ST-8000

HF MODEM

OPERATOR'S MANUAL

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ST8000

HF MODEM

OPERATOR'S MANUAL

870-08000

March, 1993 Printing

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INTRODUCTION

The ST8000 is a high-performance RTTY and CW Modem (MOdulator/DEModulator) for use in HF (High Frequency) radio data communications systems. The HF MODEM is tunable and compatible with FSK (Frequency Shift Keyed) or OOK (On-Off Keyed) RTTY systems. Controls and their functions are logically arranged to minimize personnel training. However, a thorough reading of Chapter 1 of this operator's manual is essential for proper operation of the ST8000. Chapter 2 describes how to connect the ST8000 and how to choose the proper internal jumper selections for your radio system. This Chapter need be studied only for initial installation. The REMOTE CONTROL feature is described in Chapter 3. Chapter 4 presents a a brief discussion of how the HF MODEM works. Chapter 5 lists technical specifications.

Full technical details, schematic diagrams, parts lists, and lists of recommended spare parts are included in a separate publication, the "ST8000 Technical Reference Manual", available for purchase from HAL Communications (part No. 870-08001).

UNPACKING AND INSPECTION

Carefully remove the ST8000 and its accessories from the shipping carton. Inspect the shipping carton and ST8000 for evidence of shipping damage. If damage is found, IMMEDIATELY contact your shipping carrier and file a damage claim. The following items are packed in the Shipping container:

900-08000	ST8000 HF MODEM
870-08000	ST8000 OPERATOR'S MANUAL
333-17250	AC POWER CORD - 120 VAC
310-04001	4-Pin XMTR PLUG
850-18005	ST8000 MAIN TUNING KNOB
850-80001	ALLEN WRENCH

In addition, the following cables and connectors are available for purchase from HAL Communications:

960-08010	ST-8000 to RS232 TTY Terminal (DB25P to DB25S) (same cable may be used for remote control)
960-08200	Diversity cable for two ST-8000 connection
960-08001	Audio Input Cable - tinned wires for receiver
960-08002	XMTR Cable - tinned wires for transmitter
310-00020	1/4" Stereo AUDIO INPUT plug
333-20090	DE9P DIVERSITY Connector
333-51218	Shell for DE9 Connector
333-20250	DB25P TERMINAL DATA and REMOTE CONTROL Connector
333-51228	Shell for DB25 Connector

The Main Tuning Knob is removed from the shaft before shipment to prevent damage. Install the knob on the shaft by tightening both set screws in the knob with the Allen wrench provided. The rack mounting handles and table mounting feet and tilt bail assembly are installed on the ST8000 but may be removed as desired.

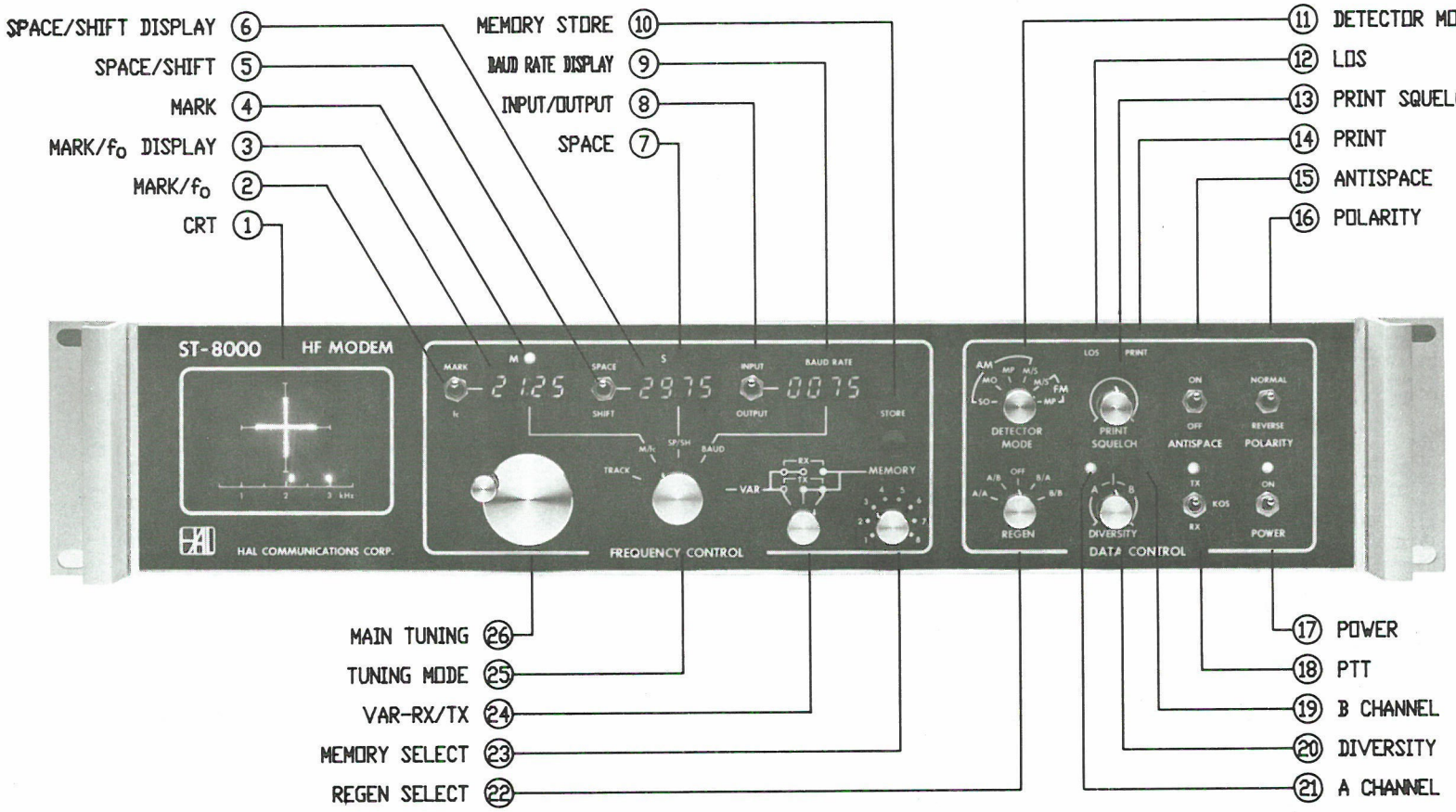


FIGURE 1. ST8000 HF MODEM

CHAPTER ONE
OPERATING THE ST8000

The ST8000 is a versatile instrument that may be adjusted to match the parameters of most high frequency radio digital communications signals. The front panel is arranged in three logical areas, outlined by the heavy white lines: CRT Indicator; Frequency Controls and Displays; and Data Controls. The following discussion is keyed to the number indentifiers in Figure 1.

1 CRT TUNING INDICATOR - shows X-Y ellipses for MARK and SPACE detector outputs and the HAL SPECTRA-TUNE### frequency spectral display (Section 1.2).

2 MARK/fo Switch - Sets left-hand display to show MARK or center frequency (fo); also affects action of MAIN TUNING control (Sections 1.1 & 1.3).

3 MARK/fo Display - Shows MARK or center frequency (fo) in Hz of receive filters and Mark transmit tone (Sections 1.1 & 1.3).

4 MARK DATA - Illuminated when a MARK signal condition is received.

5 SPACE/SHIFT Switch - Sets center display to show SPACE or SHIFT frequency; also affects action of MAIN TUNING control (Sections 1.1 & 1.3).

6 SPACE/SHIFT Display - Shows SPACE or SHIFT frequency in Hz of receive filters and Space transmit tone (Sections 1.1 & 1.3).

7 SPACE DATA - Illuminated when a SPACE signal condition is received.

8 INPUT/OUTPUT Switch - Sets right-hand display to show INPUT (received) or OUTPUT (regeneration) data rate in baud (Sections 1.1, 1.3, 1.6, & 1.11).

9 BAUD RATE Display - Shows INPUT baud rate for receive filter bandwidths or the OUTPUT REGEN I/O rates. (Sections 1.1, 1.3, 1.6, & 1.11).

10 MEMORY STORE - Store displayed frequency and baud rate parameters in selected MEMORY (Section 1.4).

11 DETECTOR MODE - Select detector mode (SO, MO, MP, M/S) and signal processing technique (AM/FM) (Section 1.7).

12 LOS Indicator - Illuminated when BOTH the PRINT SQUELCH and DIVERSITY circuits sense loss of signal (Sections 1.8, 1.12, & 1.13).

13 PRINT SQUELCH - Set print squelch level (Section 1.8).

14 PRINT Indicator - Illuminated when data output is enabled to the terminal for printing (Sections 1.8 & 1.12).

15 ANTISPACE Switch - When ON, prevents "open-loop" on received space signal longer than 180 ms (Section 1.9).

16 POLARITY Switch - Sets both receive and transmit data polarity to NORMAL or REVERSE (Section 1.10).

17 POWER Switch - Controls ALL power to ST8000.

18 PTT Switch - Selects receive only (RX), automatic keyboard RX/TX control (KOS), or transmit only (TX) modes (Section 1.13).

19 B CHANNEL Indicator - Illuminated when "B" Channel (other ST8000) is active in diversity system (requires two ST8000) (Section 1.12).

20 DIVERSITY Control - In dual ST8000 diversity system, sets threshold switch point from A to B channel. In single ST8000 system, sets amplitude squelch level (Section 1.12).

21 A CHANNEL Indicator - Illuminated when "A" Channel (this ST8000) is active in diversity system or when amplitude squelch is ON in single ST8000 system (Section 1.12).

22 REGEN Switch - Selects regeneration and code conversion; "A" = ASCII code, "B" = Baudot code (A/B = ASCII radio signal, Baudot data to terminal); baud rates shown by INPUT/OUTPUT Baud rates (Section 1.11).

23 MEMORY Switch - Select desired memory channel for storage or retrieval of preset parameters (Sections 1.4 & 1.5).

24 VAR-RX/TX Switch - Select variable tuning or memory fixed control of receive and transmit parameters (Sections 1.3, 1.4, & 1.5).

25 TUNING MODE Switch - Select desired tuning mode (Sections 1.3, 1.4, 1.5, & 1.6).

26 MAIN TUNING Control - Used with TUNING MODE switch to set all variable parameters of ST8000 indicated on the three digital displays (Sections 1.3, 1.4, 1.5, & 1.6).

1.1 TUNING CONTROLS

If you have not yet done so, install the main tuning knob on the shaft using the Allen wrench provided. Tighten both hex set screws in the Knob. Be sure to remove the knob if you must re-ship the ST8000.

When adjusting the ST8000, a few basic parameters of the RTTY signal must be determined. These parameters are:

1. SHIFT - difference between MARK and SPACE frequencies.
2. MARK or Center (fo) audio tone frequency.
3. BAUD rate of signal
4. CODE of signal (if REGEN is used)
5. POLARITY of signal (SPACE > MARK is NORMAL)

The related frequency parameters are shown below in Figure 2.

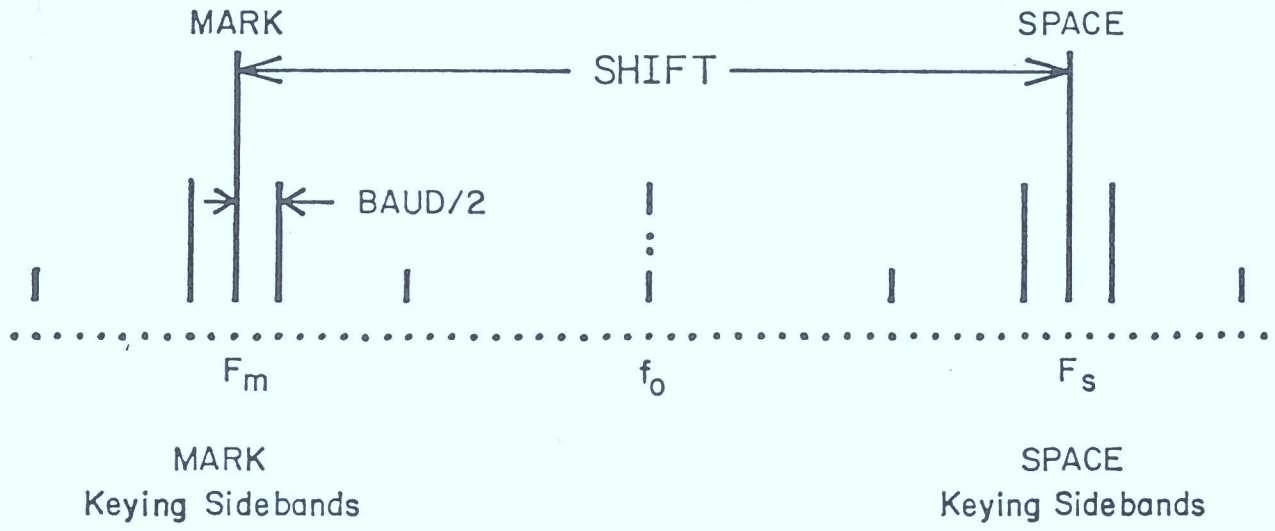


FIGURE 2. RTTY AUDIO SPECTRUM

The ST8000 features coupled adjustment of MARK, SPACE, SHIFT, and center frequencies, thus simplifying set-up procedures. All frequency and data rate parameters are set with the MAIN TUNING Control (No. 26 in Figure 1). Choice of parameter tuned is set by the TUNING MODE Control (No. 25) and the three switches adjacent to the displays (MARK/fo - #3, SPACE/SHIFT - #5, and INPUT/OUTPUT - #8). The controlled parameter for each switch combination is shown below.

TUNING MODE	MARK /fo	SPACE /SHIFT	INPUT /OUTPUT	MAIN TUNING CONTROLLED PARAMETER
BAUD	x	x	INPUT	M/S filter BW, Low Pass output filter BW, and receive data rate into regenerator.
BAUD	x	x	OUTPUT	Regenerated data rate.
SP/SH	x	SPACE	x	SPACE frequency of receive filters and transmit tones.
SP/SH	MARK	SHIFT	x	SPACE frequency of receive filters and transmit tones.
SP/SH	fo	SHIFT	x	MARK and SPACE frequency; Fo constant.
M/fo	MARK	x	x	MARK frequency of receive filters and transmit tone.
M/fo	fo	SPACE	x	MARK frequency of receive filters and transmit tones.
M/fo	fo	SHIFT	x	MARK and SPACE frequency, separated by the SHIFT.
TRACK	x	x	x	MARK and SPACE frequency; SHIFT constant.
"x" = switch position unimportant to this adjustment				

Notice that the MARK/fo, SPACE/SHIFT, and INPUT/OUTPUT switches affect BOTH the parameter displayed AND which parameters are changed by the MAIN TUNING Control.

1.2 TUNING INDICATOR

The CRT (Cathode Ray Tube) display is used to achieve correct tuning of the ST8000 controls. Two different tuning displays are shown on the face of the CRT. The upper section is devoted to the "standard" RTTY crossed-ellipse display of the MARK and SPACE detector filter outputs. Correct tuning is achieved when both MARK and SPACE tones of a RTTY signal are centered in the ST8000 MARK and SPACE filters. This is shown by a maximum major-axis deflection of the horizontal (MARK) and vertical (SPACE) ellipses. The width of each ellipse varies with the bandwidths of the ST8000 filters which are controlled by the selected Input Baud Rate.

The second tuning indicator is the HAL SPECTRA-TUNE - a line on the bottom of the screen showing the frequency spectra of received signals. Over the range of 500 to 3500 Hz, RTTY signals will appear as dots, one for MARK and the other for SPACE. The distance between the dots is proportional to the Shift of the RTTY signal. Thus the relative frequency and shift of the RTTY signal can be readily seen on this display. The SPECTRA-TUNE display will also show interfering signals and noise as additional dots on the frequency scale. This feature can be used to spot interference and adjust receiver passband tuning to minimize interference. If the receiver is set to a frequency where there are NO signals (only noise), the receiver passband tuning can then be adjusted for the appropriate audio range by observing the noise spectra on the CRT. However, strong noise on a signal will tend to smear the spectral display. In this case, rely upon the crossed-ellipse for tuning. At low data rates (110 baud and less), the spectral display shows dots for both MARK and SPACE signals. As the data rate is increased, the pattern smears and the displayed shift will be less than that of the actual signal. At 600 and 1200 baud, the spectral display shows the average center frequency rather than discrete MARK and SPACE frequencies.

To prevent "burning" the phosphor face of the CRT, the trace is deflected off-screen when valid RTTY signals are not detected. Presence of a continuous MARK pulse for more than 10 seconds also causes the trace to be turned off. The CRT trace can be restored at any time by setting the PRINT SQUELCH and DIVERSITY controls to minimum (CCW) positions OR by changing the setting of any front panel switch or tuning control. Setting PRINT SQUELCH and DIVERSITY to minimum gives a continuous CRT trace: changing switch positions restores the trace for 10 seconds (very useful for tuning and "quick-look" situations). The CRT trace may also be set externally to "ON" or "OFF" by switching to ground control lines on the TERMINAL DATA rear panel connector (Section 2.4.6). The "CRT ON/AUTO" remote control command may also be used to control the trace (Section 3.12). Other CRT parameters are set by internal circuits of the ST8000 and need no exterior adjustment. The various CRT ON/OFF controls are shown on the following page.

CRT TRACE ON:

1. PRINT SQUELCH or NON-DIVERSITY AGC SQUELCH sense valid signal and a LONG MARK is NOT detected (AGC SQUELCH ignored when dual ST8000 diversity is used).

2. Any front panel switch or frequency control is adjusted - holds for 10 seconds in lack of input from (1).

3. If pin 18 of TERMINAL DATA rear panel connector is held at ground, CRT trace stays ON, regardless of (1) or (2).

4. If "CRT ON" command is issued from Remote Control terminal.

CRT TRACE OFF:

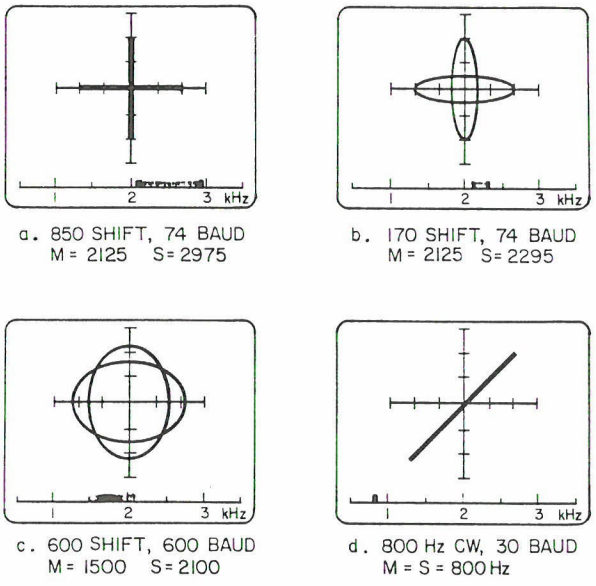
1. If remote control state is "CRT AUTO" and:

2. If both PRINT SQUELCH and NON-DIVERSITY AGC SQUELCH do not sense a valid signal (AGC SQUELCH ignored when dual ST8000 diversity is used).

3. If the output data to the receive printer remains in uninterrupted MARK state for more than 10 seconds.

4. If pin 25 of TERMINAL DATA rear panel connector is held at ground, CRT trace stays OFF, regardless of 1, 2, or 3.

Examples of typical tuning displays are shown in Figure 3.



a. 850 SHIFT, 74 BAUD
M = 2125 S = 2975

b. 170 SHIFT, 74 BAUD
M = 2125 S = 2295

c. 600 SHIFT, 600 BAUD
M = 1500 S = 2100

d. 800 Hz CW, 30 BAUD
M = S = 800 Hz

FIGURE 3. TYPICAL CRT TUNING DISPLAY

1.3 EXAMPLES OF TUNING ADJUSTMENTS

The tuning mode switch and three display switches allow a great deal of flexibility in how the ST8000 may be adjusted. The following examples show how to set-up the HF MODEM for various standard RTTY parameters. Pre-set the following switches:

```
      VAR-RX/TX = left-hand position (RX and TX variable)
         MEMORY = any position
       DETECTOR = M/S - FM
          REGEN = OFF
      ANTISPACE = OFF
       POLARITY = NORMAL
  PRINT SQUELCH = full CCW (counter clockwise)
      DIVERSITY = full CCW
      TX/KOS/RX = RX
```

EXAMPLE A: MARK, SPACE, and BAUD Known

PARAMETERS: MARK = 2125 Hz, SPACE = 2295 Hz
BAUD = 0074 BD

STEP	------SWITCH SETTINGS---------- MARK /fo	SPACE /SHIFT	INPUT /OUTPUT	TUNING MODE	ACTION
1	MARK			M/fo	Set MARK = 2125
2		SPACE		SP/SH	Set SPACE = 2295
3			INPUT	BAUD	Set BAUD = 0075
---OTHER PARAMETERS OF INTEREST---					
4	fo				Read fo = 2210
5		SHIFT			Read SHIFT = 0170

EXAMBLE B: MARK, SHIFT, and BAUD RATE known.

PARAMETERS: MARK = 1275 Hz, SHIFT = 425 Hz
BAUD = 0045 BD

STEP	------SWITCH SETTINGS---------- MARK /fo	SPACE /SHIFT	INPUT /OUTPUT	TUNING MODE	ACTION
1	MARK			M/fo	Set MARK = 1275
2		SHIFT		SP/SH	Set SHIFT = 0425
3			INPUT	BAUD	Set BAUD = 0045
---OTHER PARAMETERS OF INTEREST---					
4	fo				Read fo = 1488
5		SPACE			Read SPACE = 1700

EXAMPLE C: CENTER FREQUENCY (fo), SHIFT, and BAUD rate known.

