FUNCTIONAL DESCRIPTION

APPLICATIONS .......................................................... 68P81062E59
REMOTE CONTROL ...................................................... 68P81062E61

RF-CONTROL CHASSIS

RF-CONTROL CHASSIS (TLN2472B, 74B, 75B) (B VERSION) .......... 68P81070E88

REMOTE CONTROL

REMOTE CONTROL MODULES ............................................ 68P81062E63
  STATION CONTROL (TRN5321A) ................................ 68P81062E14
  LINE DRIVER (TRN5235A, 36A, 37A) ......................... 68P81062E13
  LINE DRIVER (TRN5240A, 54A, 55A, 56A) .................. 68P81062E16
  DC TRANSFER (TRN5239A, 57A) ................................ 68P81062E17
  GUARD TONE DECODER (TLN2443A, 50A) ..................... 68P81062E18
  F1 TONE CONTROL (TRN5320A, 22A, 27A, 28A) ............. 68P81062E19
  F2 TONE CONTROL (TLN2444A, 49A, TRN5256A, 5325A) ...... 68P81062E21
  SQUELCH GATE (TRN5324A) ..................................... 68P81062E23
  TIME-OUT TIMER (TRN2442A) .................................. 68P81062E24
  SINGLE-TONE DECODER (TLN2442A) ......................... 68P81062E26
  4-FREQUENCY CONTROL OPTION DECODER (TRN5296A) ...... 68P81062E22
  SQUELCH, REPEATER, AND PRIVATE-LINE CONTROL
    OPTION DECODER (TRN1249A, 50A, 51A) ................. 68P81062E28
    “WILD CARD” CONTROL (TLN2448A) ..................... 68P81062E27

AUDIO & SQUELCH

R1 AUDIO & SQUELCH MODULE (TRN9688A, 89) ...................... 68P81070E57
R1 AUDIO & SQUELCH MODULE (TRN5068A, 69A) .................... 68P81062E57
R2 AUDIO & SQUELCH MODULE (TRN9690A, 91A, 92A) .............. 68P81070E58
R2 AUDIO & SQUELCH MODULE (TRN5070A, 71A, 72A) .............. 68P81062E64
TONE PRIVATE-LINE ENCODER-DECODER MODULE TRN5073A, 74A, 75A) .................. 68P81062E51
DIGITAL PRIVATE-LINE ENCODER-DECODER MODULE (TRN5076A, 77A, 78A) ............... 68P81062E52

OPTIONAL EQUIPMENT

Spectra-TAC ENCODER OPTION (C269) ............................. 68P81112E78
  Spectra-TAC 4-WIRE LINE DRIVER MODULE (TRN5294A) .......... 68P81062E41
  Spectra-TAC ENCODER MODULE (TRN5293A) .................... 68P81062E42
  Spectra-TAC SQUELCH GATE MODULE (TRN5331A) ................ 68P81062E43
  MSR 2000 BASE AND REPEATER STATION MULTIPLE TONE
    PL OPTIONS (C158, C261, C262, C263) ................... 68P81112E80
  MULTIPLE PL MATRIX CONTROL MODULE (TRN5330A) .......... 68P81062E67
  MULTIPLE PL ENCODER MODULE (TRN5292A) ............. 68P81062E68
  MULTIPLE PL ENCODER MODULE (TRN5329A) ............ 68P81062E69
1. APPLICATION

The Spectra-TAC Encoder option is available for Motorola remotely controlled MSR 2000 base and repeater radios. The addition of this option permits the station receiver to operate as a receiver-encoder in a Spectra-TAC total area coverage system.

The Motorola Spectra-TAC Total Area Coverage System electronically compares and selects the receiver with the best signal of multiple receivers operating on the same rf frequency over a wide coverage area. The Spectra-TAC system consists of multiple receiver-encoder units distributed throughout a coverage area and a comparator which determines which receiver has the best signal on the same rf frequency. With the use of multiple receiver-encoders, the Spectra-TAC system can extend the talk-back range of personal portable and mobile radio units.

By selecting only one receiver-encoder unit, the high noise and phase distortion, which would result if several receiver audio lines were connected in parallel at the monitoring point, are eliminated.

One receiver-encoder unit is required at each given satellite site. The receiver monitors one rf frequency and amplifies the received audio for transmission to the comparator. An encoder generates a status tone for transmission to the comparator when there is no received signal.

The comparator receives the audio and tone signals from multiple receiver-encoder units, which are operating on the same rf frequency. It compares the signals and selects the receiver-encoder unit with the best audio signal (the generated tone is not used for voting). The audio of the receiver-encoder unit with the best signal is then sent to the dispatcher.

2. DESCRIPTION

The Spectra-TAC encoder option includes a TRN5293A Spectra-TAC Encoder Module, which is added in position 11; a TRN5294A 4-Wire Line Driver Module, which replaces the standard TRN5236A 4-Wire Line Driver Module; a TRN5331A Squelch Gate Module, which replaces the standard TRN5324A Squelch Gate Module in repeater systems; and a TKN8287A 4-Wire Cable Kit that replaces the standard 2-wire cable kit.

3. FUNCTION

3.1 GENERAL

3.1.1 When this option is added to a base station, the receiver becomes a voting receiver in the Spectra-TAC system. In this application, the receiver audio is routed to the comparator. The comparator selects (votes) the receiver with the best quality signal and routes its audio to the dispatcher console.

3.1.2 When this option is added to a repeater station, the voted audio from the comparator is applied to the station transmitter where it is retransmitted. The station automatically reverts to in-cabinet repeat (RT) operation when the comparator or the comparator wire line fails. The transmitter is normally keyed by a line PTT from the comparator. When a line PTT is not received from the comparator within approximately 200 msec after the receiver is unsquelched, the squelch gate module automatically keys the transmitter and the receiver audio is applied to the transmitter for retransmission.

3.2 TRN5293A Spectra-TAC ENCODER MODULE

The Spectra-TAC encoder module provides a status tone when the receiver is squelched. This tone is used at the comparator location to disable voting, for line checking, and for in-path loss factoring. Status tone is turned off when the receiver is unsquelched. The
module also provides 400 Hz and 2500 Hz test tones for use in equalizing audio response over the telephone line (or other path). An equalizer circuit in the 4-wire line driver module can be set (via jumpers) to add gain at either or both of the test frequencies.

3.3 TRN5294A 4-WIRE LINE DRIVER MODULE

The 4-wire line driver module accepts audio from the receiver, amplifies it, and routes it via the LINE 2 terminals to the Spectra-TAC comparator and to the local speaker. Two transformers are used; one is used for accepting the transmit audio and control signals, and the other is used to provide audio to the comparator. The module also contains a line equalization circuit to compensate for rolloff in the frequency response of the output line.

