MOTOROLA INC.
Communications
Group

CHANNEL MODEM

MODEL MLN6287A

1. FUNCTIONAL DESCRIPTION

1.1 The MLN6287A Channel Modem is designed to provide standard 4-wire audio and E & M signaling interfaces to the customer's termination equipment. A block diagram of the channel modem is provided in Figure 1.

1.2 Audio at the channel modem transmitter input is limited, filtered, and routed to a channel modulator. Modulation of a 5.2 MHz carrier and subsequent filtering generate a single sideband signal that is translated to a final baseband frequency in the line modulator.

1.3 When the channel is in use, dc control voltage on the M lead turns the reinserted carrier switch on to transmit a carrier used for synchronization and signaling purposes. This carrier functions like the 3825 Hz signaling tone used by other types of multiplex equipment.

1.4 The baseband input to the receiver, which includes all received channels, is applied to an extremely linear preamplifier and then to the line demodulator. The amplified broadband signal is applied to two separate 5.2 MHz bandpass filters. One filter has a narrow passband which allows only the carrier to pass for use in signaling and synchronization. The other filter has a 4 kHz wide passband which allows only the desired channel to pass.

1.5 For signaling, the recovered carrier is routed to a peak detector which provides a closure of the E lead signaling output. The standard E lead output consists of a solid-state switch connected to ground. A mercury wetted relay option provides isolated form-A contacts. The receive signaling circuit includes a dial pulse corrector that reduces pulse distortion with varying baseband input levels.

1.6 For synchronizing the two channel ends to recover the original audio without frequency translation error, the injection frequency into the channel modulator and channel demodulator at both channel ends must be identical. This is achieved by operating one modem in the master mode and the other modem in the slave mode. The modem operating in the master mode uses its own local 5.2 MHz oscillator as the source of its injection frequency and transmits a signaling and synchronization carrier which is recovered by the modem operating in the slave mode. The slave modem switches from its local 5.2 MHz oscillator to the recovered carrier as the source for the injection frequency into the channel modulator and channel demodulator. The same frequency is thus used at both channel ends and channel synchronization is acheived.

1.7 The master/slave status can be established automatically, with no signaling carrier being transmitted when the channel is idle. When a modem initiates a call, an applied M lead turns the signaling carrier on and establishes a master mode status for the initiating modem. The called modem or modems receive the carrier from the master modem. The recovered carrier drives the E lead switch. The E lead signal, gated by the master/slave logic, drives the master/slave carrier switch. The slave modem thus switches from its local 5.2 MHz oscillator to the recovered carrier. The master/slave logic provides a lock-out function on the E lead signal to the master/slave carrier switch. If an M lead is applied before an E lead is received, the received E lead is disabled from the carrier switch and the modem remains in the master mode. If an M lead is applied after an E lead is received, the E lead drive to the master/slave carrier switch remains undisturbed, and the modem remains in the slave mode. The master/slave logic lock-out function thus allows the slave modem to turn its signaling carrier on with an applied M lead and allows the master unit to get a received E-lead from the slave's signaling carrier, without either modem changing its master/slave status.

1.8 When signaling is not required, a permanent master/slave status can be established. This is acheived by the selective positioning of jumper JU1 so that one modem may be strapped as a permanent master unit capable of continuously generating a synchroniza-

