz frequency band to the WJ-8809/RX input frequency range of 100 to 512 MHz.

Operation over the RF input frequency range of 9.5 to 14 GHz is identical to that of the 2 to 8 GHz frequency range, with the exception that the RF input is downconverted to a first IF of 6.5 to 8 GHz, and is then converted to the final IF with a low-side injection frequency of 6 GHz at the second mixer. In the 14 to 18.5 GHz frequency band, the first IF is at 9.5 to 11 GHz with the second LO frequency at 9 GHz. The 8 to 9.5 GHz input frequency band is converted directly to the output frequency at the first mixer, with a low-side injection frequency of 7.5 GHz. The output is then routed through pin diode switches to the common 0.5 to 2 GHz output.

The LO injection frequencies required for conversions at the first and second mixers are derived from one common phase-locked Dielectric Resonator Oscillator (DRO) at 6 GHz. First LO frequencies of 3, 4.5, 6, and 7.5 GHz are provided, utilizing the divide-by-two outputs from the phase-locked loop (PLL) divider chain and the fundamental 6-GHz oscillator. Six-pole filters for each fre-

Table 1. Microwave Converter Frequency Plan (GHz)

Band	1st LO	1st IF	2nd LO	IF Output
0.1 to 2.012	N/A	N/A	N/A	0.1 to 2.012
2.012 to 2.812	7.5	9.5 to 11	9	0.5 to 1.312
2.812 to 3.512	7.5	9.5 to 11	9	1.312 to 2.012
3.512 to 5.012	6.0	9.5 to 11	9	0.512 to 2.012
5.012 to 6.512	4.5	9.5 to 11	9	0.512 to 2.012
6.512 to 8.012	3.0	9.5 to 11	9	0.512 to 2.012
8.012 to 9.512	7.5	0.5 to 2	N/A	0.512 to 2.012
9.512 to 11.012	3.0	6.5 to 8	6	0.512 to 2.012
11.012 to 12.512	4.5	6.5 to 8	6	0.512 to 2.012
12.512 to 14.012	6.0	6.5 to 8	6	0.512 to 2.012
14.012 to 15.512	4.5	9.5 to 11	9	0.512 to 2.012
15.512 to 17.012	6.0	9.5 to 11	9	0.512 to 2.012
17.012 to 18.512	7.5	9.5 to 11	9	0.512 to 2.012

