

May 1994

## Miniature VHF/UHF Microceptor Receiver WJ-8654



### Description

The WJ-8654 *Microceptor* is an extremely small [38 cubic inches (96.52 cubic cm)] general-purpose surveillance receiver covering the 20 to 1000 MHz frequency range. The small size and low power consumption make the unit ideal for portable, narrowband surveillance applications where weight and power reduction are crucial.

The WJ-8654 features low phase noise frequency synthesizers for high dynamic range and an accurate tuning resolution of 100 Hz. A high-performance tracking preselector filters incoming RF signals, and rejects undesired out-of-band signals. Up to four 21.4-MHz selectable IF filters ranging from 6.4 to 100 kHz may be installed in the unit, two of which are included in the basic receiver. A 3.2-kHz filter is also included for narrowband SSB detection.

The mechanical packaging design of the WJ-8654 Receiver uses modern surface-mount technology. The receiver circuitry is divided between four glass-epoxy printed circuit (PC) boards. Multilayer PC boards, fastened into a milled-aluminum chassis, provide RF isolation. The overall dimensions are 7.75 x 3.0 x 1.7 inches (4.32 x 7.62 x 19.69 cm). All control

### Features

- *Frequency range: 20 to 1000 MHz*
- *Low power: <5.25 W*
- *Miniature Size: 1.70 x 3.0 x 7.75 in (4.32 x 7.62 x 19.69 cm)*
- *AM, FM, SSB & CW detection modes*
- *10-Hz tuning resolution in SSB mode*
- *Up to 4 selectable IF filters between 6.4 & 100 kHz*
- *Tracking Preselector Filter*
- *Low phase noise*
- *Lightweight: <2.1 lbs (0.95 kg)*
- *Low power sleep mode of operation*
- *Control-compatible with WJ-8607A Miniceptor Receiver*

### **\*Restricted International Distribution\***

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All International sales of WJ equipment are subject to USA export license approval.

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and RF interconnections are available at one end of the unit along the 3.0 x 1.7 inch (7.62 x 4.32 cm) face. RF signals are passed in and out of the unit via SMA-type connectors. All control and power supplies are available on a miniature D-type connector.

## Control

The WJ-8654 Receiver is controlled via an asynchronous serial interface. The receiver supports any one of the following interface standards, which are changeable by setting an internal DIP switch:

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

The single-drop interface allows the connection of a single receiver to a single controlling device. It supports interface protocols such as *XON-XOFF* and *ENQ-ACK/NAK*. The receiver may generate a service request by sending an *ESC* character followed by a status byte.

The multidrop RS-422 and RS-485 interfaces allow the connection of up to 15 receivers to a single controlling device. The multidrop RS-232 interface allows the connection of up to six receivers to a single controlling device. Each of the multidrop interfaces supports address commands that require proper protocol before communication with the controlling device. The multidrop interface supports an *ACK/NAK* verification protocol. Upon receipt of a completed message, the addressed receiver issues an *ACK* or *NAK* character that validates the data transmission.

The WJ-8654 Receiver supports the standard communication data rates from 150 baud to 38.4 K baud. The WJ-8654 supports high-level ASCII command mnemonics similar to IEEE-488.2 messages. The receiver implements a *speaking-when-spoken-to* protocol. Data is accepted in a format that is forgiving, while responses are always precise. The command mnemonics of the WJ-8654 Receiver are compatible with the WJ-8607 *Miniceptor* Receiver.

