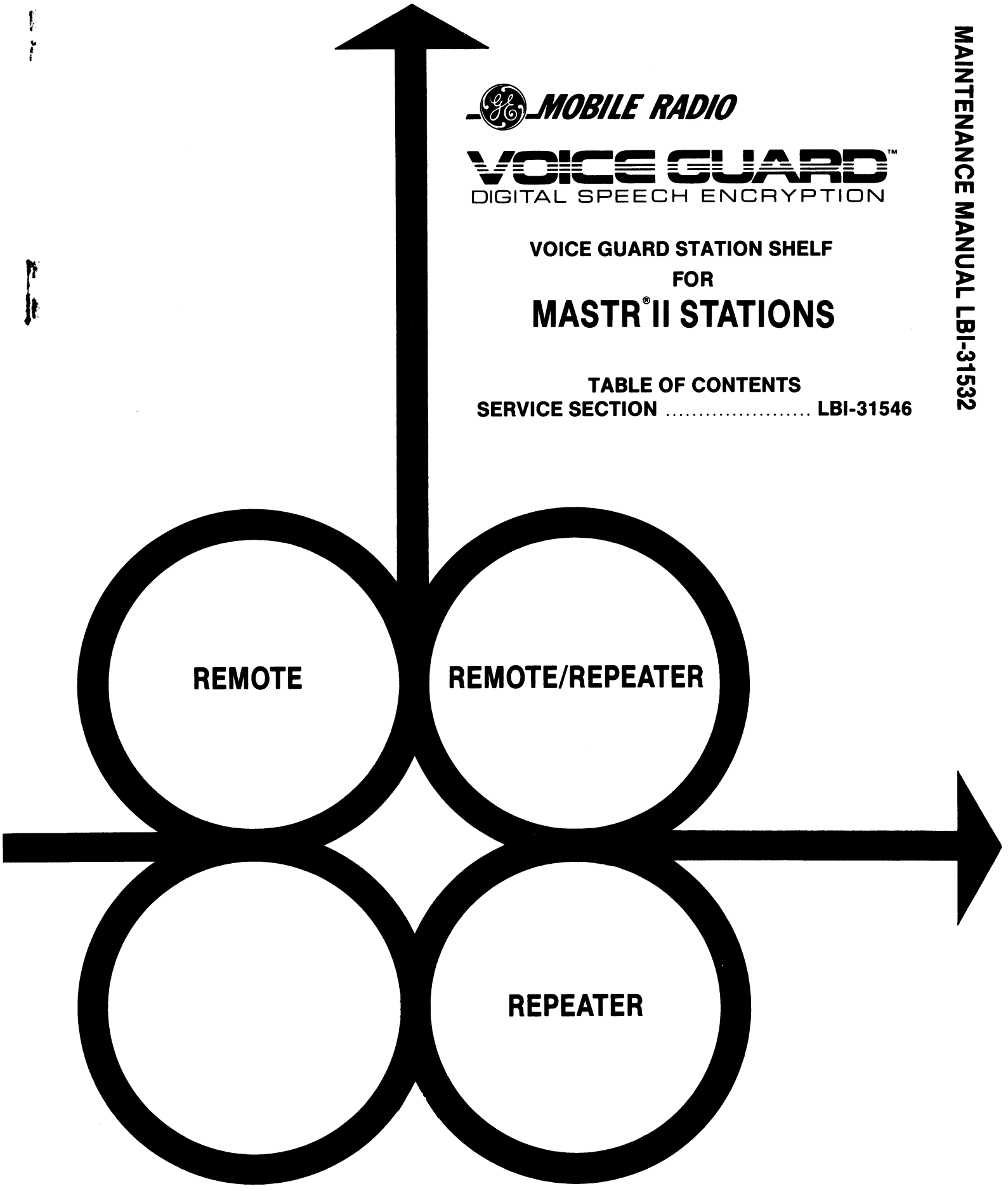
MAINTENANCE MANUAL LBI-31532

MOBILE RADIO

VOICE GUARD™
DIGITAL SPEECH ENCRYPTION

VOICE GUARD STATION SHELF
FOR
MASTR® II STATIONS

TABLE OF CONTENTS



GENERAL ELECTRIC

TABLE OF CONTENTS

SPECIFICATIONS
(VG Shelf)