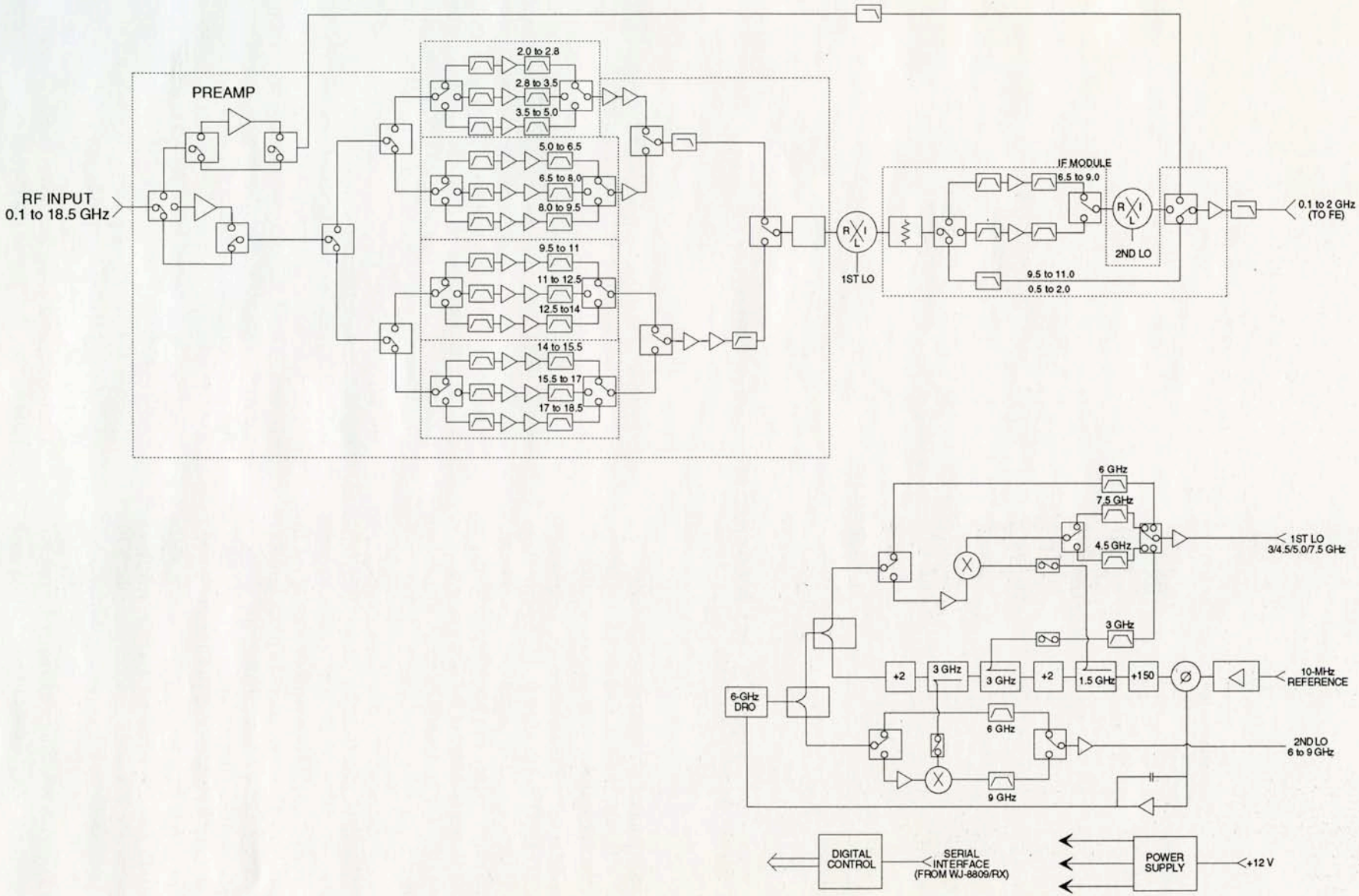

Figure 1. WJ-8809/MC Microwave Converter

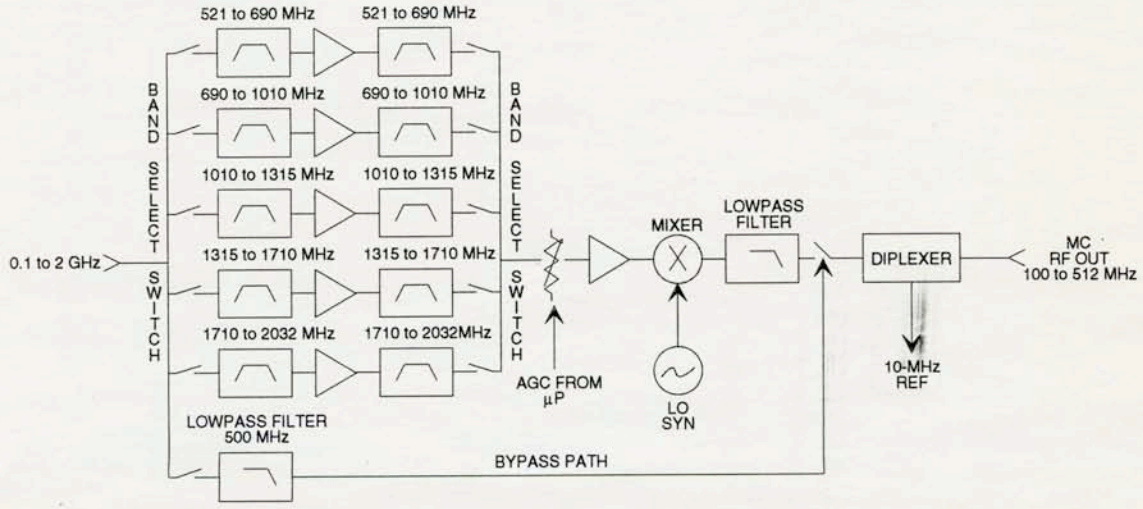

Figure 2. WJ-8809A/MC Microwave Converter FE

quency are incorporated to suppress the 1.5-GHz sidebands, along with high isolation switches, to ensure rejection of self-generated signals in the downconverter.

The 6- and 9-GHz second LO frequencies are generated from the 6-GHz DRO and the first divide-by-two stage in the PLL divider chain. The outputs are then filtered, switched, and amplified prior to being applied to the second mixer. Power required at the first mixer is +10 dBm (+13 dBm at the second mixer), with sidebands down greater than 80 dB.

The composite phase noise of the first and second LOs is less than -95 dBc at 10 kHz from the carrier. This, when added to the receiver phase noise, will result in overall microwave receiver phase noise performance of -88 dBc at 10-kHz removed. This calculates to a phase emitter of less than 2 degrees rms in a bandwidth of 100 Hz to 20 MHz. Typical phase jitter performance is less than one degree at tuned frequencies of 10 GHz and lower.

Within the 0.1 to 18.5 GHz frequency band, an operator-selectable 10-dB gain low noise amplifier is provided for improved sensitivity. Pin diode switches route the 0.1 to 2 GHz band directly to the FE, bypassing the microwave downconverter. The 2 to 18.5 