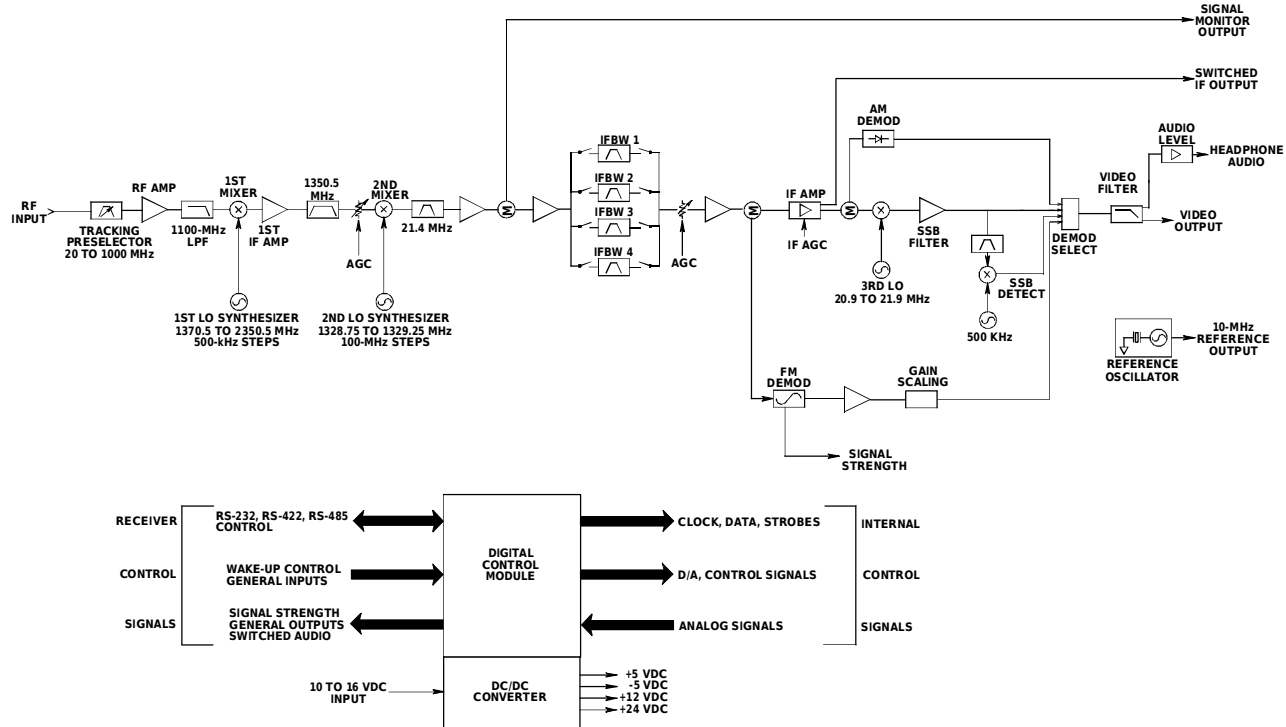
## Functional Description

Figure 1 shows the overall block diagram of the WJ-8654 Receiver. RF signals are coupled from the antenna to the input of the receiver through a front-panel-mounted SMA-type connector. A two-pole five-band

tracking preselector filter limits the incoming signal power to the receiver front end, thus providing improved spurious and second-order intermodulation performance. The filtered RF signal is passed to a low noise RF amplifier that provides excellent receiver sensitivity. After the signal is amplified, it passes through a lowpass filter that provides image rejection to the first mixer. The first local oscillator (LO) tunes from 1370.5 to 2350.5 MHz in 500-kHz steps, and provides conversion of the signal to the first IF, which is centered at 1350.5 MHz. A low-noise amplifier follows the first mixer, providing sufficient gain to overcome the losses of the first mixer and first IF filter. The output of the first IF amplifier passes through the first IF filter, which provides image rejection for the second mixer. The first IF signal passes to the second mixer through a variable gain attenuator that provides gain reduction for the receiver front end. The second mixer combines the first IF signal with the second LO, which tunes from 1328.75 to 1329.25 MHz in 100-Hz steps. The second LO is a three-loop design providing fine frequency resolution, as well as low phase noise and fast tuning. The second LO provides 100-Hz tuning resolution in AM, FM and CW modes, and 10-Hz resolution in SSB mode.