PARAMETERS: fo = 1700 Hz, SHIFT = 170 Hz
BAUD = 0100 BD

STEP	------SWITCH SETTINGS---------- MARK /fo	SPACE /SHIFT	INPUT /OUTPUT	TUNING MODE	ACTION
1	fo			M/fo	Set fo = 1700
2		SHIFT		SP/SH	Set SHIFT = 0170
3			INPUT	BAUD	Set BAUD = 0100
---OTHER PARAMETERS OF INTEREST---					
4	MARK				Read MARK = 1615
5		SPACE			Read SPACE = 1785

The ST8000 may also be used to correct for frequency drift in either the receiver or the sending station's transmitter.

EXAMPLE D: TRACKING A DRIFTING SIGNAL

1. Set-up initial parameters as per examples A, B, or C.
2. Set tuning mode switch to TRACK
3. Use tuning knob to adjust for proper CRT crossed-ellipse trace, following the frequency drift.
4. The amount of frequency drift can be determined by comparing the original MARK/fo and SPACE frequencies to those displayed after adjustment.

The ST8000 may also be used to determine the parameters of an unknown RTTY signal as in the following example:

EXAMPLE E: DETERMINING PARAMETERS OF UNKNOWN RTTY SIGNAL

STEP	------SWITCH SETTINGS---------- MARK /fo	SPACE /SHIFT	INPUT /OUTPUT	TUNING MODE	ACTION
1	MARK			M/fo	Set MARK = 1275
2		SPACE		SP/SH	Set SPACE = 2125
3			INPUT	BAUD	Set BAUD = 0100
4			OUTPUT	BAUD	Set BAUD = that for your RTTY terminal
5					If terminal is BAUDOT, Set REGEN = B/B. If terminal is ASCII, Set REGEN = B/A.
6					Tune RECEIVER for best CRT X-axis trace on LOWER RTTY tone.
7		SPACE		SP/SH	Tune ST8000 for best CRT Y-axis trace on HIGHER RTTY tone.
8			INPUT	BAUD	Set BAUD for correct print on terminal. Try NORMAL and REVERSE POLARITY for 45,50,57, 74,100, and 110 BAUD.

This procedure will at least determine the correct shift of the unknown RTTY signal and may also establish the code, baud rate, and polarity of the signal. However, many HF RTTY signals use other than the Baudot codes and therefore may not be processed by the ST8000 REGEN circuit. If so, turn the ST8000 REGEN to off and use a terminal whose code and baud rate match that of the received signal.

For example, marine SITOR transmissions can be processed by the ST8000 filter and detectors circuits but NOT by the REGEN circuit. In this case, use the ST8000 with REGEN OFF to recover the data pulses and then perform the code conversion in a SITOR terminal such as the HAL ARQ1000. NOTE: ALL SITOR transmissions presently use 100 BAUD, synchronous data.

The ST8000 may also be used for reception of Morse code (CW) signals. In this case, use the single-tone detection capability of the ST8000.

EXAMPLE F: MORSE CODE RECEPTION

	------SWITCH SETTINGS----------				
STEP	MARK /fo	SPACE /SHIFT	INPUT /OUTPUT	TUNING MODE	ACTION
1	MARK			M/fo	Set MARK = 0800
2		SPACE		SP/SH	Set SPACE = 0800
3			INPUT	BAUD	Set BAUD = 0050
4					Set DETECTOR = MO-AM
5					Tune receiver for a 45 degree diagonal line on the CRT. Reduce BAUD to reduce filter bandwidth as desired.

1.4 MEMORY FEATURE

The ST8000 has eight front panel selectable memory locations that may be used to store frequently used signal parameters. The primary first three memory locations are labeled on the front panel. Memory locations 4 through 8 are secondary and not labeled on the front panel. These locations are intended for use when the ST8000 is controlled through the REMOTE CONTROL I/O port, but may be accessed for full front-panel control by advancing the switch sequentially beyond position three. All eight memory locations are non-volatile (not erased when power to the ST8000 is turned off). The parameters stored for each location are:

MARK receive filter frequency
SPACE receive filter frequency
Center Frequency
SHIFT frequency
INPUT BAUD rate
OUTPUT BAUD rate (REGEN only)
Transmit MARK tone frequency
Transmit SPACE tone frequency

To store parameters in memory, select the desired memory, put the VAR-RX/TX switch (No. 24) in the left or center position and set the above parameters on the front panel. Next, select the desired memory channel (1-8) and then push and hold down the STORE button. Release the STORE button after the three digital displays flash off and back on. The "long-push" nature of this control is designed to prevent changing memory contents by an accidental "short-push" of the STORE button. The memories may be reprogrammed as often as desired. The memories may be set for transceive (transmit tones same as receive filters) or for split-frequency operation. The operation of the VAR-RX/TX switch (No. 24) is explained below (also refer to Figure 1).

VAR - RX / TX SWITCH OPERATIONS

SW POSITION	FUNCTION
Left VAR RX VAR TX	Both RX & TX freq. set by tuning controls and shown on displays. (TX and RX same tones)
Center VAR RX MEM TX	Receive freqs. set by tuning controls; TX freqs. from selected memory. Displays show RX freqs. 70% of time and TX freqs. 30% of time (colon in center = TX).
Right MEM RX MEM TX	Both RX & TX freqs. controlled by selected memory. Displays show RX/TX parameters (70% RX, 30% TX with colon.

Some points to remember when programming the memories are:

1. In the left position of the VAR-RX/TX switch, the transmit and receive frequencies are the SAME. If the STORE button is pressed, the receive and transmit parameters of the selected memory are programmed to the values shown on the displays. (TRANSCEIVE same frequency condition).

2. The center position of the VAR-RX/TX switch sets receive parameters to the front panel controls and transmit parameters to the selected memory. If RX and TX parameters are different, the displays show RX frequencies 70% of the time and TX frequencies 30% of the time (colon = TX freqs.).

3. The right position of the VAR-RX/TX switch sets BOTH RX and TX parameters to those of the selected memory. The front panel tuning controls have NO effect in this mode. If TX and RX frequencies are different, the displays show RX freqs. 70% of the time and TX freqs. 30% of the time (colon = TX).

4. Transmit frequencies must ALWAYS be programmed in left switch position (VAR RX / VAR TX).

5. To store "split" frequencies (different TX _& RX freqs.), set switch to left position, set transmit frequencies with front panel controls and press STORE. Next, set the VAR-RX/TX switch to the center position, set receive frequencies with the tuning controls and press STORE again. The display will "time-share" between receive and transmit frequencies (colon = TX).

1.5 TRANSMIT TONE FREQUENCIES

Transmit tones may be controlled by either the variable front panel tuning controls or by frequencies stored in a memory channel. The left-hand position of the VAR-RX/TX switch gives "transceive" operation where the transmit tones are the same as the receive filter frequencies. Both transmit and receive frequencies are VARiable, set by front panel tuning controls. The center and right-hand positions of the VAR-RX/TX switch fix the transmit tones to those programmed in the selected memory. As discussed in Section 1.4, "split-frequency" transmit-receive operation is also possible. When the transmit and receive frequencies are not the same, the MARK and SPACE frequency displays are "time-shared" to show receive frequencies 70% of the time and transmit frequencies 30% of the time. The presence of the colon (:) between the 2nd and 3rd digits (eg 21:25) indicates that the transmit tone frequency is being displayed.

1.6 BAUD RATE SETTINGS

The tuning controls allow setting of both the INPUT and OUTPUT BAUD rates of the ST8000, as shown on the BAUD display. Any data rate from 10 to 1200 baud may be set. The BAUD settings also control the REGEN feature as explained in Section 1.11. The OUTPUT BAUD setting is used ONLY for the REGEN feature. The INPUT BAUD setting is also used to compute and set the following receive filter parameters:

1. Input Filter Selection
2. MARK Filter Q
3. SPACE Filter Q
4. LP Filter Bandwidth

When the REGEN switch is set to OFF, the INPUT BAUD setting may be thought of as a bandwidth control for the receive demodulator. The optimum filter bandwidths for minimum distortion are selected when INPUT BAUD is set equal to the radio signal data rate. However, under some signal conditions, you may wish to decrease bandwidth by using a lower INPUT baud rate setting or increase bandwidth with a higher INPUT baud setting. This is a particularly convenient feature when interference is heavy or when the receive bandwidth is marginal for signals with a high data rate. The baud rate setting may deviate from that of the received signal by as much as -30% to +50% with a tolerable amount of distortion. For low data rates, use of a higher baud rate and therefore wider bandwidth will reduce inter-symbol distortion and simplify receiver tuning, but at the expense of reduced immunity to noise. Conversely, using a lower baud rate setting reduces the noise bandwidth but at the expense of increased distortion. A reduced baud rate/bandwidth may be beneficial when receiving data rates of 300 to 1200 baud. However, if REGEN is used, the INPUT baud rate setting MUST agree with the data rate of the received signal (see Section 1.11).

1.7 DETECTOR MODE

Either hard-limiting FM or AGC-controlled AM signal processing may be used in the ST8000. The choice of which technique should be used varies with signal conditions. The sensitivity and dynamic range of the ST8000 are the same for each mode. Most narrow-shift (170 Hz or less) HF RTTY signals with little M/S fading will be best demodulated using the FM mode with the M/S detector. However, conditions of strong M/S differential fading, adjacent-channel interference, or interference on either the MARK or SPACE tone frequencies may dictate that the AM mode be used. In addition, some propagation paths may induce multi-path distortion of the RTTY signal, requiring use of the MP detector in either AM or FM mode. Typical signal conditions for each mode and detector output are:

MODE	DETECTOR	APPLICATION
FM	M/S	Most common narrow-shift RTTY signals, particularly when heavy fading of both MARK and SPACE is also present; simplest to use.
FM	MP	Use when both heavy fading and multi-path distortion are present; may add distortion to otherwise "clean" RTTY signal.
AM	M/S	Use if strong MARK/SPACE fading or adjacent-channel interference is present.
AM	MP	Use if both strong adjacent-channel interference and multi-path distortion is present.
AM	MO	Use if strong interference is noted on SPACE tone frequency. Also, used for CW or other OOK (On-Off Keyed) signal.
AM	SO	Use if strong interference is noted on MARK tone frequency.

1.8 PRINT SQUELCH

This control allows adjustment of the squelch threshold of the ST8000 (sometimes called "Autostart Threshold"). The Print Squelch circuit compares the detected outputs from the MARK and SPACE filters and allows printing only when a valid RTTY signal is present in both channels. The printer output is held in a continuous MARK condition until a valid RTTY signal is sensed. PRINT SQUELCH operates in a manner similar to that on a VHF radio: minimum (full CCW) setting "opens" the squelch, passing all signals and maximum (full CW) "closes" the squelch to all but the strongest signals.

To adjust PRINT SQUELCH, set the DIVERSITY and PRINT SQUELCH controls to minimum (CCW) and tune the receiver to a frequency at which only noise is received (no signals). Advance PRINT SQUELCH (CW) until the PRINT lamp just turns OFF. Test the setting by tuning the receiver to a valid RTTY signal. After a short delay, the PRINT lamp should come ON and data will be sent to the printer. The setting of this control will vary with receiver noise level and the receiver filter selected.

The LOS and PRINT lamps and data output to the printer interact with the DIVERSITY control when NON-DIVERSITY AGC SQUELCH is used. This is discussed in more detail in Sections 1.12b and 1.13.

The trace ON/OFF circuit of the CRT is also driven by the PRINT SQUELCH circuit as discussed in Section 1.2. Therefore, it is recommended that you set PRINT SQUELCH to minimum (CCW) when tuning the receiver for new RTTY signals. Also, the control should be set to minimum whenever MO (MARK Only) or SO (SPACE Only) detectors are used.

1.9 ANTISPACE

The Antispace circuit is designed to prevent continuous spacing condition of the terminal printer when a strong continuous signal appears on the SPACE tone frequency. The time constants are optimized for data rates from 45 to 150 baud. Antispace is best used when monitoring RTTY signals within this range of data rates. It should be turned OFF when tuning, using MO or SO detectors, or when data rates slower than 45 or higher than 150 baud are to be received.

1.10 POLARITY

The Polarity switch controls the Mark-Space polarity of BOTH the receive output data and the transmit tones. This switch allows a rapid means of testing unknown RTTY signals for polarity without readjusting the receiver sideband selection or the ST8000 MARK and SPACE tuning controls. After correct polarity is determined, you may wish to reset the receiver sideband or the ST8000 tuning controls for reception in the NORMAL polarity position.

1.11 REGEN FEATURE

The ST8000 REGEN feature is very powerful and may be used for a number of different applications. The REGEN switch and INPUT/OUTPUT data switches are inter-related. The operation of the REGEN switch is as follows:

REGEN POSITION	INPUT CODE (From/To Radio)	OUTPUT CODE (To/From Terminal)
A/A	ASCII	ASCII
A/B	ASCII	BAUDOT
OFF	any	same as radio
B/A	BAUDOT	ASCII
B/B	BAUDOT	BAUDOT

The Baud rate of the radio signal may be different from that of the terminal, thus providing a speed conversion capability. Use the INPUT/OUTPUT BAUD switch in conjunction with the TUNING MODE switch and MAIN TUNING control knob to set the two baud rates.

The speed conversion capability does, however, present potential buffer storage problems for receive or transmit data to the terminal. For example, if a 45 baud Baudot signal is being received and then converted to a 74 baud Baudot signal (B/B option), the receive data arrives at a slower rate than the terminal printer operates and there is no buffer problem for received data. However, when the keyboard of the same 74 baud Baudot terminal is used to transmit, characters are transmitted from the ST8000 tone keyer at 45 baud, much slower than they are generated. In this case, the RS232C CTS (Clear-To-Send) control signal should be connected to the terminal to prevent loss of transmit characters which might otherwise occur if the 256 character buffer overflows.

However, if the data from the receiver is at a higher baud rate than the terminal, a similar control signal is not available to slow the transmitting station's character rate. In this case, the 256 character buffer of the ST8000 REGEN circuit will help for short transmissions, but will quickly overflow on a continuous data stream. Therefore, speed conversion will be most sucessful when the terminal is operated at a HIGHER data rate than that of the received signal, but ONLY if CTS is used to control the terminal transmit data stream. When ASCII is used as the terminal I/O code, BOTH CTS and X-ON/X-OFF (DC1/DC3) protocols are available: Baudot terminals must use the RS232C CTS signal.

If both code and speed conversion are used, note that the character rate of a Baudot signal is faster than that of an ASCII signal of the same data rate. For example, 74 baud Baudot has a character rate of 10/sec, while a 75 baud ASCII signal has a character rate of 6.8/second. Thus, an ASCII terminal should be operated at 110 baud or higher to receive 74 baud Baudot signals that have been processed by the REGEN circuit.

The REGEN feature is particularly useful when a mechanical machine is used as the data terminal. In this case, the REGEN circuit provides a clean, minimum distortion RTTY signal to the machine's selector magnet drivers. When using a CRT terminal that has multi-code and multi-speed capability (HAL DS3100ASR for example), the REGEN circuit should be set to OFF as the electronic terminal already includes the data regeneration feature plus buffer storage. However, the code and speed conversion capability may be put to good use when using an ASCII code device such as a computer or computer terminal with the ST8000 to receive Baudot signals.

1.12 DIVERSITY FEATURE

The ST8000 is in itself a two-tone diversity demodulator, making full use of the data available in both the MARK and SPACE data signals. Correct print will be maintained even when deep fades temporarily eliminate the SPACE or MARK signal. The AM-M/S Detector mode gives the best results in these conditions.

1.12.1 TWO-RECEIVER DIVERSITY

The ST8000 also contains a unique capability to use the data outputs from dual radio receiver and ST8000 systems. In this system, two RTTY receiving systems are interconnected to give protection from selective fading of the received signal from either receiver. A complete two-channel diversity system requires two receivers and two ST8000 HF Modems. A single-frequency diversity system uses spaced and often different style receiving antennas connected to separate receiver/ST8000 systems to assure that fading rates at the two antennas are different. This is usually called "space diversity" or "spaced-antenna diversity". If the desired RTTY signal is transmitted simultaneously on two different frequencies, the receivers and antennas may be adjusted to take advantage of differing propagation conditions. This is often called "frequency diversity".

The ST8000 Infinite Resolution Diversity circuit will work with any two-channel receiver system in which separate audio outputs are available. Unlike other diversity combiners, the ST8000 does NOT simply sum the detected Mark and Space signals from each channel for the diversity output. This technique is very susceptable to over-load from on-channel (MARK or SPACE) interference from either receiver and performance is often BETTER when such a diversity system is turned OFF.

Rather, the ST8000 diversity circuit samples the signal strength AND Print Squelch conditions of EACH radio signal. Dynamically, the "best" RTTY signal is chosen from the two available signals. Further, the decision point between the two signal strengths is infinitely adjustable with the front panel DIVERSITY control. When this control is at midpoint ("12 O'clock"), the switch threshold is set for equal AGC voltage and therefore equal signal strengths in the two audio channels. When the control is CCW of center (towards "A"), the decision point will favor weaker "A" channel signals. Conversely, a CW position favors the "B" channel. Thus, the decision point may be set to compensate for differences in antenna efficiencies, receiver gain, or signal strength between the two diversity receiver channels.

The diversity control samples the AGC voltage of each ST8000, producing a decision switch between the two channels corresponding to the control setting. To prevent rapid switching between signals that might be caused by "flutter" or rapid fading of one signal, a dual-rate integrator is used to control the actual change from one channel to the other. When the variation in signal strength is less than approximately +/- 5 dB, the transistion will be much slower than if the difference between the two signals is, say, 10 or 20 dB. The "A" and "B" lamps indicate which diversity channel is presently being used for output data to the terminal printer. The "A" lamp refers to signals processed by the "local" ST8000 demodulator; "B" channel is the "other" ST8000 demodulator.

The diversity feature applies ONLY to receive data and the transmitter will be keyed ONLY by the ST8000 and terminal combination connected to the transmitter.

As will be discussed in Section 2.7, an internal jumper in the ST8000 may be removed to allow BOTH the "A" and "B" channel inputs to the diversity circuit to be driven from external devices. A most useful application of this feature is to monitor the receiver AGC voltages of identical receivers in a diversity system, basing the decision switch point upon receiver AGC rather than ST8000 audio AGC. However, be careful to observe the voltage and impedance limitations mentioned in Chapter 2.

1.12.2 NON-DIVERSITY AGC SQUELCH

Since diversity reception may not be a normal mode for most data communications systems, the ST8000 Diversity feature also serves as a single channel signal-strength controlled print squelch, different from the PRINT SQUELCH control described in Section 1.8. When a second ST8000 is either disconnected or turned off, this condition is sensed and the entire range of the DIVERSITY control is used as a second print squelch control, driven by input signal amplitude alone. This squelch output also controls the CRT beam as explained in Section 1.2. The action of the dual-squelch system is additive -- received data is not passed to the terminal printer until BOTH PRINT SQUELCH and AGC SQUELCH criteria are met. Either squelch system may be defeated by setting its respective control to full CCW position. When using a single-channel RTTY system to monitor a frequency channel, the combined squelch system may be used to give very clean signal/no-signal discrimination.

1.13 LOS, PRINT, RX DATA, AND MOTOR CONTROL

The LOS and PRINT lamps and the data passed to the terminal printer are affected by several parameters of the ST8000. In a non-diversity, single ST8000 system, the LOS lamp will not turn ON until a signal-loss condition is sensed in BOTH the PRINT SQUELCH and NON-DIVERSITY AGC SQUELCH circuits. In a dual ST8000 diversity system, ONLY the PRINT SQUELCH status drives the LOS lamp. The RS232C "CD" signal (pin 8 of the TERMINAL DATA connector) has the inverse of the LOS lamp state: high when the LOS lamp is OFF and low when LOS is ON.

The PRINT lamp is ON only when valid data is passed to the terminal printer device. In a single-channel (non-diversity) system, BOTH the PRINT SQUELCH and AGC SQUELCH circuits must sense a valid signal for receive data to be printed or for the PRINT lamp to turn ON. In a dual ST8000 diversity system, receive data and PRINT LAMP are controlled by the PRINT SQUELCH signals of both demodulators. Therefore, data will be printed when PRINT SQUELCH from the selected demodulator channel permits. As noted in Sections 1.8 and 1.12, the effect of either squelch system may be defeated by simply setting the PRINT SQUELCH controls to minimum (CCW).

The ST8000 also includes provision for control of a relay to switch power ON and OFF to a teleprinter motor (pin 12 of TERMINAL DATA connector). The motor control signal follows the operation of the PRINT lamp except that an additional time-delay is added, holding the motor relay ON for 20 seconds after the PRINT lamp is turned OFF. This prevents rapid ON/OFF switching of the motor. This feature may be used when the ST8000 is connected to the LP1200 to drive a TTY loop-connected printer.

As noted in Section 1.2, the CRT trace ON/OFF control also interacts with the settings of the PRINT SQUELCH and DIVERSITY controls and the Remote Control "CRT ON/AUTO" command.

1.14 TRANSMITTER PTT CONTROL

The TX-KOS-RX switch allows positive front panel control of the transmitter PTT (Push-To-Talk or transmit/receive) control line. The KOS (Keyboard Operated Switch) position allows use of the ST8000's internal automatic transmit-receive sensing circuit. The KOS circuit will automatically go to transmit state when a Mark-to-Space transition is detected on the input data from the terminal (TXD). The PTT line will then stay in transmit condition for a period of 1-10 seconds, depending upon the setting of an internal control (KOS Delay - see Chapter 2). The PTT line may also be rapidly forced to the receive condition by application of a continuous space condition for greater than 0.5 seconds ("BREAK-mode" override).

The RX switch position selects receive mode UNLESS the RS232 RTS control signal OR the terminal KOS input signal indicate transmit condition. Thus, the transmitter may be controlled manually from the ST8000 front panel (TX position), automatically by the ST8000 KOS circuit (KOS position), or externally by RTS or terminal KOS (RX position). In any case, the TX lamp is on when the transmitter PTT line is in transmit state.

