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WJ-8986 N-CHANNEL CORRELATIVE VECTOR DF SYSTEM



FEATURES

- DF, Acquisition and Display (IF/RF Pan) Capability
- Correlative Vector DF Technique for High Accuracy/Antenna Versatility
- 3 to 5 Channel Simultaneous Signal Processing
- Utilizes Digital Signal Processing (DSP) Technology for High Processing Gain/DF Sensitivity
- 50 MHz/Second Scan Rate (With DF) Is Effective Against Frequency Agile and PTT-Type Signals
- DFs on 10 Microsecond Pulses (Monopulse-Type Design)
- Graphical Front Panel Displays (Including Spectrum FFT)
- Single Rack-Mountable Unit With EL Display
- Full Remote Control
- PC-AT Based Design With 3.5" Floppy and 40 MB Hard Disks

DESCRIPTION

The WJ-8986 represents the leading edge in low-cost, compact DF systems. By combining advanced digital processing techniques with state-of-the-art hardware, a DF system with outstanding, across-the-board performance is achieved. New synthesizer techniques provide a fast tuning rate, while parallel A-to-D converters simultaneously digitize signals. This combination allows for a high probability of intercept and accurate lines of bearing (LOBs) for short duration signals. Specialized digital signal processors and parallel computation techniques considerably reduce the time needed for LOB calculations. In addition, graphical data processing options provide the user with a powerful tool in applications such as resolving 60-channel signals and DFing of low power signals.

These features allow the WJ-8986 to perform three major communications intercept system functions: high

quality DF, signal acquisition and monitoring, and RF/IF Pan Display using high resolution spectral FFTs.

With all of its performance, the WJ-8986 still remains a practical, easy-to-use box. The system consists of an 8.75-inch high rack mountable chassis. The front panel of the DF contains a lighted keypad and EL display as well as jacks for an optional keyboard and headset. The DF antenna and accompanying cables are the only additional hardware. Options are installed internally in a modular fashion. Typical system power is less than 250 watts making the WJ-8986 ideal for vehicular applications.

Operator interface is either via the front panel keypad of the Processor or IEEE-488.2 remote control. If desired, an optional personal computer-style keyboard can be added. All DF operations can be performed from this keyboard. System output is by a multiple grey scale, high resolution EL display located on the front panel. This display provides the operator with system configuration, LOB results and various graphical displays, such as angle-of-arrival versus signal strength and angle-of-arrival versus frequency. An optional external CRT can be added which gives an enhanced color graphics display.

The WJ-8986 has been designed to be very flexible. LOBs are calculated using a correlation algorithm on signals obtained from monopulse antenna arrays. This technique easily adapts to a wide variety of DF antennas. Dipole antenna arrays are primarily used to provide DF coverage in the VHF/UHF ranges. Other compatible antenna configurations include crossed loop antennas for HF ground waves, large baseline arrays for HF sky waves, and annular slot or ferrite loops for covert applications. In general, the WJ-8986 can utilize many arbitrary antenna arrays for DF applications.

CONFIGURATION FLEXIBILITY

The standard WJ-8986 VHF/UHF DF System consists of the WJ-8986 Correlative Vector DF Processor and a WJ-9886 DF Antenna. A wide variety of options are offered which allow the system to be configured for a particular customer's application including HF and airborne DF. The standard system configuration consists of:

- WJ-8986 Correlative Vector DF Processor
 - 2 to 512 MHz DF Unit
 - 3 Channels
 - Front Panel Keypad/IEEE-488 Bus
 - EL Front Panel Display
- WJ-9886-X DF Antenna
 - 20 to 1200 MHz
 - Flexible Configurations
 - Low Profile
 - High Sensitivity
 - Three or Four Element Array
 - Vertically Polarized
 - Low Cost
 - Lightweight

TYPICAL APPLICATIONS

Resolving Co-Channel Signals

In many situations, two or more signals are located in the passband of the receiver. To accurately DF on the desired signal, we must identify and isolate it from the undesired signals. A high resolution frequency spectrum display can be obtained and the signal of interest selected by using the graphical processing software. Through use of the software, the operator can eliminate the effects of other signals in the passband and calculate an LOB for the selected signal only.