GHz band is routed through the low noise amplifier, or bypassed, prior to being coupled to the input of the 2 to 18.5 GHz preselector. Pin diode switches having low insertion loss are used for switching throughout the WJ-8809A/MC.

The WJ-8809A/MC's low power consumption of less than 14 watts is accomplished by using a single fixed-tuned phase-locked oscillator to generate all of the LO frequencies required for downconverting the 2 to 18.5 GHz frequency band. Also, the use of suboctave filters with pin diode switching greatly reduces the power necessary for preselection of the WJ-8809/RX.

The WJ-8809A/MC FE block diagram, shown in Figure 3, demonstrates how signals in the 512 to 2032 MHz range are filtered with five suboctave filters, and then converted to a 200 to 512 MHz range. Signals between 100 and 512 MHz bypass the suboctave filter, and go through a low-pass filter instead. The RF signal then passes through a diplexer that separates the 10-MHz reference from the WJ-8809/RX. The RF signal then is connected to the WJ-8809/RX via a short length of sem-irigid cable that is external to the unit.

There is a diplexer at the input of the WJ-8809/RX to allow the 10-MHz reference to be sent to the WJ-8809/MC module. The RF signal then passes through a voltage-tuned tracking preselector that rejects out-of-band signals, thus improving the second order intercept