Station Options	
Option 9780	Remote or Remote/Repeat
Option 9781	Repeat only
Input Voltage	12-16 Volts DC from station
Current Drain	
With 9600 Baud Modem	1.5 amperes
Without 9600 Baud Modem	0.75 amperes
Dimensions (H X W)	1 Rack Unit (1.75 x 19 inches)
Temperature Range	-30°C to +60°C (-22°F to +140°F)

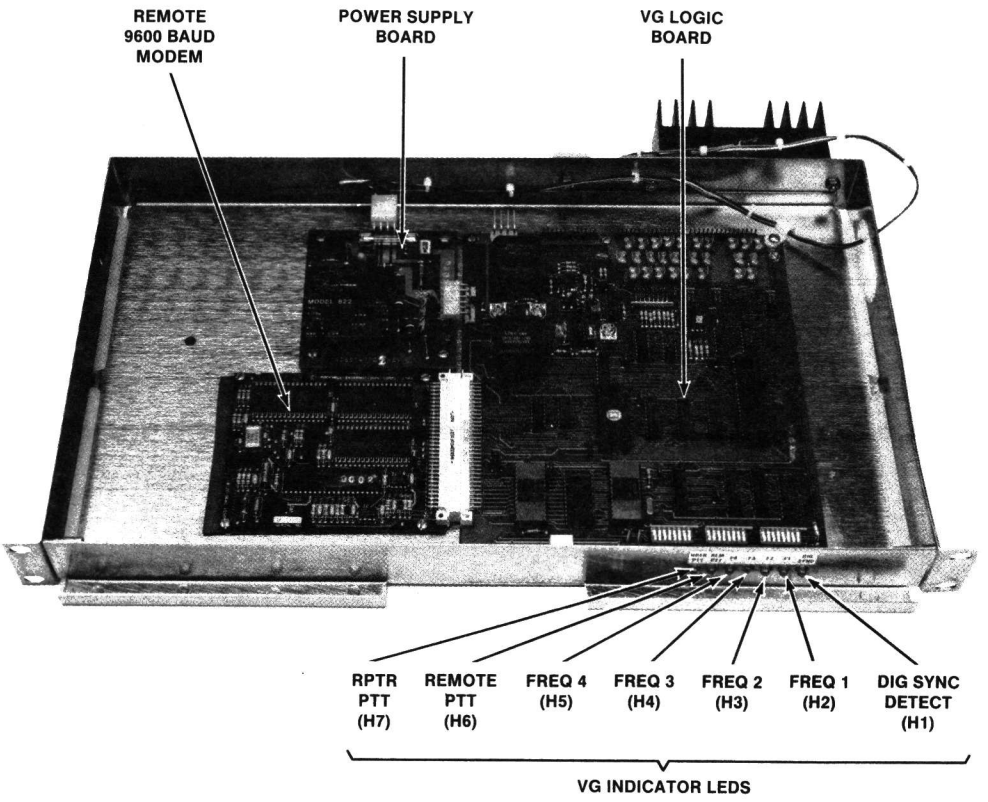


Figure 1 - VG Panel Layout

DESCRIPTION

General Electric Voice Guard Options 9780 and 9781 are used with MASTR II stations to provide remote, remote/repeater or repeater station operation in digital speech encryption-decryption (Voice Guard) systems. Stations equipped with the Voice Guard option will operate in both the clear (not encrypted) or Guarded (encrypted) modes in either the 138-174 MHz or 406-512 MHz range.

When operating in the Guarded mode, the Voice Guard (VG) signal format is recognized and the digital signal is regenerated before being applied to the repeater transmitter and/or the remote controller during remote receive.

In the clear mode, both the remote or repeater VG station operates with the normal 5 kHz deviation FM configuration.

In the Guarded mode, the remote and repeater stations transmit 9600 baud, NRZ data at 3 kHz deviation.

The VG station receiver automatically switches between the clear and Guarded mode. A layout of the VG shelf is shown in Figure 1.

No encryption-decryption equipment containing the cyptographic key is located in the station.

The VG circuitry is contained in a shelf one rack-unit (1.75 inches) high, and is normally mounted above the MASTR II radio assembly. The shelf contains the VG Logic board, a DC-DC converter for 12-Volt DC station operation, and a 9600 baud telephone line modem for remote control stations.

INTERCONNECTIONS

The VG shelf is interconnected to the MASTR II station radio assembly. The three plugs normally connected to station Mother Board 19D417214G1 are unplugged and reconnected to the mating connectors in VG station cable 19C851484G4. The remaining plugs on the VG cable are connected to the mating connectors on station harness assembly 19C320811G1. The other end of the VG cable is connected to the VG shelf by means of three in-line connectors. Refer to the Interconnection Diagram in LBI-31546.