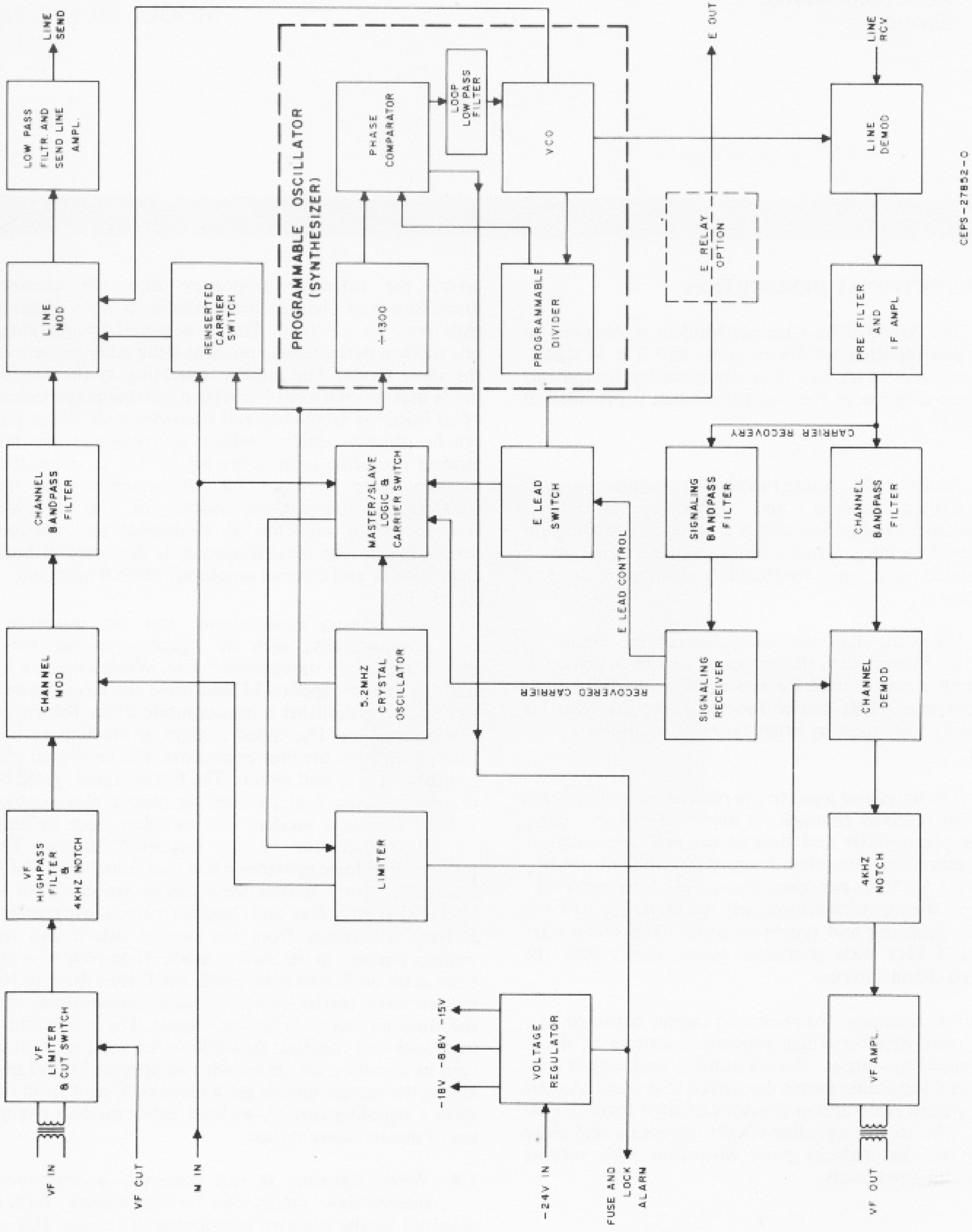

Figure 1. Channel Modem Block Diagram

tion carrier. The called modem or modems can be turned into slave units by strapping them to disable their M inputs.

1.9 The channel modem (Figure 1) uses a programmable oscillator (synthesizer) whose frequency determines the channel operating frequency. The modem's channel operating frequency can be set to any of the 614 available channel frequencies by means of a programmable code plug. The MLN6309A Code Plug, which establishes the programmable oscillator (synthesizer) frequency, is normally programmed at the factory. However, blank code plugs can be easily programmed in the field, using common tools. Refer to the System Adjustments section in this manual for further information on the code plug.

2. STRAPPING OPTIONS

2.1 By selectively strapping jumper JU1, it is possible to select the mode of operation of the modem: automatic, permanent master, or permanent slave. In the automatic mode, no carrier is transmitted when the channel is idle. When a modem initiates a call, it becomes the master and the called modem or modems become the slave units. In the permanent master mode, the modem always sends a carrier and is always the master unit. In the permanent slave mode, the modem never sends a carrier and is always the slave unit.

2.2 Strapping information for the desired mode of operation of the modem is provided on the schematic diagram located at the end of this section. Jumper JU2 is used to provide a solid-state E lead signaling output from the modem. If the MLN6300A Relay option is used, jumper JU2 is removed.

3. THEORY OF OPERATION

(Refer to the channel modem block diagram provided in Figure 1. Also refer to the channel modem schematic diagram and block and ac level diagram, both of which are attached to the end of this section.)

3.1 5.2 MHz OSCILLATOR (U38)

The 5.2 MHz oscillator is a crystal-controlled Colpitts oscillator that provides an output to buffer circuits which provide two separate isolated outputs: one output is used as a reference signal by the programmable oscillator (synthesizer); it is also used for carrier reinsertion for use in signaling and synchronization. The second output is supplied to the Master/Slave Carrier Switch & Limiter, U47, for modulation and demodulation purposes.

3.2 MASTER/SLAVE CARRIER SWITCH & LIMITER (U47)

The carrier switch in U47 accepts two different 5.2 MHz sources and selects one of them for use as an injection source for the channel modulator and channel demodulator. One signal source is the local 5.2 MHz oscillator (U38). The other source (which is the recovered carrier) is received from the distant channel end modem. The signal source selected is a function of the mode of operation of the unit (master or slave). The local 5.2 MHz oscillator is used in the master mode, while the recovered carrier is used in the slave mode. The selected source signal is then applied to the limiter whose function is to regulate the injection level to the channel modulator and channel demodulator.

3.3.1 The programmable oscillator (synthesizer) generates injection frequencies for the modulator and line demodulator. The injection frequencies range from 4.652 MHz to 7.740 MHz, separated by 4 kHz, the standard channel spacing. The programmable oscillator consists of: (1) a voltage-controlled oscillator (U6) which generates an output frequency corresponding to a dc control voltage; (2) a divide-by-N circuit (U17 and U18), in which N is programmed by means of a code plug; (3) a phase comparator (U15) which determines the phase and frequency difference between a reference frequency and the divided-by-N VCO (voltage-controlled oscillator) output and, then, generates a correction voltage, as required, to move the control voltage in a direction that will maintain the VCO locked on frequency; and (4) a low-pass filter (U16) which controls the loop.