Direction Finding on Low-Powered Signals

In real life situations, it is often desirable to DF on signals with very poor signal-to-noise ratios. Accurate LOBs can be obtained with a low noise figure system and the use of signal processing gain to improve the effective signal-to-noise ratio. The noise figure of the WJ-8986 Receiver section is typically less than 10 dB. In addition, the FFT algorithm used allows for very narrow resolution bandwidths, thus reducing the noise power seen by the processor. By using averaging techniques, random noise can quickly be reduced giving accurate LOBs. The processing gain realized by this averaging technique becomes practical due to the fast processing time of the WJ-8986. This is a vast improvement over conventional DF systems which often require very strong signals to maintain a 2 to 3 degree RMS accuracy.

Large Systems

The three (or more) channel correlative DF technique eliminates the need for any type of antenna switching and allows for a fast DF response or throughput time. This is critical in large system applications where the DF may be tasked by a fast acquisition receiver, such as the WJ-9195C, WJ-8695, or compressive receiver units. Many current DF units require antenna switching which results in very slow throughput. The DF then becomes too slow to keep up with the large queue of signals being sent by the acquisition receiver, thus short duration signals are often gone by the time the DF operation is performed. Using the techniques mentioned above, the low cost and high accuracy of the WJ-8986 DF unit makes it ideal for an emitter location in a netted configuration of two or three units.

Signal Acquisition

The WJ-8986 with graphics software will allow the operator to establish a target list of up to 100 different frequencies. Priorities can be assigned to each frequency and the DF will continuously collect data on the targeted frequencies. The collected information can be stored on disk or displayed in a tabular or histogram format. This mode of operation is called channel search. The system can also perform standard frequency (F1-F2) scans with DF at 50 MHz/second. The combination of scan rate, pulse response and graphical displays allow the unit to DF on frequency agile signals. In these modes, the WJ-8986 may also be effectively used as an acquisition unit for a typical collection system.

OPTIONS

DF Processor

WJ-8986/488—IEEE-488 Remote Interface

This option provides remote control of the DF processor using IEEE-488.2 commands. This allows for complete operation of the WJ-8986 by a remote processor.

WJ-8986/OC—Operator Channel

This option adds an additional RF channel with AM, FM, CW and SSB demodulation capabilities. This allows the operator to monitor the frequency spectrum for signals of interest. Standard IF bandwidths included in the option are 10 kHz, 20 kHz, 50 kHz, 100 kHz and 300 kHz. (A 3 kHz IF bandwidth is used for SSB demodulation.) See WJ-8607 data sheet for further details.

NOTE: When used with the WJ-8986 DF frequency extension to 2 GHz, the operator channel should be specified as WJ-8986/OCE.

WJ-8986/4CH or 5CH—Additional RF Channels

This option allows for up to five total processing channels. This feature is especially useful when using specialized antenna arrays. The standard WJ-8986 utilizes three RF channels.

WJ-8986/FE3—512 MHz to 2 GHz Frequency Extender

An external frequency extender can be included to expand the frequency range of the DF to 2 GHz. It is a 3.5-inch rack mountable unit. Four and five channel frequency extenders are also available (WJ-8986/FE4 or FE5).

WJ-8986/AAU—Antenna Adapter Unit

This interface unit provides the necessary interface circuitry that allows the WJ-8986 DF unit to use the WJ-8976/AU-5 and AU-3 DF antennas. It is a 3.5-inch rack mountable unit. Use of only the WJ-8976/AU-3 (i.e., HF DF only) does not require the AAU unit.

WJ-8986/CRT and/or KBD—CRT Display and Keyboard

An external CRT display can be added to view graphics displays in color. An external personal computer-style keyboard can also be added to further ease operator interface. (Units are available commercially or through Watkins-Johnson Company.)

WJ-8986/EDD—External Disk Drive

An external disk drive or other SCSI mass storage device can be added to provide additional storage capabilities. This feature is useful for applications requiring a removable hard disk.

WJ-8986/BFP—Blank Front Panel

This option allows for a blank front panel to be put on the unit. This is ideal for applications where the DF is operated exclusively in a remote mode.