STATION OPTION 9780 & 9781

Station option 9780 is used in remote or remote/repeater stations. Option 9781 is used in repeater only stations. The equipment used in each option is shown in Table I.

STATION EXCITERS

In addition to options 9780 and 9781, the MASTR II VG stations must be equipped with direct FM exciters only. In 138-174 MHz stations, PLL exciter 19D423249 is used. In 406-512 MHz stations, direct FM exciter 19D432679 is used. The exciter boards and associated equipment for each frequency split are shown in LBI-31546.

MODIFICATIONS

In addition to installing the VG shelf, minor modifications are required to the station Mother Board, the repeater control board (if present), and the transmitter exciter and receiver IFAS boards. The receiver IF stages must also be realigned to assure optimum VG operation.

The required Modification Instructions and Adjustment Procedures are contained in LBI-31546.

SYSTEM DESCRIPTION

Each VG station shelf contains the required software for several different modes of operation. The desired mode is selected by DIP switches in the VG shelf. Transmit and receive functions are independent in remote station configurations and may occur simultaneously. Repeat and remote/repeat configurations use variations of the transmit and receive functions.

TABLE I - Option Equipment Breakdown

OPTION 9780 Remote, Remote/Repeater	OPTION 9781 Repeater Only
1. Voice Guard Panel 19D438054G1 Includes: • VG Logic Board 19D901685G1 • Power Supply 19C851477G1 • 9600 Baud Modem	1. Voice Guard Panel 19D438054G2 Includes: • VG Logic Board 19D901685G1 • Power Supply 19C851477G1
2. Station Harness 19C851484G4	2. Station Harness 19C851484G4
3. Tone Voting Board 19C320880G1	

The VG shelf also contains a DC-DC converter power supply which provides the shelf with the required +12, +5 and -12 volts. This allows the VG shelf to be operated from the station 12-to-16-volt DC supply which also supports normal battery backup operation.

REMOTE STATION

The VG-equipped MASTR II station can be operated as a tone remote-controlled base. The control link can either be an unconditioned 4-wire data grade (type 3002) telephone line or an equivalent radio or microwave link. Additional line conditioning such as C1, C2 or C4 is not required. Clear voice audio or Guarded mode data goes over the same control link path.

Remote control in the clear mode is accomplished with the standard AC tone remote control system. When in the Guarded mode, control is accomplished digitally. Channel Guard is used in the clear mode, it will be disabled when operating in the Guarded mode.

A remote base can support up to four remotely selected transmit frequencies. Receive frequencies are slaved to the transmit selection. In the clear mode, frequency control is accomplished in the normal (selected tone-burst) manner. When in the Guarded mode, frequency selection is accomplished over the control up-link with several otherwise unassigned bits in the VG sync word. The tone and digital frequency selector inputs are connected in parallel in the remote controller.

REPEATER STATION

The repeater configuration of a VG equipped MASTR II station employs the same VG hardware as the remote station except that no telephone line data modem is required. The repeater configurations are intended to support only one transmit and one receive frequency.

REMOTE/REPEAT STATION

In this mode, the station operates both as a remote station and as a repeater. Operation is limited to one transmit and one receive frequency. The remote base control path has pre-emptive control over the repeated path. This lets the "dispatcher" retain control over the system operation.

TRANSMIT PRE-EMPTION

Transmitter keying pre-emption in the clear mode remains unchanged. While in the Guarded mode, the VG Shelf software looks at LOCAL PTT and Guarded transmit requests and services them on a first come-first served basis. Once keyed up, the other input is no longer examined.

In a remote/repeater operating in the Guarded mode when the repeater path is keyed ON first, the remote path will continue to be monitored for pre-emptive takeover. Should a remote controller pre-emption occur, the repeater path, with a unit still transmitting, will be permitted to resume at the end of the pre-emption on a late entry basis. This means that 250 milliseconds to 1 second may elapse before the repeater path is again established with a unit still transmitting in the Guarded mode. If the responding unit starts transmitting after the remote initiated transmission has been completed, then the full preamble will be processed and the repeater path will be keyed ON in approximately 60 milliseconds.

CIRCUIT ANALYSIS

All versions of the VG station shelf contain a logic board and a power supply board. In addition, VG station shelves to be used in remote control applications will also have a 9600 baud telephone line modem.