CHAPTER TWO
CONNECTIONS AND OPTION SELECTION

A minimum of five cable connections are required to install the ST8000 in a radio data system. These are: (1) RF ground wire, (2) AC power, (3) Audio from the receiver, (4) Audio (or FSK) and PTT control to the transmitter, and (5) Data to and from the terminal device. Cables may also be connected for diversity operation and for remote control of front panel features. In addition to these connections, internal option switches must be set to match the parameters of the receiver and transmitter.

2.1 CONNECTOR AND JUMPER LOCATION

Refer to Figure 4 for the location of the seven rear panel connections. Wiring of each connector will be discussed in this Chapter.

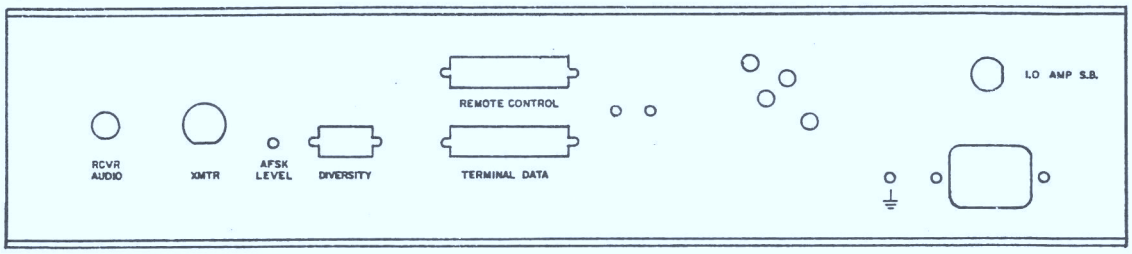


FIGURE 4. REAR PANEL CONNECTIONS

In addition to making the proper cable connections, a number of internal switches must also be set. Most of the option switches are located on the lower of the two large circuit boards in the ST8000. To gain access to these option switches, it is necessary to remove the cabinet top cover and pivot the upper circuit board.

```
**                                                              **
**  CAUTION - BE SURE TO DISCONNECT THE AC POWER CORD BEFORE     **
**            OPENING THE CABINET OF THE ST8000.                **
**                                                              **
```

Refer to Figure 5 and do the following:

1. Remove 12 4-40 screws from the top cover.

2. Remove the top cover and set it and the screws aside.

3. Orient the cabinet so that the front panel faces toward you.

4. Refering to Figure 5, locate the cable between the upper circuit board and the REMOTE CONTROL rear panel connector: unplug this cable from the board.

5. Locate and remove the three REAR hold-down screws for the top circuit board. DO NOT REMOVE the front two hold-down screws.

6. Grasp the rear edge of the top board and GENTLY swing it up toward the front panel until it is vertical. Be sure to dress the REMOTE CONTROL cable so that it does not interfere with pivoting of the top circuit board. You may wish to use an insulated rod or alignment tool to prop the top circuit board in a vertical position.

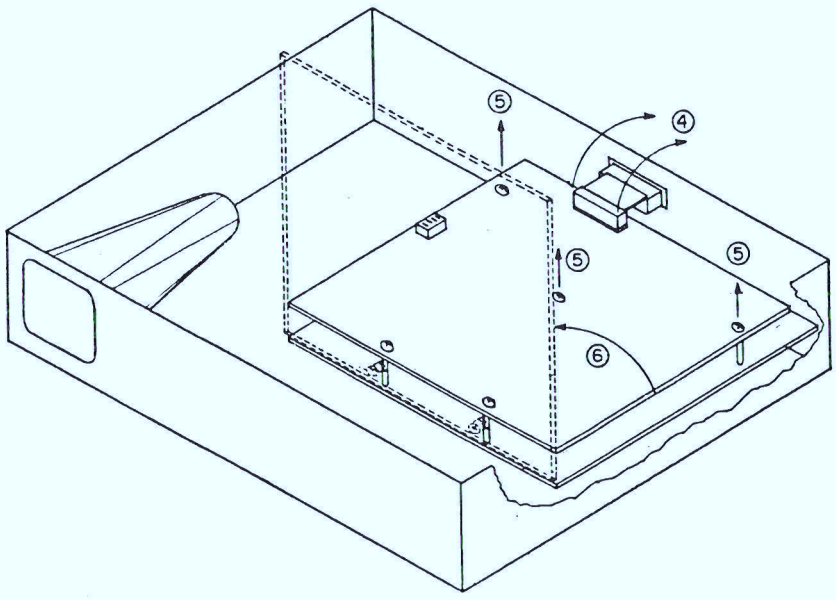


FIGURE 5. ACCESS TO LOWER CIRCUIT BOARD

The location of the option switches is shown in Figure 6.

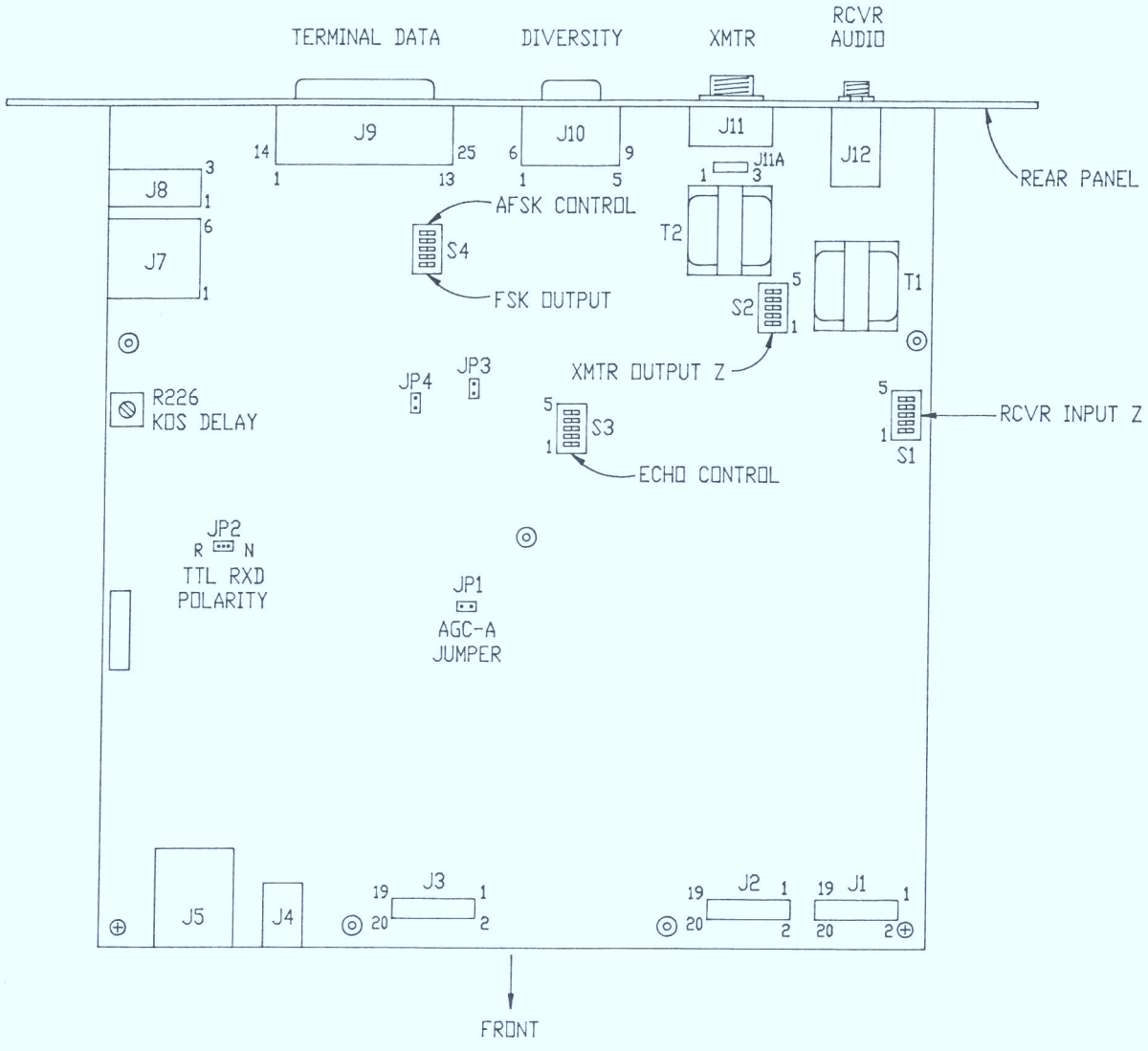


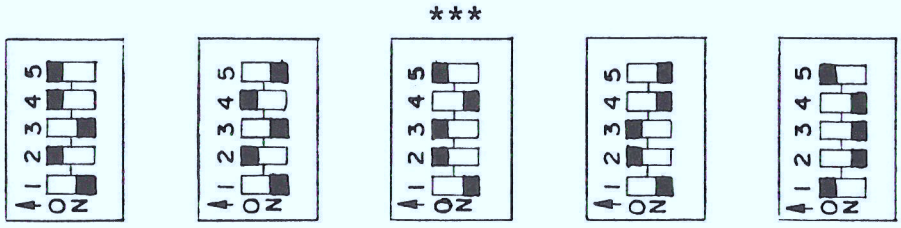
FIGURE 6. OPTION SELECTIONS ON DEMODULATOR BOARD

2.2 RECEIVER CONNECTIONS

The ST8000 HF Modem requires audio output signals from the radio receiver. Receiver output impedances from 8 to 10K ohms can be matched by the ST8000 input circuitry. The ST8000 can also be set for balanced or unbalanced audio input. These options are chosen with the DIP switch near the RCVR AUDIO rear panel jack, switch S1. Be sure that only the indicated options for each switch are turned on. For example, do NOT turn ON both S1-1 and S1-2, S1-3, or S1-4; do NOT set S1-2 and S1-3 both ON. The factory setting is with S1-2, S1-3, and S1-5 ON; S1-1 and S1-4 OFF - 600 ohms, unbalanced input. Set switch S1 to match your receiver as follows:

	----8 OHMS----		---600 OHMS---		10K OHMS
S1 POS.	UNBAL.	BAL	UNBAL.	BAL	UNBAL
S1-5	ON	OFF	ON	OFF	ON
S1-4	ON	ON	OFF	OFF	OFF
S1-3	OFF	OFF	ON	ON	OFF
S1-2	ON	ON	ON	ON	OFF
S1-1	OFF	OFF	OFF	OFF	ON

SET S1



FACTORY SETTING -- ***

(A partial schematic diagram of switch S1 appears in section 2.10 at the end of this chapter.)

Refer to Figure 7 and connect a 1/4" stereo phone plug to the receiver audio output. Note that in un-balanced systems, both the "ring" and "sleeve" terminals are at ground potential: in balanced audio systems, only the "sleeve" is connected to ground.

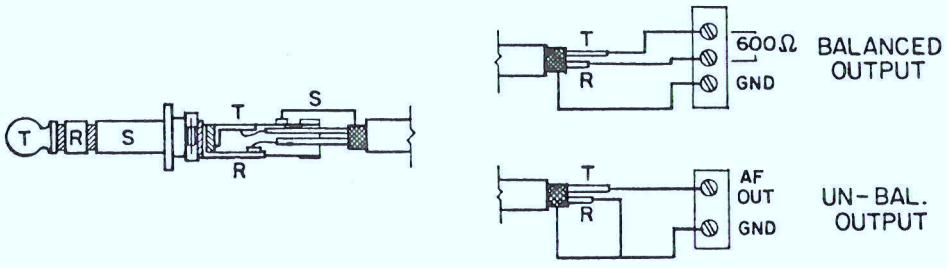


FIGURE 7. RCVR AUDIO CONNECTIONS

2.3 TRANSMITTER CONNECTIONS

The XMTR connector may be used for connections to either a SSB transmitter using audio tones or a transmitter with direct FSK input. Before making any connections, refer to the transmitter instruction manual and decide whether you will use audio tones to a SSB transmitter or FSK pulses to an FSK-equipped transmitter. Selection of the desired connection is made with switch S2.

2.3.1 AFSK TRANSMITTER CONNECTION

Two ranges of transmit audio output level are available. The HIGH LEVEL range is intended for use with 600 ohm balanced or unbalanced transmitter audio inputs. A LOW LEVEL output should be used when connecting directly to a low-level microphone input. The output levels are also adjustable over a 35-40 dB range with the rear panel AFSK LEVEL control. The available output levels into a 600 ohm load are:

	MAX. OUTPUT (full CW)	MIN. OUTPUT (10% CW)
HIGH LEVEL	+6 dBm (1.1 V rms)	-36 dBm (100 mV rms)
LOW LEVEL	-6 dBm (.55 V rms)	-50 dBm (44 mV rms)

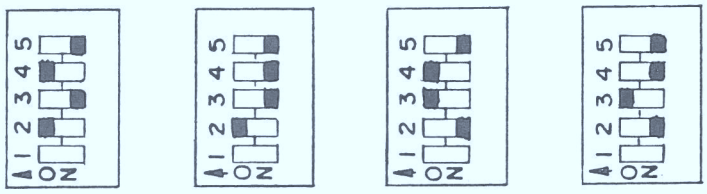
FACTORY SETTING = HIGH LEVEL, 0 dBm

Refer to the transmitter instruction manual to determine audio input level requirements. The ST8000 output level and balanced/unbalanced options are set with switches S2-2 through S2-5 as follows (see Figure 6 for location):

	--HIGH LEVEL--		--LOW LEVEL--	
S2 POS.	UNBAL.	BAL	UNBAL.	BAL
S2-5	OFF	OFF	OFF	OFF
S2-4	ON	OFF	ON	OFF
S2-3	OFF	OFF	ON	ON
S2-2	ON	ON	OFF	OFF

***

SET S2



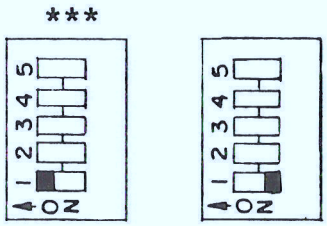
FACTORY SETTING -- ***

(A partial schematic of switch S2 appears in section 2.10 at the end of this chapter.)

Note that S2-5 is always OFF for AFSK tones.

Some transmitter audio inputs have a DC bias voltage on the microphone input. Use the DC-isolation option for connection to this type of transmitter. Refer to the transmitter instruction manual to determine if DC-isolation is required. Switch S2-1 provides a choice of DC-continuity (50 ohms) or AC coupling (0.47 uF series capacitor) to the XMTR output. Settings of S2-1 for DC isolation are shown below:

	DIRECT CONN.	DC ISOL.
S2-1	ON	OFF

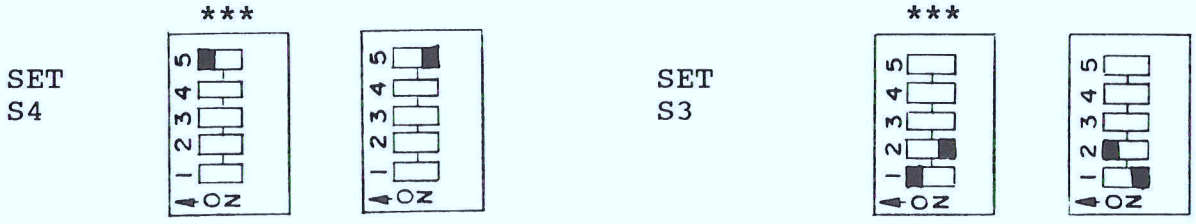


FACTORY SETTING -- ***

The ST8000 AFSK may be set for output only when transmitting or for continuous output, regardless of transmit/receive condition. The source of tone-keying data may also be set for transmit data only (from TXD on the TERMINAL DATA connector), or for transmit data when transmitting and demodulated receive data (RXD) when in receive mode. Switch S4-5 controls the AFSK tone ON/OFF condition. Other sections of S4 are used for FSK options (see Section 2.3.2). Switches S3-1 and S3-2 control the data source used to key the AFSK tones. Switches S3-3 through S3-5 are used for receive echo options (see Section 2.4).

	---AFSK TONE ON---- TX Only	TX and RX
S4-5	ON	OFF

	AFSK KEYING SOURCE TXD	TXD and RXD
S3-2	OFF	ON
S3-1	ON	OFF



*** --- FACTORY SETTINGS --- ***

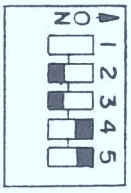
AFSK output connections are made to the XMTR connector on the ST8000 rear panel. Refer to Figure 8a when connecting the ST8000 to an AFSK driven transmitter.

2.3.2 DIRECT FSK CONNECTION

If your transmitter requires FSK input signals, switch S2-4 and S2-5 should be set ON. S2-2 and S2-3 should be set OFF. S2-1 has no effect in FSK mode. The polarity of ST8000 FSK output voltage is set with switch S4-3 and S4-4. The output level of the FSK voltage is set with switches S4-1 and S4-2. Switch S4-5 controls AFSK tone ON/OFF as explained in Section 1.2a and will not affect FSK operation.) Refer to the transmitter manual to choose the proper option.

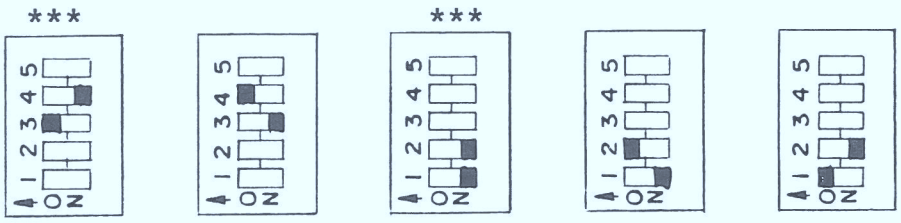
	FSK
S2-2	OFF
S2-3	OFF
S2-4	ON
S2-5	ON

SET S2



	----FSK POLARITY--- NORMAL M = HIGH	REVERSE S = HIGH	---FSK KEYING VOLTAGE--- OPEN COLLECTOR	+5V	+8V
S4-4	OFF	ON	--choose		
S4-3	ON	OFF		polarity	
S4-2	choose		OFF	ON	OFF
S4-1	voltage--		OFF	OFF	ON

SET S4

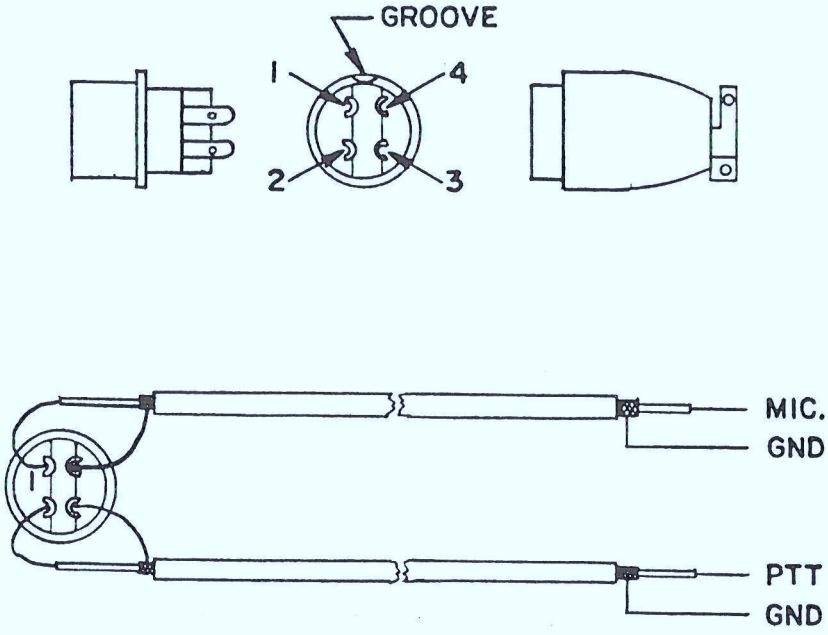


*** FACTORY SETTINGS ***

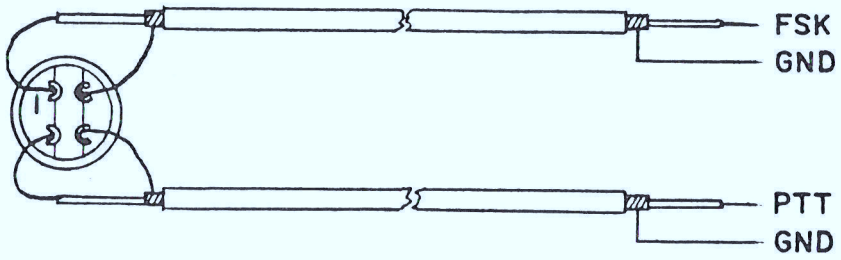
(A partial schematic of switch S4 appears in section 2.10 at the end of this chapter.)

Note: The FSK option may be used to key ONLY positive voltage to ground circuits. A relay or additional isolation switching transistors will be required to key a negative voltage FSK circuit.

Plug connections to an FSK transmitter are shown in FIGURE 8b.



8a. AFSK XMTR



8b. FSK XMTR

FIGURE 8. XMTR PLUG CONNECTIONS

2.4 TERMINAL DATA CONNECTIONS

The RTTY teleprinter, CRT terminal, or computer data signals are available at the TERMINAL DATA connector. Depending upon the terminals used, data signals using RS232C, MIL-188C, or TTL formats may be used.

****

NOTE: The ST8000 does NOT have a high voltage loop connection for the terminal. If such a connection is required, the HAL LP-1200 Dual Current LOOP Supply should be purchased and added between the ST8000 and the loop terminal.

SERIOUS DAMAGE WILL BE CAUSED IF A HIGH-VOLTAGE LOOP IS CONNECTED DIRECTLY TO THE ST8000.

