Technical Data

WATKINS-JOHNSON

May 1997

Digital FDM Channel/Group Demultiplexer WJ-9543

The WJ-9543 Digital FDM Channel/Group Demultiplexer is a compact, multichannel demodulator that incorporates the accuracy and repeatability of a Digital Signal Processing (DSP) approach. Through the use of DSP, exceptional amplitude and group delay characteristics are simultaneously achieved. An analog tuner in the front end of each channel demodulator permits the use of a high-resolution Analog-to-Digital (A/D) converter and a significant degree of filtering prior to the sampling process. These effects combine to produce superior noise performance and high dynamic range. The WJ-9543 merges analog and digital techniques in a scheme that achieves significant performance enhancements relative to demultiplexer implementations that are purely analog or digital.

The WJ-9543's modular design simultaneously provides up to twelve FDM channel demodulators and two FDM group demodulators. If desired, either or both of the group demodulators can be commanded to perform

HEIGHT	3.5 in (8.89 cm)	**DEPTH**	20 in (50.80 cm)
WIDTH	8.25 in (20.96 cm)	**WEIGHT**	20 lbs (9.05 kg)

Features

- ❑ *Up to 12 independently tunable FDM channel demodulators in a single unit*
- ❑ *Up to 2 independently tunable FDM group demodulators in a single unit*
- ❑ *Tunable from 0 to 20 MHz in 1-Hz steps*
- ❑ *Compact size: 2 units mount in a 19-in rack, 3.5-in high*
- ❑ *Very-low-differential group delay & flat amplitude response*
- ❑ *4 analog baseband inputs with nonblocking connection to any of the channel demodulators*
- ❑ *Scanning capability & preprogrammed CCITT frequency plans facilitate tuning*
- ❑ *Drop-in option cards to permit a variety of analog & digital output formats as well as additional VGC processing*
- ❑ *Up to 8 units configurability, to share their digital outputs allowing option cards access to as many as 112 VGC signals*
- ❑ *Built-in test capability & modular design to facilitate field maintenance*
- ❑ *Full local & IEEE-488 remote control*
- ❑ *Selectable analog outputs -*
  Group A - 12 to 60 kHz
  Group B - 60 to 108 kHz

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standard 4-kHz channel demodulation. Units with fewer than 12-channel demodulators are field-upgradable by installing 6-channel demodulation cardsets into the appropriate motherboard slots. Likewise, units with fewer than two group-band demodulators are field-upgradable with group-band demodulator cardsets. Other optional capabilities are also field-installable with similar ease.

The demodulators within the WJ-9543 are independently tunable over the 0 to 20 MHz base-band in 1-Hz steps. Four different tuning modes are available in the standard unit.

Direct frequency tuning allows an operator to enter a nominal tuned frequency in kHz. Channel tuning divides the input tuning range into 5001 contiguous 4-kHz increments, and allows the operator to enter the desired channel number. Likewise, Group tuning divides the input tuning range into 417 contiguous 48-kHz increments. In addition to these tuning schemes, two common CCITT frequency plans (960 channel and 2700 channel) are preprogrammed into the WJ-9543. Tuning is accomplished within these modes by specifying the appropriate CCITT hierarchies (SMG, MG, SG, G and CH). Scans can be performed within each of the four tuning modes. To compensate for frequency offsets between the WJ-9543 reference and the baseband, a parts-per-million (PPM) correction factor can be entered for each baseband input, and the tuned frequencies will be automatically computed and adjusted from the nominal frequencies entered.

In addition to baseband selection and tuned frequency, independent channel control of gain, upright/invert detection, scan threshold, headphone selection, and routing to installed option cards are available. A thorough built-in test feature, capable of detecting circuit faults to the module level, is also provided. Control of the WJ-9543 can be performed either locally, via the front panel Liquid Crystal Display (LCD) and keypad controls, or remotely, via the standard IEEE-488 interface. The display is a menu-driven, 8 x 40 character LCD with LED backlighting. Unit and demodulator level parameters are presented in a variety of formats. Parameter entry is accomplished via the numeric keypad, or the cursor and edit control knobs on the unit's front panel. With the exception of headphone volume control and the unit's bus address, all operator-selectable parameters are controllable and accessible via the standard IEEE-488 interface. Consult the factory for alternate remote control interfaces.