For further details on the Spectra-TAC encoder and 4-wire line driver, refer to sections 68P81026E28 and 68P810296E04 attached to this section.

3.4 TRN5331A SQUELCH GATE MODULE

Keying of the transmitter by the squelch gate on Spectra-TAC repeaters is only desired if a wire line failure occurs. A 200 msec delay in the squelch gate allows time for the normal line transmit command before the repeater will initiate in-cabinet repeat operation.

4. INSTALLATION

The Spectra-TAC option is factory installed. The encoder module plugs into the remote control chassis in the single tone decoder slot. The 4-wire line driver module provides for "4-wire; 1 receiver; receiver audio on line 2" operation.

Install the station in the same manner as described for stations without this option, with the following exceptions:

• Connect the transmitter audio lines from the Spectra-TAC comparator output to the station's LINE 1 terminals.

• Connect the receiver audio lines from the station's LINE 2 terminals to one of the inputs of the comparator.

• After all other station levels are adjusted, as described in the station instruction manual, perform the line level, status tone level, and line equalization adjustments as described in paragraph 5.

5. ADJUSTMENTS

Three adjustments, in addition to the standard station adjustments, are required for Spectra-TAC operation: line level adjustment, status tone level adjustment, and line equalization adjustment. These adjustments are to be made after the standard station adjustments and must be made in the sequence given below.

5.1 LINE LEVEL ADJUSTMENT

There are two basic reasons for observing correct line level settings; (1) to avoid exceeding maximum levels allowed by the phone company, and (2) to assure correct operation of the Spectra-TAC equipment. The phone company will specify a maximum audio level on the phone line and the customer must specify the signal level required at the opposite end which determines the maximum line loss. In addition, for voice quality lines, the phone company may specify the maximum allowable power level. This is done to minimize crosstalk and equipment overloading. The maximum power level is determined by averaging the audio signal level over a 3-second period. Due to the pauses between speech syllables and words, the 3-second average will be in most cases, a power level 13 dB below the peak level of voice. The allowable peak level of voice is specified by the phone company as the Transmission Level Point (TLP). A 1000 Hz tone at full system deviation (±5 kHz) is recommended for setting the line level.

Step 1. Connect an ac voltmeter to the LINE 2 (+) and (-) screw terminals on the junction box. If LINE 2 terminals are not connected to the comparator, the meter must be bridged by a 600-ohm load.

Step 2. Turn the SQUELCH control fully counterclockwise and disable the PL module (if used).

Step 3. Inject an on-frequency carrier signal into the receiver antenna input.

Step 4. Modulate the receiver input with a 1000 Hz tone at ±5 kHz deviation. Determine the maximum allowable level permitted on the line and set the LINE LEVEL control on the audio control module for this level. If the specified maximum is the maximum allowable power (3 second average), then set the LINE LEVEL control for 13 dB above this level. Do not exceed +11 dBm.

5.2 STATUS TONE LEVEL ADJUSTMENT

5.2.1 General

5.2.1.1 Status tone level settings must be done correctly to assure correct receiver voting at the comparator. The AGC circuitry on the signal quality module provides compensation for phone line losses and permits correct receiver voting. The AGC circuitry is "set" relative to the status tone generated by the receiver encoder module. The encoder module must be installed in a TLN5935A Extender Card for TONE LEVEL adjustment access.

5.2.1.2 Two methods of status tone level adjustment are employed in the Spectra-TAC receivers depending upon the type of signal quality modules
utilized in the Spectra-TAC comparator. It is recommended that the status tone level be adjusted only after the line level has been adjusted, because both the LINE LEVEL and TONE LEVEL controls affect the level of the status tone on the line.

5.2.2 0 dB System

In a 0 dB system, the TRN6091A Signal Quality Module is required, or a TRN6091B Signal Quality Module may be jumpered to operate as a TRN6091A by installing JU4. These signal quality modules are located in the comparator chassis. The status tone level must be adjusted equal to receiver peak audio at full system deviation (±5 kHz). The status tone must not exceed maximum power and peak audio levels specified by the phone company. The following conditions must be met for proper operation of a 0 dB system:

<table>
<thead>
<tr>
<th>Module</th>
<th>Jumper</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>TRN6091A</td>
<td>JU3, JU5</td>
<td>IN</td>
</tr>
<tr>
<td>TRN294A</td>
<td>JU1</td>
<td>OUT</td>
</tr>
</tbody>
</table>

Step 1. Connect an ac voltmeter across the LINE 2 (+) and (−) terminals which must be terminated by a 600-ohm load. Disconnect any rf input to the receiver. Turn the SQUELCH control fully clockwise until the receiver is fully squelched.

Step 2. Adjust the TONE LEVEL control on the encoder module until the line level, as measured by the ac voltmeter, is the same as the 1000 Hz test tone level set in Step 4 of paragraph 5.1.

Step 3. Remove the extender card and re-install the encoder module in the card cage.

5.2.3 -13 dB System

In a -13 dB system, the TRN6091B Signal Quality Module is utilized; JU4 is removed. The status tone level must be adjusted 13 dB below receiver peak audio at full system deviation (±5 kHz). The following conditions must be met for proper operation of a -13 dB system:

<table>
<thead>
<tr>
<th>Module</th>
<th>Jumper</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>TRN629A</td>
<td>JU3, JU5</td>
<td>OUT</td>
</tr>
<tr>
<td>TRN294A</td>
<td>JU1</td>
<td>IN</td>
</tr>
</tbody>
</table>

Step 1. Connect an ac voltmeter across the LINE 2 (+) and (−) terminals which must be terminated by a 600-ohm load. Disconnect any rf input to the receiver so that the receiver is squelched.

Step 2. Adjust the TONE LEVEL control on the TRN5293A Encoder Module until the line level, as measured by the ac voltmeter, is 13 dB below the 1000 Hz test tone level set by the LINE LEVEL control.

Step 3. Remove the extender card and re-install the encoder module in the card cage.

5.3 LINE EQUALIZATION ADJUSTMENT

5.3.1 General

The purpose of the line equalization procedure is to ensure sufficient audio gain to the comparator site to compensate for line losses. Two men are required to perform the line equalization procedure; one man at the receiver site and one man at the comparator site. The man at the receiver site measures the line level at the output of the receiver while the man at the comparator site measures the line level at the input to the comparator. Line equalization is performed by setting the 1 kHz test tone (used in the line level adjustment procedure) level equal to the LOW and HIGH test tone levels generated by the encoder module. The line driver must be installed in an extender card for equalization adjustment access.

5.3.2 Procedure

Step 1. Establish communications between both sites. The TMN6067A Handset may be used for transmission and monitoring purposes at the station and comparator sites. Plug the handset into J1 on the line driver module. Refer to the Maintenance section of the comparator manual (68P81026E40) for further instructions regarding operation of the handset at the comparator site.