****

The signals available on the TERMINAL DATA connector are:

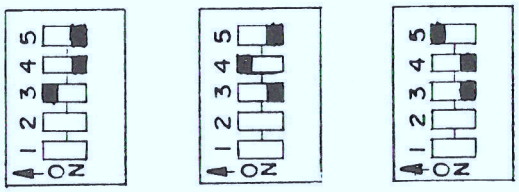
PIN	FUNCTION
1	Cabinet Ground
2	RS232 TXD - Input data to be transmitted
3	RS232 RXD - Demodulated received data
4	RS232 RTS - From terminal; high = transmit
5	RS232 CTS - To terminal; high = send data
6	RS232 DSR - +5V when power applied to ST8000
7	Signal Ground
8	RS232 CD - Carrier Detect; high = signal rcvd
9	MIL-188 TXD - Input data to be transmitted
10	MIL-188 RXD - Demodulated received data
11	FSK voltage - same as on XMTR connector
12	Motor Control to relay; low = motor ON
13	No connection
14	TTL TXD - Input data to be transmitted
15	RS232 TX CLOCK
16	TTL RXD - Demodulated received data
17	RS232 RECOV. RX CLOCK
18	CRT Trace ON Control; ground = trace ON
19	Terminal KOS Input; low = transmit ON
20	No Connection
21	TTL CD; low = signal rcvd
22-24	No Connection
25	CRT Trace OFF Control; ground = trace OFF

Terminal connections to the ST8000 are full duplex (FDX): separate signal wires are used for printer and keyboard data. The terminal should therefore be set for FDX operation (not HDX). Consideration should be given to the local echo requirements of your terminal. In general, a FDX terminal will NOT print or display its own typed text (transmitted data) unless some form of echo is provided. Some terminals have option selections for this feature, others do not. A study of the terminal's installation manual is therefore required. Echo of transmitted text is often supplied by the modem (ST8000). Switches S3-3 through S3-5 allow selection of RXD echo (S3-1 and S3-2 set the AFSK data source as explained in Section 2.3.1).

-----SOURCE OF RX DATA TO PRINTER-----

	RXD in Rcve TXD in Xmit	RXD in Rcve No TXD	RXD in Rcve or Xmit
S3-5	OFF	OFF	ON
S3-4	OFF	ON	OFF
S3-3	ON	OFF	OFF
			***

SET S3



FACTORY SETTING -- ***

(A partial schematic of switch S3 appears in section 2.10 at the end of this chapter.)

Note: DO NOT turn on more than one of the switches S3-3, S3-4, or S3-5 at a time.

With the factory setting, the ST8000 will only provide received data back to the printing device. If you want to print out your transmitted text then the terminal must have a local echo, or you must turn OFF S3-5 and turn ON S3-3.

2.4.1 RS232C Terminal Connections

All standard RS232C Modem signals are available for terminal or computer connection to the ST8000. Virtually any computer or data terminal may be used with the ST8000. Most terminals will require use of only the RXD, TXD, CTS, and possibly RTS I/O signals. If RTS is connected, be sure that RTS is at +V high when transmitting is desired and at -V during receive. Otherwise, leave this signal unconnected and use the ST8000's internal KOS to make transmit-receive decisions. Typical RS232C terminal connections are shown in Figure 9. This cable is available separately from HAL (part number 960-08010).

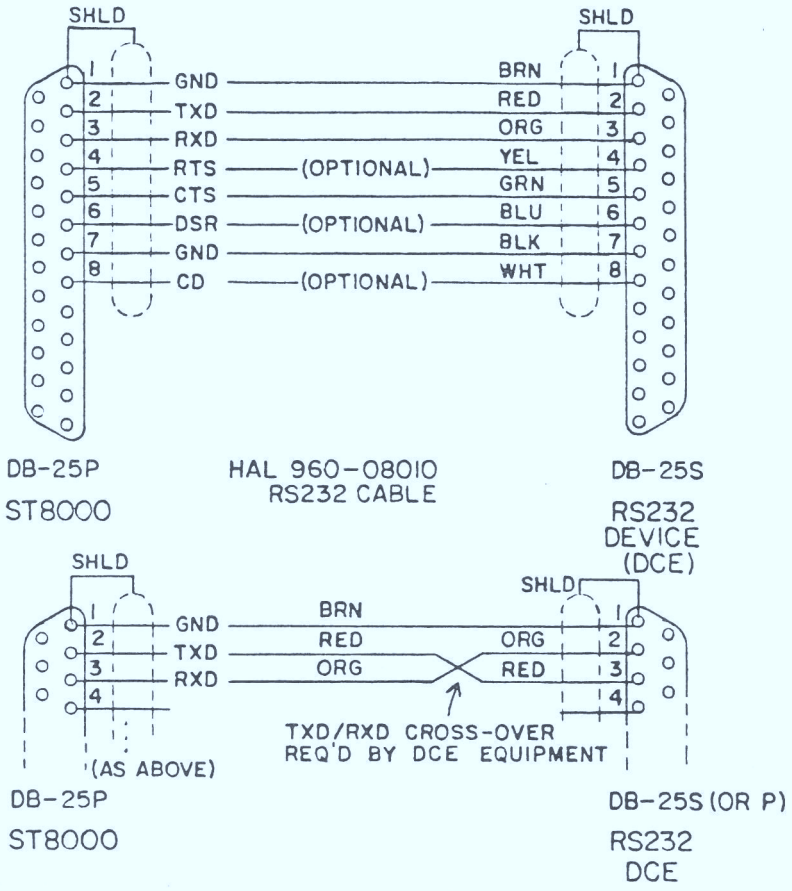


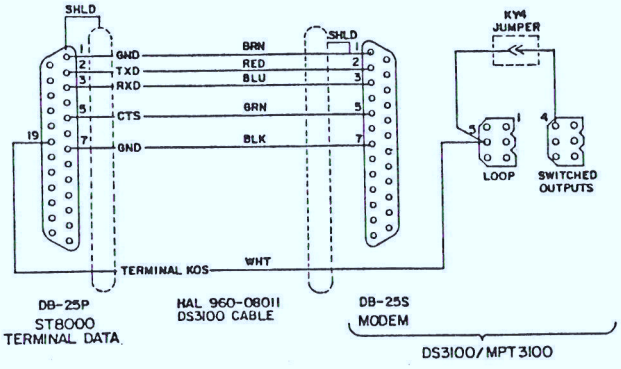
FIGURE 9. RS232C TERMINAL CONNECTIONS

2.4.2 DS3100 Connections to ST8000

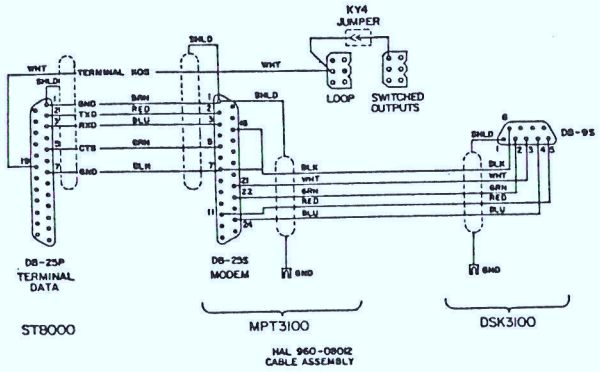
The HAL DS3100ASR Terminal may be operated in either FDX or HDX modes. When used in HDX mode, the DS3100 has the additional advantage that local echo of transmit text into the receive buffer is shown by "dim" video, compared to "bright" video for received text. Therefore, HDX operation of the DS3100 with switches S3-4 or S3-5 turned ON (but NOT BOTH) is recommended. The wiring diagram for connection of the DS3100 to the ST8000 is shown in Figure 10.

A modified RS232C connection is recommended when using the DS3100 to take advantage of the terminal's built-in KOS feature. To use only the DS3100 KOS circuit (fast-ON and fast-off), operate the ST8000 PTT switch in "RX" position: to use BOTH the DS3100 and ST8000 KOS circuits (fast-ON, time delayed-OFF), set the PTT switch to "KOS".

DS3100 or MPT3100 terminals WITHOUT the DSK3100 option require HAL cable No. 960-08011: MPT3100 terminals WITH DSK3100 require the No. 960-08012 cable.



A. DS3100/MPT3100 Connection (no DSK3100)



B. MPT3100 with DSK3100 Connection

FIGURE 10. DS3100 TO ST8000 CONNECTIONS.

2.4.3 MIL-188C Connections to ST8000

Separate connections are available for MIL-188C data systems. Use pin 9 for TXD from the keyboard or sending device and pin 10 for RXD to the printer or receive device. Control signals for RS232C or MIL-188C are the same, but the polarity may be reversed for some MIL-188C systems. The most important control signal is CTS (pin 5). CTS provides flow-control of the transmit data device when speed conversion is used. The sense of this signal is that transmit data (TXD) MUST stop when CTS is zero or a negative voltage. If transmit-receive control is provided from the MIL-188C terminal (KOS), either polarity may be accomodated by connection to either RTS (+V = transmit) or Terminal KOS (+V = receive, ground = transmit). Other RS232 control signals may be used as desired, observing polarity conventions. Jumper JP6 on the control circuit board may be changed to invert RX Clock for MIL-188C if required. A typical MIL-188C connection is shown in Figure 11.

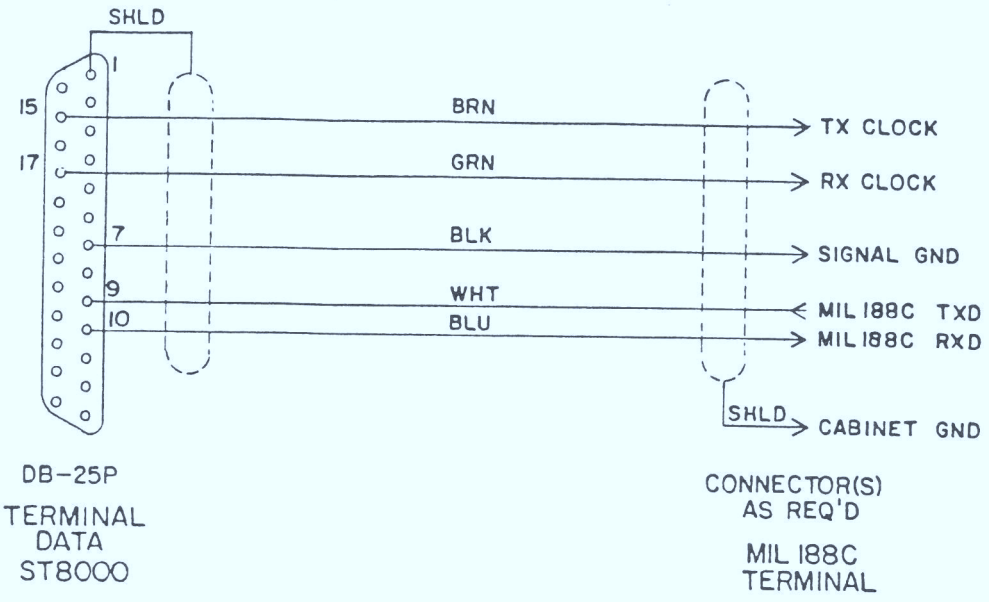


FIGURE 11. MIL-188C TERMINAL CONNECTIONS

2.4.4 TTL Terminal Connections

A direct TTL connection to a computer is also provided. Some computer software requires a direct TTL connection rather than using a RS232C serial I/O port. Pins 14 and 16 provide TXD and RXD TTL connections. In addition, the RS232C control signals may be used if attention is given to polarity and voltage levels. Two of these control signals are of particular interest - CTS and RTS. The RTS input (Request-To-Send) may be used as a TTL compatible transmit-receive control input if the convention of [+V = transmit] is observed. Receive condition may be either ground or -V. If the computer transmit-receive output is reverse polarity, use the Terminal KOS input instead of RTS (Ground = transmit, +V = receive). The CTS (Clear-To-Send) flow-control signal may likewise be used if required, but a protection zener diode should be included on the cable connections to limit the voltage swing from 0 to +5V (0V = inhibit keyboard data). Some computer software using TTL I/O provides separate received data inputs for RTTY and Morse code (CW). In this case, the two computer inputs should both be connected to the TTL RXD data output. Some computer software requires inverted receive data (RXD). Jumper location J1 can be used to set TTL RXD polarity to NORMAL (Mark = high) or REVERSE (Mark = low), as shown in Figure 6. A TTL Carrier Detect (CD) signal is provided on pin 21 (low = signal received). A typical TTL I/O connection to the ST8000 is show in Figure 12.

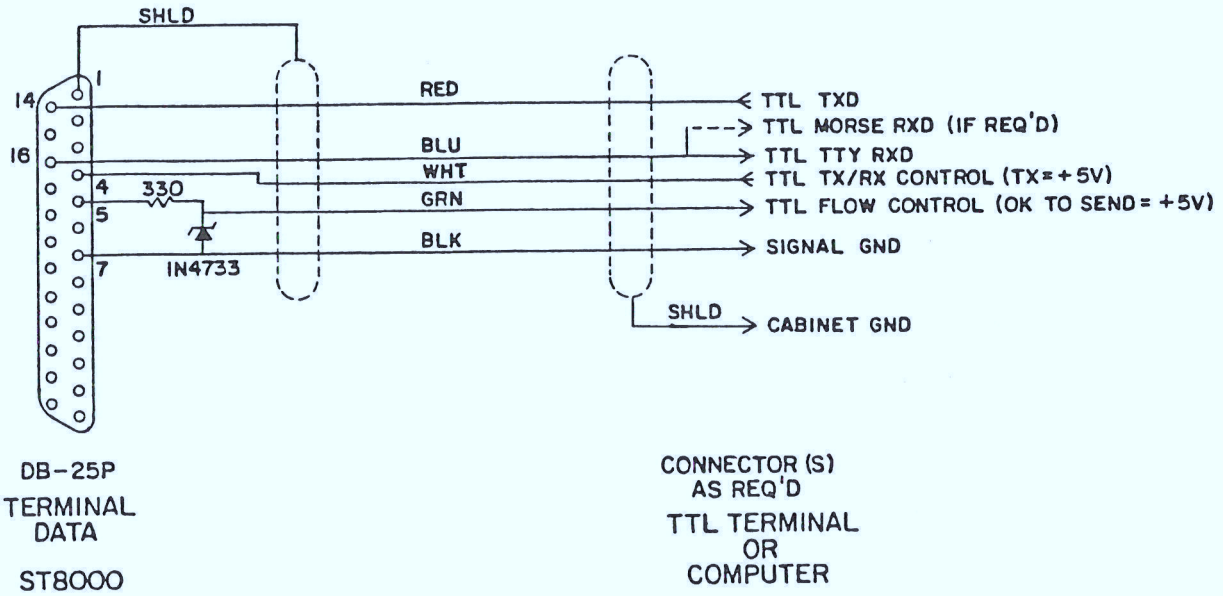


FIGURE 12. TTL TERMINAL CONNECTIONS

2.4.5 LOOP TERMINAL CONNECTIONS

As mentioned earlier, the ST8000 has NO internal provisions for direct connection to high-voltage loop devices. However, the HAL LP-1200A Dual Loop Power Supply may be used for such terminals. In this case, an RS232C interface is used between the ST8000 and LP1200A (the LP1200A converts from RS232C to LOOP levels). The LP1200A may be wired for FDX with separate keyboard and printer loops, HDX with a common loop, and for polar (+/-60V) or neutral (+120/0V) loops. The loop currents may be set for either 20 or 60 ma. Further data on the loop connection is found in the LP1200 Instruction Manual. The LP1200A also includes a relay and motor power socket so that the teleprinter motors may be controlled by the ST8000. HAL cable No. 960-08120 is available for ST8000 to LP1200A connection. These connection are shown in Figure 13.

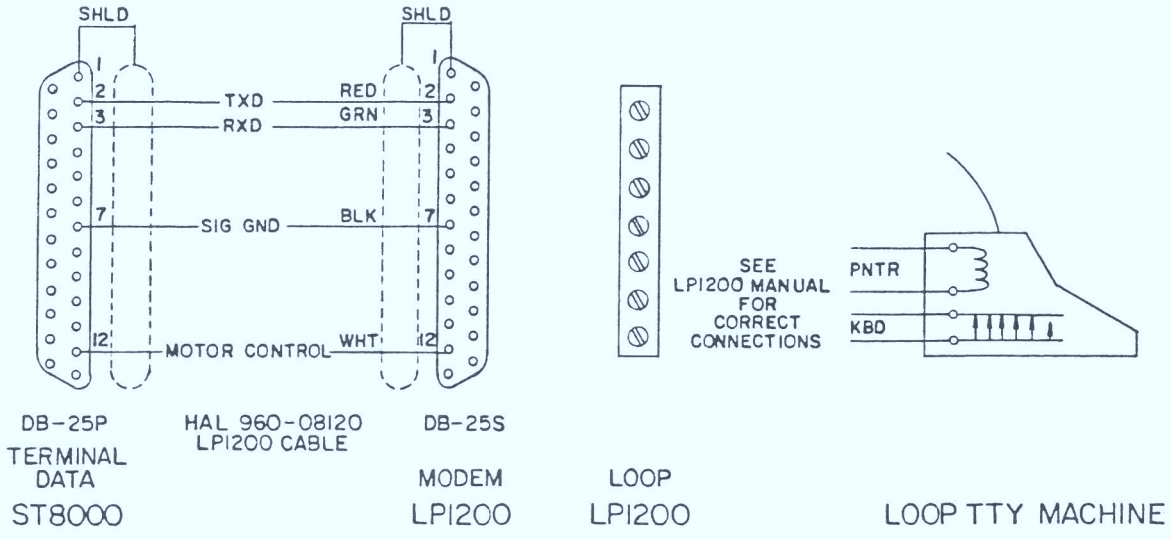


FIGURE 13. LOOP CONNECTION WITH LP1200A

2.4.6 MISCELLANEOUS TERMINAL DATA CONNECTIONS

Several accessory controls are also provided on the Terminal Data connector in addition to data I/O connections mentioned in previous sections. These additional control connections are:

PIN	NAME	FUNCTION
11	FSK	FSK keying voltage output
12	MOTOR	Switch motor control relay
18	CRT ON	External CRT-ON input (ON = ground)
19	TERM KOS	Input for external TX/RX switch
25	CRT OFF	External CRT-OFF input (OFF = ground)

Use of the FSK signal is discussed in section 2.3.2. This signal may also be connected to pin 1 of the XMTR rear panel plug by proper setting of option switch S2-5. Polarity and voltage of the FSK output is controlled by option switches S4-1 through S4-4.

The MOTOR output is an NPN transistor rated for +40V, 0.5A. This output may be used to switch a DC relay to control AC power to a printer motor. Do NOT attempt to switch the AC power line directly with this output. Also, ONLY positive voltage control lines may be switched.

TERM KOS signal may be used with a terminal that includes an NPN transistor switch to ground for TX/RX control. The input should be open-collector for RX and shunted to ground for transmit. Such a connection is shown for the DS3100 in Figure 10.

The two CRT control signals on pins 18 and 25 may be used to override the automatic CRT trace ON/OFF control of the ST8000. Either an open-collector NPN transistor or a switch contact may be used. The KY1 or KY2 switches of the DS3100 may be used for terminal control of the CRT. Grounding pin 18 forces the CRT trace ON, regardless of the ST8000 automatic control state. Likewise, grounding pin 25 turns the CRT trace OFF. The CRT trace may also be controlled via the remote terminal with the CRT ON/AUTO command as explained in section 3.12.

2.5 GROUND CONNECTION

The ST8000 is designed to work in a radio data system. Signal and power-line filters and by-pass capacitors are included in the ST8000 to minimize RFI (Radio Frequency Interference). However, a good RF ground is essential to the proper operation of any radio system and solid-state digital devices are particularly prone to RF interference. Use a low-inductance ground connection between the cabinets of each piece of the radio station, particularly between the ST8000 and receiver, transmitter, transmitter amplifiers, antenna tuner, and teleprinter or terminal. A good local ground buss between cabinets is MUCH more important than the classical driven ground rod which may give good lightning protection but not be a good radio ground connection.

2.6 POWER CONNECTION

The ST8000 may be operated from AC power sources of 100 to 130 VAC or 200 to 250 VAC, at frequencies from 44 to 440 Hz. However, two internal jumpers must be changed to select the 100-130 or 200-250 VAC ranges. The factory AC voltage selection is shown by a label on the rear panel near the AC power input connector. The power jumpers are located on the power transformer of the ST8000. No changes are required over the 44-440 Hz frequency range. Both conditions are shown in Figure 14. The ST8000/DC model is available for 13.8 VDC operation.

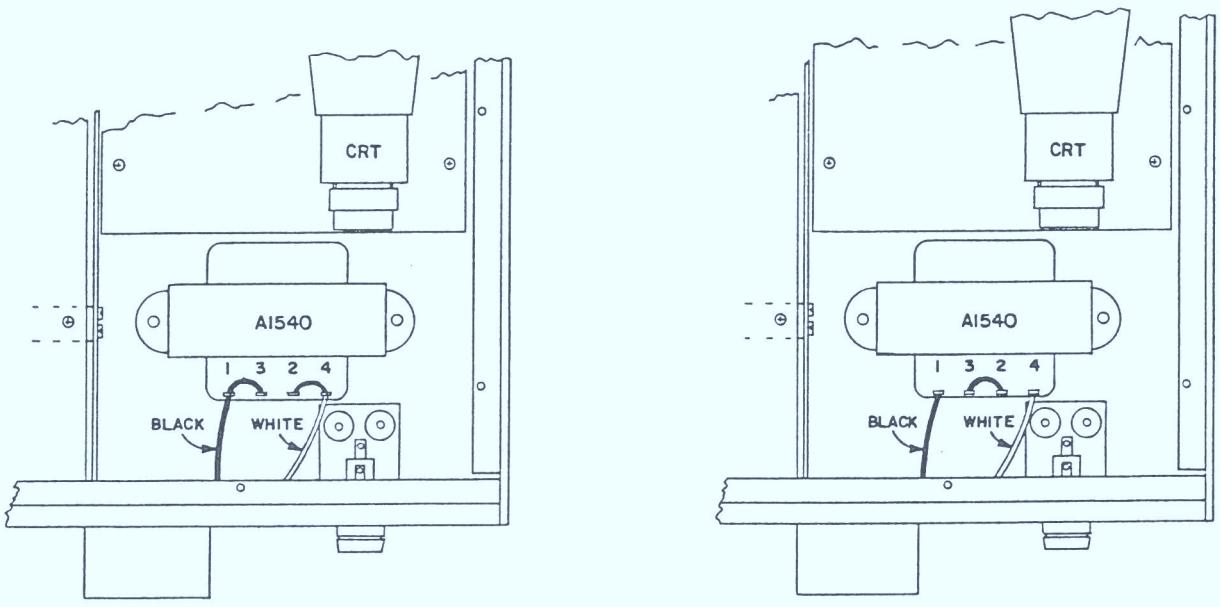


FIGURE 14. 120/240 JUMPER ARRANGEMENT

This completes the minimum connections required to install the ST8000. In addition, if two-channel diversity operation or remote control of the ST8000 front panel controls are desired, two additional cables will be required.