The modular construction of the Voice Grade Channel (VGC) option cards allows the WJ-9543 to be tailored to meet specific system requirements. Each of these option cards can access one or more operator-selected VGCs, and can perform a specific operation on them. Possible operations include, but are not limited to:

- Analog reconstruction
- PCM formatting
- Data storage interfacing
- Signal characterization
- Data demodulation

For all of its capability, the WJ-9543 Digital FDM Demultiplexer is extremely compact. Two units, mounted side-by-side, fit into a standard 19-inch (48.26 cm) equipment rack, occupying only 3.5 inches (8.89 cm) of vertical rack space. The weight of the unit is approximately 20 pounds (9.05 kg).

Functional Description

The unit accepts up to four 20-MHz analog FDM basebands and applies each to an automatic gain control (AGC) amplifier with a long response time. This baseband AGC adjusts the front-end gain to optimize the unit's noise and distortion performance over a 30-dB composite baseband power range. The baseband signals are then connected, under operator control, to any of the installed channel demodulators in a completely nonblocking fashion. A buffered version of each baseband input is also provided as an output allowing multiple units to access the same basebands.

As shown in the Functional Block Diagram, the outputs from each group of 6-channel tuners are routed to a 6-channel A/D converter, and the six resulting digital channels are sent to a 6-channel DSP demodulator. The channel tuner card is a fully synthesized, two-conversion analog front end. It covers the 20-MHz tuning range in 500-Hz steps producing a final IF approximately 8-kHz wide, centered at 8 kHz. This output is applied to a 6-channel A/D converter card where it is digitized to 14 bits of resolution at a sampling rate of 32 kHz. Raw digital data is applied to a 6-channel DSP demodulator card that performs fine tuning, SSB demodulation, critical channel filtering, and gain control.

Group-band demodulators within the WJ-9543 consist of a group-band tuner and a group-band processor. The group-band tuner card is similar to the channel tuner card, except that the final IF is approximately 48-kHz wide and is centered at 96 kHz. The group-band processor card includes an A/D converter that digitizes the analog IF to 12 bits of resolution at a sampling rate of 384 kHz. The

group-band processor performs fine tuning, SSB demodulation, critical channel filtering, and gain control. It also performs analog reconstruction in order to provide a selectable analog output in accordance with the Group A (12 to 60 kHz) or Group B (60 to 108 kHz) format.

The bus controller generates address, clock, and control signals necessary to the operation of the 6-channel A/D converter, the DSP demodulator and the group-band processor cards, as well as the timing and control of the internal TDM data bus. It performs the audio reconstruction of two selected channels for the front-panel stereo-headphone jack, and monitors slot occupancy and run-time error status of the A/D converter and the DSP demodulator cards. The bus controller also plays a role in the built-in test sequence by performing signature analysis on the unit's digital data paths.