Step 2. At the receiver site, be sure the 400 Hz, 2500 Hz, and 1 kHz test tones are at equal levels.

Step 3. Send the 1 kHz test tone, making sure the man at the comparator site measures and records the received level.

**NOTE**

Maximum equipment output level is +11 dBm. Be sure not to exceed this limit at any time.

Step 4. At the receiver site, send the 2500 Hz high tone by setting and holding the momentary HIGH TONE switch on the encoder module. At the comparator site, measure and compare this level with the 1 kHz level previously recorded. Inform the man at the receiver site of the difference.

Step 5. At the receiver site, install the 2500 Hz equalization jumper (on the line driver) in the position necessary to obtain the level equivalent to the 1 kHz level.

Step 6. Repeat Steps 4 and 5 using the 400 Hz low tone switch and equalization jumper.

Step 7. Repeat the entire procedure to ensure correct equalization adjustment.

Step 8. Remove the extender card and re-install the line driver in the card cage.
## 1. MULTIPLE TONE PL OPTION COMPLEMENT CHART

<table>
<thead>
<tr>
<th>Factory Option No.</th>
<th>Module Used</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>C158AB/AE</td>
<td>4-PL Transmit X</td>
<td>TRN5330A Matrix Control Module</td>
</tr>
<tr>
<td></td>
<td>4-PL Receive X</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4-PL Repeat X</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4-PL Transmit &amp; Receive X</td>
<td></td>
</tr>
<tr>
<td>C261AC/AH</td>
<td>X</td>
<td>TRN55292A Encoder Module</td>
</tr>
<tr>
<td>C262AE</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>C263AB</td>
<td>X</td>
<td>TRN5329A Decoder Module</td>
</tr>
</tbody>
</table>

## 2. TECHNICAL CHARACTERISTICS

### Matrix Control Module

<table>
<thead>
<tr>
<th>Max. No. of Frequencies</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control Tone Frequencies</td>
<td>Std: (Hz) 1050, 1150, 1250, 1350</td>
</tr>
<tr>
<td></td>
<td>Can Be Modified To: (Hz) 1450, 1550, 1650, 1750, 1850, 1950, 2050</td>
</tr>
<tr>
<td>Frequency Determining Device</td>
<td>LC Circuits</td>
</tr>
<tr>
<td>Output</td>
<td>4 switched ground outputs</td>
</tr>
</tbody>
</table>

### PL Encoder Module

<table>
<thead>
<tr>
<th>Max. No. of Frequencies</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>PL Tone Frequency Range</td>
<td>67-210 Hz</td>
</tr>
<tr>
<td>Frequency Determining Device</td>
<td>Vibrasender Resonant Reed</td>
</tr>
<tr>
<td>Stability</td>
<td>±0.15%</td>
</tr>
<tr>
<td>Level (Nominal)</td>
<td>1 V rms @ 67-210 Hz</td>
</tr>
<tr>
<td>Output Impedance</td>
<td>1k ohm</td>
</tr>
<tr>
<td>Power Requirements</td>
<td>13.8 volts dc @ 20 mA</td>
</tr>
</tbody>
</table>

### PL Decoder Module

<table>
<thead>
<tr>
<th>Max. No. of Frequencies</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>PL Tone Frequency Range</td>
<td>67-210 Hz</td>
</tr>
<tr>
<td>Frequency Determining Device</td>
<td>Vibrasponder Resonant Reed</td>
</tr>
<tr>
<td>Stability</td>
<td>±0.15%</td>
</tr>
<tr>
<td>Tone Bandwidth</td>
<td>Approx. 1 Hz</td>
</tr>
<tr>
<td>Tone Sensitivity</td>
<td>0.25 volts rms reed drive</td>
</tr>
<tr>
<td>Output</td>
<td>13.0 volts dc switched</td>
</tr>
<tr>
<td>Power Requirements</td>
<td>13.8 volts dc @ 20 mA</td>
</tr>
</tbody>
</table>
3. DESCRIPTION

3.1 PURPOSE AND APPLICATION

These factory installed multiple PL options are available for one- or two-frequency remotely controlled fully optionable MSR 2000 base and repeater stations. One of the options is required whenever it is desired to transmit, receive or repeat more than one PL tone, with the capability of handling up to four PL tones. An application table at the end of this section simplifies the selection of the appropriate option for each specific type of station.

The multiple PL transmit options require that the station be equipped with tone remote control facilities; for dc remote control stations, tone remote control capability must also be added. Since the multiple PL options include modules which are inserted into the RF-Control Chassis, use of these options may exclude the use of other modules. The multiple PL transmit options prohibit the use of the “Wild Card” module or the 4-frequency control module and the multiple PL receive and repeat options prohibit the use of the Single-Tone Decoder module.

Each multiple PL option consists of one or more of the following modules (refer to paragraph 1): multi-PL decoder module, multi-PL matrix control module, and multi-PL encoder module. Each of these items is further described in the following paragraphs.

3.2 MULTI-PL DECODER

The multi-PL decoder module contains four parallel decoder circuits, each of which detects a different PL tone and provides switched ground outputs when the proper PL tone is detected. The switched ground output un-squelches the receiver's audio. In repeater stations, the switched ground output also keys the transmitter. In repeater stations, an independent switched ground output from each decoder circuit selects the desired PL tone to be transmitted. This module occupies the Single-Tone Decoder position in the RF-Control Chassis. One Vibrashover resonant reed is required for each PL tone to be decoded; for less than four PL tones, reeds are omitted.

3.3 MULTI-PL MATRIX CONTROL MODULE

The multi-PL matrix control module permits remote control selection of the PL tone to be transmitted. The module detects four function tones (refer to Table 1) from a remote control console and provides switched ground outputs that are applied to the multi-PL encoder module, thereby selecting one of four PL tones. The matrix control module occupies the “Wild Card” module position in the RF-Control Chassis. Although the function tones used in this module are identical to the standard function tones used in the 4-frequency control module and “Wild Card” module, there is no conflict because both modules cannot be used in the same station.

<table>
<thead>
<tr>
<th>Function Tone</th>
<th>PL Tone Selected</th>
</tr>
</thead>
<tbody>
<tr>
<td>1350 Hz</td>
<td>#1</td>
</tr>
<tr>
<td>1250 Hz</td>
<td>#2</td>
</tr>
<tr>
<td>1150 Hz</td>
<td>#3</td>
</tr>
<tr>
<td>1050 Hz</td>
<td>#4</td>
</tr>
</tbody>
</table>

3.4 MULTI-PL ENCODER MODULE

The multi-PL encoder module generates the PL tones which are to be transmitted. The module contains four identical oscillator circuits and is thus capable of generating up to four PL tones. Each oscillator requires a switched ground input to become activated. The multi-PL encoder module occupies the “spare” position in the RF-Control Chassis.