3.3.2 When the two frequencies at the input of the phase comparator are equal and in phase, the programmable oscillator output will be "locked". The phase comparator enables the VCO to track the reference frequency, which is derived from the highly stable 5.2 MHz crystal-controlled oscillator. The VCO frequency stability is achieved by means of the feedback action of the loop. Refer to the programmable oscillator block diagram shown in Figure 2.

3.3.3 The channel baseband frequency is determined by the programmable oscillator frequency which, in turn, is controlled by the programmable code plug. The programmable oscillator output is applied to the line modulator and line demodulator. Except for channels in supergroup 2 (312 to 552 kHz) and channels 1 to 14, the programmable oscillator frequency is greater than 5.2 MHz by an amount equal to the channel baseband frequency. For the channels in supergroup 2 and channels 1 to 14, the programmable oscillator frequency is less than 5.2 MHz by an amount equal to the channel baseband frequency. This provides an upper sideband orientation that conforms to the CCITT frequency plan. The test tone frequency is 1 kHz greater than the signaling carrier frequency for supergroup 2 (312 to 552 kHz) and channels 1 to 14, and is 1 kHz less than the signaling carrier frequency for all others.

3.4 TRANSMIT CIRCUITS

3.4.1 VF Limiter and VF Cut Switch (U12)

The 4-wire vf signal is applied to the vf limiter and cut switch via T1, a 600-ohm balanced transformer. The limiter removes the audio signal peaks, thus eliminating the possibility of overload and reducing crosstalk. Normally, the vf signal is muted during signaling; this is achieved by applying a negative voltage on the VF CUT input to prevent transmission of transient voltages that may be present at the VF input line during signaling.

3.4.2 VF High-Pass Filter (U11)

The vf output of U12 is applied to the input of the channel modulator via U11, a high-pass filter with a 4 kHz notch. The 4 kHz notch is set by means of L1. The high-pass characteristics of the filter attenuate frequencies below 300 Hz and prevent talkdown on the channel's signaling circuits, whereas the 4 kHz notch prevents voice falsing of the signaling on the adjacent channel.

3.4.3 Channel Modulator

The channel modulator receives the vf signal from the high-pass filter (U11) and the 5.2 MHz carrier injection signal from the master/slave carrier switch and limiter (U47). This is a balanced modulator that switches its inputs at a carrier rate and generates an output consisting of upper and lower sidebands, with a suppressed carrier. This output is applied to the send i-f amplifier (U10).

3.4.4 Send I-F Amplifier (U10) and FL1

3.4.4.1 The send i-f amplifier receives the channel modulator output and amplifies the double-sideband signal to a level sufficient to drive the line modulator. This signal is applied to the line modulator via FL1, the 5.2 MHz channel bandpass filter. FL1 eliminates the lower sideband but passes the upper sideband (the 5.200 to 5.204 MHz standard channel) to the input of the line modulator.

3.4.4.2 Signaling is achieved by reinserting the 5.2 MHz carrier at the channel modulator input via the reinserted carrier switch (Q7). When an M lead input is present, the carrier is gated through the CARR LVL (carrier level) control, R10, where it is adjusted to a -20 dBm0 reinjection level and then applied to the line modulator. (The -20 dBm0 level is 20 dB lower than the channel test tone level.)

3.4.5 Line Modulator and Low Pass Filter

The balanced line modulator receives the upper sideband signal (5.201 MHz for a 1 kHz vf input), with suppressed carrier, and the 5.200 MHz reinserted carrier, when the M lead is on. The line modulator generates an output that is applied to a low-pass filter. This filter removes the residual 5.2 MHz signal, the upper sideband signal from the line modulator, as well as any spurious modulation components. The line modulator output consists of the total channel information translated to the final frequency slot on the baseband.

3.4.6 Send Line Amplifier (U9)

The send line amplifier provides the required baseband transmission level. This baseband level is adjustable by means of R4, the XMIT LVL (transmit level) control.

3.5 RECEIVE CIRCUITS

3.5.1 Receive Line Amp (U1) and Line Demodulator

The receive line amplifier (U1) receives the transmitted information from the distant channel end and applies this signal to the input of the line