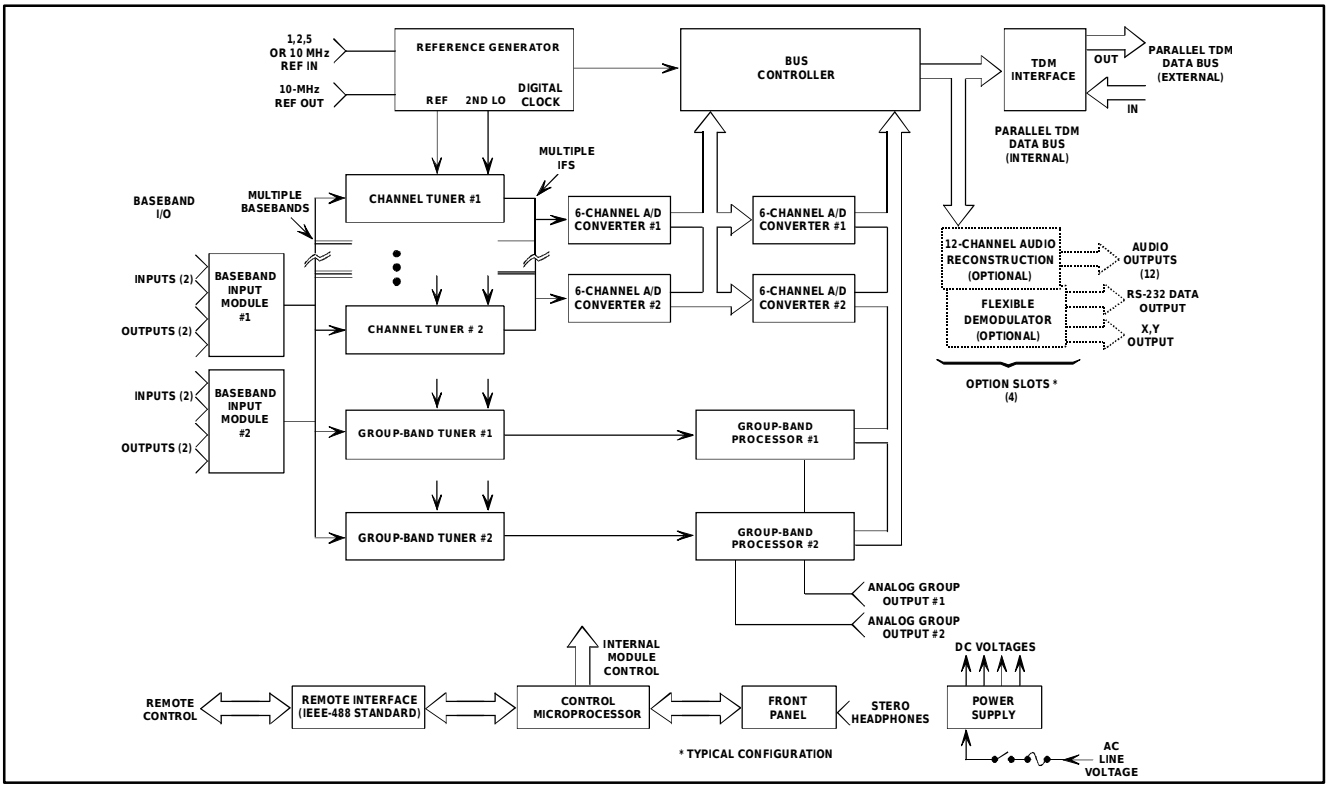
The internal TDM data bus supplies digitized VGC data to up to four option cards for further processing. VGC data can be placed on the bus, not only by resident demodulators, but also by demodulators installed in other WJ-9543s. By interconnecting up to eight WJ-9543s, via the TDM interface as shown in the simplified diagram for connnecting multiple WJ-9543s in a stacked configuration, as many as 112 channels of voice grade data can be made available to the option cards within each unit.

Systems Applications

The WJ-9543 design incorporates several features that facilitate the integration of the unit into a system. The flexibility of nonblocking baseband switching improves the utilization of demodulator resources relative to bridging schemes used in earlier designs. The inclusion of buffered baseband and reference frequency outputs

Connectors (Inputs/Outputs)

I/O	Function	Type
Inputs	4 baseband inputs TDM Data input Reference input AC Power	BNC Multipin BNC IEC Male
Outputs	4 baseband outputs TDM Data output Reference output Headphones	BNC Multipin BNC 1/4-in stereo jack
Both	Remote Control	IEEE-488