3.5 C158AB OPTION (4-PL TRANSMIT)

This option adapts the station for up to four PL transmit capability with remote control selection of the desired PL tones. Function tones generated at a remote control console are detected by the multi-PL matrix control module which, in turn, selects the PL tone generated by the multi-PL encoder module.

3.6 C261AC OPTION (4-PL RECEIVE)

This option adapts the station to receive up to four different PL tones. Reception of any of the correct PL tones will unsquelch the receiver.

3.7 C262AE OPTION (4-PL REPEAT)

This option gives multiple PL capability to a non wiring repeater station. Up to four different received PL signals will key the transmitter and automatically select up to four different PL tones to be transmitted. If cross coding is desired, the received PL tones need not match the transmitted PL tone.

3.8 C263AB OPTION (4-PL TRANSMIT & RECEIVE)

This option incorporates all of the factory installed multiple PL option modules. It adapts the transmitter for up to four PL tone transmit capability with remote control selection of the desired PL tones. In addition, this option allows the receiver to respond to up to four different received PL tones.
4. INDEPENDENT COMMAND — STATION CONTROL

Independent command signifies that PL tone selection is completely independent of transmitter keying and all other control functions applied to the station. Refer to Figure 1.

When one of the four PL select switches on the remote console is activated, a momentary 2175 Hz high level guard tone signal is generated, which allows the station to accept a forthcoming PL select function tone. The PL select function tone then sets a corresponding bistable and resets three others in the multi-PL matrix control module. At this time, a PL encoder is selected and will remain selected until a new PL encoder is selected. Notice that selection of a PL tone does not, in itself, key the transmitter and that no additional function tones follow the PL select function tone.

When the transmitter is subsequently keyed by activating the remote console's transmit switch, a momentary 2175 Hz high level guard tone signal is again applied to the base station. Next, the transmitter key function tone is applied to the station (1950 Hz for F1; 1850 Hz for F2), which keys the transmitter and the previously selected PL tone is transmitted. Low level guard tone keeps the transmitter keyed for the duration of the message. With loss of low level guard tone, the transmitter unkeys, but the previously selected PL tone remains selected.

5. TRANSMIT COMMAND — STATION CONTROL

Transmit command signifies that the function tone applied to the station to select a PL tone also, simultaneously, keys the transmitter. Refer to Figure 1.

When one of the four PL select switches on the remote console is activated, the frequency of the PL select function tone is determined, but not generated, as with independent command selection. The difference is, however, that when one of the PL select switches is activated in the transmit command mode, the PL select function tone is not immediately applied to the station. When the transmit switch is activated, a momentary 2175 Hz high level guard tone signal is applied to the station. Next, the PL select/transmitter key function tone is applied to the station which causes the station to transmit with the chosen PL tone. As with independent command selection, the function tone is followed by low level guard tone for the duration of the message. But, unlike independent command selection, loss of low level guard tone resets the previously selected PL tone as well as unkeys the transmitter. The transmit command mode of operation is necessary when multiple consoles are used with a station, to give the correct PL selection status indication to all consoles. Stations are shipped from the factory jumpered for independent command — station control. The multi-PL matrix control module jumpers must be changed to convert to transmit command — station control.

Figure 1. Independent vs. Transmit Command Timing Diagram
1. FUNCTIONS

The multi-PL matrix control module is primarily used to control the multiple PL encoder module and provides the following functions — not all simultaneously:

- Four switched ground outputs in response to received function tones.
- Four AND function switched ground outputs in response to receive function tones when guard tone is received simultaneously.
- Five OR function outputs in response to any switched ground output generated by the module.

The matrix control module can be used in other applications also, which can be compared to the "Wild Card" module — the difference being that the matrix control module has diode matrix outputs rather than relay outputs as possible in the "Wild Card" module.

2. DESCRIPTION

The multi-PL matrix control module is fully transistorized and occupies the "Wild Card" position in the RF-Control Chassis. All components and circuitry are mounted on a sturdy card with connecting pins to mate with the backplane interconnect board of the RF-Control Chassis.

Figure 1. Functional Diagram
3. CIRCUIT DESCRIPTION

The matrix control module responds to specific momentary function tones as illustrated in Table 1.

<table>
<thead>
<tr>
<th>Function Tone (Hz)</th>
<th>Bistable Operated (No.)</th>
<th>Ground Appears at Module Pin (No.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1350</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>1250</td>
<td>2</td>
<td>8</td>
</tr>
<tr>
<td>1150</td>
<td>3</td>
<td>16</td>
</tr>
<tr>
<td>1050</td>
<td>4</td>
<td>23</td>
</tr>
</tbody>
</table>

NOTE: These frequencies can be changed for special applications as detailed in paragraph 9 of this section.

Each bistable, when operated, provides a switched ground output capable of handling up to 100 mA dc.

All function tones are applied to the matrix module at pin 11. They are amplified and clipped to a 16 dBm level by function tone amplifier Q1, then simultaneously routed to all four bistable multivibrators. All four detector circuits are functionally identical, except for the actual acceptance frequency.

For example, a 1350 Hz function tone passes through tuned circuit L1-C4 into tone detector stage Q2. When a 1350 Hz function tone is detected, Q2 causes the function #1 bistable multivibrator (Q3-Q4) to change state, causing the collector of Q4 to go to ground. This ground is applied to output pin 3 and the #1 bistable remains in the active state until reset. How each bistable is reset is determined by a diode matrix and jumper configuration in the module. As shipped from the factory, all diodes and jumpers are installed (except jumpers JU1, JU2 and JU3 which are removed). These diodes and jumpers can be rearranged to fit various applications.

Diodes involved with OR operation are CR13 through CR20 through CR24, CR27 through CR31, and CR34 through CR38. When any of the four bistable multivibrators is actuated, its switched ground output is simultaneously applied to output pins 4, 7, 9, 10 and 17. These OR output pins are useful when using two multiple PL matrix control modules. Each set of outputs is routed to the other module's local reset inputs for cross resetting all bistables. When using a second matrix control module, the option's position in the RF-Control Chassis should be modified with jumpers and plating cuts as required.

Components involved with reset operation are indicated in Table 2. The use of these diodes and jumpers, with regard to reset operation, is described in the following paragraphs.

Table 2. Reset Components Identification

<table>
<thead>
<tr>
<th>Diode (CR)</th>
<th>Jumper (JU)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3, 5, 7, 9, 11, 12, 18, 19, 25, 26, 32, 33</td>
<td>1, 2, 5 thru 11</td>
</tr>
</tbody>
</table>

4. STANDARD RESET OPERATION

As shipped, any one bistable that is set, in turn, resets all others. The factors involved are shown in Table 3.