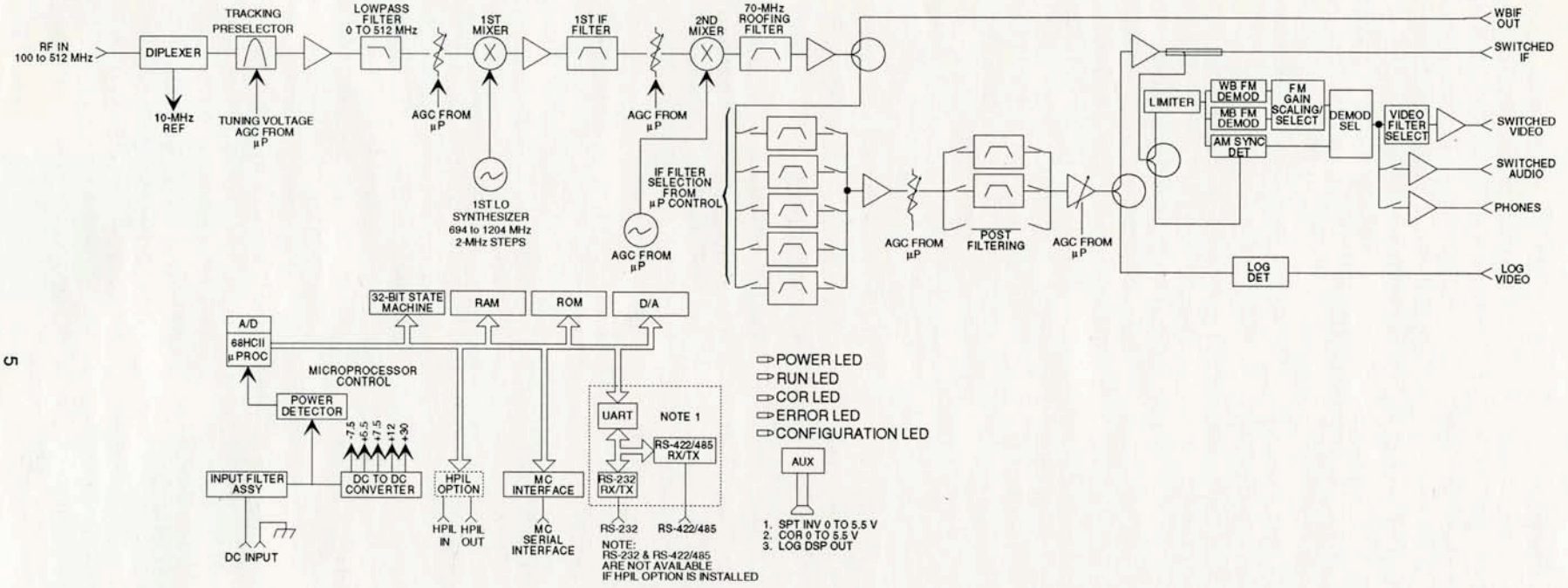

Figure 3. WJ-8809/RX Simplified Block Diagram

point of the receiver. The bandwidth of the pre-selector is nominally 10 percent. After the input signal is filtered, it passes through an RF amplifier and a lowpass filter, before entering a mixer where it is mixed with the first LO.

This first LO tunes from 694 to 1204 MHz in 2-MHz steps. The upconverted IF signal at 691 MHz is amplified and filtered before it enters a second mixer, where it is mixed with a second LO that tunes from 620 to 622 MHz in 100-Hz steps. The output from the second mixer is centered at 70 MHz, and is filtered and amplified before entering the switchable IF bandwidth filters. A sample of the prefiltered signal is provided for the wideband IF output.

Up to five IF bandwidths can be installed in the WJ-8809A/SYS. An additional feature of the receiver permits the IF filters to be bypassed on command, allowing the bandwidth to be determined totally by the tracking preselector, the first IF filter, and the final IF roofing filter. With a simple control command, the tracking preselector can also be bypassed. This bypass feature is particularly desirable when relatively wide bandwidths are required.

After the signal is filtered in the selected IF filter, it passes through several stages of IF amplification and gain control. A sample of the 70-MHz bandlimited IF signal is provided at -30 dBm. AM detection is provided with a synchronous-type detector that provides greater than 35-dB linear dynamic range. The wide-band FM detector is a delay-line-type demodulator. Medium band FM detection utilizes a quadrature-type demodulator. A *LOG* Video Output, having a 50-dB dynamic range, is provided by the *LOG* detection circuit.

Control

Two types of user-selected remote interfaces are available to control the WJ-8809/RX. The first is an asynchronous serial interface that supports any one of the following interface standards via internal DIP switch setting:

- Single drop full-duplex RS-232,
- Single drop full-duplex RS-422,
- Multidrop half-duplex protocol RS-232,
- Multidrop half-duplex protocol RS-422,
- Multidrop half-duplex RS-485

The single drop interface allows connection from a controller to a single receiver. It supports interface protocols such as *XON-XOFF*, *ENQ-ACK/NAK*, and *SERVICE REQUEST* by sending an *ESC* character, followed by a status byte.