The output of the second mixer is centered at 21.4 MHz. A 10-MHz-wide roofing filter follows the mixer, which provides LO rejection and limits the bandwidth of the signal passed to the second IF amplifier. The output of the second IF amplifier is split before being routed to the switchable IF filters. A sample of the 21.4-MHz IF signal is routed to the receiver front panel for use with an external signal monitor. Four selectable filters provide predetection filtering of the received signal to a maximum bandwidth of 100 kHz. After final filtering, the signal is split between the inputs of the AM and FM detectors. Synchronous AM detection (SAM) is accomplished by mixing the gain-controlled IF signal with a sample of the IF that has been hard-limited. A quadrature detector provides FM detection. A third LO provides conversion to 500 kHz for detection of SSB signals. The third LO also provides a translated IF output with a maximum center frequency of 150 kHz. When the receiver is operated in the translated IF mode, the demodulators are disabled.

The receiver digital section provides control functions for the synthesizer, converter, preselector, and demodulator sections. It contains RAM, EPROM, EEPROM, analog-to-digital (A/D) converters, digital-to-analog (D/A) converters, and a serial interface. The digital control section combines the various low-level internal receiver hardware interfaces with a single, high-level serial interface. The receiver operations of SWEEP, STEP, and LOCKOUT are implemented in the digital section firmware.



**Figure 1. WJ-8654 Receiver Block Diagram**

The digital control section is based on the Motorola HC11 family of microcontrollers, which is capable of a high level of integration in a small package that consumes very little power. The functional requirements of the receiver require the microcontroller to operate in an expanded mode, with an additional 32 k RAM and 128 k EPROM. A quad D/A converter connected to the data bus creates Automatic-Gain Control (AGC) and preselector tuning voltages. The Serial Peripheral Interface (SPI) of the microcontroller creates a synchronous serial bit stream that controls the other sections of the receiver. Detected AM, FM, SSB, and RSSI (log) inputs are conditioned and provided to the A/D converter of the microcontroller to implement AGC, AFC, and COR operations. Non-volatile memory, included in the receiver, stores up to 200 SWEEP or STEP setups, and up to 200 LOCKOUT bands.

The power supply for the receiver is a simple, low-power switching regulator. The main 10 to 16 volts dc input is converted into regulated +12, +24, +5, and -5 volts dc for use by various receiver circuits.

## High Frequency Extender (HFE)

The HFE for the WJ-8654 *Microceptor* extends the receiver's frequency range by upconverting 0.5 to 30 MHz to 40.455 MHz. The receiver is then fix-tuned to the 40.455-MHz output frequency of the

converter, where it is used as a demodulator. Tuning from 0 to 0.5 is also obtainable, but with unspecified performance.

As shown in Figure 2, the HFE contains an 11-band suboctave preselector that bandpass filters the input spectrum to limit the energy at the first mixer. The first mixer is a high-performance quad FET-balanced ring mixer. This assures the high-intercept-point performance required in the large HF signal environments. For applications using a short or inefficient antenna, a switch-selected RF preamplifier increases sensitivity.

The upconverted signal is bandpass filtered with four poles of selectivity so that only 16 kHz of spectrum is applied to the WJ-8654 Receiver. Fine tuning of the desired signal is accomplished with a high-performance three-loop synthesizer. The 16-kHz bandpass filtering assures that the HFE synthesizer determines the reciprocal mix performance of the receiver system. This is superior to blockconverter approaches.

The HFE converter consists of two circuit boards in a milled-aluminum housing that complements the receiver in style and footprint. The first board contains the entire signal path and power supply circuits. The second board contains the frequency

synthesizer. The HFE fastens on top of the WJ-8654 Receiver from which it derives dc power, digital control, and frequency reference. When installed, the HFE adds one inch (2.54 cm) in height to the receiver.

## Ultra-High Frequency Extender (FE)

The WJ-8654 FE option extends the upper frequency limit of the receiver from 1000 MHz to 2400 MHz. The FE mechanical packaging is similar to the HFE. However, when installed, the FE adds 0.86 inches (2.18 cm) in height to the receiver.