<table>
<thead>
<tr>
<th>Bistable Multivibrator Set</th>
<th>Diode Used (CR)</th>
<th>Jumper Used (JU)</th>
<th>Bistable Multivibrator Reset</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>5</td>
<td>6</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>11</td>
<td></td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>12</td>
<td></td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>19</td>
<td></td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>18</td>
<td></td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>26</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>25</td>
<td></td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>9</td>
<td>8</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>32</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>33</td>
<td></td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>7</td>
<td>3</td>
</tr>
</tbody>
</table>

5. "AND" RESET OPERATION (TRANSMIT COMMAND)

The matrix control module can be strapped to provide a switched ground output on receipt of a proper function tone and low level guard tone. Whichever bistable multivibrator is actuated will automatically be reset when the guard tone signal is removed. The receipt of guard tone is indicated at this module by the presence of switched A+ at pin 22. When switched A+ is removed, the bistables operating with the voltage (depending on jumper configuration) are reset.

AND reset operation specifically requires jumper and diode changes as indicated in Table 4 (these are changes required to a previously unmodified standard module). Notice that the AND function is used with either two bistables at a time or all four at a time. This is due to switched A+ distribution allowed by jumper availability.

Components involved with reset operation are indicated in Table 2. The use of these diodes and jumpers, with regard to reset operation, is described in the following paragraphs.

Jumpers JU1 and JU2 are not factory installed and must remain out for this application. They are described in a following paragraph.
Table 4. AND Reset Component Configuration

<table>
<thead>
<tr>
<th>Function Involved (Hz)</th>
<th>Module Pins Involved</th>
<th>Jumpers to be Cut (JU)</th>
<th>Bistable - Multivibrator Involved</th>
<th>Diode to be Cut (CR)</th>
<th>Wire To Be Added</th>
</tr>
</thead>
<tbody>
<tr>
<td>1150</td>
<td>16</td>
<td>7, 8, 10</td>
<td>3 &amp; 4 only</td>
<td>11, 12, 18, 19, 25, 26, 32, 33</td>
<td>From pin 22 of this module to pin 24 of the backplane interconnect board at the option decoder position (provides sw A+).</td>
</tr>
<tr>
<td>1050</td>
<td>23</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1350</td>
<td>3</td>
<td></td>
<td>All 4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1250</td>
<td>8</td>
<td>5 thru 9</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

6. MATRIX MODULE RESET OPERATION

This module can be set up such that the loss of an externally applied voltage causes all bistables to automatically reset simultaneously. In this mode of operation, each bistable is set by the applicable function tone and stays set until the loss of switched A+. The function tone amplifier Q1 is unaffected by the reset function because it operates from steady A+.

Matrix module reset operation specifically requires jumper and diode changes as indicated in Table 5 (these are changes that are required to a previously unmodified standard module).

Table 5. Matrix Module Reset Component Configuration

<table>
<thead>
<tr>
<th>Remove Diode (CR)</th>
<th>Remove Jumper (JU)</th>
<th>Add Jumper (JU)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3, 5, 7, 9, 11, 12, 18, 25, 26, 32</td>
<td>5 thru 9</td>
<td>11</td>
</tr>
</tbody>
</table>

NOTE: Delayed switched A+ or switched A+ must be applied to pin 22 of this module.

7. UNIQUE JUMPER APPLICATIONS

Table 6 identifies jumpers that are used in special applications not described previously.

Table 6. Unique Jumper Applications

<table>
<thead>
<tr>
<th>Jumper (JU)</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Pull up jumper — causes bistable #1 to actuate when A+ is applied while no reset function is applied.</td>
</tr>
<tr>
<td>2</td>
<td>Same as JU1 except functional with #3 bistable.</td>
</tr>
<tr>
<td>3</td>
<td>AND function jumper — causes all bistables, in order to be actuated, to require applicable function tone and external (switched) ground. Jumper JU4 must be removed.</td>
</tr>
</tbody>
</table>

8. MAINTENANCE AND TROUBLESHOOTING

8.1 TECHNIQUES OF ISOLATION

Four local test switches (S1-S4) are located on this module to facilitate identification of a malfunction. If a tone function cannot be performed from the remote control point, the malfunction can be isolated to circuitry either before or after a bistable multivibrator using an applicable test switch.

When a test switch is activated, a switched ground output should appear at the output of the associated bistable multivibrator. If a switched ground output is produced, the malfunction is before the bistable multivibrator: (1) in this module itself (possibly a malfunctioning tone amplifier), (2) somewhere else in the station (RF-Control Chassis/intercabling), or (3) in the remote control sending unit (generator/associated circuitry/intercabling). If a switched ground output is not produced when a local test switch is actuated, the malfunction is in the bistable multivibrator itself or following circuitry.

8.2 MODULE SERVICING

8.2.1 In-Circuit Module Servicing

The Model TLN5935A Service Board Kit can be used to extend a control or audio module out of the front of the RF-Control Chassis. This provides access for service and maintenance without interrupting the power and signal connections.

If the service board kit is not available, the module can be plugged on to the back of the backplane interconnect board. (Tilt the RF-Control Chassis forward to obtain access to the rear of the backplane interconnect board.)

CAUTION

Care must be taken to insert the module onto the correct connector by using the legend on the backplane. Match pin 1 of the module connector with pin 1 of the proper backplane connector. An outline of the front panel's position, with respect to the backplane connector is given as part of the backplane legend to assist proper insertion.

8.2.2 Out-Of-Circuit Servicing

The matrix control module may be serviced out of the RF-Control Chassis by connecting it to a signal genera-
8.3 TROUBLESHOOTING

8.3.1 Bistable Multivibrator

Step 1. Connect a dc voltmeter between pin 1 and the collector of Q4 (Q7, Q10, Q13).

Step 2. Connect an audio oscillator (high side) through a coupling capacitor to the base of Q1. The output level must not exceed 1 volt.

Step 3. Adjust the audio oscillator frequency to 1350 (1250, 1150, 1050) Hz. The voltmeter reading should fall to zero volts, indicating that the bistable multivibrator has changed state. If the change of state does not occur, check detector stage Q2 (Q5, Q8, Q11) then bistable multivibrator Q3-Q4 (Q6-Q7, Q9-Q10, Q12-Q13). If the change of state occurs, look to the function tone amplifier for a malfunction.

8.3.2 Function Tone Amplifier

Step 1. Connect an ac voltmeter from the capacitor connected to the collector of Q1 (C3) to ground.

9. SPECIAL MODIFICATIONS

To change the function tone decoder frequencies from the standard value, change those parts indicated in Figure 2, per Table 8.