The multidrop interface allows connection from a controller to multiple receivers. Up to eight receivers can be connected and controlled via a multidrop RS-485 interface. Up to six receivers can be interconnected when using the multidrop RS-422 or RS-232 interfaces. The multidrop interface supports address commands, and requires a receiver to be addressed before communicating with a controller. It supports an *ACK/NAK* verification protocol. Upon receiving a completed message, an *ACK* or *NAK* character is issued from a receiver to assure the validity of the data transmission. The asynchronous serial interface offers communication data rates of up to 9600 baud.

The second type of control interface is the Hewlett-Packard Interface Loop (HPIL). The HPIL is a low power, interruptible, and addressable serial interface loop supported by controlling devices, such as various personal computers. Up to 31 receivers can be controlled and hooked up to the HPIL. An internal DIP switch allows the user to select different HPIL addresses for the receiver. The WJ-8809/RX supports an HPIL basic talker function /addressed listen operation, generates *Service Request* and outputs data at approximately 3 Kbytes per second.

The WJ-8809/RX supports high-level ASCII IEEE-488.2-like messages. It accepts data in a forgiving format, while responses are always precise.

Capabilities

The WJ-8809/RX employs a Motorola 68HC11 Microcontroller to monitor and control all receiver functions, such as AGC, AFC, synthesizer tuning, and others. The WJ-8809/RX is capable of three basic modes of operation:

- MANUAL (fixed-frequency operation)
- SWEEP (continguous coverage from start-to-stop frequency)
- STEP (preprogrammed discrete frequencies)

The receiver is interactive in all modes and is capable of alerting the host computer of signal activity. While in either the SWEEP or STEP mode of operation, the receiver can log individual signals in the coverage area and report only changes in signal presence to the host computer. This capability greatly reduces overhead time required by the host computer, since it eliminates the need to sort data from each receiver sweep, and it determines which signals are new and which are repeats. In SWEEP mode, the receiver is capable of locking out portions of the RF spectrum, allowing previously identified portions of the spectrum to be excluded from the coverage area. Non-volatile memory is included in the receiver for storage of up to 100 SWEEP or STEP setups, and 200 lockout bands.

Specifications

Frequency Range	0.1 to 18.5 GHz
Frequency Resolution	100-Hz, synthesized
RF Input Impedance	50 ohms, nominal
Input VSWR	2.0:1, typical 3.0:1, max
Noise Figure	19 dB, max (0.1 to 2 GHz) 18 dB, max (2 to 8 GHz) 20 dB, max (8 to 15.5 GHz) 22 dB, max (15.5 to 18.5 GHz) 12 dB, max (with preamplifier selected)
Intermodulation	
2nd-Order Intercept Point	+30 dBm, min*
3rd-Order Intercept Point (MC)	-5 dBm, min*
Image Rejection	80 dB, min
IF Rejection	80 dB, min
Antenna-Conducted LO Radiation	-90 dBm, max
Internal Reference Frequency Accuracy	$\pm 1 \times 10^{-6}$ (0 to 50°C)
External Reference Frequency	10 MHz, 5 MHz, 1 MHz Selectable, 0 dBm input
Phase Noise @ 10 kHz	88 dBc/Hz, max
Phase Jitter	2° rms, max (100 Hz to 20 MHz)
Tuning Speed (Sweep)	4 msec, typical to within 10 kHz
Tuning Speed	
[Manual, From Receipt of (LF) to LO Lock]	10 msec, typical to within 10 kHz
Signal Monitor Output (Nominal)	25 dB above RF input
Gain Control Modes	Manual or automatic (80-dB range, min)
Internally Generated Spurious	<-100 dBm equivalent input
Demodulation Modes	AM, FM, & Pulse
Video Response	DC to 1/2 the IF bandwidth
Log Video Output	0 to 0.5 V into 50-ohm load for 50-dB dynamic range (from noise floor)
AM/FM Audio Response	100 Hz to 15 kHz
COR/Squelch	Adjustable threshold to 45-dB above noise floor for IF bandwidth selected
Audio Output	10 mW, min into 600 ohms
Temperature	
Operating Temperature Range	-25 to +55°C
Full Specification Compliance	+20 to +30°C
Non-operating	-40 to +70°C
Shock	Meets the environmental conditions of MIL-E-5400T, paragraph 3.2.24.6.1 pertaining to equipment shock
Vibration	Meets the environmental conditions of MIL-STD-810D, method 514.3, second I-3.2.4, category 4-propeller aircraft. Figure 514.3-25(a) defines the power spectral density with Li=0.3 (g^2/Hz), & Fi=68 Hz
Humidity	95% relative humidity, noncondensing
Power Requirements	12 Vdc (+10 to +16 Vdc)
Power Consumption	35 W, max
IF Bandwidths	5