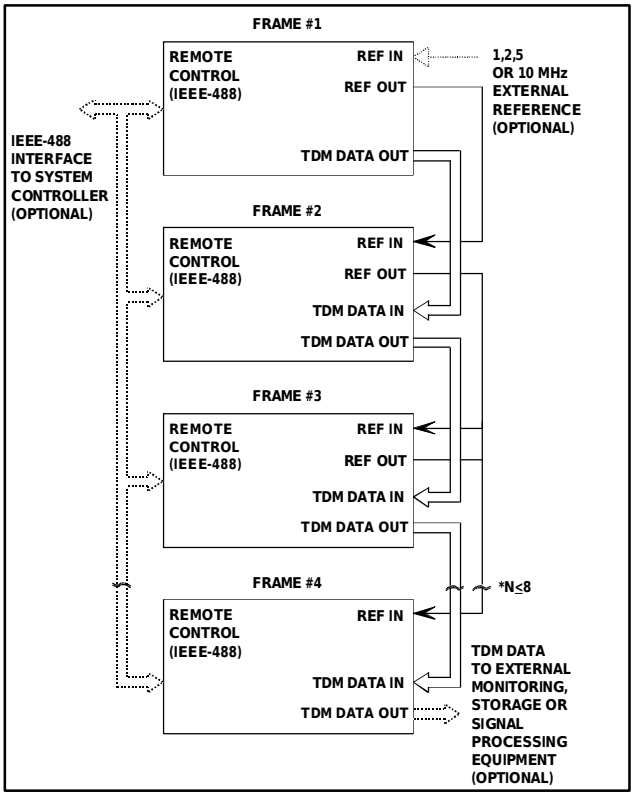


WJ-9543 System Block Diagram

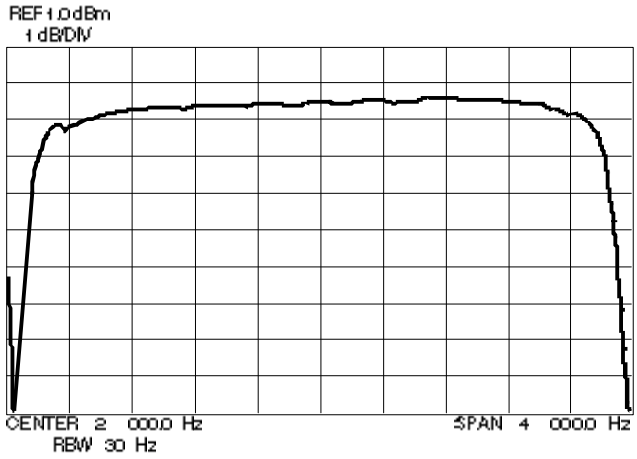
allows these signals to be shared among multiple units without elaborate switching or multicoupler networks.

The modular construction of the WJ-9543 makes the unit easy to maintain with a minimum amount of down time. A thorough built-in test capability permits hardware faults to be quickly detected and isolated to the board level. Many of the installed boards exist in multiple quantities, thus reducing the required inventory for spares. A key advantage of the modular construction is the ability to configure the WJ-9543 to best satisfy the specific operational requirements of the system. Off-the-shelf or custom option cards can be incorporated, in many cases eliminating the need for additional demodulation or post-processing equipment. Alternate remote control interfaces are also available in drop-in form to accommodate a variety of system control schemes.

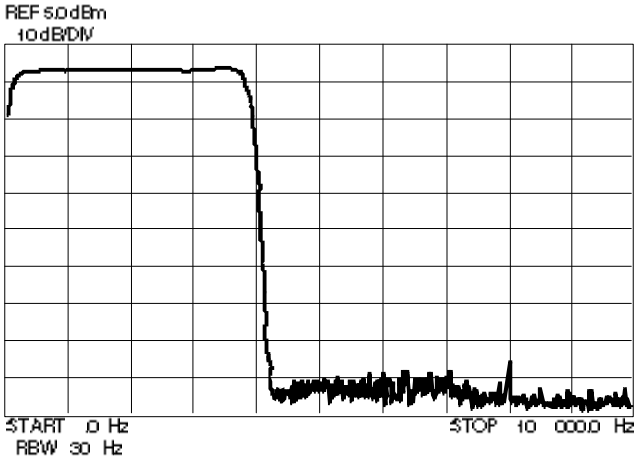
The architecture of the WJ-9543 allows up to eight units to be connected in a *stacked* configuration as illustrated in the Simplified Diagram below. In this configuration, the VGC data from all the units are timeshared on the TDM data bus and are therefore available to the option cards installed in each unit. In systems where multiple FDM demultiplexers are required, as much as an eight-fold increase in the number of option boards available to each demodulator can be achieved.