Example:
Changing function decoder frequency to 1850 Hz:

<table>
<thead>
<tr>
<th>Freq.</th>
<th>R1</th>
<th>R2</th>
<th>R3</th>
<th>R4</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>1850 Hz</td>
<td>22k</td>
<td>1.5k</td>
<td>2.7k</td>
<td>221</td>
<td>.0069 uF</td>
</tr>
<tr>
<td>±5%</td>
<td>±5%</td>
<td>±5%</td>
<td>±1%</td>
<td>±2%</td>
<td></td>
</tr>
</tbody>
</table>

Table 7. Out-Of-Circuit Connections

<table>
<thead>
<tr>
<th>Module Pin Number</th>
<th>Connection</th>
</tr>
</thead>
<tbody>
<tr>
<td>1, 13</td>
<td>Ground</td>
</tr>
<tr>
<td>11</td>
<td>Audio Oscillator</td>
</tr>
<tr>
<td>12</td>
<td>A+ (13.6 V dc)</td>
</tr>
</tbody>
</table>

Table 8. Special Modifications

<table>
<thead>
<tr>
<th>To Change Function Tone Tank Freq. To</th>
<th>R1 ±5% (In Ohms)</th>
<th>R2 ±5% (In Ohms)</th>
<th>R3 ±1% (In Ohms)</th>
<th>R4 ±1% (In Ohms)</th>
<th>C ±2% (In uF)</th>
<th>Capacitor Part No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>2050 Hz</td>
<td>33k</td>
<td>1.5k</td>
<td>2.7k*</td>
<td>221</td>
<td>.0056</td>
<td>8-84326A13</td>
</tr>
<tr>
<td>1950 Hz</td>
<td>27k</td>
<td>1k</td>
<td>2.2k*</td>
<td>221</td>
<td>.0062</td>
<td>8-84326A14</td>
</tr>
<tr>
<td>1850 Hz</td>
<td>22k</td>
<td>1.5k</td>
<td>2.7k*</td>
<td>221</td>
<td>.0069</td>
<td>8-84326A15</td>
</tr>
<tr>
<td>1750 Hz</td>
<td>22k</td>
<td>1k</td>
<td>2.43k</td>
<td>221</td>
<td>.0077</td>
<td>8-84326A16</td>
</tr>
<tr>
<td>1650 Hz</td>
<td>18k</td>
<td>1k</td>
<td>2.21k</td>
<td>221</td>
<td>.00865</td>
<td>8-84326A17</td>
</tr>
<tr>
<td>1550 Hz</td>
<td>15k</td>
<td>1k</td>
<td>2.21k</td>
<td>221</td>
<td>.0098</td>
<td>8-84326A18</td>
</tr>
<tr>
<td>1450 Hz</td>
<td>12k</td>
<td>1k</td>
<td>2.21k</td>
<td>221</td>
<td>.012</td>
<td>8-84326A19</td>
</tr>
<tr>
<td>1350 Hz</td>
<td>10k</td>
<td>1k</td>
<td>2.21k</td>
<td>221</td>
<td>.0129</td>
<td>8-84326A20</td>
</tr>
<tr>
<td>1250 Hz</td>
<td>9.1k</td>
<td>1k</td>
<td>2.43k</td>
<td>221</td>
<td>.015</td>
<td>8-84326A21</td>
</tr>
<tr>
<td>1150 Hz</td>
<td>8.2k</td>
<td>1k</td>
<td>2.43k</td>
<td>221</td>
<td>.0178</td>
<td>8-84326A22</td>
</tr>
<tr>
<td>1050 Hz</td>
<td>6.8k</td>
<td>1k</td>
<td>2.43k</td>
<td>221</td>
<td>.0213</td>
<td>8-84326A23</td>
</tr>
</tbody>
</table>

* ±5% is allowable.
1. FUNCTIONS

The multi-PL encoder module generates four different PL tones which are routed to the station transmitter. This module is installed with a modified tone PL encoder-decoder module, that provides the transmitter turn-off delay of 180 milliseconds when the transmitter is unkeyed, via the removal of Delayed Keyed A+.

When a switched ground signal is applied from the matrix control module, one of the PL tone oscillators is enabled. A fast start feature provides usable output from the selected oscillator within 30 milliseconds. A reverse burst feature reverses the phase of the generated PL tone for 180 milliseconds before the transmitter is unkeyed. This dampens the Vibraponder resonant reeds in listening receivers and eliminates receiver squelch tail noise bursts at the end of each message. The modifications to the tone PL encoder-decoder module are given in Table 1.

<table>
<thead>
<tr>
<th>Factory Option No.</th>
<th>Tone PL Module</th>
<th>Components Removed</th>
</tr>
</thead>
<tbody>
<tr>
<td>C158AB/AE</td>
<td>TRN5074A</td>
<td>C51 and C52</td>
</tr>
<tr>
<td>C261AC/AH</td>
<td>TRN5074A</td>
<td>R19</td>
</tr>
<tr>
<td>C262AE</td>
<td>TRN5075A</td>
<td>C51, C52, R19, Z1, and Z2</td>
</tr>
<tr>
<td>C263AB</td>
<td>TRN5074A</td>
<td>C51, C52, R19, and Z1</td>
</tr>
</tbody>
</table>

2. DESCRIPTION

The multi-PL encoder components and circuitry are mounted on a sturdy card with connecting pins to mate with the backplane interconnect board of the RF- Con-
control Chassis. The multiple PL encoder module occupies the SPARE position of the RF-Control Chassis.

3. CIRCUIT DESCRIPTION

3.1 MULTIPLE PL ENCODER MODULE

Operation of all four PL tone oscillators is identical. Therefore, the following theory describes only the circuit operation of PL tone oscillator #1, and is applicable to the other three.

The tone oscillator consists basically of a two-stage oscillator (Q101 and Q104), a turn-off stage (Q103), and tone amplifiers (Q904 and Q905). The frequency-determining element of the oscillator is Vibrasender resonant reed E101 (an electromechanical equivalent of a parallel-tuned high Q tank circuit). The output stage of the oscillator Q104 provides a tone from both its emitter and its collector. Tones from the two outputs are of opposite phase, with the Q104 emitter supplying the PL tone during a transmission and the Q104 collector supplying the out-of-phase tone (reverse burst) at the end of a transmission. These tone outputs are fed into separate amplifiers (Q901 and Q903) where they are amplified to a usable level before routing to the PL tone gate and reverse burst gate.

Passage of tones from one or the other outputs to the base of tone amplifiers Q904 and Q905 is controlled by the PL tone gate and the reverse burst gate. During a transmission, the PL tone gate is open, passing the tones from the emitter output of Q104, through amplifier Q903, to tone amplifiers Q904 and Q905. From the collector of Q904 the tone is fed into the transmitter modulator. (At this time, the reverse burst gate is closed.) When the operator releases his push-to-talk switch at the end of a transmission, the PL tone gate closes, terminating transmission of the in-phase Private-Line tone. Simultaneously the reverse burst gate opens, passing the out-of-phase tone signal from Q104 through amplifier Q901 to tone amplifiers Q904 and Q905. Q902 is an inverter stage that feeds the reverse burst switch (Q906).