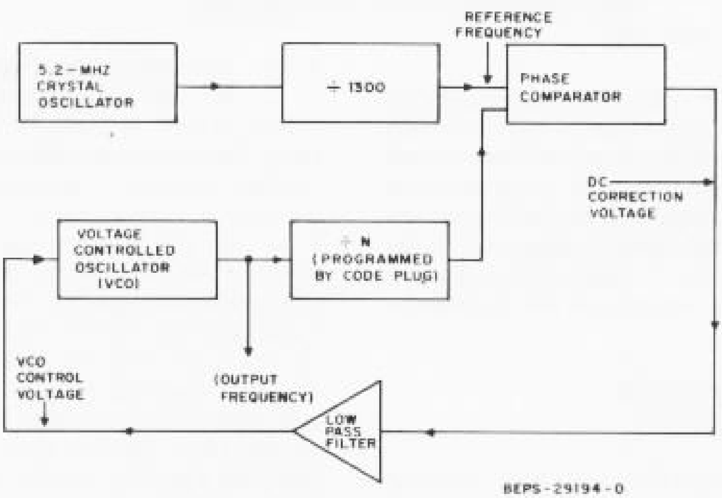

Figure 2. Programmable Oscillator Block Diagram

demodulator. The line demodulator receives an injection signal that is provided by the programmable oscillator. The line demodulator translates the channel back to the standard channel spectrum (5.200 MHz to 5.204 MHz) and provides an output signal that is applied to a discrete bandpass filter. This filter attenuates the undesired signals to reduce the loading effect on the receive i-f amplifier (U2). The filtered baseband with the desired channel (5.200 to 5.204 MHz) is applied to U2.

3.5.2 Receive IF Amplifier (U2), FL2, and FL3

The receive i-f amplifier has two isolated outputs to provide impedance matching and proper signal levels to the signaling filter (FL3) and the receive channel filter (FL2). FL2, a channel bandpass filter, attenuates the entire baseband spectrum, with the exception of the desired channel (5.200 to 5.204 MHz). FL3, a very narrow bandpass filter centered at 5.2 MHz, removes the modulation from the received carrier; this filtered 5.2 MHz signal will then be used for signaling and synchronization.

3.5.3 Channel Demodulator (U33)

The channel demodulator receives the 4 kHz bandwidth channel (5.200 to 5.204 MHz) from FL2 and demodulates this signal with a 5.2 MHz carrier. This carrier can be either from the local 5.2 MHz oscillator (U38) (master mode) or the recovered carrier from another modem (slave mode). The channel demodulator output (which is the original vf information transmitted) is applied to a 4 kHz notch filter to prevent the adjacent channel carrier from appearing in the vf output. (The 4 kHz notch filter is adjustable by means of L6.) The notch filter output is applied to the receive vf amplifier (U3).

3.5.4 Receive VF Amplifier (U3)

The receive vf amplifier is an operational amplifier that is used to amplify the channel demodulator vf output and ultimately present it, at the proper level, to the 4-wire, 600-ohm vf receive line. This amplifier drives T8, a transformer that matches the modem to a 600 ohm impedance. The vf level is adjustable by means of the VF control, R35, which is normally set for + 7 dBm 600.

3.5.5 Signaling Amplifier and E Lead Detector (U34)

U34 is a high-gain amplifier that receives the recovered 5.2 MHz signaling carrier from the signaling filter (FL3) and amplifies it to the appropriate level to drive the master/slave carrier switch and limiter (U47); this signal, when selected by U47, is used as the injection source for the channel modulator and channel demodulator in the slave mode of operation. The signal level is further amplified and detected by U34 to provide a dc voltage to the E lead switch (U5). The level of the detected signal is adjustable by means of R43 (E SENS), the E lead sensitivity control.

3.5.6 E Lead Switch (U5)

The dc voltage output from the signaling amplifier is received by the E lead switch. This dc voltage drives a dial pulse corrector circuit that reduces pluse distortion with varying baseband input levels. The output from the corrector circuit drives a bipolar transistor switch that provides an E lead closure upon detection of a received carrier.

4. MAINTENANCE

4.1 GENERAL

The availability of replacement components facilitates repair of channel modems. Some components, such as thick film circuits, require special care. Testing of channel modems can be made easier by using the MLN6298A Extender Board, which can be inserted into the card shelf. For bench servicing, a special test circuit can be constructed, as explained below.

4.2 TEST EQUIPMENT REQUIRED

Refer to the System Maintenance section in this manual for a list of the test equipment required to service the channel modem.

4.3 ABBREVIATIONS AND TERMS USED IN THIS SECTION

SVM	*Selective voltmeter.*
WBVM	*Wideband ac voltmeter.*
dBm 600	*Power level reading: decibels below 1 millivolt measured across 600 ohms.*
dBm 75	*Power level reading: decibels below 1 millivolt measured across 75 ohms.*
T	*Transmit: refers either to voice frequency function or level at modem input or to channel frequency function or level at modem output.*
R	*Receive: refers either to channel frequency input or to voice frequency output.*
VF	*Voice frequency.*
4W	*Four-wire: refers to input or output on modem front panel or on test fixture.*
HF	*High frequency: Refers to baseband frequencies.*
M Level	*Normal carrier level: 20 dB below test tone level.*
XMIT LVL	*Transmit level.*
CARR LVL	*Carrier level.*
E SENS	*E lead sensitivity.*

NOTE

All measurements with the wideband voltmeter are made in the bridging mode on a dB scale calibrated for dBm into 600 ohms. Measurements with the selective voltmeter are made in the bridging mode on a dB scale calibrated for dBm into 75 ohms. If the meter is not calibrated for 75 ohms, the necessary correction factor should be used. For example, a meter referenced to 600 ohms provides an indication 9 dB lower than a meter referenced to 75 ohms.