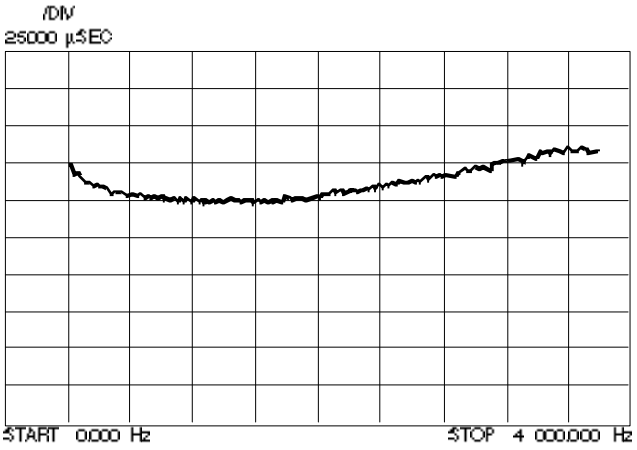
Simplified Diagram for Connecting Multiple WJ-9543s in a Stacked Configuration



Typical Passband Response (Audio Output)



Typical Channel Filter Response (Audio Output)



Typical Group Delay Response (Audio Output)

Specifications

Input Characteristics

Number of Inputs	4 analog basebands (connects to any channel demodulator in a nonblocking manner)
Input Range	150 Hz to 20 MHz (reduced performance below 8 kHz)
Input Impedance	75 ohms, unbalanced
Input Level Range	-30 to 0 dBm, composite baseband
Baseband Gain Control	Long time-constant AGC that optimizes input gain over input level range

Output Characteristics

Digital VGC Output (Standard)	Parallel TDM data bus; 16-bit linearly coded VGC data with word & framing clocks
Frequency Response	175 to 3825 Hz (-3 dB)
Bandpass Ripple	±0.35 dB, max (600 to 3400 Hz)
Adjacent Channel Rejection	60 dB, min (at 300 & 3700 Hz)
Total Harmonic Distortion	0.1%, max (820-Hz test tone at nominal output)
Residual Noise	57 dB, min below nominal output
Noise Power Ratio (NPR)	50 dB, min (600 channel noise load at -7 dBm)
Differential Group Delay	75 microseconds, max (400 to 3825 Hz)
Incidental FM	1.00 Hz rms (0 to 15 MHz tuned frequency) 1.25 Hz rms (15 to 20 MHz tuned frequency)
Analog VGC Outputs (with/AUD option)	High-fidelity audio; 16-bit D/A converter with 2X oversampling, available in 12-channel increments
Output Impedance	600 ohms, unbalanced
Nominal Output Level	1 Vrms into 600 ohms (AGC mode, no audio attenuation)
Audio Attenuation Range (All Outputs)	30 dB, nominal
Output Connector	D-type, 25-pin female
Performance Specifications	Compliant with all specifications listed under *Digital VGC Output (Standard)*

Group Outputs

Type	High-fidelity analog: 12-bit D/A converter with 2X oversampling
Output Frequency Band	Selectable 12 to 60 kHz (Group A mode) or 60 to 108 kHz (Group B mode)
Bandwidth	48 kHz (-2 dB), narrower bandwidth available for processing of wideband modems (V.36 & V.37)
Transition Bandwidth	8 kHz, max (-2 to -60 dB)
Differential Group Delay	15 microseconds, max (40 kHz BW)
Residual Noise	46 dB, min below nominal output
NPR	50 dB, min (600 channel noise load at -7 dBm)
Output Impedance	75 ohms, unbalanced
	-21 dBm into 75 ohms (AGC)
Nominal Output Level	-25 dBm into 600 ohms (AGC mode)
	-21 dBm into 75 ohms (AGC)
Output connector	BNC female
T1 PCM Output (Optional)	T1; 24-channel capacity, 1.544 Mbps
Line Length	0 to 655 ft (0 to 42.26 meters)
Output Impedance	100 ohms, balanced
Output Connector	Bayonet-style Triax
Line Code	AMI or B8ZS (operator-selectable)
Encoding Characteristic	u255 or linear (operator-selectable)
Framing Formats	F4, F12 (D4), F24 (ESF) or F72 (SLC-96)
Transmit Clock	Internal or external (operator-selectable)
Internal	On-board phase-locked 1.544 MHz
External	Derived from T1 data input, or from 772-kHz square-wave or sine-wave signal source
Slip Control (External Clock)	Slips corrected on frame boundaries