The FE contains four bandpass filter/amplifier circuits that provide rejection to unwanted RF responses, which fall at the image and IF frequencies. Tuning the receiver within the basic 20 to 1000 MHz frequency range provides a bypass path (Figure 3). After the incoming signal is filtered and amplified, it is routed to the mixer where it is downconverted to 615-MHz. The 615-MHz IF signal is then bandpass filtered before it's routed to the WJ-8654 Receiver for further conversion and detection.

A high-quality double-balanced mixer provides good port-to-port isolation. This port-to-port isolation, in conjunction with the RF filters in the front-end,

provides suppression of the LO feed-through to the antenna.

Low noise figure is achieved through the use of broadband GaAs FET amplifiers throughout the signal path. Signals falling outside the IF filter passband attenuate significantly before they generate unwanted distortion products in the WJ-8654 Receiver circuits which follow.

## WJ-8654-3 Description

The WJ-8654-3 Wideband Receiver supports AM and FM detection in bandwidths from 300 kHz to 12 MHz. With the exception of power consumption, video output impedance, and available detection modes, the standard receiver specifications apply. The remote-control command set is identical to the standard receiver.

## Specifications

**Power Consumption** ..... 6 W

**Video Output Impedance** ..... 50 ohms

**Video BW** ..... dc to 1/2 the selected IFBW

**Detection Modes** ..... AM, FM

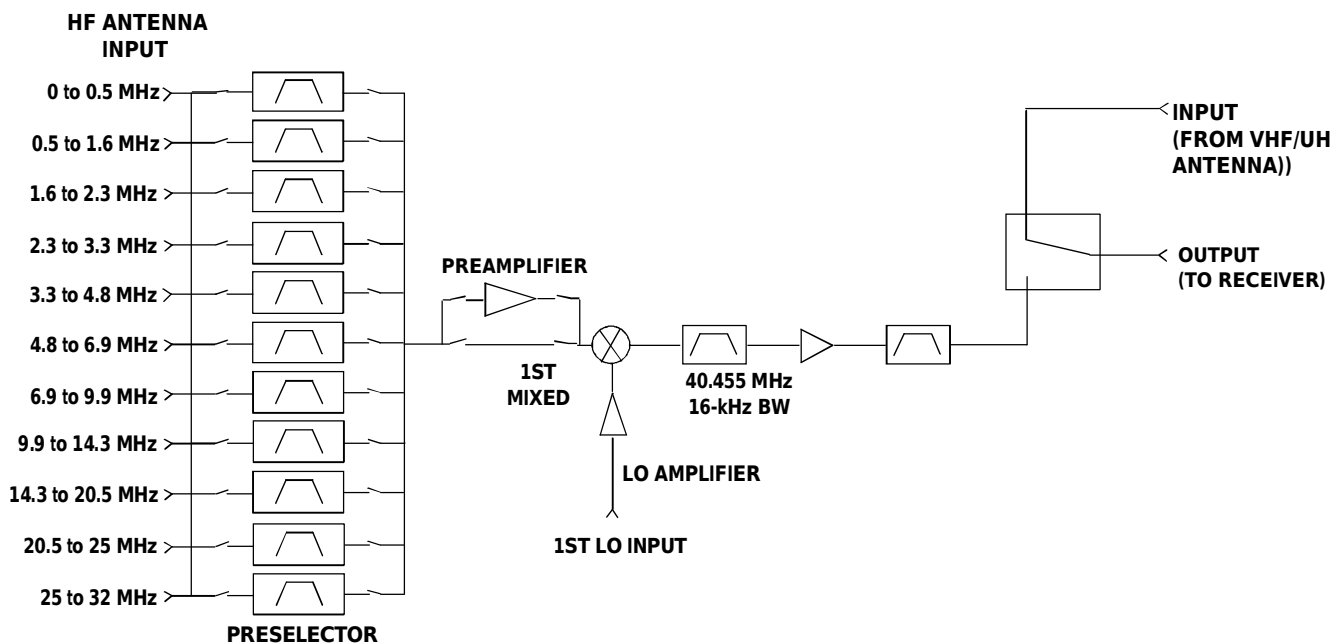
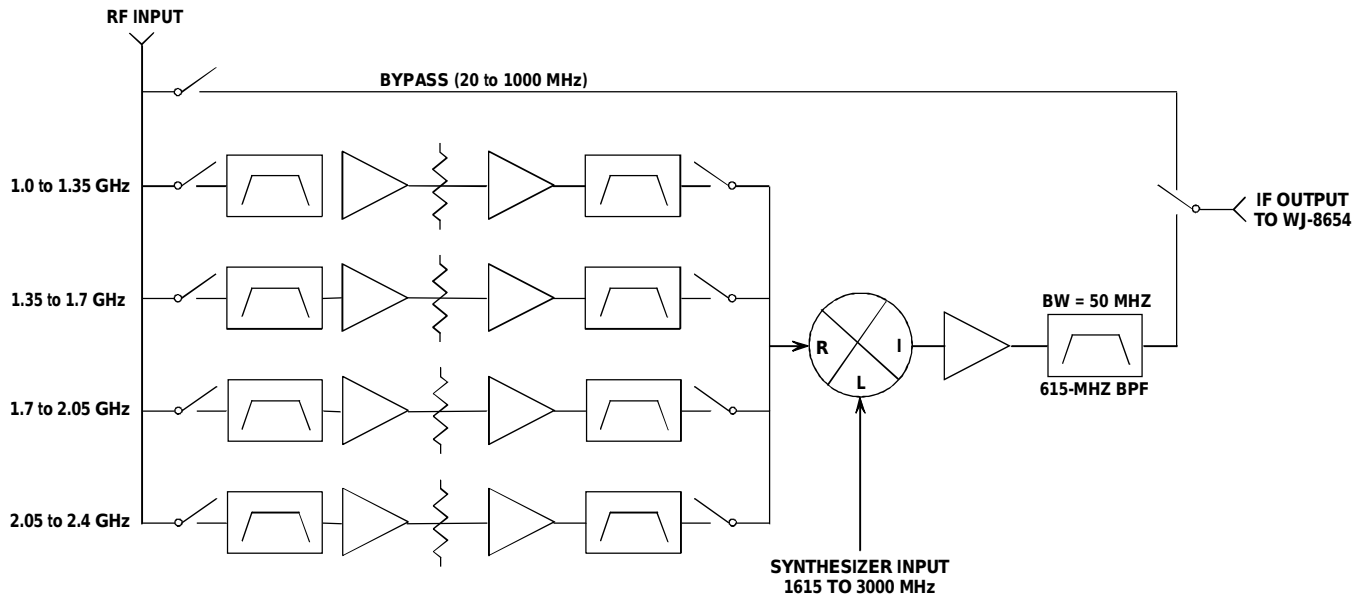


Figure 2. HFE Preselector/1st Converter



**Figure 3. FE Preselector/1st Converter**

**Table 1. WJ-8654 Receiver Connectors**

I/O		Functions	Type
<b>Inputs</b>		Antenna 10 to 16 Vdc power	SMA 1.3 mm miniature connector
<b>Outputs</b>		SW IF Video Headphone Signal Monitor 10-MHz Internal Reference	SMA SMA 1/8-in stereo jack SMA SMA
<b>Bidirectional</b>	<b>Receiver Control</b>	RS-232 serial receiver control dc power Line & switched audio CMOS level input for Wake-up mode	9-pin microminiature D
	<b>Aux Control Port</b>	RS-422 & -485 serial receiver control RS-232 & -485 ancillary device control Line & switched audio Received signal strength indicator COR	25-pin microminiature D