2.7 DIVERSITY CONNECTIONS

Two ST8000 HF MODEMs may be connected in a two-channel diversity system using the DIVERSITY connector on each unit. The signals available on this connector are:

PIN	SIGNAL
1	Ground
2	Received Data - Channel A (this ST8000)
3	Print Squelch - Channel A
4	AGC Voltage - Channel A
5	Ground
6	Ground
7	Received Data - Channel B (other ST8000)
8	Print Squelch - Channel B
9	AGC Voltage - Channel B

The wiring of this cable is shown in Figure 15. This cable is available separately from HAL as Part No. 960-08200.

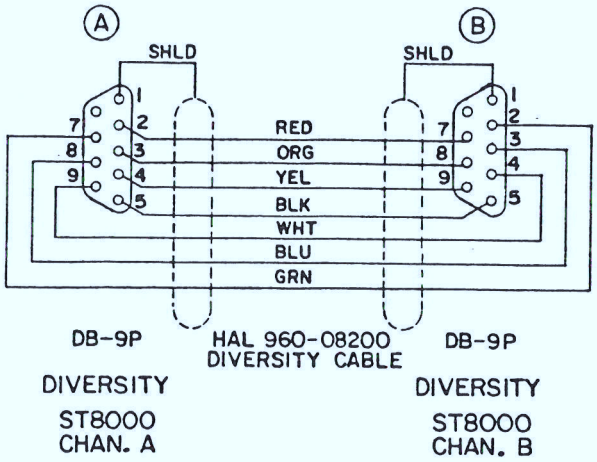


FIGURE 15. DIVERSITY CABLE

The diversity system of the ST8000 may also be used to sample the AGC voltages of the two receivers in a two-receiver system. To do this, it is first necessary to REMOVE jumper J2, shown in Figure 6. Also, the receiver AGC voltage outputs must conform to the following specifications:

Receiver AGC Voltage:	0 to +8VDC maximum
Receiver AGC Impedance:	4.7K ohms or lower

Make careful measurements to be sure that the minimum and maximum voltages are NOT exceeded by the receiver AGC voltage BEFORE using this connection. A typical connection using receiver AGC voltages is shown in Figure 16.

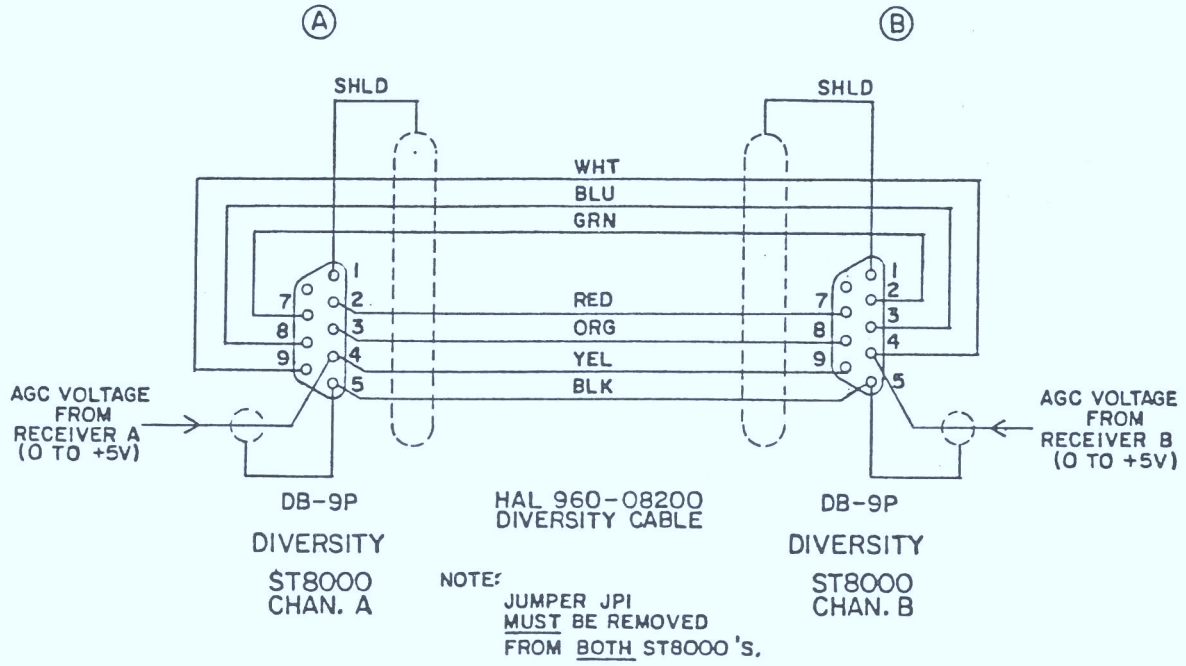


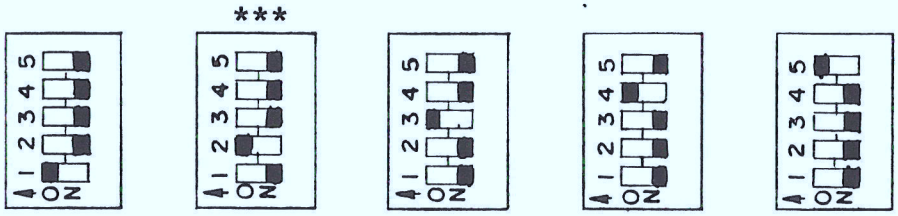
FIGURE 16. DIVERSITY FROM RCVR AGC VOLTAGES

2.8 REMOTE CONTROL CONNECTIONS

A separate 25-pin data connector is provided for remote computer or terminal control of ALL ST8000 front panel switches. This I/O port is designed for connection to a SEPARATE device or port from that used as the RTTY terminal (connected to the TERMINAL DATA connector). The remote control terminal MUST use RS232C serial ASCII at data rates from 300 to 9600 baud. No control signals are provided on this connector. The data rate of the REMOTE CONTROL port is set with switches S5-1 to S5-5 on the top (Control) circuit board. These are set as follows:

	--REMOTE CONTROL TERMINAL ASCII DATA RATE--				
	300	1200	2400	4800	9600
S5-5	OFF	OFF	OFF	OFF	ON
S5-4	OFF	OFF	OFF	ON	OFF
S5-3	OFF	OFF	ON	OFF	OFF
S5-2	OFF	ON	OFF	OFF	OFF
S5-1	ON	OFF	OFF	OFF	OFF

SET S5



FACTORY SETTING -- ***

A typical connection for a remote control terminal or computer is shown in Figure 17. The HAL 960-08010 cable may also be used for the remote terminal connection.

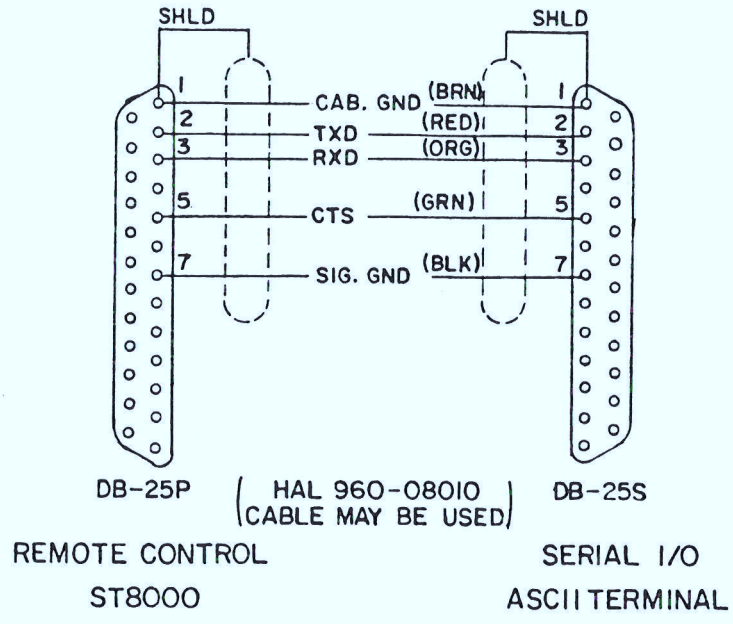


FIGURE 17. REMOTE CONTROL TERMINAL CONNECTION

2.9 INITIAL POWER-ON TESTS

After all of the desired connections have been made between the ST8000, radio transmitter, radio receiver, and RTTY terminal, the system should be turned on and tested. However, be sure to check that all cables are wired correctly before proceeding.

1. If you wish to change the KOS delay to other than the factory setting (= minimum delay, or fully CCW), locate the KOS adjustment pot on the lower circuit board in front of connector J7 (to the power transformer). This pot may be adjusted even when the top board is down, BUT - be careful not to touch the AC connections to the power transformer.
2. Swing the upper circuit board back down and replace the three 6-32 screws removed in section 2.1.
3. Make sure that none of the cables attached to the front of the upper circuit board have come loose during the switch and jumper setting procedures.
4. Reconnect the Remote Control cable to the upper circuit board.
5. Replace the top cover and 12 4-40 screws.
6. Connect all cables and power cords to the ST8000, receiver, transmitter, and RTTY terminal.
7. Turn the ST8000 POWER ON and all other equipment OFF.
8. Set ST8000 controls for desired Mark, Space, and INPUT Baud rates (see section 1.3).
9. Set DETECTOR MODE = M/S, FM
   PRINT SQUELCH = Counter Clockwise (CCW)
   ANTISPACE = OFF
   POLARITY = NORMAL
   REGEN = OFF
   DIVERSITY = A = CCW
   TX-KOS-RX = RX
10. Turn the RTTY terminal and receiver ON.
11. Tune-in a RTTY signal and adjust RTTY terminal data rate and code until correct printing is observed (see section 1.2). Adjust NORMAL/REVERSE switch if necessary.
12. Put the TX-KOS-RX switch in TX position and type characters on the RTTY terminal keyboard. If echo and polarities are right, text will be printed on receive screen (see section 2.4 if not).
13. Return TX-KOS-RX switch to RX and be sure that terminal KOS or RTS is not in TX condition (XMIT INHIBIT on DS3100ASR).
14. Connect transmitter to dummy antenna load and turn ON transmitter power.

IF LSB TRANSMITTER IS USED WITH TONES:

14. Set AFSK LEVEL rear panel control to mimimum (CCW) and transmitter output power (MIC GAIN) to mid-range.
15. Set TX-KOS-RX switch to TX (transmitter will turn on, but with minimum power).
16. Increase AFSK LEVEL control (CW) until desired TX RF power output is achieved.

IF FSK TRANSMITTER IS USED:

14. Set TX power output control to minimum.
15. Set TX-KOS-RX switch to TX (transmitter will turn on, but with minimum power).
16. Increase TX power output control until desired TX RF power output is achieved.

LSB or FSK TRANSMITTER:

17. While transmitter is ON, tune a separate receiver to the transmitter frequency. Type some text on the RTTY terminal keyboard and be sure that the transmitter frequency is shifted as characters are sent. (On DS3100, use FN-XMIT to get XMIT ENABLE/ACTIVE status.)
18. Put TX-KOS-RX SWITCH in KOS and test action of ST8000 KOS circuit. The transmitter should turn on whenever keys are typed and turn off a few seconds after last-typed character is sent (delay adjustable with KOS control R226 on the demodulator board).
19. Return TX-KOS-RX switch to RX.
20. The ST8000 is now ready for communications.

2.10 Option Switch Diagrams

The following partial schematic diagrams are included to provide a more clear understanding of option switches S1, S2, S3, and S4. Each switch diagram includes a chart showing the results of each switch setting. The factory setting is also clearly indicated.