CEPT PCM Output (Optional)	**Primary level CEPT; 30-channel capacity, 2.048 Mbps**
Output Impedance	**75 ohms, unbalanced**
Output Connector	**BNC**
Line Code	**HDB3 per CCITT G.703**
Encoding Characteristic	**A-law or linear (operator-selectable)**
Framing Format	**CCITT G.704 or operator-defined**
Pulse Shape	**Compliant with CCITT G.703**
Flexible Demodulator (Optional)	
Demodulator Modes	**See separate Flexible Demodulator data sheets for specific Modem, FAX, VFT, & Signaling modulations & protocols supported Output**
Digital	**RS-232 serial data at 9.6 or 19.2 kbps (transmit only)**
Analog	**I, Q baseband or symbol synchronization signals used for eye diagram & constellation display**
Output Connector	**D-type, 25-pin female**
Headphone Audio (Standard)	**Toll quality stereo; independent channel selection & volume control for each side**
Output Impedance	**600 ohms, unbalanced**
Nominal Output Level	**Adjustable up to 8 dBm into 600 ohms**
Video Baseband Output (Standard)	**4 buffered outputs; 1 for each baseband input**
Output Impedance	**75 ohms, unbalanced**
Gain Relative to Input	**0 dB, nominal**
Passband	**150 Hz to 18 MHz (-1 dB)**
Control	
Local Control	**LCD display (8 x 40 characters), keypad, cursor & edit control knobs, & headphone volume controls**
Remote Control	**IEEE-488 interface (standard); consult factory for alternate interfaces**
Gain Control Modes	**Manual or AGC, applied to individual VGCs or Group Bands**
Gain Range	**42 dB, min**
Tuning Modes	**Direct frequency, Channel, Group, CCITT 960 & CCITT 2700 (operator-selectable for each demodulator)**
Tuning Range	**0 to 20 MHz**
Tuning Resolution	**1 Hz (offsets may be entered as PPM corrections)**
Scans	**Selectable (start, stop, step) or formatted (SMG, MG, SG, G) based on CCITT 960 & 2700 frequency plans**
Detection Modes	**SSB upright or inverted spectrum (operator-selectable for each demodulator); USB/LSB tuning convention selectable via internal switch**
Frequency Reference	
Internal Reference Stability	**+5 x 10^{-7}, max**
Internal Reference Aging	**+3 x 10^{-9} drift per day, max**
External Reference	**Accepts 1, 2, 5 or 10 MHz; +1 PPM, 200 mV peak-to-peak min into a high impedance load; automatically switches to external reference upon application of signal**
Reference Output	**10 MHz, 0 dBm nominal into 50 ohms**
Physical Environment	
Temperature Range	
Operating	**0 to 50°C**
Meets All Specifications	**10 to 40°C**
Power Requirements	**115/230 Vac ±10% (48 to 72 Hz) 108 to 118 Vac (380 to 420 Hz)**
Power Consumption	**45 W, Approx (no output options installed)**

Options[*]