References to symbol numbers mentioned in the following text may be found on the applicable Schematic Diagram, Outline Diagram and Parts List located in the Service Section of this manual (LBI-31546). The Service Section also contains complete Adjustment Procedures and Modification Instructions.

POWER SUPPLY BOARD

The Power Supply Board contains a modular DC-DC converter which accepts the 12 to 16 volts from the station and delivers a regulated +12 volts and -12 volts at up to 140 milliamperes for use by the logic board and telephone line modem. Regulator IC1 provides +5 volts at up to 1.5 amps for operating the VG shelf logic circuitry.

±12-Volt Supply

The station 12-to-16 Volt supply is applied to the Power Supply board thru connector P2-6. The input is protected by 3-amp fuse F1. Diodes D3 and D4 drop the station supply voltage down to 10.4 Volts to 14.4 Volts as required by the modular DC-DC converter.

The modular power supply requires a minimum load at all times, supplied by 270-ohm, 1-watt resistors R5 and R6.

The +12 volt regulated output is applied to P2-1, and the -12 volt regulated output is applied to P2-2.

+5-Volt Supply

The station 12 volt supply is connected through 3-ohm, 7-watt resistor R1 to the input of 5-volt regulator IC1. The resistor and regulator IC are mounted on a heatsink on the rear of the shelf housing to help dissipate up to a maximum of 17 watts.

Capacitors C1, C2 and C4 provide noise bypassing and filtering, while C2 also provides the required stabilization for the regulator. Diode D1 prevents regulator lockup, and diode D2 provides a discharge path for C3 when the input supply voltage is removed. Resistors R2 and R3 and potentiometer R4 form an adjustable feedback path to the control input of regulator IC1. R4 is also used to set the regulator output to +5.0 volts. The regulated +5 volts is applied to P2-4.

LOGIC BOARD

The logic board is a microprocessor-based unit that services the radio receiver and telephone line ports for activity. In response, the unit controls the operation of the transmitter, the steering of audio paths, and clear/Guarded mode switching.

Microprocessor U1, in conjunction with address latch U3, data bus driver U6, RAM U3, address decoder U10 and EPROM U2 form the heart of the microprocessor control circuitry. U1 is a 8031 microprocessor and is clocked at 11.0592 MHz. The resident operating code is located in EPROM U2. Address decoder U10 provides the required chip enable, read, and write control signals to be used by the peripheral devices. U5 serves as the latch for the low order address bits (A0-A7). These bits are normally multiplexed on the data bus by the microprocessor. U6 is a bi-directional data bus driver. U3 is the RAM used for intermediate storage of data and parameters as required by the operating software.

The three sets of DIP switches used to establish the transmitter and receiver outside addresses (TX OA, RX OA) and station operating mode. Each switch is buffered by a separate octal tri-state driver. U8 buffers switch S1, U9 buffers switch S2, and U7 buffers switch S3. Upon receipt of chip enable signals from decoder U10, the bit patterns set into each switch are applied to the data bus. This occurs at power ON, and at each depression of the RESET button.

U4 is a custom modem chip. In the receive mode, U4 recognizes the Barker code sync signal (11100010010) and delivers the resulting VG data in 8-bit parallel form to the data bus. It also provides the necessary interrupt signals to the processor. In the transmit mode, U4 provides a properly formatted serial VG data train that is ready to be delivered to the transmit filter.

Modem chip U4 receives its data input from the radio receiver, and its output provides the digital modulation for the transmitter. U4 also serves as the 11.0592 MHz crystal oscillator for the logic board. Modem chip U4 is used in all configurations of VG station shelves.

The four sections of U16 serve as the transmit data filter and buffer/driver. This is an active GMSK (Gaussian Minimum Shift Keying) filter that serves to filter the data transitions so that the transmitted bandwidth in the Guarded mode is minimized. R31 is the Guarded mode transmit deviation adjustment. One section of CMOS switch U15, under the control of a latched output of U21, steers the transmitter modulator input between the Guarded and clear audio paths as established by the microprocessor.

Op-amp U17a accepts radio receiver data from VOL/SQ HI and serves as the data limiter. The limited output is delivered to Modem chip U4. U17b, in conjunction with Q2, provides the power-on-reset function for the logic board. A RES-IN (reset) signal through connector J7-3 or the depressing of RESET button S4 serves to discharge capacitor C5, causing the collector of Q2 to go high. This high reset signal is delivered to Modem chip U4. Releasing the reset input causes Q2 to go low after capacitor C5 has had sufficient time to charge to a voltage high enough to turn on transistor Q2. The buffered RESET signal from U4 is used by the rest of the logic board.