The oscillator turn-off circuit (Q103), connected across the secondary winding of the Vibrasender resonant reed coil, shorts that winding so as to disable the tone output of Q101 whenever ground is removed from the oscillator turn-on point (pin 2).

The purpose of the Q102 pulse circuit is to "faststart" the tone oscillator to permit faster receiver PL squelch action thereby speeding up system operation. The pulse circuit increases the PL tone oscillator rise time to a usable level in approximately 30 milliseconds. This is accomplished by pulsing the primary input of the tone oscillator Vibrasender resonant reed with a 3 millisecond pulse which causes the tone oscillator to "fast-start."

4. MAINTENANCE

4.1 RECOMMENDED TEST EQUIPMENT

- Motorola SLN6221A Private-Line Tone Generator — used for testing Vibrasender resonant reeds.
- Motorola solid state ac voltmeter — used for tone level measurements.
- General purpose oscilloscope — valuable for signal tracing and locating sources of distortion.
- Motorola solid state dc multimeter — used for dc voltage measurement.
- Motorola S1343A Series Frequency Counter or S1344A Series Frequency Counter — used for measuring PL tone frequency.

4.2 PERFORMANCE TEST

Measure frequency deviation of the transmitter in which the PL encoder is installed. With the transmitter keyed and PL tone modulation (only), deviation should read $\pm 0.5$ to $\pm 1.0$ kHz.

4.3 TROUBLESHOOTING

Step 1. If no deviation is measured, the trouble may lie in the tone oscillator or tone output circuit. The trouble may be isolated by the following steps.

- Check A+ input to encoder.
- Check ac signal voltage at collector of Q903.
- If signal is present, check Q904.
- If no signal is present any component in the oscillator loop could cause the trouble. Check the Vibrasender resonant reed in the Private-Line tone generator.
- If the tone generator does not produce an output signal the reed is defective.
- If the reed is good, replace it in the encoder and make dc voltage measurements in the tone oscillator circuit to locate the defective component.

Step 2. If low deviation is measured, check ac signal voltages and compare them with the schematic voltage readings to find the source of trouble.
Step 3. If deviation is normal, but calls are not being received, check the frequency of the PL encoder tone. If off-frequency, replace the Vibrasender resonant reed.

Step 4. If squelch tail noise bursts are heard by all listening receivers, check dc voltages of Q902 and Q906 in keyed and unkeyed conditions.

Step 5. If reverse burst is not being transmitted, check the delayed keyed A+ circuitry on the PL module.

Step 6. If too much tone deviation is measured, check feedback amplifier Q904.
1. FUNCTIONS

This multi-PL decoder module is used with base and repeater stations to provide multiple PL receive operation. It is also used with non-wire line repeater stations to select the PL tone transmitted with repeated messages. Depending on the PL tone received, a switched ground signal will appear at one of the outputs of this module which is used to:

- (with base stations) unsquelch the receiver, or
- (with non-wire line repeater stations) unsquelch the receiver and enable an associated PL oscillator in the multi-PL encoder module.

This module is installed with a modified tone PL encoder-decoder module, that provides this module with Delayed Keyed A+. The modifications to the tone PL encoder-decoder module are as given in Table 1.

<table>
<thead>
<tr>
<th>Factory Option No.</th>
<th>Tone PL Module</th>
<th>Components Removed</th>
</tr>
</thead>
<tbody>
<tr>
<td>C158AB/AE</td>
<td>TRN5074A</td>
<td>C51 and C52</td>
</tr>
<tr>
<td>C261AC/AH</td>
<td>TRN5074A</td>
<td>R19</td>
</tr>
<tr>
<td>C262AE</td>
<td>TRN5073A</td>
<td>C51, C52, R19, Z1, and Z2</td>
</tr>
<tr>
<td>C263AB</td>
<td>TRN5074A</td>
<td>C51, C52, R19, and Z1</td>
</tr>
</tbody>
</table>

2. DESCRIPTION

This module is fully transistorized and occupies the single-tone decoder module position in the RF-Control Chassis. All components and circuitry are mounted on a sturdy card with interconnecting pins to mate with the backplane interconnect board of the RF-Control Chassis.

Figure 1. Functional Diagram
3. CIRCUIT DESCRIPTIONS

3.1 INTRODUCTION

This module responds only to specific continuous low-frequency tones from a transmitter in the same Private-Line system. Four Vibrasponder resonant reeds are used as tone detectors by the decoder. These reeds detect tones within an accuracy of less than one Hertz (0.15%). A switched ground from an open collector output stage is provided for each of the four detected tone inputs by the decoder.

3.2 PL TONE PRESENT

When PL tones are present on the input signal to the decoder, the PL filter will pass the low frequency PL tones and attenuates voice and noise frequencies above 300 Hz. The noise switch shorts out high frequency noise frequencies. The tone from the PL filter is amplified by the PL amplifier and is limited to a fixed level by the amplifier/clipper. The tone is applied to the Vibrasponder resonant reed which vibrates when the tone is the same frequency as the reed's resonant frequency. When the reed is vibrating, the device acts as a transformer and couples the tone from primary to secondary. The tone is amplified in the next stage and applied to a detector. When a tone is present, the detector develops a dc output which activates the detector output switch. When the detector output switch is activated, its ground output is applied to three circuits:

- Receive PL indicate switch which, in turn, drives the high frequency noise switch (shorts input high frequency noise and voice signals to ground) and provides an output "high" on the PL indicate line to the station's receiver (unsects the receiver).
- Squelch gate PL indicate switch which, in turn, provides an output "high" on the PL indicate line to a repeater station's squelch gate module (keys the station's transmitter).
- Through inverter and latch circuits to an applicable output switch which, in turn, is activated (provides an associated ground level output in response to the particular PL tone detected).

3.3 PL TONE NOT PRESENT

When no PL tone is present, or when a PL tone of an incorrect frequency is present, the Vibrasponder resonant reed does not operate. Therefore, the output of all detector switches is high which inhibits the squelch gate through pin 21.

When no PL tone is detected, switch Q6 is off. This allows high frequency noise to bypass the PL filter which prevents random low frequency noise from activating the Vibrasponder resonant reeds.

3.4 INPUT CIRCUITS

The receiver discriminator output signal is applied to the multi-PL decoder input at pin 3. When no carrier is received this signal consists of noise only. When voice or voice/PL tone frequencies are received, the noise is reduced and the voice/PL tone frequencies are routed through the low pass PL filter and noise gate circuits. The low pass PL filter, which consists of L2, C2, C3, and C4, sharply attenuates all signals above 300 Hz. Therefore, voice and noise frequencies above 300 Hz are effectively blocked while PL tones are passed.