Nomenclature	Functions[**]	Physical Characteristics
954X/6CH **6-Channel Cardset**	• Contains all hardware needed to add 6 FDM channel demodulators • Installs easily in field • Requires no software updates to the Control Processor	• Does not use any of the 4 VGC option slots • Consists of: -6 Tuner PC Assemblies -A/D Converter PC Assembly
9543/GBD **Group-band Demodulator**	• Contains all hardware needed to add a single FDM group-band demodulator • Provides single analog output in either Group A (12 to 60 kHz) or Group B (60 to 108 kHz) format • Installs easily in field • Requires no software updates to Control Processor	• Does not use any of the 4 VGC option slots • Consists of: - Group-band Tuner PC Assembly - Group-band Processor PC Assembly - Internal Cable Assembly for Group output
954X/ACT1 **Activity Monitor (Level 1)**	• Provides automatic signal classification for up to 12 selected VGCs simultaneously • Categorizes signals as *Voice, Data, Signaling Tones* or *No Activity*	• Uses 1 of 4 VGC option slots • Consists of an Activity Monitor PC Assembly
954X/ACT2 **Activity Monitor (Level 2)**	• Provides signal classification as in the ACT1 Option, except data signals are classified as *FSK* signals (includes FSK modems & VFT signals), or *PSK* signals (includes BPSK, QPSK & QAM modems)	• Uses 1 of 4 VGC option slots • Consists of an Activity Monitor PC Assembly
954X/AUD **12-Channel Audio Reconstruction**	• Provides high-fidelity analog reconstruction of any 12 selected VGCs • Provides operator-adjustable nominal output levels of all 12 outputs over a 30-dB range (up to a max of 1 Vrms into a 600-ohm lead)	• Uses 1 of 4 VGC option slots • Consists of: - Audio Reconstruction PC Assembly - Internal Cable Assembly - Set of rear panel identification (ID) plates & decals - External Cable Assembly that makes each of the 12 audio output signals available on an individual BNC connector
954X/T1 **T1 Output Formatter**	• Provides a standard T1 PCM data stream containing up to 24 selected VGCs • Allows assignment of VGC outputs, from the various demodulators, to arbitrary T1 channels, in a nonblocking fashion • Allows the selection of linear & u-law encoding on a channel-by-channel basis • Allows the T1 timing to be derived from an external clock source	• Uses 1 of 4 VGC option slots • Consists of: - T1 Formatter PC Assembly - Cable Assembly - Set of rear panel ID plates & decals - Accessory Cable Assembly with ID plates & decals to allow for external T1 clock sources

Options (Continued)*

Nomenclature	Functions**	Physical Characteristics
954X/CEPT CEPT Output Formatter	• Provides a standard, primary level CEPT PCM data stream containing up to 30 selected VGCs • Allows the assignment of VGC outputs, from various demodulators within the WJ-9543, to arbitrary CEPT channels in a nonblocking fashion • Allows the selection of Linear & A-law encoding	• Uses 1 of 4 VGC options slots • Consists of: - CEPT Formatter PC Assembly - Cable Assembly - Set of rear panel ID plates & decals
954X/FLX Flexible Demodulator	• Provides a single-channel voice frequency demodulator capable of demodulating & decoding a variety of Modem, VFT & FAX signal formats • Performs: - Symbol timing recovery - Adaptive blind equalization - Carrier recovery - Data derandomizing - Data decoding • Provides demodulated character data via an RS-232 output port • Outputs eye diagrams & constellation patterns on 2 analog ports • See separate Flexible Demodulator data sheets for a list of protocols supported • In VFT applications, all data canals, or a single-selected data canal, can be output through the RS-232 port	• Uses 1 of 4 VGC option slots • Consists of: - Flexible Demodulator PC Assembly - 2 Cable Assemblies - Set of rear panel ID plates & decals - A 5.25-in floppy disk providing FAX reconstruction & data display/storage programs (MS-DOS compatible) - Up to 4 Flexible Demodulator option cards installed and cabled to a single rear-panel multipin connector
WJ-8615/BR Blank Rack	• Allows the mounting of a single WJ-9543 into a standard 19-in rack	

* The basic WJ-9543, as ordered from the factory, contains no channel or group-band demodulators. To order the desired number of factory-installed channel demodulators, specify the appropriate number of 6-channel cardsets (WJ-954X/6CH) up to a maximum of two per unit. To order the desired number of factory-installed group-band demodulators, specify the appropriate number of group-band demodulator cardsets (WJ-9543/GBD) up to a maximum of two per unit. In addition to the 6-channel and the group-band demodulator cardset slots, the WJ-9543 contains four option slots for the installation of a variety of output formatters or special signal processing options. Option cards can be installed in any combination, subject only to the four-slot restriction and the availability of rear panel space for I/O connectors. Some options may require an upgrade of the control software and/or hardware. To satisfy unique system requirements such as additional baseband inputs (up to eight), digital baseband inputs, special VGC processing options, or alternate remote control interfaces, contact the factory.

** See specifications for details