A second custom Modem chip (U19) is required whenever wire-line remote operation is to be employed. It serves as the interface between the telephone line modem and the microprocessor bus. It also recognizes the Barker code sync word when a Guarded remote transmission is initiated. U14a, c, d and U27a, b provide an RS232 interface port via connector J9 for an external 9600 baud telephone line modem. In this case, jumper P11 connects J11-2 to -3, and jumper P12 connects J12-2 to -3.

Provisions have been made for plugging a 9600-baud modem directly into connector J3. In this case, jumper P11 connects J11-1 to -2 and jumper P12 connects J12-1 to -2.

When using the 9600 baud modem, the telephone line input connection is at J6-7 and J6-6. H9 and H10 provide for the strapping-in of a 600-ohm line termination resistor R36. R1 is used to set the input level to the 9600 baud modem. The telephone line output connection is at J6-9 and J6-8. H11 and H12 allow for the strapping-in of a 600-ohm resistor (R37) across the output line. R2 is used to set the signal level delivered to the telephone line. The microprocessor also provides direct control of the 9600 baud modem through decoder U10, and the address and data bus lines.

Microprocessor output signals controlling the station are latched in octal latches U20 and U21 which are also controlled by decoder U10. U21 latches the RUS and TX audio path control signals. U20, in conjunction with drivers U23, U25 and U26, provide control and frequency select signals. COMBINED PTT, DELAYED PTT and TX CG DIS are produced in conjunction with U22 and U24.

Some of the transmitter control signals also drive LED panel indicators H1 through H7. The function of each indicator LED is shown in Table II.

Input signals from the station including REP PTT, LOC PTT, REM PTT, CAS, RUS and CG MON are all buffered by U11 or U13 and then directly delivered as inputs to the parallel port of the microprocessor.

U14 and U27 provide the RS232 interface between the serial port of microprocessor U1 and connector J8, pins 1, 2 and 3, to be used for connecting a 2400 baud serial computer terminal to the logic board for testing and verification as discussed in section 5. U12 and connector J8, pins 4, 5 and 6, are used in conjunction with voting applications of of the VG station shelf.

9600 BAUD MODEM

The telephone line modem employed in the VG station shelf is a synchronous, serial 9600 baud modem. The I/O connections to the modem are shown in Table III.

TABLE II - VG Panel Indicators

INDICATOR	FUNCTION
H7	RPTR PTT - The station PTT has been activated in the Guarded mode via the repeater receiver over a radio (RF) path.
H6	REMOTE PTT - The station PTT has been activated in the Guarded mode via the remote control (telephone line) path.
H5	FREQUENCY 4 - Frequency 4 has been selected by the remote control path in a remote base-only application.
H4	FREQUENCY 3 - Frequency 3 has been selected by the remote control path in a remote base-only application.
H3	FREQUENCY 2 - Frequency 2 has been selected by the remote control path in a remote base-only application.
H2	FREQUENCY 1 - Frequency 1 has been selected in remote or repeater applications.
H1	DIGITAL SYNC DETECTOR - Indicates whenever the VG sync signal is being successfully decoded by either the radio or line input ports.