High pass filter C1, R1 and R7, provides a shunt for high frequency noise around the PL filter when no tones are detected. The high frequency noise desensitizes the amplifier/clipper and prevents low frequency noise from triggering the decoder. When a PL tone is detected, noise switch Q6 shorts all high frequency signals to ground.

3.5 AMPLIFIER/CLIPPER

The noise and PPL tones are amplified and coupled to amplifier/clipper Q2 by Q1. Diode CR1 and Q2 (base emitter junction) limit both the positive and negative signal swing to a maximum amplitude. The output of Q2 provides a constant drive to compensate for the tone amplitude deviation between transmitters. Q2 also reduces the sensitivity of the Vibrasponder resonant reeds to noise. Drivers Q3 and Q4 operate as emitter followers to provide current drive to the low impedance Vibrasponder resonant reed assembly.

3.6 VIBRASPONDER RESONANT REEDS

The Vibrasponder resonant reeds are the frequency detecting devices of the decoder. When the input tone from the Vibrasponder resonant reed driver is the same frequency as a reed's resonant frequency, the reed vibrates. At resonance, the reed acts as a high Q transformer coupling energy from the primary to the secondary winding. At all other frequencies, the reed will not vibrate and no energy is coupled to the secondary winding. The reed is a precision built device consisting of a tuned cantilever reed of special steel mounted on a rugged base with a coil and permanent magnets. The entire assembly is spring-mounted and hermetically sealed in a metal housing to insure long life at peak performance under all types of conditions. Its design eliminates the need for servicing throughout its useful life. The plug-in unit is easily removed and replaced. The reed is sensitive to within 1 Hz of its resonant frequency. Specific tones in the 82.5 to 210 Hz range are used.

3.7 TONE DETECTORS

The following description applies to the signal flow through Vibrasponder resonant reed "A" and associated

When a PL tone is detected by a Vibrasponder resonant reed, a resonant sinusoidal waveform appears at its output. This signal is amplified by Q7. (Negative feedback through C11 maintains the sinusoidal voltage.) The output of Q7 is detected by Q8.

Detector Q8 is normally turned off by +13.4 volts on the base and +12.3 volts on the emitter. Therefore, when a tone is detected, Q8 turns on each time the tone signal waveform goes negative more than 1.3 volts (the amount of Q8 reverse bias). Each time Q8 turns on, C13 is charged by the +12.3 volts on the emitter. When Q8 turns off, C13 discharges through R25 and the base of Q9 turning on Q9. When Q9 turns on, it applies a ground to the base of Q5 and Q29, turning them on. When Q5 and Q29 are turned on, they apply a positive level to the receiver and squelch gate respectively. The positive level from Q5 also turns on Q6 which shunts high frequency noise from the PL filter to ground.

3.8 DECODER OUTPUT

When a tone is detected, the low output of Q9 is applied to inverter U1-5. This low is inverted and applied to NAND gate U2-2. When delayed keyed A+ is applied to U2-3, a low level is generated and fed back to U1-5, causing a latch condition and applying a continuous low to the base of Q27. This low turns on Q27 and Q28 producing a low (ground level) output #1 signal at pin 2.

When transmission has been completed, and the PL tone has dropped, the collector of detector output switch Q9 goes high. This high reverse biases all three isolation diodes, causing the three associated circuits to reverse their operation as previously described. Delayed Keyed A+ remains on for approximately 180 milliseconds. The voltage delay keeps the NAND gate on, feeding back the output to the input of inverter U1, thereby keeping a high applied to pin 1 of U2. This state continues until Delayed Keyed A+ drops, causing the NAND gate to return to its normal state.

4. MAINTENANCE

4.1 RECOMMENDED TEST EQUIPMENT

- Motorola S1318A, S1319A, S1320A, or S1321A RF Signal Generator. This solid-state unit provides receiver rf carrier signals.

- Motorola SLN6221A PL Tone Generator and Vibrasender resonant reeds on the same frequency as the Vibrasponder resonant reeds of the decoder. An audio signal generator may be used if it is accurately set to the decoder frequency. However, to obtain the accuracy necessary, the frequency should be adjusted while the signal is measured on a frequency counter.

- Tektronix/Telequipment Model D61 Oscilloscope for tone signal measurement. Some measurements may be taken with a high impedance ac voltmeter.

- Motorola solid state multimeter for dc voltage measurements.

4.2 PERFORMANCE TESTS

A 0.25 microvolt rf carrier signal modulated ±0.5 kHz with PL tone should unsquelch the receiver. This can be checked as follows:

Step 1. Connect the rf signal generator to the receiver rf input receptacle. Set the signal generator output to the receiver carrier frequency, then set the output to minimum.

Step 2. Modulate the signal generator output ±0.5 kHz with a PL tone of the frequency stamped on one of the Vibrasponder resonant reeds. The tone can be generated with a Motorola SLN6221A PL Tone Generator and a Vibrasponder resonant reed. A Vibrasender resonant reed from the PL encoder may be used if it is the proper frequency.

Step 3. Also modulate the signal generator with an audio tone in the 300 to 3000 Hz range at ±3.3 kHz deviation.

Step 4. Increase the output of the signal generator until the receiver unsquelches and the audio tone is heard on the speaker. No more than 0.25 microvolt should be required to unsquelch the receiver.

4.3 TROUBLESHOOTING

If the PL decoder does not operate, or operates improperly, the following hints may be helpful in locating the malfunction.

4.3.1 Testing the Vibrasponder Resonant Reeds

One of the first tests should be a check of the Vibrasponder resonant reeds. Inject 340 millivolts rms of PL tone at the proper frequency directly to the primary of each reed. Use an oscilloscope or ac voltmeter to check the output across the secondary of the reeds. Approximately 75 millivolts rms should be measured. If the reeds are good, continue with other decoder tests.

4.3.2 Decoder Testing

Step 1. To test the decoder, inject a 1000 microvolt carrier signal into the receiver. Adjust PL modulation for 60 millivolts rms tone signal at the input to the decoder. If the PL tone is injected directly onto the decoder for testing, an rf carrier signal should be injected into the receiver to quiet the receiver noise. Otherwise,
noise and PL tone will both be present and will produce erroneous readings.

Step 2. With 60 millivolts PL tone input, measure signal and dc voltages at various points in the decoder to isolate the trouble. Typical values for a normally operating decoder are given on the schematic diagram. Some waveforms are not sinusoidal and should be measured with an oscilloscope. Most ac voltmeters are calibrated to read accurately only for sinusoidal signals.

Step 3. If under normal operating conditions, the PL tones are heard with the speaker audio, the high pass filter on the decoder board should be checked.