Software

Graphics Enhanced Data Processing Software

This software includes additional data processing and sorting. Standard software includes four basic displays: Frequency Versus Amplitude (IF Pan with DF), Frequency Versus Amplitude and LOB (RF Pan with DF), LOB Versus Amplitude (Polar), and 100-Channel Search With Histogram. Contact factory for further details.

Antenna Calibration Software

This software permits the generation of data bases for arbitrary antenna configurations or for the correction of site-related errors. Contact factory for further details.

Antennas

20 to 512 MHz Fixed Site/Vehicular Antenna

Dipole antenna arrays are used to cover the VHF frequency band. Fixed site or vehicular antenna array configurations are available (WJ-8976/AU-6, WJ-9886-X, or WJ-34901).

20 to 1200 MHz Fixed Site/Vehicular Antenna

Extended VHF antenna arrays are used to provide coverage of the UHF frequency band. Fixed site or vehicular antenna array configurations are available (WJ-8976/AU-5, WJ-9886-X, or WJ-34901).

2 to 30 MHz Fixed Site (Sky Waves)/Vehicular (Ground Waves) Antenna

A fixed site monopole array provides DF coverage for both HF sky waves and ground waves. A vehicular mountable crossed loop antenna provides HF ground wave coverage (WJ-8976/AU-3 or WJ-34901).

Special Antenna Configurations

The flexibility of the DF allows for special antenna configurations to be used for DF purposes. These antenna configurations may be dictated by the unique application or by the required use of an existing antenna array, and include airborne, heliborne, shipborne and vehicular applications.

SPECIFICATIONS

System

Frequency Range	20 to 512 MHz (2 to 2000 MHz optional)
Required Minimum Signal Duration	10 μ sec (with trigger mode)
Scan Rate	50 MHz/second typical (with DF)
LOB Response Time	35 msec plus integration time, typical (see Note 1)
FFT Bin Size	22 kHz to 86 Hz (22 kHz roofing filter) 200 kHz to 782 Hz (200 kHz roofing filter)
FFT Window	Blackman-Harris
Resolution Bandwidths	22 kHz to 172 Hz (22 kHz roofing filter)
(including windowing)	200 kHz to 1.56 kHz (200 kHz roofing filter)
Accuracy	2 degrees RMS typical (see Note 2)
Sensitivity	Less than 10 μ V/m for 2 degrees RMS jitter typical (see Note 3)

DF Processor

Frequency Range	2 to 512 MHz (512 to 2000 MHz optional)
Noise Figure	12 dB maximum, 20 to 512 MHz 15 dB maximum, 512 to 2000 MHz with FE
Input Impedance	50 ohms nominal
Input VSWR	2.0:1 typical, 3.0:1 maximum at the tuned frequency
Tuning Resolution	100 Hz, synthesized
Internal Reference Accuracy	± 1 part in $10E^{-6}$ (0 to 50 $^{\circ}$ C)
External Reference Frequency	10 MHz, 0 dBm nominal input level
Preselection	Tracking Preselector, 20 to 512 MHz. 10 percent nominal bandwidth. Suboctave filters 512 to 2000 MHz
Third Order Intercept Point	+5 dBm (2 to 20 MHz) +8 dBm (20 to 512 MHz)
Second Order Intercept Point	0 dBm (512 to 2000) MHz +45 dBm (20 to 512 MHz) +35 dBm (512 to 2000 MHz)
Dynamic Range	100 dB
Instantaneous Dynamic Range	65 dB, typical
Control Processor	80486/33 MHz
FFT Processors	DSP56001/20 MHz
Correlation Processor	TMS320C30/30 MHz
Graphics Processor	Vector Scan RISC
LO to Antenna Radiation	Less than -90 dBm
Processor Roofing Bandwidths	22 kHz and 200 kHz
Display Type	EL panel (Color CRT optional)
Display Resolution	640 \times 480 pixels (VGA)
LOB Resolution	0.1 degrees
Instrument Accuracy	Less than 1 degree RMS (see Note 4)
Remote Control	IEEE-488.2 (RS-232 optional)
Operating Temperature	0 to 50 $^{\circ}$ C
Power Requirements	110/220 VAC
Power Dissipation	250 watts, typical 350 watts, maximum
Size	8.75" \times 19" \times 20"
Weight	Less than 66 lbs. (30 kg)

Antennas (See separate data sheets for detailed information.)