9600 Baud Modem Hardware Circuits

Name	Type	Pin No.	Description
A. OVERHEAD:			
Ground (A)	AGND	31C,32C	Analog Ground Return
Ground (D)	DGND	3C,8C,5A,10A	Digital Ground Return
+5 volts	PWR	19C,23C,26C,30C	+5 volt supply
+12 volts	PWR	15A	+12 volt supply
-12 volts	PWR	12A	-12 volt supply
POR	I/OA	13C	Power-on-reset
B. MICROPROCESSOR INTERFACE:			
D7	I/OA	1C	
D6	I/OA	1A	
D5	I/OA	2C	
D4	I/OA	2A	Data Bus (8 Bits)
D3	I/OA	3A	
D2	I/OA	4C	
D1	I/OA	4A	
D0	I/OA	5C	
RS3	1A	6C	
RS2	1A	6A	Register Select (4 Bits)
RS1	1A	7C	
RS0	1A	7A	
CS0	1A	10C	Chip Select Transmitter Device
CS1	1A	9C	Chip Select Receiver Sample Rate Device
CS2	1A	9A	Chip Select Receiver Baud Rate Device
READ	1A	12C	Read Enable
WRITE	1A	11A	Write Enable
IRQ	0B	11C	Interrupt Request
C. V.24 INTERFACE:			
RDCLK	0C	21A	Receive Data Clock
TDCLK	0C	23A	Transmit Data Clock
XTCLK	1B	22A	External Transmit Clock
RTS	1B	25A	Request-to-Send
CTS	0C	25C	Clear-to-Send
TXD	1B	24C	Transmitter Data
RXD	0C	22C	Receiver Data
RLSD	0C	24A	Received Line Signal Detector
D. ANCILLARY CIRCUITS:			
RBCLK	0C	26A	Receiver Baud Clock
TBCLK	0C	27C	Transmitter Baud Clock
		29A	(Future Use)
		18C	(Future Use)
E. ANALOG SIGNALS:			
TXA	AA	31A	Transmitter Analog Output
RXA	AB	32A	Receiver Analog Input
AUXIN	AC	30A	Auxiliary Analog Input
F. DIAGNOSTIC:			
EYEX	0C	15C	Eye Pattern Data--X Axis
EYEY	0C	14A	Eye Pattern Data--Y Axis
EYECLK	0A	14C	Eye Pattern Clock
EYESYNC	0A	13A	Eye Pattern Synchronizing Signal

TABLE III - 9600 bps Fast Train Modem

TERMINOLOGY

TX F1, TX F2, TX F3, TX F4: Are open-collector frequency select outputs from the VG shelf. They will be activated prior to "Remote PTT" from the VG shelf and will remain for the duration of "Remote PTT" during transmissions in the remote mode. TX F1 will be activated with "RPT KEY" during repeater mode of operation.

REMOTE PTT: Is an open-collector remote key output from the VG shelf and input to the VG shelf. It is activated by the shelf logic to key the transmitter for Guarded mode transmissions. It is monitored by the VG shelf logic during a Guarded mode repeat to detect remote pre-emption.

RPT KEY: Is an open-collector repeater key output from the VG shelf logic. It is activated by the shelf logic to key on the transmitter for Guarded repeat transmissions. The station hardware timers will provide repeat limit timing and hang timing.

DET DISABLE: Is an open-collector tone remote control disable. This signal will be activated by the VG shelf logic while receiving VG data from the remote controller. It is used to disable the clear mode tone control circuits in the station, which may be falsed by the VG telephone modem signal.

TX CG DISABLE: Is activated by the VG shelf logic and goes low only during Guarded transmissions.

COMB PTT IN: Combined PTT from the station. This signal will be active when the station transmitter is to be keyed for any reason.

COMB PTT OUT: Combined PTT from the VG shelf logic to the station transmitter control circuitry. This signal will follow the "COMB PTT IN" signal during clear transmissions, and is used to activate Channel Guard encoder.

DELAYED PTT OUT: Delayed PTT Out from the VG shelf is wire-"OR"ed with the Channel Guard encoder DPTT output. During clear transmission, the Channel Guard DPTT keys the transmitter. During Guarded transmissions, the VG shelf Delayed PTT OUT keys the transmitter.

LOCAL PTT IN: This is the locally generated PTT input to the VG shelf. This is used to sense local PTT for pre-emption.

RUS (RADIO): This signal is an active high input and output to the VG shelf logic. Input is normally echoed to RUS (SHELF) and can be monitored by the VG logic. The signal is forced high by the VG shelf logic to disable the voter tone (1950 Hz) while VG data is being sent to the remote controller.

RUS (SHELF): This signal is an active high output to the station. It normally follows the RUS (RADIO) input but can be forced low by the VG logic to inhibit clear mode received audio.

CG MON: This signal is an active low input to the VG logic. It indicates that the VG logic should pass all received VG data on to the remote controller. This signal comes from the station control logic in response to a command from the remote controller.

CAS: This is the RF carrier detect input to the VG logic. It must be active for the VG logic to decode a received RF VG signal.

VOL/SQ HI: This is the radio FM detector output. It is an input to the VG shelf.

TX MOD IN: This is the transmitter clear audio output from the TX audio processor. It is connected to 'TX AUDIO OUT" by a CMOS switch except during Guarded mode transmissions.

TX AUDIO OUT: This is the transmitter modulator input and comes from the VG shelf. It is connected to "TX MOD IN" during clear mode transmissions and to the VG data filter output during Guarded mode transmissions.

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