4.4 BENCH TEST SET-UP

Unit testing and repair can be conveniently performed on the bench by using an interface between the modem and the test equipment. A test fixture with all the appropriate controls and indicators that permit such test should be constructed, as shown in the schematic diagram of Figure 3. The switches allow the operation of the signaling circuits, while the LED indicator monitors the state of the received E signal. The transmission path pads are built-in and can be switched as required for the test. Coaxial connector J1 permits the injection of test signals into the receive side only (LOOP switch open). The test fixture requires a 24 V dc, positive-ground power supply that has a ripple rated at less than 300 millivolts rms. A typical test set-up is shown in Figure 4.

4.5 PERFORMANCE TEST PROCEDURES AND ADJUSTMENTS

NOTE

The modems can be configured to operate in the automatic, master, or slave mode. The carrier signaling characteristics of a mode will depend on the type of operation selected.

It is recommended that the test fixture be used for the test, adjustment and troubleshooting procedures presented in this section. Reference symbols, test points, and test levels used in the following paragraphs will either refer to the test fixture or be found in the modem schematic diagram located at the end of this section. Refer to the Troubleshooting procedure in this section, whenever a malfunction is detected but no corrective action is suggested.

4.5.1 Operational Tests

The following steps require that the channel modem be strapped for the automatic mode of operation. This is done by connecting the MODE jumper (JU1) from A to B. Use of the test fixture illustrated in Figure 1 is recommended; however, the extender board can be used, if and as required. Proceed as follows:

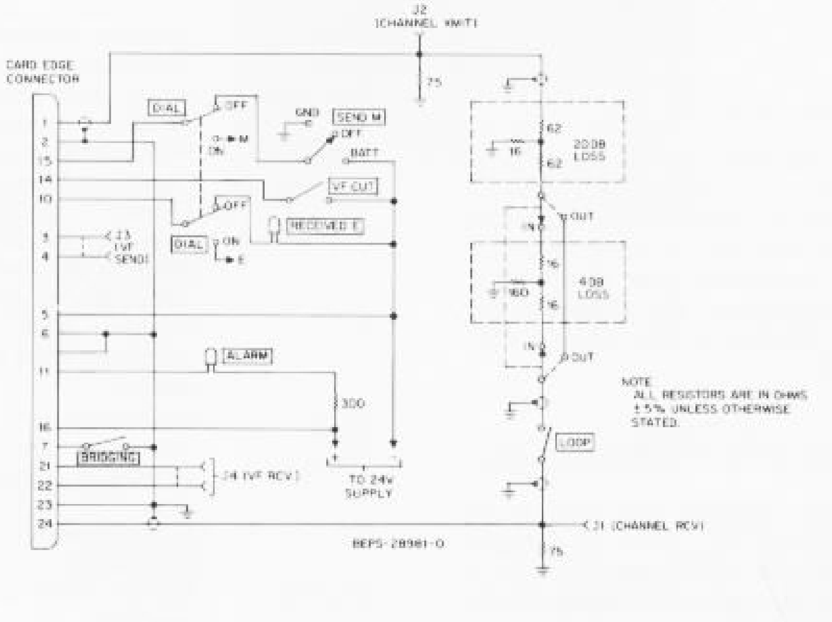

Figure 3. Modem Test Fixture Schematic Diagram

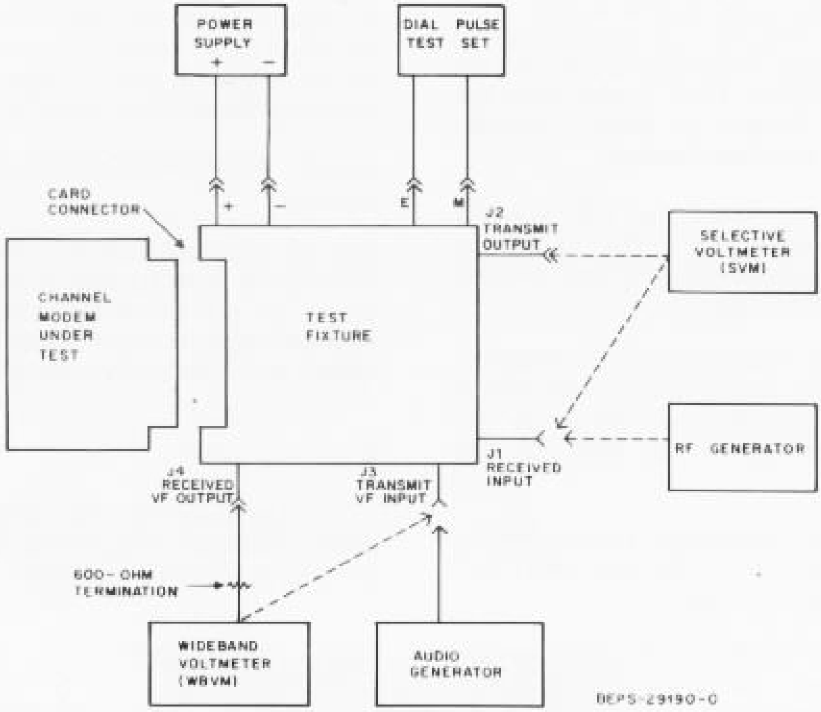

Figure 4. Typical Modem Test Set-Up

Step 1. Set the test fixture switches as follows:

- SEND M — on
- VF CUT — open
- BRIDGING — closed
- 4 dB PAD — out
- LOOP — closed
- DIAL — off

Step 2. Apply a 1000 Hz vf input signal at -16 dBm 600 to the 4 WT input (J3).