## Specifications

<b>Frequency Range</b> .....	20 to 1000 MHz (tuning to 2 MHz allowed)
<b>Tuning Resolution</b> .....	100 Hz (10-Hz SSB)
<b>Internal Frequency Accuracy</b> .....	±2.5 ppm, max
<b>Detection Modes</b> .....	AM, FM, CW, SSB, CW & IFT
<b>RF Input</b> .....	50 ohm (2.5:1 VSWR, typical)
<b>Preselection</b> .....	20%, nominal tracking
<b>Noise Figure</b> .....	10 dB, max (below 500 MHz) 12 dB, max (above 500 MHz)
<b>3rd-Order Intercept</b> .....	-5 dBm, typical (-10 dBm, min)
<b>2nd-Order Intercept</b> .....	+45 dBm, typical (+25 dBm, min)
<b>Max RF Input without damage</b> .....	+20 dBm
<b>Image Rejection</b> .....	80 dB, typical (70 dB, min 1st image) 65 dB, typical (60 dB, min 2nd image)
<b>IF Rejection</b> .....	80 dB, typical (70 dB, min)
<b>Phase Noise</b> .....	-60 dBc/Hz @ 1 kHz -98 dBc/Hz @ 20 kHz, max (20 to 500 MHz) -96 dBc/Hz @ 20 kHz, max (500 to 1000 MHz)
<b>Tuning Time (SWEEP)</b> .....	2 msec, typical to within 1 kHz of final frequency
<b>Tuning Time (STEP)</b> .....	15 msec, max to within 1 kHz of final frequency
<b>LO Level at RF Input</b> .....	-90 dBm, max
<b>Internally Generated Spurious</b> .....	-110 dBm equivalent RF input, max
<b>Gain Control Modes</b> .....	MGC/AGC, 90-dB typical range
<b>AFC</b> .....	Automatic, with disable
<b>Signal Monitor Output</b> .....	Nominally 6-dB gain above the RF input
<b>Selected IF Output</b> .....	Centered at 21.4 MHz, -40 dBm nominal output level
<b>Translated IF Output (IFT)</b> .....	IF Output with center frequency variable from 10 to 150 kHz in 1-kHz steps; supersedes the detected video
<b>IFBWs</b> .....	4 selectable (2 supplied & 2 optional) plus 3.2-kHz BW SSB filter
<b>Video Output Level</b> .....	0.5 V peak-to-peak into 600 ohms (30% deviation in FM or 50% AM modulation)
<b>Video Frequency Response</b> .....	dc to 1/2 the IFBW, -3 dB
<b>Audio Output</b> .....	ac-coupled headphone jack
<b>Sensitivity</b> .....	See Table 2
<b>COR/Squelch (TTL Output)</b> .....	55-dB range, min
<b>RSSI Output</b> .....	0 to 5 V into 10K ohms
<b>Control Interface</b> .....	RS-232, <i>Minicaptor</i> -compatible
<b>Power</b> .....	10 to 16 Vdc (5.25 W, max)
<b>Power Control</b> .....	<i>Sleep</i> or power-down mode, (10 mW, max)

## Environmental Specifications

### Receiver Case Temperature

Operating Temperature Range .....	-20 to +55°C
Non-Operating Temperature Range .....	-40 to +70°C
Full Specification Compliance .....	+20 to +30°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, section I-3.2.4, category 4, propeller aircraft. Figure 514.3-25(a) defines the power spectral density with  $L_i = 0.3$  ( $g^2/Hz$ ), &  $F_i = 68$  Hz.