Table 2. Weights & Dimensions

Unit	Height	Width	Depth	Weight
SYS	3.20 in (8.13 cm)	6.5 in (16.51 cm)	11.25 in (28.58 cm)	13.5 lbs (6.11 kg)
RX only	1.5 in (3.8 cm)	6.5 in (16.51 cm)	11.25 in (28.58 cm)	5.5 lbs (2.49 kg)
MC only	1.66 in (4.22 cm)	6.5 in (16.51 cm)	11.25 in (28.58 cm)	8.0 lbs (3.62 kg)

Table 3. Bandwidth Sets

Bandwidth Sets (BWS)	Bandwidths (MHz)
BWS 1	2, 5, 10, 20, 40
BWS 2	1, 2, 5, 10, 20
BWS 3	0.5, 1, 2, 5, 10
BWS 4	0.5, 2, 5, 10, 20
BWS 5	0.5, 2, 10, 20, 40

Note: Other IF BWS are available. Contact factory for details.

Table 4. IF Shape Factors

Bandwidth (MHz)	Shape Factor 50:3 dB BW	Sensitivity (dBm) 8 to 15.5 GHz (Preamp out)	*Sensitivity (dBm) 8 to 15.5 GHz (Preamp In)
0.5	4.5:1	-79	-87
1.0	4.0:1	-76	-84
2.0	2.5:1	-73	-81
5.0	2.0:1	-69	-77
10.0	1.5:1	-66	-74
20.0	1.5:1	-63	-71
40.0	1.5:1 (40:3 dB)	-60	-68

*2nd- and 3rd-order intermodulation degraded by 10 dB with low-noise preamplifier switched in.
AM—An input signal AM modulated 50% by a 1-kHz tone will produce a minimum video output S+N/N ratio of 10 dB.
FM—An input signal FM modulated at a 1-kHz rate with a peak deviation equal to 30% of the selected IF BW will produce a minimum video output S+N/N ratio of 17 dB. (Note: A 400-Hz modulation rate is required for IF bandwidths of 10 kHz or less.)

Table 5. WJ-8809A/SYS Inputs & Outputs

Name	Function	Connector Type
RF IN	0.1 to 18.5 GHz RF Input	SMA
SW IF	70-MHz Switched IF Output	SMB
SW VID	Selected AM/FM Video Output	SMB
SAO	Selected AM/FM Audio Output	SMB
FM MON	FM Audio Output	SMB
WBIF	70-MHz Wideband IF Output	
LOG VID	LOG Video Output	SMB
REF IN	10-MHz External Reference Input	SMB
PWR IN	+12 Vdc Power Input	Multipin
RS-232	Remote Control I/O	Multipin
RS-422/485	Remote Control I/O	Multipin
AUX	COR, Spectrum Inv., & Log Display Out	Multipin
HPIL (Optional)	Remote Control I/O	