Step 3. Check the programmable oscillator frequency at TP4 (TP3, ground). Adjust C73 to obtain the programmable oscillator frequency ± 5 Hz.

NOTE

Allow the frequency counter and the channel modem 15 minutes to warm up before adjusting the programmable oscillator frequency. Since the oscillator has a specification of ±5 Hz, all frequency counters used in maintenance and repair must be calibrated to a single reference.

Step 4. Refer to the Test Frequencies Table provided in the Installation Section of this manual, and select the required test tone frequency. Adjust the XMIT LVL control (R4), located near the modem connector, until a test tone output level of -15 dBm75 is indicated by the SVM at J2. A channel carrier level of -35 dBm75 is also produced at this point. The difference between the test tone and channel carrier levels should be 20 dB ± 1 dB.

NOTE

If an SVM other than the one recommended in the test equipment list is used, it may be possible that the substituted SVM may not be capable of accurately distinguishing between the signaling carrier level and the 1000 Hz side-band level. To test this accuracy, tune the SVM to the signaling carrier frequency and remove the 1000 Hz tone. If the measured signaling carrier level changes, an accurate carrier level measurement can be made only when the vf tone is removed. If the carrier level is correct, proceed to Step 9; otherwise, go to Step 5.

Step 5. Set the CARR LVL control (R10) to mid-range.

Step 6. Adjust the XMIT LVL control (R4) until a test tone output level of -15 dBm 75 is obtained at J2.

Step 7. Adjust the CARR LVL control (R10) for a carrier level of -35 dBm 75 at J2.

Step 8. Repeat Steps 6 and 7 until the requirements of both steps are met.

Step 9. The signal levels at the modem receive input (J1) should be -35 dBm 75 at the test tone frequency, and -55 dBm 75 at the carrier frequency, as indicated by the SVM in the bridging mode. If the correct levels are not present at this point, readjust the XMIT LVL control (R4) until the proper levels are obtained.

Step 10. Connect a 600-ohm-terminated WBVM to J5 (4WR) on the modem. Adjust the modem vf control (R35), located on the front panel of the modem, until an indication of + 7 dBm 600 is obtained.

Step 11. Vary the vf input frequency at J3 from 300 Hz to 3400 Hz. Verify that the output level remains within the frequency response specifications. (Refer to the Specifications sheet provided at the head of this manual.)

Step 12. Vary the vf input frequency at J3 from 300 Hz to 50 Hz and then from 3400 Hz to 4000 Hz. Verify that the output levels decrease in both cases.

Step 13. Verify closure of the E lead relay by observing the RECEIVED E indicator on the test fixture; the indicator should be lit. (If the test fixture is not used, connect a voltmeter to pins 5 and 10 of the modem; a closed E to ground will cause the voltmeter to indicate the power supply voltage.) If the relay option is used, the unit must be in its normal (vertical) position to allow the relay to correctly respond to the E lead closure.

Step 14. Reduce the received signal level by switching in the 4 dB PAD on the test fixture.

Step 15. Verify that the received test tone and carrier levels are, respectively, -39 dBm 75 and -59 dBm 75. Also verify that the RECEIVED E indicator is still lit.

Step 16. Set the test fixture SEND M switch to the OFF position and verify that the RECEIVED E indicator has extinguished. If it did not, it is an indication of a faulty U5 (signaling detector).

Step 17. Open the LOOP switch and the BRIDGING switch, and set the SEND M switch to the ON position.

Step 18. Apply the appropriate channel carrier frequency, at -55 dBm 75, to the channel receive input (J1) from an external source.

Step 19. Monitor the frequency of the 5.2 MHz signal at pin 16 or pin 19 of U47. Vary the carrier frequency applied at J1 by approximately ± 50 Hz and verify that the frequency at pin 16 (or pin 19) of U47 stays the same despite the variation in the carrier frequency. (Master mode of operation.)

Step 20. Set the test fixture SEND M switch to the OFF position.

Step 21. Vary the carrier frequency applied at J1 by approximately ± 50 Hz and verify that the frequency at pin 16 (or pin 19) of U47 varies cycle-for-cycle in a direction opposite to the change in the input carrier frequency. (Slave mode of operation.)

Step 22. Set the test fixture SEND M switch to the ON position.

Step 23. Vary the carrier frequency applied at J1 by approximately ± 50 Hz and verify that the frequency at pin 16 (or pin 19) of U47 varies cycle-for-cycle in a direction opposite to the change in the input carrier frequency (slave mode of operation).

4.5.2 Carrier Test

The following tests assume that the programmable oscillator frequencies, as determined in the previous procedures, are correct.