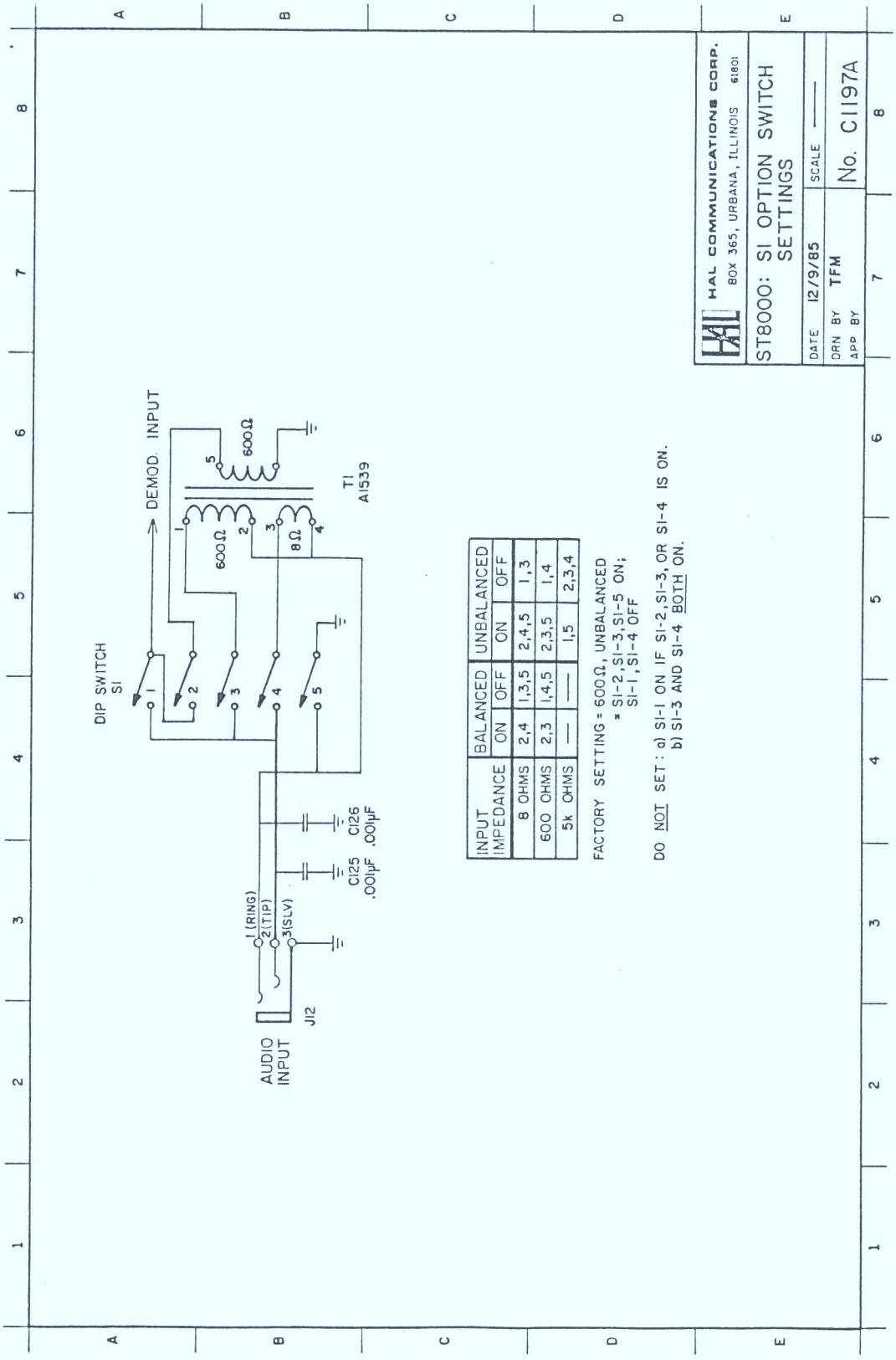


Figure 18. S1 OPTION SWITCH SETTINGS

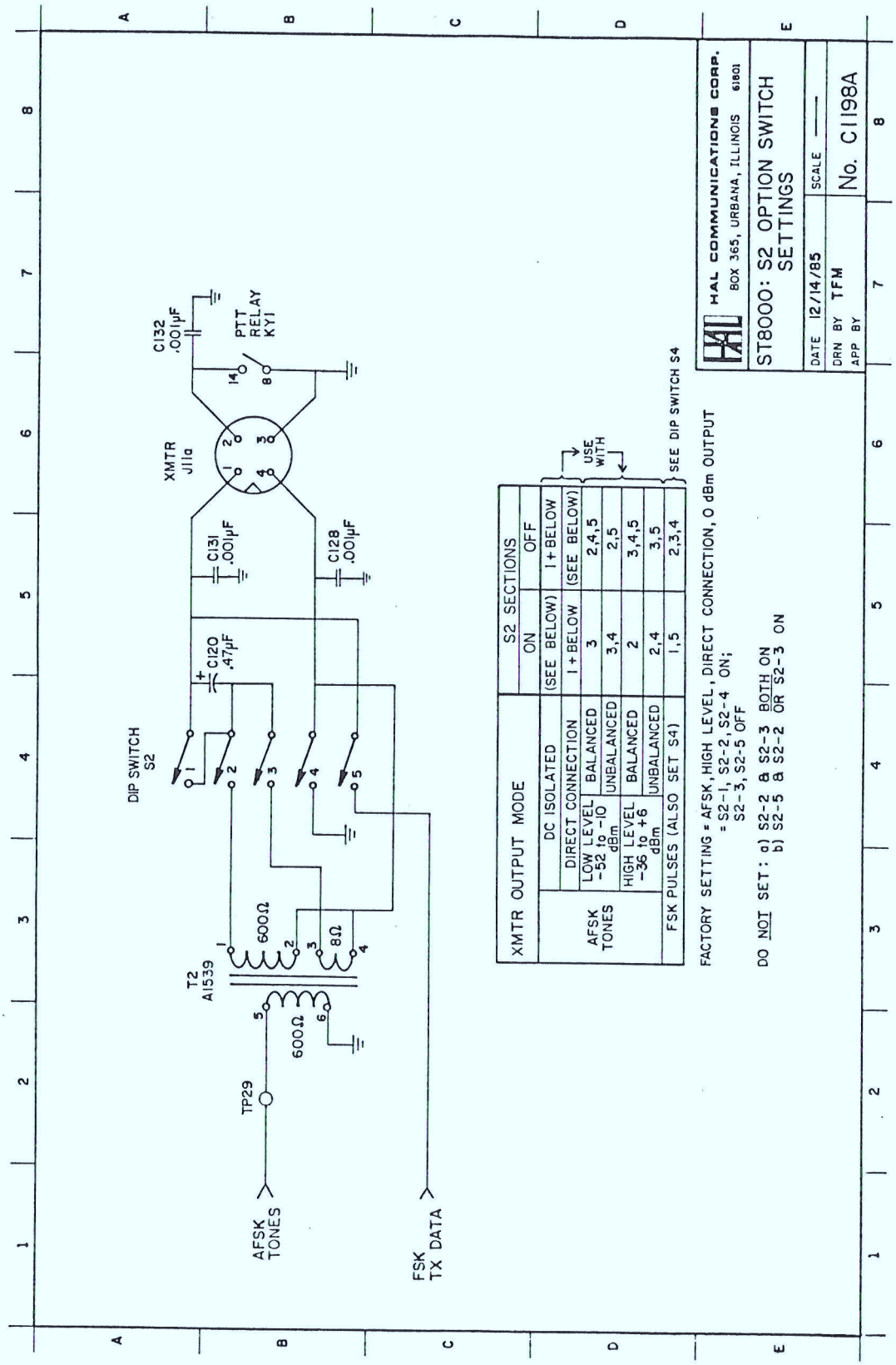


Figure 19. S2 OPTION SWITCH SETTINGS

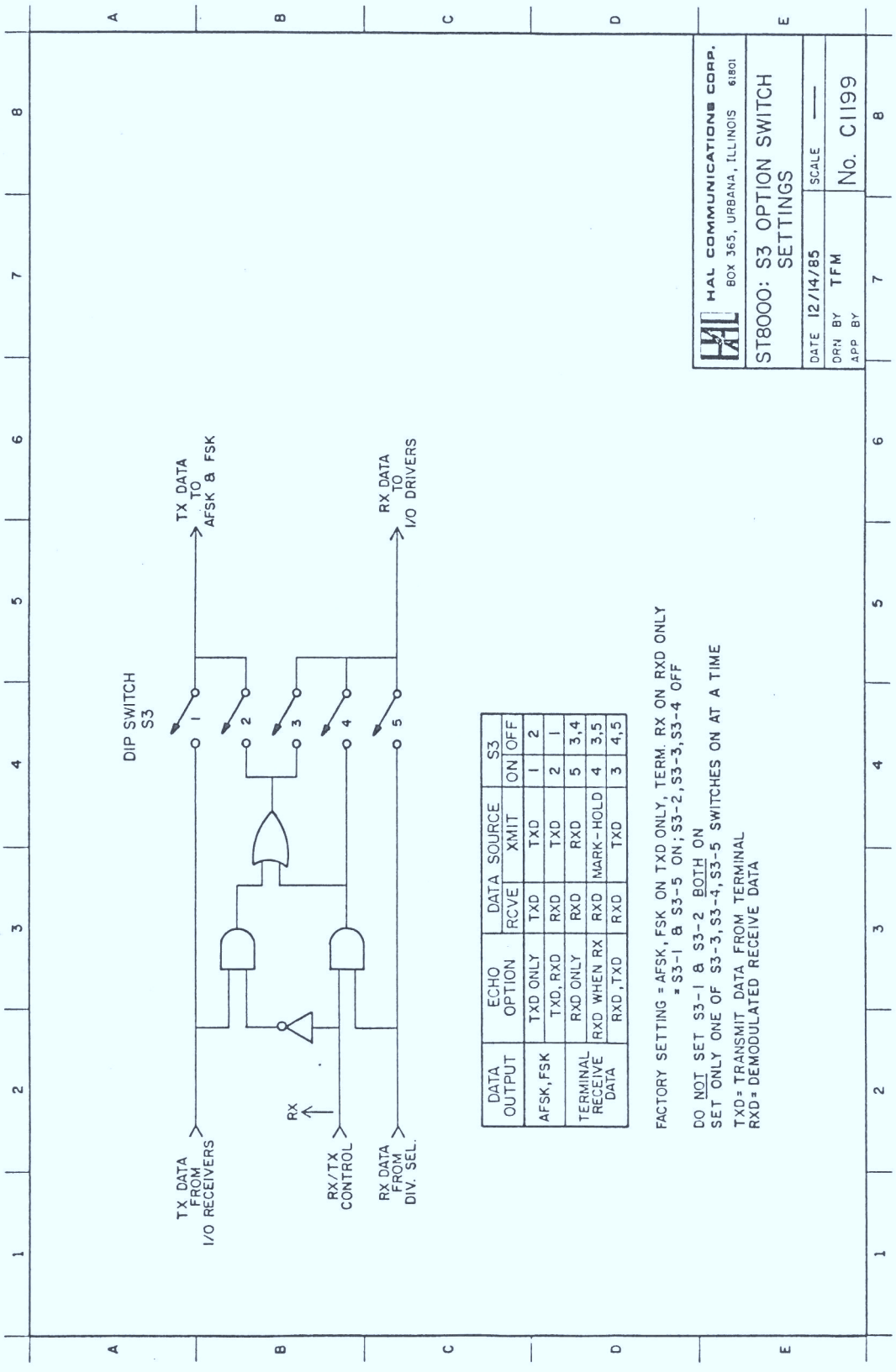


Figure 20. S3 OPTION SWITCH SETTINGS

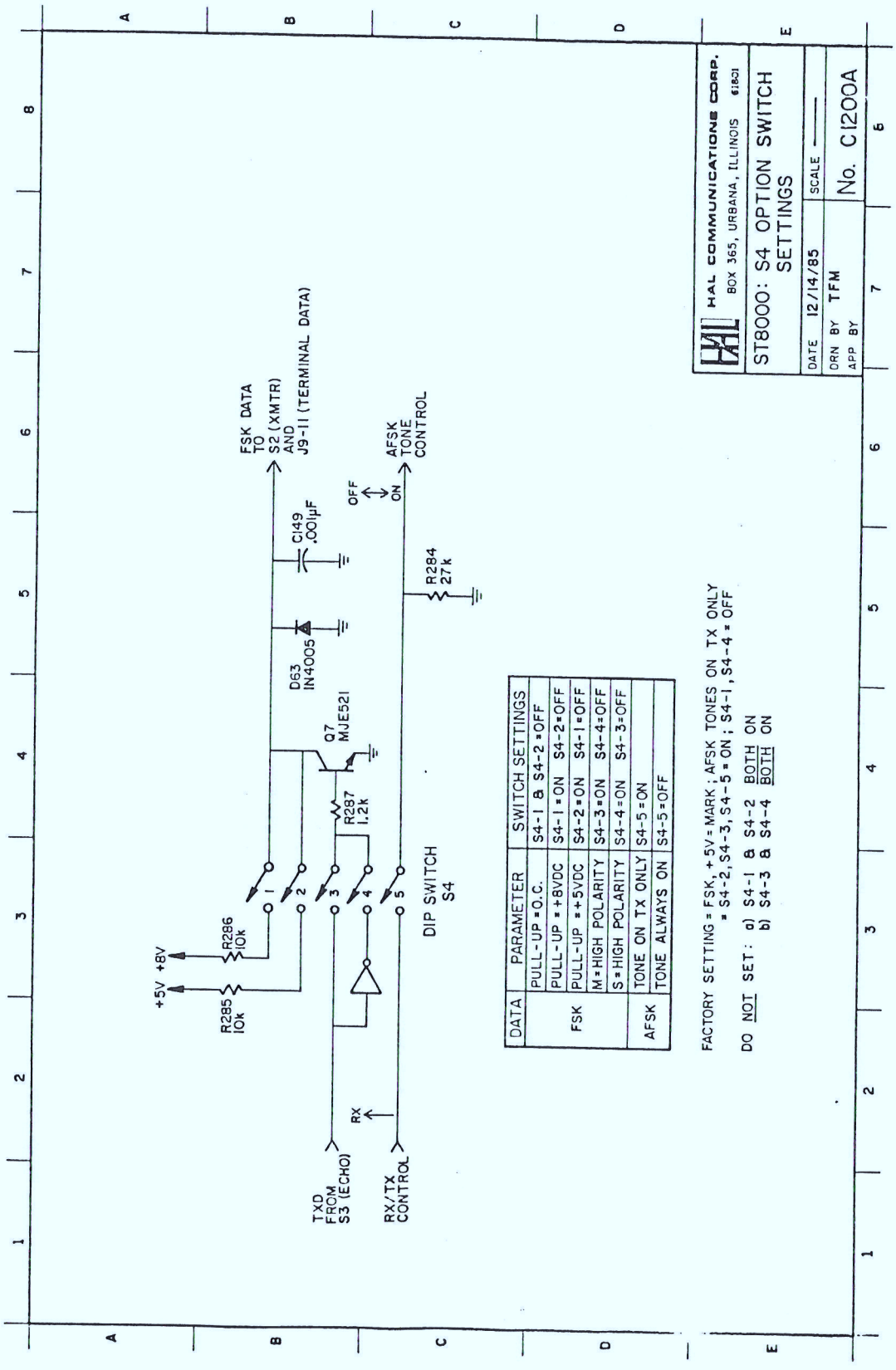


Figure 21. S4 OPTION SWITCH SETTINGS

CHAPTER THREE
ST8000 REMOTE CONTROL

All parameters of the ST8000 except Print Squelch and Diversity level may be controlled from an external terminal or computer. As discussed in section 2.8, the remote control terminal must use asynchronous ASCII code at a data rate of 300, 1200, 2400, 4800, or 9600 baud. The normal factory setting is for 1200 baud. A full-dulpex (FDX) terminal should be used with an internal echo feature turned OFF. Be sure to note that the REMOTE CONTROL I/O port is a DIFFERENT connection from that used for the receive/transmit data terminal. Received data does NOT appear at the REMOTE CONTROL port.

3.1 Remote Control Modes

The REMOTE CONTROL serial I/O port is always active, requiring only a few keystrokes from the remote control terminal to take command of ST8000. The control port may be used BOTH to READ the STATUS of the ST8000 parameters and to CHANGE these parameters. Three modes are available for remote control: (1) MONITOR, (2) FRONT PANEL (FP), and (3) DIRECT CONTROL (DC). The ST8000 always turns on in MONITOR MODE. The STATUS parameters may be read in any mode: you must enter either Front Panel (FP) or Direct Control (DC) modes to change parameters. A list of all REMOTE CONTROL commands is given in section 3.15 at the end of this chapter.

MONITOR mode allows reading of ST8000 parameters, but may not be used to change them. This mode is generally used with the STatus commands (ST, STC, STM, STQ, STT, or STM). In addition, the BYE, Front Panel, Direct Control, Help, and RESet commands may also be used in MONITOR mode. Commands that indicate a change in a parameter (such as MArk or SPace) cannot be used in MONITOR mode and the prompting message "*** Command Not Valid in MONITOR Mode ***" will result if these commands are entered in monitor mode.

FRONT PANEL mode (FP) allows remote control of all ST8000 parameters, using the automatic bandwidth computation features of the ST8000 microprocessor. For example, to specify parameters for an RTTY signal, it is only necessary to enter MArk, SPace, IBaud, OBaud, XMAark, and XSPace data. The proper Mark, Space, and Input filter Q's (QM, QS, and QI) will be automatically set as will the Low Pass filter bandwidth (LP).

DIRECT CONTROL mode (DC) allows the user to set ALL parameters, including filter Q and Low Pass filter bandwidth. This mode is the most flexible, but requires computation by the user.

3.2 Entering Commands

Receipt of a NEW LINE (CR or CR/LF) from the remote control terminal will cause execution of any typed command, ending with a prompt ">>" response from the ST8000. Commands to the ST8000 must ALWAYS END in a NEW LINE operation (CR or CR/LF). The command selection is menu driven and command format varies with requirements of a selection. All commands may be typed in full or abbreviated as shown in the Help response (see next section).

When the ST8000 is first turned ON, or after the first NEW LINE from the remote control terminal, the following will be the messages returned:

```
Enter:     CR  or CR/LF  ("NEW LINE", "ENTER", "RETURN")

Response:  *** HAL ST-8000  V1.x ***
           AT YOUR COMMAND >> __
```

The ST8000 is now in MONITOR mode and all parameters may be read but not changed. The "V1.x" in the above response is the software version installed in the ST8000.

Two types of commands are used - those implying a direct action (Help, STatus, etc), and those requiring an operand, such as the frequency and switch control commands. Direct action commands such as Help require entry of only the command letters shown in the Help menu. Operand commands may be entered with complete specification or in several steps. For example, if in FRONT PANEL mode (FP), and it is desired to change the receive MArk frequency to 2125 Hz, the command may be "MA" and then "2125", "MA 2125", or "MARK2125".

The frequency commands may also use incremental operands. For example, if MArk is presently 2122 and it is desired to set it to 2125, the commands "MA2125", "MA+++", or "MA+3" will also produce the desired change. In a like manner, the minus sign "-" may also be used for a negative increment. The increment commands may be used for frequencies and Q's (DC mode only).

Commands may also be concatenated in a command line by using the semicolon (;) as the delineator. For example, the command:

```
FP; TR OFF; M2000; SP4000; IB300
```

Sets the ST8000 to FRONT PANEL mode, TRack feature off, receive Mark to 2000 Hz, receive SPACE to 4000 Hz, and input baud rate to 300 baud.

3.3 Help Command

The ST8000 Remote Control feature is menu-driven and all available commands may be reviewed by entering the "H" or "Help" command. For example, type "HELP" and enter a NEW LINE:

```
*** HAL ST-8000  V1.x ***
AT YOUR COMMAND >> HELP

   ***  HAL ST-8000 Console Commands   ***

  Tones - RX: MArk, SPace, Center, SHift
          TX: XMArk, XSPace, XCenter, XSHift
              RX=TX, TX=RX, EXchange M/S
   I/O Rates: IBaud, OBaud
   Q Control: QMark, QSpace, QInput, LPass
              BWMark, BWSpace, BWInput
 Load Memory: LMemory
Store Memory: SMemory
 Front Panel: DMode, ASpace, POlarity, REGen, PTT
      System: BYE, FPanel, DControl, ECho, Help
              STatus, STB, STC, STM, STQ, STT
              TXLock, TRack, QBF, RY, RESet
              CRT, PRint, SC, SCON, SCOFF, SCCode

*** HAL ST-8000  V1.x ***
AT YOUR COMMAND >> __
```

All of the available ST8000 commands are listed in the Help response. The commands may be either typed in full or abbreviated with the capital letters shown. For example, "STatus" or "ST" may be used to get a full status list. The ST8000 only looks for the capital letter abbreviations shown and therefore "STAIGHT", "STAND", or "ST8000" will also cause a STatus listing. However, as mentioned above, some commands may be used in only specific modes.

A summary of all commands, required operands, and valid modes of operation is given in section 3.15 at the end of this chapter.

3.4 ECHO Command (EC)

The ST8000 Remote Control I/O port is configured for full-duplex (FDX), ASCII terminals. When the command "EC ON" is in force, characters typed on the remote control terminal keyboard are echoed back to the terminal printer or display. This is the default condition and standard for most FDX terminals. If your remote control terminal has internal echo, use the command "EC OFF" to turn off the terminal echo feature.

3.5 STATUS Commands

There are five STatus commands that may be used to get a full or partial list of the ST8000 parameters. These are:

COMMAND	OUTPUT LISTING
STatus	All frequencies and switch settings
STT	Current tone frequencies
STQ or STB	Current filter Q's and bandwidths
STC	Only control switch settings
STM	All parameters stored in memory

These commands may be issued in ALL modes of remote control operation. Except for the STM command (STatus of Memory channels), STatus commands always give a listing of CURRENT ST8000 parameters. Typical STatus command responses are:

```
*** HAL ST-8000  V1.x ***
AT YOUR COMMAND >> ST

     ***  Current ST-8000 Parameters  ***

         MARK---SPACE--Fc-----SHIFT--IBAUD--OBAUD
RX(Hz): 2125   2295   2210   0170   0074   0074
TX(Hz): 2125   2295   2210   0170

         MARK---SPACE--INPUT--LOW PASS
BW(Hz): 0113   0111   0491   0056
    Q : 18.8   20.6   04.5

DETMODE=FM-M/S  ANTISP=ON     POLARITY=NORM  REGEN=OFF  PTT=RX
  TRACK=ON      TXLOCK=ON       QBF/RY=OFF    ECHO=ON
    CRT=AUTO     PRINT=AUTO

SEL-CAL=ON        SCON="1234"
 SCCODE=ASCII    SCOFF="NNNN"


*** HAL ST-8000  V1.x ***
AT YOUR COMMAND >> STT

         MARK---SPACE--Fc-----SHIFT--IBAUD--OBAUD
RX(Hz): 2125   2295   2210   0170   0074   0074
TX(Hz): 2125   2295   2210   0170
```

```
*** HAL ST-8000  V1.x ***
AT YOUR COMMAND >> STQ        (or STB)

        MARK---SPACE--INPUT--LOW PASS
BW(Hz): 0113   0111   0491   0056
   Q  : 18.8   20.6   04.5


*** HAL ST-8000  V1.x ***
AT YOUR COMMAND >> STC

DETMODE=FM-M/S  ANTISP=ON     POLARITY=NORM  REGEN=OFF  PTT=RX
  TRACK=ON      TXLOCK=ON       QBF/RY=OFF    ECHO=ON
    CRT=AUTO     PRINT=AUTO

SEL-CAL=ON        SCON="1234"
 SCCODE=ASCII    SCOFF="NNNN"


*** HAL ST-8000  V1.x ***
AT YOUR COMMAND >> STM

      ***  Memory Preset Parameters  ***

MEM -- MARK---SPACE--Fc-----SHIFT--IBAUD--OBAUD
 1 RX: 2125   2295   2210   0170   0075   0075
   TX: 2125   2295   2210   0170
 2 RX: 2125   2550   2337   0425   0075   0075
   TX: 2125   2550   2337   0425
 3 RX: 2125   2975   2550   0850   0075   0075
   TX: 2125   2975   2550   0850
 4 RX: 2225   2025   2125   0200   0300   1200
   TX: 1270   1070   1170   0200
 5 RX: 1200   2200   1700   1000   1200   1200
   TX: 1200   2200   1700   1000
 6 RX: 2083   2168   2125   0085   0075   0075
   TX: 2083   2168   2125   0085
 7 RX: 1270   1070   1170   0200   0300   0300
   TX: 2225   2025   2125   0200
 8 RX: 2225   2025   2125   0200   0300   0300
   TX: 2225   2025   2125   0200


*** HAL ST-8000  V1.x ***
AT YOUR COMMAND >> __
```

3.6 Control Commands

Control commands may be used in either FRONT PANEL (FP) or DIRECT CONTROL (DC) modes. The commands and operands are:

SWITCH	COMMAND	[OPERANDS]
DETECTOR MODE	DM [ ]	AM, FM, MS, MP, MO, SO
ANTISPACE	AS [ ]	ON, OFF
POLARITY	PO [ ]	NORM, REV
REGEN	REG [ ]	OFF, AA, AB, BA, BB

Each of these commands may be used with or without operands. For example, if in FP mode and just "DM" is entered, the response will be as follows:

```
FP: [] >> DM   [DETMODE=FM-M/S]
FP: [] >> __
```

If it is desied to change to AM mode, enter "DM AM":

```
FP: [] >> DM AM  [DETMODE=AM-M/S]
FP: [] >> __
```

If it is desired to now change to FM and MP (Multipath Path Correction), enter first the "DM FM" and then "DM MP" commands:

```
FP: [] >> DM FM  [DETMODE=FM-M/S]
FP: [] >> DM MP  [DETMODE=FM-MP]
FP: [] >> __

       OR

FP: [] >> DM FM MP  [DETMODE=FM-MP]
FP: [] >> __
```

The choice of AM/FM and detector may be made in one command as noted in the alternate example. Note that Mark Only (MO) and Space Only (SO) detectors may only be used in AM mode and the ST8000 will automatically switch to AM-MO if "MO" is entered in FM mode.

Only two options may be chosen to set the ANTISPACE (AS) and POLARITY (PO) switches - ON/OFF, and NORM/REV, respectively. As above, entering the AS or PO commands without an operand will give a response stating the current ST8000 settings.

Five options are available with the REGENeration switch (REG). As explained in Section 1.11, the regeneration feature provides digital signal regeneration, and code and speed conversion. The speed conversion feature is set with the Input Baud (IB) and Output Baud (OB) commands. The available options are:

REG Option	RADIO LINK RATE = IBaud	DATA TERMINAL RATE = OBaud
AA (or A/A)	ASCII	ASCII
AB (or A/B)	ASCII	BAUDOT
OFF	--Same code and speed--	
BA (or B/A)	BAUDOT	ASCII
BB (or B/B)	BAUDOT	BAUDOT

3.7 Frequency Commands

The ST8000 frequencies and bandwidths may be set in either FRONT PANEL (FP) or DIRECT CONTROL (DC) modes. The FP mode uses the bandwidth calculation routines in the ST8000 software to set all filter Q's. In DC mode, Q's are NOT changed unless specified from the remote control terminal. In addition, the frequencies in both modes may interact, depending upon the setting of the TRack command.

3.7.1 TRack Command

The TRack command simulates the TRACK position of the front panel TUNING MODE switch. When TR is ON, the MArk and SPace frequencies are always set to maintain a constant difference or SHift frequency. Thus, changing MArk, SHift, or Center frequencies will also affect the SPace frequency when TR is ON. The conditions available for TRack are:

COMMAND	Response
TR	Statement of TR status (ON/OFF)
TR ON	Turn TRack feature ON (default mode)
TR OFF	Turn TRack feature OFF

In either FP or DC modes, the ST8000 controlling software prevents the setting of MArk or SPace frequencies beyond the limits of 500 to 4000 Hz, giving priority to maintaining the previously set SHift. Thus, if the frequencies were MA=2000 and SP=3000 and a change was entered for MA=3500, the ST8000 would set the SPace to SP=4000 and give a response of "MA=3000". Conversely, a change of SP=1000 would set the MArk to 500 and SP=1500, maintaining 1000 Hz SHift. Unless TRack is definitely desired, it is best to set "TR OFF" when setting individual MArk and SPace frequencies.

3.7.2 MArk, SPace, Center, and SHift Commands

The MArk and SPace commands are primary to the operation of the ST8000 receive demodulator. The input and detector filter frequencies are set according to these parameters. When TR is turned OFF, either MArk or SPace may be set independently. However, in FRONT PANEL mode (FP), changing Center frequency will move BOTH MArk and SPace by the SHift amount, centered on the new center frequency. In DIRECT CONTROL mode (DC), "Center" controls ONLY the center frequency of the input filters and is NOT coupled to MArk, SPace, or SHift.

In FP mode with TRack OFF, changing SHift will maintain the previous Center frequency, and change BOTH MArk and SPace frequencies. If TRack is ON, changing SHIFT affects ONLY SPace, leaving MArk fixed. In DC mode, changing SHift affects ONLY MArk and SPace frequencies, but NOT Center frequency. This is shown in the following examples.

```
*** HAL ST-8000  V1.x  ***
AT YOUR COMMAND >> FP

***  Front Panel Mode  ***

FP: [] >> TR OFF  [TRACK=OFF]
FP: [] >> STT

         MARK---SPACE--Fc-----SHIFT--IBAUD--OBAUD
RX(Hz): 2125   2295   2210   0170   0075   0075
TX(Hz): 2125   2295   2210   0170

FP: [] >> MA
FP: [RX MARK=2125] >> MA2295
FP: [RX MARK=2295] >> SP
FP: [RX SPACE=2295] >> MARK 2125
FP: [RX MARK=2125] >> SP
FP: [RX SPACE=2295] >> SP2550
FP: [RX SPACE=2550] >> MA
FP: [RX MARK=2125] >> SPACE2295
FP: [RX SPACE=2295] >> SH
FP: [RX SHIFT=0170] >> SH425
FP: [RX SHIFT=0425] >> MA
FP: [RX MARK=1998]  >> SP
FP: [RX SPACE=2423] >> SHIFT 170
FP: [RX SHIFT=0170] >> C
FP: [RX CENTER=2210] >> C 2295
FP: [RX CENTER=2295] >> MA
FP: [RX MARK=2210] >> SP
FP: [RX SPACE=2380] >> CENTER2210
FP: [RX CENTER=2210] >> MA
FP: [RX MARK=2125] >> SP
FP: [RX SPACE=2295] >> __
```

If TRack is now turned ON, the action of the SHift command is to leave MArk at the previous setting and change only the SPace frequency. The difference between the two modes is shown by comparing the above results to the following example.

```
*** HAL ST-8000  V1.x ***
AT YOUR COMMAND  >> FP

***  Front Panel Mode  ***

FP: [] >> TR ON  [TRACK=ON]
FP: [] >> STT

         MARK---SPACE--Fo-----SHIFT--IBAUD--OBAUD
RX(Hz): 2125   2295   2210   0170   0075   0075
TX(Hz): 2125   2295   2210   0170

FP: [] >> MA
FP: [RX MARK=2125] >> MA2295
FP: [RX MARK=2295] >> SP
FP: [RX SPACE=2465] >> MARK 2125
FP: [RX MARK=2125] >> SP
FP: [RX SPACE=2295] >> SP2550
FP: [RX SPACE=2550] >> MA
FP: [RX MARK=2380] >> SPACE2295
FP: [RX SPACE=2295] >> SH
FP: [RX SHIFT=0170] >> SH425
FP: [RX SHIFT=0425] >> MA
FP: [RX MARK=2125]  >> SP
FP: [RX SPACE=2550] >> SHIFT 170
FP: [RX SHIFT=0170] >> C
FP: [RX CENTER=2210] >> C 2295
FP: [RX CENTER=2295] >> MA
FP: [RX MARK=2210] >> SP
FP: [RX SPACE=2380] >> CENTER2210
FP: [RX CENTER=2210] >> MA
FP: [RX MARK=2125] >> SP
FP: [RX SPACE=2295] >> __
```

Notice that the difference between TR ON and TR OFF affects both SPace and SHift related specifications.