**Humidity** ..... 95% relative humidity, non-condensing

## Frequency Extenders

	<b>WJ-8654/HFE</b>	<b>WJ-8654/FE</b>
<b>Frequency Range</b> .....	0.5 to 30 MHz	1.0 to 2.4 GHz
<b>Phase Noise</b> .....	-115 dBc/Hz @ 20 kHz (HF Converter only)	-90 dBc/Hz @ 20 kHz, max (including WJ-8654)
<b>Noise Figure</b>		
w/out Preamp .....	16 dB	15 dB, max
with Preamp .....	11 dB	(1.0 to 2.4 GHz)
<b>3rd-Order Intercept</b> .....	+20 dBm, min	-15 dBm, min
<b>2nd-Order Intercept</b> .....	+40 dBm, min	+20 dBm, min
<b>Max RF Input, no damage</b> .....	+15 dBm	+15 dBm
<b>Image Rejection</b> .....	80 dB, min	70 dB, min (VHF)
<b>IF Rejection</b> .....	80 dB, min	70 dB, min (VHF)
<b>LO at RF Input</b> .....	-90 dBm, max	-90 dBm, max
<b>Power Consumption</b> .....	8.5 W (including WJ-8654)	7.65 W (including WJ-8654)
<b>Temperature Range</b>		
Full-spec compliance .....	+20 to +30°C	+20 to +30°C
Operating .....	-20 to +55°C	-20 to +55°C
Storage .....	-40 to +70°C	-40 to +70°C

**Table 2. Receiver Sensitivity**

<b>BW (kHz)</b>		<b>Shape Factor 60:3 dB BW</b>		<b>*Sensitivity (dBm)</b>			
				<b>20 to 500 MHz</b>		<b>500 to 1000 MHz</b>	
<b>WJ-8654</b>	<b>WJ-8654-3</b>	<b>WJ-8654</b>	<b>WJ-8654-3</b>	<b>WJ-8654</b>	<b>WJ-8654-3</b>	<b>WJ-8654</b>	<b>WJ-8654-3</b>
6.4	300	3:1	5:1	-107	-90	-105	-88
10	500	3:1	5:1	-106	-88	-104	-86
20	1000	3:1	4:1	-103	-85	-101	-83
30	2000	3:1	4:1	-101	-82	-99	-80
50	4000	3:1	4:1	-99	-79	-97	-77
<sup>1</sup> 100	6000	3:1	4:1	-96	-77	-94	-75
	8000		4:1		-76		-74
	12000		4:1		-74		-72

\*Sensitivity Conditions:

AM - An input signal AM-modulated 50% by a 1-kHz tone produces 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 IFBW produces a minimum video output S+N/N ratio of 17 dB. (Note: A 400-Hz modulation rate is required for IFBWs of 10 kHz or less.)

<sup>1</sup>FM discriminator limited to 75-kHz max BW.

Note: Consult factory for additional bandwidth sizes.



**Table 3. Weights & Dimensions**

Unit	Height	Width	Depth	Weight
<b>8654</b>	1.7 in (4.32 cm)	3.0 in (7.62 cm)	7.75 in (19.68 cm)	<2.1 lbs (0.95 kg)
<b>HFE</b>	1.0 in (2.54 cm)	3.0 in (7.62 cm)	7.75 in (19.68 cm)	1.2 lbs (0.54 kg)
<b>FE</b>	0.86 in (2.18 cm)	3.0 in (7.62 cm)	7.75 in (19.68 cm)	1.2 lbs (0.54 kg)

**Table 4. Options**

Nomenclature	Function	Physical Characteristics
<b>WJ-8654/IFBW</b> IF Bandwidth	<ul style="list-style-type: none"> <li>● Provides additional IFBW's</li> </ul>	<ul style="list-style-type: none"> <li>● 2 IFBW's standard, 2 optional</li> </ul>
<b>WJ-8654/MCS-1</b> Miniceptor Control Software	<ul style="list-style-type: none"> <li>● Provides applications software for                             <ul style="list-style-type: none"> <li>- Receiver control/RF Pan display</li> <li>- Mnemonic control</li> <li>- Quick, reset/flush receiver operations</li> <li>- Missions storage/retrieval</li> <li>- Data logging</li> <li>- Data analysis</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>● MS/DOS-based</li> <li>● Requires as a minimum:                             <ul style="list-style-type: none"> <li>- 386/16-MHz PC</li> <li>- EGA, VGA, or SVGA displays</li> <li>- COM port</li> </ul> </li> </ul>



**WJ-8654 Briefcase System Using *Miniceptor* Control Software**