4.5.2.1 Master Mode

The following procedure applies to modems used as master modems (MODE jumper JU1 set A to C) or as automatic modems with their M lead at pin 15 activated.

Step 1. Set the test fixture switches as follows:

- SEND M — on
- VF CUT — open
- BRIDGING — closed
- 4 dB PAD — out
- LOOP — closed
- DIAL — off.

Step 2. Verify that the channel carrier level at J2 of the test fixture is -35 dBm 75.

Step 3. Remove the M lead; this is done by removing jumper A-C on master modems and opening the test fixture SEND M switch on automatic modems.

Step 4. Verify that the channel carrier level at J2 is not greater than -55 dBm 75 (20 dB below -35 dBm 75 carrier). If the carrier is greater that -55 dBm 75, refer to the Carrier Leak procedure presented in subparagraph 4.5.2.3.

4.5.2.2 Slave Mode

The following procedure applies to modems that are jumpered as slave modems (M lead jumper open) or as automatic modems whose M lead at pin 15 is not activated.

Step 1. Set the test fixture switches as follows:

- SEND M — off
- VF CUT — open
- BRIDGING — open
- 4 dB PAD — out
- LOOP — open
- DIAL — off.

Step 2. Apply a channel carrier frequency signal at -55 dBm 75 to J1 on the test fixture.

Step 3. Verify that the channel carrier signal at J2 is not greater than -55 dBm 75 (20 dB below -35 dBm 75 carrier level). If this level is greater than -55 dBm 75, proceed to the next procedure (Carrier Leak).

4.5.2.3 Carrier Leak

If the carrier leakage is greater than -55 dBm 75, as indicated by the preceding test, the most likely causes are excessive leakage from the first modulator or improper operation of the carrier injection switch Q2.

To determine the source of excessive leakage, proceed as follows:

- Short the collector of Q2 to its emitter and verify whether or not the carrier leakage is still greater than -55 dBm 75. If the carrier leakage is greater than -55 dBm 75, then the leakage from the first modulator is excessive.
- Remove the short from Q2 and connect the output of the first modulator (pin 6 of U10) to ground and verify whether or not the carrier leakage is still greater than -55 dBm 75. If the carrier leakage is greater than -55 dBm 75, then the carrier reinsertion switch Q2 is not operating properly.

4.5.3 Channel Synchronization

When a problem with channel synchronization is encountered, both channel ends should be tested to verify the E lead lockout function of the master/slave logic (U29). The ability of the channel modem to synchronize (operate in the slave or master mode) with a remote carrier source can be tested by using the test fixture shown in Figure 4 and performing Steps 1 and 17 through 23 in paragraph 4.5.1 (Operational Test). (The modem must be strapped for automatic mode.) To test the channel modem using only the carrier from a remote source, place the modem on an extender board and proceed as follows (here again, the modem must be strapped for automatic mode):

Step 1. Apply M lead to the channel modem under test by applying -24 V dc to pin 15.

Step 2. Enable the M level carrier from the remote modem on the same channel.

Step 3. Connect a frequency counter to pin 16 or 19 of U47. (When a modem is in the master mode, the frequency at pins 16 and 19 of U47 will be controlled by the local 5.2 MHz oscillator.) Warp the incoming carrier frequency approximately ± 50 Hz by varying C73 of the remote modem. Verify that the frequency observed at U47-16 (or U47-19) does not vary.

Step 4. Remove the M lead from the modem under test.

Step 5. Warp the incoming carrier frequency approximately ± 50 Hz by varying C73 on the remote modem. (When a modem is in the slave mode, the frequency at pins 16 and 19 of U47 will be controlled by the carrier from the remote modem.) Verify that the frequency observed at U47-16 (or U47-19) varies cycle-for-cycle in a direction opposite to the change in the input carrier frequency.

Step 6. Re-apply the M lead to the modem under test.

Step 7. Warp the incoming carrier frequency approximately ± 50 Hz by varying C73 on the remote modem. Verify that the frequency at U47-16 (or U47-19) varies cycle-for-cycle in a direction opposite to the change in the input carrier frequency.

Step 8. Remove the M lead from the modem under test. Return the programmable oscillator of the remote modem to the proper frequency ± 5 Hz after waiting a period of 15 minutes to allow the modem to stabilize. Restrap the modem under test for master or slave operation, as required.

4.5.4 Signaling Sensitivity and Distortion

The following tests require that both the line oscillator frequency (at TP4) and the external received carrier signal be accurate within ± 5 Hz.

4.5.4.1 Sensitivity Test

Step 1. Set the test fixture switches as follows:

- SEND M — off
- VF CUT — open
- BRIDGING — open
- 4 dB PAD — out
- LOOP — open
- DIAL — off.

Step 2. Apply the appropriate channel carrier frequency at J1 (of the test fixture) and adjust the level to -55 dBm 75.

Step 3. Verify that the RECEIVED E indicator is lit.

Step 4. Verify that the voltage at card edge connector pin 7 is -12 V dc ± 2 V.

Step 5. Reduce the input signal level to -63 dBm 75 and verify that the RECEIVED E indicator is still lit.