There is a difference in the operation of the Center command between FRONT PANEL (FP) and DIRECT CONTROL (DC) modes. In FP mode, the Center frequency is computed to be the mid-frequency between MArk and SPace and the frequency of the input bandpass filters are then set to this mid-frequency. Also, note that changing the Center frequency in FP mode affects BOTH MArk and SPace frequencies, whether TRack is ON or OFF (maintains constant SHift).

In DC mode, all parameters are decoupled and the setting of the Mark, Space, and input filter frequencies are independent. Therefore, in DC mode, setting Center affects ONLY the center frequency of the input bandpass filters. The behavior of Center frequency in DC mode is the same with TRack ON or OFF. The following example shows the differences in Center frequency control in DC mode.

```
*** HAL ST-8000  V1.x ***
AT YOUR COMMAND >> DC

***  DIRECT CONTROL MODE  ***

DC: [] >> STT

        MARK---SPACE--Fc-----SHIFT--IBAUD--OBAUD
RX(Hz): 2125   2295   2210   0170   0075   0075
TX(Hz): 2125   2295   2210   0170

DC: [] >> C
DC: [CENTER=2210] >> C2295
DC: [CENTER=2295] >> STT

        MARK---SPACE--Fc-----SHIFT--IBAUD--OBAUD
RX(Hz): 2125   2295   2295   0170   0075   0075
TX(Hz): 2125   2295   2210   0170

DC: [CENTER=2295] >> C2210
DC: [CENTER=2210] >> MA
DC: [MARK=2125] >> SP
DC: [SPACE=2295] >> __
```

The interaction of parameters in FP and DC mode is summarized in the following table.

PARAM. CHANGED	PARAMETERS AFFECTED	
	TRack OFF	TRack ON
MArk (FP)	MArk, SHift, Center change; SPace does NOT change.	MArk, SPace, Center change; SHift does NOT change.
MArk (DC)	MArk, SHift change; Center, SPace do NOT change.	MArk, SPace change; Center, SHift do NOT change.
SPace (FP)	SPace, Shift, Center change; MArk does NOT change.	MArk, SPace, Center change; SHift does NOT change.
SPace (DC)	SPace, SHift change; MArk, Center do NOT change.	MArk, SPace change; SHift, Center do NOT change.
SHift (FP))	MArk, SPace, SHift change; Center does NOT change.	SPace, SHift, Center change; MArk does NOT change.
SHift (DC)	MArk, SPace, SHift change; Center does NOT change.	SPace, SHift, change; MArk, Center do NOT change.
Center (FP)	MArk, SPace, Center change; SHift does NOT change.	
Center (DC)	Center of Input Filters change frequency; MArk, SPace, and SHift do NOT change.	

These combinations give a great variety of ways in which the frequencies of the ST8000 may be set. However, the simplest and least confusing mode is to use FP mode with TR set to OFF, specifying MArk and SPace frequencies individually unless a TRacking mode is required.

3.7.3 EXchange Command

The EXchange command can be very useful during set-up procedures. This command exchanges MArk and SPace frequencies, performing a similar role to the NORMal/REVerse switch. If TXLock is also set ON, the transmit tones will likewise be interchanged. The EXchange command has no operand and it is only necessary to enter "EX" in either FP or DC modes.

3.7.4 Transmit Tone Commands (XMA, XSP, XSH, XC, TXL, TX=RX, and RX=TX)

The ST8000 transmit tone frequencies may also be set from the remote control terminal. The transmit tone frequency control parallels the manner in which the front panel VAR-RX/TX control operates (see sections 1.4 and 1.5), but with greater flexibility. The TXLock ON command is used to set the transmit tones to be equal to the receive filter frequencies. Also, the commands "TX=RX" or "RX=TX" may also be used to quickly equalize transmit and receiver frequencies.

Setting transmit tones follows the same rules as those for setting receive filter tones. The transmit tone parameter commands are: XMArk, XSPace, XSHift, and XCenter. The previous table of section 3.7.2 also shows the behavior of these transmit commands in FP and DC modes for TR ON and TR OFF conditions with the exception that XCenter defines the mid-frequency between XMArk and XSPace in both FP and DC modes.

The TXLock command locks the transmit tone frequencies to those set for the receive filters, giving "transceive" conditions. The effect TXL=ON is to set XMA=MA, XSP=SP, XSH=SH, and XC=C. Thus, any change in receive MArk, SPace, SHift, or Center will affect the transmit tones when TXLock is ON. The variations of the TXL command are:

COMMAND	RESPONSE
TXL	Statement of TXLock status (ON/OFF)
TXL ON	Turn TXLock feature ON
TXL OFF	Turn TXLock feature OFF

The TXLock command works the same in both FRONT PANEL (FP) and DIRECT CONTROL (DC) modes, but cannot be used in MONITOR mode.

The TX=RX sets operational TX parameters to be the same as the current receive parameters. Conversely, the RX=TX command sets receive parameters to be the same as current transmit parameters. These commands are convenient to use when doing an analog loop-back test of a full-duplex (FDX) tone set such as the 103 Modem tones (1270/1070 and 2225/2925), or when it is desired to use just one of the tone set for simplex HDX operation. These commands should be entered in the following manner:

```
*** HAL ST-8000  V1.x ***
AT YOUR COMMAND >> FP

*** Front Panel Mode ***

FP: [] >> LM4  [LOAD MEMORY  4]
FP: [] >> STT

         MARK---SPACE--Fc-----SHIFT--IBAUD--OBAUD
RX(Hz): 2225   2025   2125   0200   0300   1200
TX(Hz): 1270   1070   1170   0200

FP: [] >> TX=RX  [SET TX=RX]
FP: [] STT

         MARK---SPACE--Fc-----SHIFT--IBAUD--OBAUD
RX(Hz): 2225   2025   2125   0200   0300   1200
TX(Hz): 2225   2025   2125   0200

FP: [] >> LM4  [LOAD MEMORY  4]
FP: [] >> STT

         MARK---SPACE--Fc-----SHIFT--IBAUD--OBAUD
RX(Hz): 2225   2025   2125   0200   0300   1200
TX(Hz): 1270   1070   1170   0200

FP: [] >> RX=TX  [SET RX=TX]
FP: [] >> STT

         MARK---SPACE--Fc-----SHIFT--IBAUD--OBAUD
RX(Hz): 1270   1070   1170   0200   0300   1200
TX(Hz): 1270   1070   1170   0200

FP: [] >> __
```

The TX=RX command differs from the TXLock ON command in that TX=RX is a one-time command and further changes in receiver frequencies will NOT be reflected by the transmit tones UNLESS TXLock is turned ON.

3.8 Bandwidth Commands (QM, QS, QI, LP, IB)

The ST8000 is both a variable frequency and variable bandwidth receiver demodulator. When the front panel controls are used or when FRONT PANEL (FP) remote control mode is used, the bandwidths for the input, Mark, Space, and low pass filters are computed and set from the INPUT BAUD panel setting or IBAUD remote control parameter. However, all filter bandwidths may be set independently when DIRECT CONTROL (DC) remote control mode is used. (IBAUD also controls the radio link data rate when REGEN is used as explained in sections 1.6 and 1.11; OBAUD sets only the REGEN terminal data rate.) The bandwidth commands affect ONLY the receive section of the ST8000; transmit tone parameters are not affected by bandwidth commands. However, transmitted data rate will be set by IBaud when REGeneration is used.

The actual bandwidth control of the ST8000 involves selection of discrete filter Q's for the input, Mark, and Space filters and cut-off frequency for the two low-pass filters. Therefore, in FP mode, the IBAUD, MArk, SPace, Center, and SHift parameters are used to compute the appropriate filter Q. The formulas used for front panel control settings or in FP remote control mode are:

```
INPUT FILTER:    C (Center) = (Mark + SPace)/2
                     QInput = C/(SHift + 1.5 IBaud)
                            = C/(|MArk-SPace| + 1.5 IBaud)

MARK FILTER:         QMark  = MArk/(1.5 IBaud)

SPACE FILTER:        QSpace = SPace/(1.5 IBaud)

LP FILTER:            LPass = 0.75 IBaud

                      IBaud = baud rate of received signal
                            = setting of IBaud parameter
```

The choice of the 1.5 multiplier factor has been chosen as an optimum compromise for fading radio signals. If DIRECT CONTROL (DC) mode is used, the user may choose other multipliers for his bandwidth criteria (between 1.0 for non-fading signals with relatively constant S/N and 2.0 for minimum inter-symbol distortion with heavy fading).

The ST8000 has a choice of 4 input bandpass filters, three of which are 6-pole, sharp skirt tunable filters. The fourth filter is fixed-tuned for the full 500-4000 Hz bandpass. When computing the input filter requirements, the Q calculation is first made and then the filter with the next LOWER avaialble Q is chosen. The available filters are:

INPUT FILTER SELECTION

FILTER	QI	BW	SELECTION CRITERIA
1/3 OCT	4.5	C/4.5	QI> 4.5
1/2 OCT	3.0	C/3.0	4.7 >QI> 3.0
1.0 OCT	1.5	C/1.5	3.0 >QI> 1.5
WIDE	<1.5*	500-4000 Hz	1.5 >QI

* = shown in STQ or STB response as QI=1.0
C = Center frequency of input filters

The Mark and Space receive filters are identical 4-pole tunable filters with a choice of 32 discrete Q's, selected in two 16 step ranges. The available selections are:

MARK and SPACE FILTER Q SELECTION

LOW RANGE Q	LOW RANGE BW	HIGH RANGE Q	HIGH RANGE BW
1.9	F/1.9	3.9	F/3.9
2.1	F/2.1	6.1	F/6.1
2.3	F/2.3	8.3	F/8.3
2.6	F/2.6	10.5	F/10.5
2.9	F/2.9	12.5	F/12.5
3.1	F/3.1	14.8	F/14.8
3.4	F/3.4	16.6	F/16.6
3.7	F/3.7	18.8	F/18.8
3.9	F/3.9	20.6	F/20.6
4.2	F/4.2	22.3	F/22.3
4.5	F/4.5	24.5	F/24.5
4.7	F/4.7	26.1	F/26.1
5.0	F/5.0	27.8	F/27.8
5.3	F/5.3	29.4	F/29.4
5.6	F/5.6	31.3	F/31.3
5.8	F/5.8	32.7	F/32.7

F = MA (Mark Frequency) or SP (Space Frequency)

Because of the slight overlap, the lower step of the high range is not used in FP mode, prefering the closer increments of the low range for Q's less than 6.1. When the limit of the available Q range is reached for the Mark or Space filter, the ST8000 software sets the other filter Q to maintain similar bandwidths rather than continuing to increment the non range-limited filter.

Separate post-detection 7-pole linear phase low-pass filters are used for the Mark and Space data. When front panel controls or FP remote control mode is used, the -3 dB cut-off frequency is set to 0.75 times the IBaud parameter. As mentioned above, use of DIRECT CONTROL (DC) mode allows setting this frequency independent from MArk, SPace, or IBaud settings.

To view the current settings of the filter Q's and bandwidths, use the STQ or STB commands. Since the Q's are computed automatically in FP mode, only DC mode may be used to change the filter Q's. However, the QM, QS, QI, and LP commands may be used without operands in FP mode to check the current settings. For example:

```
*** HAL ST-8000  V1.x ***
AT YOUR COMMAND >> STQ

        MARK---SPACE--INPUT--LOW PASS
BW(Hz): 0113   0111   0490   0056
    Q : 18.8   20.6   04.5

*** HAL ST-8000  V1.x  ***
AT YOUR COMMAND >> QM  *** Command Not Valid in MONITOR MODE ***

*** HAL ST-8000  V1.x  ***
AT YOUR COMMAND >> FP

***  Front Panel Mode  ***

FP: [] >> QM
FP: [Q MARK=18.8] >> QM 10  *** Command only Valid in DC Mode ***
FP: [Q MARK=18.8] >> QS
FP: [Q SPACE=20.6] >> QI
FP: [Q INPUT=04.5] >> LP
FP: [LOW PASS=0056] >> __
```

When using the DIRECT CONTROL (DC) mode, each of the filter Q's may be set as desired. The ST8000 controlling software compares the requested Q and selects the next LOWER avaiable Q for the chosen filter. For example, if "QM 20.8" were entered, the QM=20.6 condition would be set and will be so indicated in the prompt message. Likewise, entering "QM20.7", "QM20.9", or "QM21.9" would also result in choice of QM=20.1, the next LOWER available Q. All three filter Q's, Input (QI), Mark (QM), and Space (QS) must be specified separately in DC mode.

Conflicting conditions govern the choice of optimum Mark and Space filter bandwidths. Optimum S/N ratio is generally agreed to be at a bandwidth equal to the baud rate of the received signal. Conversely, intersymbol distortion on heavily fading radio signals is higher at this narrow bandwidth, decreasing as bandwidth is increased. Also, narrow bandwidths make receiver tuning more difficult and more sensitive to transmitter or receiver drift. Tests at HAL Communications on actual radio signals show an overall system advantage for slightly wider bandwidths (50_%), particularly for shifts greater than 170 and baud rates higher than 110.

The bandwidth of the input filter should be set to include both the Mark and Space tones and their data sideband spectral components. The input bandwidth should therefore be set to be greater than the sum of the shift plus a multiple of the signal data rate. As discussed previously, tests by HAL have shown that setting the input filter bandwidth equal to the shift plus 1.5 times the baud rate produces optimum results for typical radio signals. If interference is a great problem, the input filter Q (QI) and center frequency (C) may be adjusted in DC mode much like the pass-band tuning features of a radio receiver to pass the signal and reject the interference. Severe on-channel interference (on Mark or Space frequency) may be considerably reduced by using an AM detector mode and proper selection of input filter Q and center frequency.

The Low Pass filter bandwidth may also be set in DC mode using the LP command. The desired cut-off frequency should be specified directly in Hz. The Mark and Space LP filters are identical and always set for the same cut-off frequency, specified by LP. The skirt selectivity of the linear phase filters is quite gradual and the cut-off frequency may be lowered to 1/2 the baud rate with a small increase in error rate. However, intersymbol distortion increases as the bandwidth is reduced below approximately 3/4 of the baud rate.

In DC mode, the ONLY parameter controlled by the IBaud setting is the REGeneration data rate for the radio link. All other automatic features of FP mode must be set manually in DC mode.

3.9 Memory Commands (STM, LM, SM)

A total of 8 non-volatile and user-programmable memories are available for storage of ST8000 frequency parameters. The stored parameters for each channel are:

MA:	Receive MArk filter center frequency
SP:	Receive SPace filter center frequency
IB:	Input Baud rate (radio link)
OB:	Output Baud rate (data terminal)
XMA:	Transmit Mark tone frequency
XSP:	Transmit Space tone frequency

In addition, the following parameters are computed and listed for each memory channel:

C:	Receive Input filter center frequency
SH:	Difference between MA and SP
XC:	Mid-frequency between XMA and XSP
XSH:	Difference between XMA and XSP

The STM (STatus Memory) command may be used in MONITOR, FRONT PANEL (FP), or DIRECT CONTROL (DC) modes to get a list of currently stored parameters. The LM (Load Memory) and SM (Store Memory) commands may be used ONLY in FP or DC remote control modes. The LM and SM commands also require a one-digit operand to specify the memory channel desired. For example:

```
*** HAL ST-8000  V1.x ***
AT YOUR COMMAND >> STM
```

MEM --	MARK	SPACE	Fc	SHIFT	IBAUD	OBAUD
1 RX:	2125	2295	2210	0170	0074	0074
TX:	2125	2295	2210	0170		
2 RX:	2125	2550	2337	0425	0075	0075
TX:	2125	2550	2337	0425		
3 RX:	2125	2975	2550	0850	0075	0075
TX:	2125	2975	2550	0850		
4 RX:	2225	2025	2125	0200	0300	1200
TX:	1270	1070	1170	0200		
5 RX:	1200	2200	1700	1000	1200	1200
TX:	1200	2200	1700	1000		
6 RX:	2083	2168	2125	0085	0075	0075
TX:	2083	2168	2125	0085		
7 RX:	1270	1070	1170	0200	0300	0300
TX:	1270	1070	1170	0200		
8 RX:	2225	2025	2125	0200	0300	0300
TX:	2225	2025	2125	0200		

```
*** HAL ST-8000  V1.x ***
AT YOUR COMMAND >> LM1 *** Command Not Valid in MONITOR Mode ***

*** HAL ST-8000  V1.x ***
AT YOUR COMMAND >> SM1 *** Command Not Valid in MONITOR Mode ***

*** HAL ST-8000  V1.x ***
AT YOUR COMMAND >> FP

***  Front Panel Mode  ***

FP: [] >> LM2  [LOAD MEMORY 2]
FP: [] >> SM2  [STORE MEMORY 2]
FP: [] >> STM
                    (same response as above STM)
FP: [] >> DC

***  Direct Control Mode  ***

DC: [] >> LM1  [LOAD MEMORY 1]
DC: [] >> SM1  [STORE MEMORY 1]
DC: [] >> __
```

There is actually a ninth memory location, used to store current ST8000 parameters. This memory is always active and restores the ST8000 to previous settings when power is switched OFF and ON. This memory is NOT dependent upon the parameters set in the other eight memory channels.

Notice that switch settings and bandwidths are NOT stored in the memory channels. When power is first applied to the ST8000, the demodulator is set-up for the the last-used frequency parameters and all switch settings are the same as on the front panel switches. Also, the ST8000 always turns-ON in MONITOR mode, assuming front panel control. Therefore, entry to FP or DC modes must be re-established each time power to the ST8000 is turned OFF and ON.

3.10 Test Modes (QBF and RY)

The QBF (Quick Brown Fox ...) test message and alternate RYRY... test messages may be sent from the ST8000 using FP or DC modes. However, to use these modes, the REGeneration feature must also be in one of the four "ON" modes (AA, AB, BA, BB). After entry of "QBF ON" or "RY ON" commands, the designated test message will be transmitted continuously until stopped with "QBF OFF" or "RY OFF" commands. Unless a local audio "loop-back" connection is made between the ST8000 audio output and audio input, these messages will NOT be seen on the ST8000 tuning oscilloscope. The messages may, however, be echoed to the terminal data print device if echo switches on the ST8000 are set accordingly (see section 2.4).

3.11 Selective-Call (SC) and Print (PR) commands.

The Selective-Call (SEL-CAL) feature of the ST8000 controls BOTH the data stream passed to the printer AND the Motor Control output switch transistor of the ST8000. If an EXTERNAL motor control relay is used, the ST8000 SEL-CAL feature will turn that printer motor ON or OFF. If Motor Control is NOT used, the ST8000 RX Data output will be held in Mark condition whenever SEL-CAL is OFF, passing data when SEL-CAL is in the ON condition. See section 2.4 for use of the Motor Control output switch.

The PRint command may be used to over-ride BOTH the SEL-CAL and front panel PRINT SQUELCH control operations.

SEL-CAL and PR commands may be set in either FP or DC modes (not MONITOR mode) as outlined below:

COMMAND	OPERATION
SC ON	Enable SEL-CAL control of printer
SC OFF	Disable SEL-CAL control
SCON [zzzzz]	Set turn-on character stream (10 char. max)
SCOFF [wwww]	Set turn-off character stream (10 char. max)
SCCODE ASCII	Select ASCII as turn-on/off code (IB rate)
SCCODE BAUDOT	Select BAUDOT as turn-on/off code (IB rate)
PR AUTO	Data and printer controlled by SEL-CAL or PRINT SQUELCH control.
PR ON	Over-ride SEL-CAL and PRINT SQUELCH control

A typical turn-on character stream might be the station call sign or an identifier for specific message to be printed. The turn-off character sequence is usually set to "NNNN", but may be set to any other desired sequence. Note that SEL-CAL may be used whether REGEN is ON or OFF, BUT the code MUST match that specified by SCCODE (ASCII or BAUDOT) and the data rate MUST be the same as that set for INPUT BAUD (IB command). Typical selective call and printer commands are shown in the following example.

```
*** HAL ST-8000  V1.x ***
AT YOUR COMMAND >> FP

***  Front Panel Mode  ***

FP: [] >> SC  [SEL-CAL ENABLE=ON  ]
FP: [] >> SC OFF  [SEL-CAL ENABLE=OFF ]
FP: [] >> SC ON  [SEL-CAL ENABLE=ON  ]
FP: [] >> SCON  [SEL-CALL ON="1234"]
FP: [] >> SCON KBBG  [SEL-CALL ON="KBBG"]
FP: [] >> SCOFF  [SEL-CALL OFF="NNNN"
FP: [] >> SCC  [SEL-CALL CODE=ASCII]
FP: [] >> SCC B  [SEL-CALL CODE=BAUDOT]
FP: [] >> PR  [PRINTER=AUTO]
FP: [] >> PR ON  [PRINTER=ON]
FP: [] >> PR AUTO  [PRINTER=AUTO]
FP: [] >> __
```

3.12 CRT Control (CRT Command)

The ST8000 features an automatic circuit that "turns-off" the CRT whenever valid RTTY signals are no longer detected. This feature helps prevent burning of the CRT phosphor that might otherwise occur. However, this feature may be defeated by using the "CRT ON" command in either FP or DC modes. When "CRT ON" is specified, the CRT trace will remain on-screen until "CRT AUTO" is used and valid RTTY signals are no longer sensed. The CRT trace may also be controlled by switched inputs to the Terminal Data connector as discussed in Chapter 2.