HF

WJ-8976/AU-3—Ground Mounted Monopole Array

Frequency Range	2 to 30 MHz
Signal Type	Vertically polarized ground waves and sky waves
Monopole Length	15 feet (4.6 m)
Baseline	14 feet (4.3 m)
Weight	120 lbs. (54.5 kg)
Operating Temperature	-20 to +60 $^{\circ}$ C

WJ-34901 Crossed Loop/Dipole Array
(HF/VHF/UHF)

Frequency Range	2 to 2000 MHz
Signal Type	Vertically polarized ground waves
Maximum Elevation	20 degrees
Size	18" diameter, 40" high
Operating Temperature	-20 to +60 °C

VHF/UHF

WJ-9886-1 (Variable Configuration)

Frequency Range	20 to 1200 MHz
Low Bay	20 to 160 MHz
High Bay	160 to 1200 MHz
Signal Type	Vertically polarized
Dipole Length (Full Height)	
Low Bay	80 inches
High Bay	20 inches

WJ-9886-2 (Variable Configuration)

Dipole Length (Low Profile)	
Low Bay	12 inches
High Bay	12 inches
Baseline	
Low Bay	30 inches (76.2 cm)
High Bay	4 inches (10.2 cm)
Height	Configuration dependent
Weight	Configuration dependent
Operating Temperature	-20 to +60 °C

WJ-8976/AU-5 (Fixed Site, Ruggedized)

Frequency Range	20 to 1200 MHz
Low Bay	20 to 100 MHz
Mid Bay	100 to 500 MHz
High Bay	500 to 1200 MHz
Signal Type	Vertically polarized
Dipole Length	
Low Bay	48 inches (122 cm)
Mid Bay	27 inches (68 cm)
High Bay	14.9 inches (38 cm)
Baseline	
Low Bay	46.8 inches (119 cm)
Mid Bay	10.4 inches (26 cm)
High Bay	4.0 inches (10 cm)
Height	152.25 inches (3.8 m)
Weight	75 lbs. (34 kg)
Operating Temperature	-20 to +60 °C

NOTE 1: Response times include remote commands to change frequency and take line-of-bearing. This specification assumes a 25 kHz resolution bandwidth and single line-of-bearing calculation.