Step 6. Reduce the input signal level to -64 dBm 75 and verify that the RECEIVED E indicator is extinquished.

NOTE

Adjust R43 on the modem until Steps 5 and 6 above are satisfied.

4.5.4.2 E Lead Pulse Distortion

Step 1. Set the test fixture switches as follows:

- SEND M — off
- VF CUT — open
- BRIDGING — open
- 4 dB LOSS — out
- LOOP — closed
- DIAL — on.

Step 2. Connect the dial pulse test set to the test fixture as follows:

- Connect the dial pulse test set output lead to the test fixture M lead.
- Connect the pulse distortion input lead to the test fixture E lead.
- Connect a ground lead between the dial pulse test set and the test fixture.

Step 3. Set the dial pulse test set to 8 pps, 60% break. Verify that the pulse distortion is less than ±4%.

Step 4. Set the dial pulse test set to 14 pps, 60% break. Verify that the pulse distortion remains less than ±4%.

Step 5. Close the 4 dB PAD switch on the test fixture. Repeat Steps 4 and 5 and verify that the indicated distortion is still less than ±4%.

4.5.5 Filter Adjustments

4.5.5.1 Channel Filter Assemblies

Replacement of channel filter assembly (FL1 and/or FL2) or signaling filter FL3 or replacement of any components in the discrete filter circuits will necessitate adjustment of R4, R10, R35, and R43.

4.5.5.2 Notch Filter Adjustments (L1 and L6)

L1 and L6 should be adjusted to reject 4000 Hz signals. Adjust L1 as follows:

Step 1. Set the test fixture switches as explained below:

- SEND M — on
- VF CUT — open
- BRIDGING — open
- 4 dB PAD — out
- LOOP — closed
- DIAL — off.

Step 2. Apply a 1000 Hz (±10 Hz) tone to test fixture connector J3. Connect the WBVM to TP1 (4WT) on the modem and adjust it to obtain an indication of -16 dBm 600.

Step 3. Connect a bridging voltmeter to TP2 on the modem, and measure the audio signal level.

Step 4. Change the tone applied at J3 to 4000 Hz ±5 Hz. Adjust L1 for minimum meter indication (Minimum notch of 20 dB below the measured 1000 Hz level indicated in Step 3).

Step 5. Proceed with the adjustment of L6 as follows:

- Keep the test fixture switches set as explained in Step 1 of this subparagraph.
- Inject a 1000 Hz ±10 Hz test tone (approximately -25 dBm 600) at TP5.
- Connect a 600-ohm-terminated voltmeter to TP6 (4WR) and adjust the 1000 Hz level to obtain +7 dBm 600.
- Change the test tone applied at TP5 to 4000 Hz ±5 Hz.
- Adjust L6 for a minimum meter indication (minimum notch of 20 dB below the + 7 dBm 600 level indicated in Step 3.)

4.6 TROUBLESHOOTING

Understanding the operation of the system is essential to the detection of faults in a logical manner. Certain signal paths are self-evident and follow customary techniques for isolating faulty components. Other possible faults in circuits having multiple functions and logic processes are described below.

4.6.1 Mutual Faults

Failure of both the send and receive functions may be caused by defective circuits that are common to both sides of the modem. When a mutual send and receive failure occurs, the following checks should be made before performing other modem troubleshooting procedures.

- Verify that the proper dc voltages exist at the outputs of the power regulator (U20, U21, and VR1) and throughout the distribution paths.
- Verify that the channel oscillator signal is present at pins 2 and 6 of the oscillator (U38).

- Verify that the 5.2 MHz injection signal is present at pins 16 and 19 of the carrier switch and limiter (U47).

4.6.2 Send Side Faults

Troubleshooting on the send side of the modem is facilitated by the send side troubleshooting flowchart located at the end of this section. The signal levels are provided on the modem schematic diagram and the modem level diagram, both of which are attached to the end of this section. If the modem is strapped for slave operation, it should be temporarily restrapped to place it in the automatic mode. Carrier recovery may be checked by studying the receive side flowchart, also attached to the end of this section.

4.6.3 Receive Side Faults

The receive side troubleshooting flowchart (located at the end of this section) facilitates troubleshooting the receive side of the modem. The signal levels are provided on the modem schematic diagram and the modem level diagram, both also located at the end of this section. The modem should be strapped to operate in the automatic mode. If it is not, then it should be temporarily restrapped to place it in the automatic mode of operation.

4.6.4 Programmable Oscillator Faults

Refer to the programmable oscillator troubleshooting flowchart for information on how to troubleshoot this oscillator. This flowchart is appended to the end of this section.

4.6.5 Power Supply and Alarm Circuit Faults

For information on how to troubleshoot these circuits, refer to the power supply and alarm circuits troubleshooting flowchart attached to the end of this section.

4.7 REPLACEMENT OF HYBRID ASSEMBLIES (PRECAUTIONS)

Do not use excessive heat while unsoldering any hybrid assemblies. Extra care should be taken while working on that side of the circuit board that has solder pads without runners. For clearing solder from the solder board, use a piston-type or bulb-type unsoldering tool.