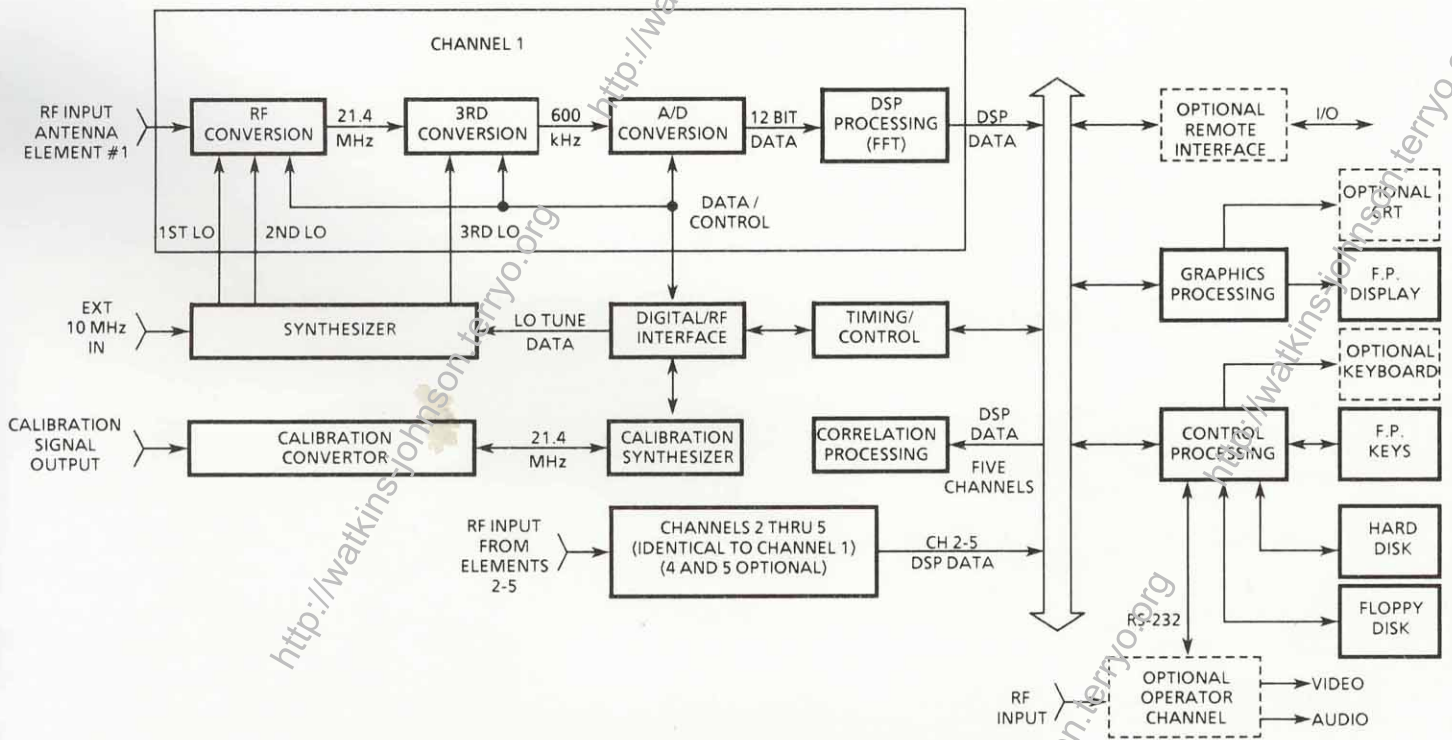
NOTE 2: System accuracy is highly dependent on the environment in which the antenna is deployed and the ability to calibrate out these effects. Typical systems perform with 2 degrees RMS error in controlled antenna range conditions. Contact Watkins-Johnson for estimates of accuracy performance in other situations.

NOTE 3: Sensitivity is dependent on frequency, antenna configuration, integration time, resolution bandwidth, external noise contributions, and other factors. Contact Watkins-Johnson for exact sensitivity specifications.

NOTE 4: Instrument accuracy is measured using an input signal level of -99 dBm, a resolution bandwidth of 25 kHz, and 100 integrations.

REAR PANEL CONNECTIONS

Connector	Reference Designator	Function
STANDARD UNIT		
PRINTER	J1	25 pin D-type. Centronix standard parallel output port provided for connection to an external printer. (Contact factory for details.)
VGA VIDEO	J2	15 pin D-type. Provides RGB video for an external color monitor.
EXTERNAL CONTROL	J4	25 pin D-type. Accepts an ANTENNA DISABLE input and controls the WJ-8986/FEX option.
ANTENNA CONTROL	J5	25 pin D-type. Provides DC power and control for the antenna or WJ-8986/AAU option.
ANT #1	J10	N-type. RF input from Element #1 of antenna.
ANT #2	J11	N-type. RF input from Element #2 of antenna.
ANT #3	J12	N-type. RF input from Element #3 of antenna.
CAL SIG	J15	N-type. Calibration signal output to the antenna.
10 MHz OUT	J16	BNC. 10 MHz reference output.
EXT 10 MHz REF	J17	BNC. External 10 MHz reference input.
AC Power Input	FL1J1	110/230 VAC.
WJ-8986/488 OPTION		
IEEE-488	J8	IEEE-488.2-1987 interface.
WJ-8986/4CH or 5CH OPTION		
ANT#4	J13	N-type. RF input from Element #4 of antenna.
ANT#5	J14	N-type. RF input from Element #5 of antenna.
WJ-8986/OC OPTION		
OPERATOR CHANNEL VIDEO	J18	BNC. Switched video output from operator channel.
OPERATOR CHANNEL SWITCHED AUDIO	J19	BNC. Switched audio output from operator channel.
OMNI ANTENNA	J20	BNC. Omni antenna input for operator channel.
WJ-8986/EDD OPTION		
SCSI	J9	Multipin SCSI interface for external disk drive.



WJ-8986 Overall Functional Block Diagram