3.13 Frequency Displays in Remote Control

The three 4-digit displays will show the current operating parameters of the ST8000, whether the input data originates from front panel controls or from remote control commands. The MARK/Fo, SPACE/SHIFT, and INPUT/OUTPUT switches control ONLY the display and NOT the parameters being set via remote control.

When DIRECT CONTROL (DC) mode is used, the MARK/Fo display may be slightly confusing at first. When front panel controls or FRONT PANEL (FP) remote control modes are used, the MARK, SPACE, CENTER, and SHIFT frequencies are inter-related -- changing one will affect the others. However, in DC mode, The MArk and Center (Fc) settings are not necessarily related - MARK shows the center frequency of the MARK filter and Fc shows the center frequency of the input filter, NOT necessarily the mid-frequency between MARK and SPACE. The SHIFT frequency is ALWAYS computed to be the difference between MARK and SPACE. The INPUT/OUTPUT BAUD display ALWAYS shows baud rates for the REGENeration circuit in both remote or front panel modes. However, as explained above, INPUT BAUD (IBaud) also relates to filter bandwidths when front panel controls or remote control FP modes are used.

3.14 Ending Remote Control (BYE, RES)

Remote control of the ST8000 may be stopped at any time and front panel operation resumed with the BYE or RESet commands. The two commands differ in what parameters are set on the ST8000 when remote control is terminated.

When the BYE command is used, the ST8000 remains set to the parameters last used in FP or DC modes. This can be confusing to the operator since it may result in leaving a switch mode set to a condition DIFFERENT from that shown on the ST8000 front panel. For example, the front panel DETECTOR MODE switch may be set to "FM-M/S" but its function may have been reset in FP or DC modes to "AM-M/S". If BYE is used as an exit command, the ST8000 will remain set in "AM-M/S" mode. However, the first change in the DETECTOR MODE front panel switch will restore operation to front panel control.

The RESet command forces a complete power-on reset of the ST8000 microprocessor. After entering RESet, the normal power-on display and software check codes will be shown on the frequency display of the ST8000 and all parameters are set as indicated by front panel switches.

3.15 ST-8000 REMOTE CONTROL COMMAND SUMMARY

COMMAND	ABBREV	OPERAND	AVAIL. MODES MON	FP	DC	USE	REF
FRPAN	FP	none	x	x	x	Set FRONT PANEL Mode	3.1
DIRCONT	DC	none	x	x	x	Set DIRECT CONTROL Mode	3.1
Help	H	none	x	x	x	List All Commands	3.3
ECHO	EC	ON,OFF	x	x	x	Remote Terminal Echo	3.4
STatus	ST	none	x	x	x	List All Parameters	3.5
STB	STB	none	x	x	x	List Q and BW Param.	3.5
STC	STC	none	x	x	x	List Switch Settings	3.5
STM	STM	none	x	x	x	List Memory Parameters	3.5
STQ	STQ	none	x	x	x	List Q and BW Param.	3.5
STT	STT	none	x	x	x	List Tone Parameters.	3.5
DETMODE	DM *	AM,FM,MS MP,MO,SO		x	x	Set Detc. Mode	3.6
ANTSPACE	AS *	ON,OFF		x	x	Set Antisp. mode	3.6
POLARITY	PO *	NORM,REV		x	x	Set Polarity	3.6
REGEN	REG*	OFF,AA,AB BA,BB		x	x	Set Regen. Mode	3.6
TRACK	TR *	ON,OFF		x	x	Set TRack Mode	3.7.1
MARK	MA *	[xxxx]		x	x	Set RX MArk Freq.	3.7.2
SPACE	SP *	[xxxx]		x	x	Set RX SPace Freq.	3.7.2
CENTER	C *	[xxxx]		x	x	Set RX Center Freq.	3.7.2
SHIFT	SH *	[xxxx]		x	x	Set RX SHift Freq.	3.7.2
EXCHANGE	EX	none		x	x	Exchange RX Mark/Space	3.7.3
TX MARK	XMA*	[xxxx]		x	x	Set TX Mark Freq.	3.7.4
TX SPACE	XSP*	[xxxx]		x	x	Set TX Space Freq.	3.7.4
TX CENT.	XC *	[xxxx]		x	x	Set TX Center Freq.	3.7.4
TX SHIFT	XSH*	[xxxx]		x	x	Set TX Shift Freq.	3.7.4
TX=RX	TX=	none		x	x	Set TX=RX Freqs.	3.7.4
RX=TX	RX=	none		x	x	Set RX=TX Freqs.	3.7.4
TXLOCK	TXL	ON,OFF		x	x	Lock TX to RX Freqs.	3.7.4
MARK Q	QM *	[xxxx]		(x)	x	Set RX Mark Filter Q	3.8
SPACE Q	QS *	[xxxx]		(x)	x	Set RX Space Filter Q	3.8
INPUT Q	QI *	[xxxx]		(x)	x	Set RX Input Filter Q	3.8
LOWPASS	LP *	[xxxx]		(x)	x	Set RX LP Freq.	3.8
INBAUD	IB *	[xxxx]		x	x	Set Input Baud Rate	3.8
OUTBAUD	OB *	[xxxx]		x	x	Set Output Baud Rate	3.8
LOADMEM	LM *	[y]		x	x	Load Memory Parameters	3.9
SAVEMEM	SM	[y]		x	x	Save Param. to Memory	3.9
QBF	QBF	ON,OFF		x	x	Send QBF Test Msg.	3.10
RY	RY	ON,OFF		x	x	Send RYRY.. Test Msg.	3.10
SEL-CAL	SC *	ON,OFF		x	x	Turn SEL-CAL ON/OFF	3.11
SEL-CAL	SCON*	[zzzz]		x	x	Set SEL-CAL ON Char.	3.11
SEL-CAL	SCOFF*	[wwww]		x	x	Set SEL-CAL OFF Char.	3.11
SEL-CAL	SCC *	A,B		x	x	Select ASCII/Baudot SC	3.11
PRINT	PR *	ON,AUTO		x	x	ON=Defeat SC and PR SQ	3.11
CRT	CRT *	ON,AUTO		x	x	ON=Defeat auto CRT Cont.	3.12
BYE	BYE	none	x	x	x	No Change Exit	3.14
RESET	RES	none	x	x	x	Full uP Reset	3.14

* = Command may be used with no operand to list current setting
(x) = Command may be only used with no operand to list parameter
[xxxx] = four digit operand [y] = 1-8 memory selection
[zzzz] = SEL-CAL ON code [wwww] = SEL-CAL OFF code

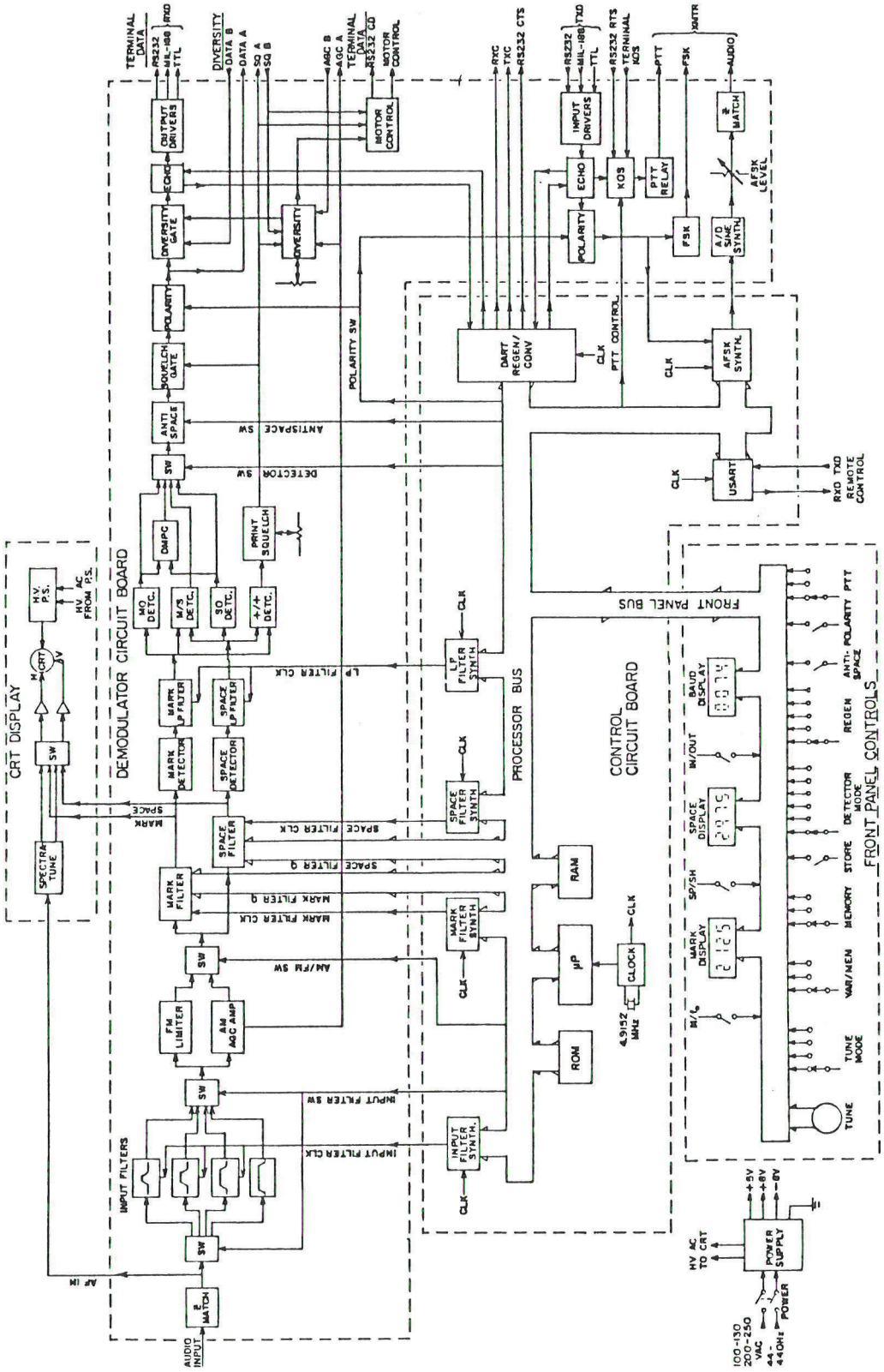


FIGURE 18. ST8000 BLOCK DIAGRAM

CHAPTER FOUR
ST8000 TECHNICAL DESCRIPTION

This chapter provides a general overview of how the ST8000 works and how basic parameters are determined from front panel controls. An understanding of this section will assist the operator to take full advantage of the many features of the ST8000. However, a full circuit description and maintenance data are beyond the scope of this Operator's Manual. These topics as well as full parts lists and spare parts lists are contained in the companion manual, the "ST8000 TECHNICAL REFERENCE MANUAL", available for purchase from HAL Communications. A generalized block diagram of the ST8000 is shown in Figure 18. Please refer to this diagram for the following discussion.

4.1 ST8000 DESIGN CONCEPT

When data is sent via HF radio, many factors conspire to degrade the quality of the digital signal between the transmitter and receiver. Propagation conditions are a particular source of signal anomalies. The job of the HF Modem is to extract what little there may be of a distorted RTTY signal and process it to recover as much of the original data as possible. Since the signal may exhibit strong fading, interference, and distortion of either Mark or Space pulses, a modem designed for good HF data signal recovery is necessarily much more complex than modems that might be used for the almost ideal-signal case of phone lines. Also, because of interference and weak signals, data rates on HF circuits are usually much slower than is possible over voice-grade wire-line or microwave systems. As in the case of a radio receiver, the difference between sucessful and unsucessful reception is often related to the quality and complexity of the receiver device. In fact, the HF Modem IS part of the receiver chain and the ST8000 has been designed with much the same considerations as would be given to any high-performance HF receiver.

4.2 RECEIVE FILTERS AND AMPLIERS

Primary to the design of any receiver is the ability to accept the desired signal and reject undesired or interfering signals. This quality is measured both by the selectivity of the receiver and the over-load resistance of amplifier stages to strong, off-channel signals. The ST8000 filter and amplifier stages have been carefully balanced to provide a wide amplitude dynamic range while preserving selectivity and over-load rejection. The tunable nature of the ST8000 imposed more constraints on the filter stages. The ST8000 uses a combination of fixed-tuned active filters and tunable monolythic switched-capacitor filters (SCF's). The switched-capacitor filters have the advantage of easy tuning over a wide range while maintaining constant filter Q and skirt selectivity.

The audio signal from the receiver is applied to one of four different input bandpass filters of different bandwidth. Three of these filters are tunable with the center frequency chosen automatically from front panel control settings. When different Mark, Space, Shift, and Baud rates are chosen by the tuning controls, the input filter bandwidth and center frequency are computed and the proper filter is automatically selected. The bandwidths of the three tunable input filters are 1/3, 1/2, and 1.0 octave (Q = 1.5, 3.0, or 4.5, respectively). If the shift and/or baud rate require a bandwidth greater than the widest tunable filter, a fixed-tuned 800-3000 Hz filter is automatically selected. To prevent aliasiing of the SCF stages by frequencies close to the clock frequency, each SCF is preceeded and followed by 2-pole low-pass stages, further improving the over-all ST8000 selectivity. Selection of the proper input filter is made electronically to allow full microprocessor control.

Following the input filters, the audio signal is fed to both a wide-bandwidth / high-gain limiter and to a wide-dynamic range AGC amplifier. Both the limiter and AGC-controlled amplifiers allow an over-all ST8000 dynamic range of -65 to +20 dBm. The limiter and AGC stage operate at all times; one output or the other is selected electronically by the DETECTOR MODE front panel switch. The AGC voltage is conditioned to be in the 0 to +5V range for use in the Diversity decision circuit. The AGC voltage is linear (dB vs Vagc) over the range of -55 to 0 dBm.

Either the FM (limiter) or AGC (AM) amplifier outputs are then passed through identical 4-pole SCF active filters to separate the Mark and Space tones. The center frequency of each channel filter is set by the front panel tuning controls. In a departure from conventional HF demodulator design, the Q (or bandwdith) of both filters may be adjusted in 16 steps from a Q of 3.9 to 32.3. When the front panel INPUT BAUD is changed, the proper matching bandwidths for both Mark and Space filters are computed and set automatically. Previous HF Modem designs all fix this bandwidth at a compromise for common data rates, thus giving less than optimum selectivity under most operating conditions. The outputs of the Mark and Space channel filters drive the tuning oscilloscope crossed-ellipse display and the Mark and Space detector stages.

4.3 RECEIVE SIGNAL PROCESSING

Separate and indentical full-wave, ideal-diode active detectors are used to recover the Mark and Space data signals. These detectors have a linear dynamic range in excess of 50 dB, thus assuring proper Mark/Space discrimination, even on weak signals below the limiter or AGC threshold. The detectors are followed by identical 7-pole linear phase SCF low-pass filters for the Mark and Space data. The linear phase design of these filters assures minimum pulse distortion of the recovered digital pulses. The cut-off frequency of these low-pass filters is again computed and set from Baud rate data entered with the front panel tuning controls. This is also a notable departure from previous HF

Modem designs in which the post-detection filter corner is usually set for a compromise high baud rate, seriously undermining the performance for lower data rates.

Four separate pulse discriminators are then used to give the desired pulse output for Mark Only (MO), Space Only (SO), Mark/Space (M/S), and signal squelch (+/+) outputs. The MO and SO outputs are then used to drive the Digital Multi-Path Correction (DMPC) circuit. The DMPC circuit examines the Mark and Space pulses and provides positive Mark-to-Space transistions, even when the two signals over-lap in time. The outputs of the MO, SO, MP, and M/S circuits are then selected electronically by the DETECTOR MODE front panel switch.

The output digital signal is then processed by the Antispace circuit, Polarity switch, Print Squelch, and Diversity switch circuits. Separate data (RXD) outputs are provided for RS232, MIL-188, and TTL terminal devices.

4.4 PRINT SQUELCH AND DIVERSITY

The Print Squelch circuit uses the combined +/+ Mark and Space output to provide detection of valid Mark-Space RTTY signals. The threshold level is controlled by the front panel PRINT SQUELCH control. The output of the print squelch circuit also drives a delayed control circuit for a motor power relay. This feature requires use of an external relay, included in the HAL LP1200 Dual Loop Power Supply.

The Infinite Resoltuion Diversity (IRDC) circuit provides "Selection Mode" diversity combination of the outputs of two ST8000 demodulators. The AGC voltages, and therefore signal strengths, of each ST8000 in the two channel system are sampled and compared. A dual time-constant threshold detector is used to make the "A" or "B" channel switch decision. Use of the dual time-constant prevents rapid channel switching which might otherwise occur for minor signal fluctuations between the two channels. When the signal difference exceeds approximately +/- 5dB, a more rapid integration is used, causing a prompt switch to the stronger signal channel. The ratio of the signals required to produce a diversity channel switch is infintely variable with the front panel DIVERSITY control. The diversity circuit also samples the condition of the squelch circuit of each ST8000, automatically defeating the output of either unit when its squelch circuit is in the LOS (Loss-Of-Signal) condition.

When only one ST8000 is used in a non-diversity system, the diversity circuit provides a second Print Squelch function, controlled by input signal strength, rather than by tone match to the Mark and Space channel filters. The non-diversity condition is sensed and automatically selected whenever the second ST8000 is either not connected or turned OFF. In non-diverstity mode, the DIVERSITY control functions as a second print squelch, driven by signal amplitude.

4.5 TRANSMIT CONTROL AND TONE CIRCUITS

Transmit data (TXD) from the terminal may be in either RS232C, MIL-188C, or TTL format. This data drives the KOS circuit, the FSK circuit, and the AFSK tone oscillator. It may also be combined with RXD to provide local echo to the terminal.

The internal KOS (Keyboard Operated Switch) circuit samples the data and will automatically key the transmitter PTT relay when TXD data pulses appear. The KOS circuit also includes an adjustable timer that may be set to return to receive state 1 to 10 seconds after transmit data pulses have ceased. A continuous BREAK (Space) condition may also be used for a rapid return to receive condition.

The transmitter PTT line may also be controlled by the front panel switch, or a Terminal KOS input or the RS232 RTS signals on the Terminal Data rear panel connector. A relay is used to switch the transmitter PTT to assure compatibility with positive or negative control lines.

The FSK circuit may be set with on-board jumpers for either Mark output polarity (Mark = +V or Space = +V), and for open-collector (NPN transistor) or pull-up to +5 or +8 VDC.

The transmit AFSK tones are synthesized from data entered with the front panel tuning controls. The Mark and Space tones may be independently set in 1 Hz increments over the full ST8000 frequency range. The front panel tuning controls allow setting the transmitter tone frequencies to be the same as or different from the receive filter frequencies. A 10-step sine-wave synthesis circuit is used to assure minimum distortion transmit tone waveform. The AFSK output is transformer coupled and a wide variety of impedances may be matched with internal switch settings. The output level is rear panel adjustable over the range of -40 to +10 dBm (600 ohms).

4.6 CONTROL CIRCUITRY

A total of six separate frequency synthesizers are used in the ST8000 to set the required input, Mark, Space, and low-pass filter frequencies as well as the transmit Mark and Space tones. All of these synthesizers are under microprocessor control. When front panel tuning controls are adjusted, the microprocessor uses this information to compute proper filter and tone frequency settings. The bandwidth and Q of the input, Mark, and Space filters is also computed and the proper conditions set. Thus, changing the tuning knob on the front panel may well change the frequency settings of six synthesizers and 5 filter bandwidths. The microprocessor and its associated memory also provide frequency memory storage, also as selected by the front panel controls. The frequency displays are driven by the microprocessor.

All front panel controls except PRINT SQUELCH and DIVERSITY are controlled by the microprocessor. A separate serial I/O port to the microprocessor allows remote control of all front panel controls, frequency synthesizers, and filter bandwidths. Two additional serial I/O ports are provided to support the REGEN feature, allowing code conversion and speed conversion in addition to simple data regeneration.

4.7 TUNING INDICATOR

The tuning indicator of the ST8000 is unique in that it includes both the standard crossed-ellipse Mark-Space X-Y display and a frequency spectra display. The crossed-ellipse display shows the outputs of the Mark and Space discriminator filters. Correct tuning is therefore shown by maximum amplitude ellipses in both the X and Y directions. The width of the ellipses is proportional to the bandwidth chosen for the Mark and Space filters. Because the CRT ellipses provide a dynamic display of both amplitude and phase, the operator can see both correct tuning condition and some indication of what direction to change receiver tuning when the tones are not matched to the demodulator filters. This information is not available on linear or single lamp LED displays.

The Spectra-Tune frequency spectra display shows the broad-bandwidth audio output of the receiver, BEFORE any of the ST8000 filter circuits. The signal and close interference frequencies appear as bright lines on the display, giving the operator a "coarse" tuning guide and relative indication of where in frequency interfering signals are located. The frequency spectra display shows the audio frequency range of 500 to 3500 Hz, but is usually limited to less range due to receiver bandwidth restrictions.

4.8 POWER SUPPLY

All power for the ST8000 is obtained from three low-voltage regulated supplies and a high-voltage supply for the CRT. The ST8000 may be operated from 100-130 or 200-250 VAC at power line frequencies from 44 to 440 Hz.

4.9 CRT ADJUSTMENTS

The CRT section of the ST8000 has been carefully set at the factory and should require no adjustment in normal use. However, if the operating position has lower or higher than normal ambient lighting, it may be desireable to change the CRT trace intensity. In this case, it will be necessary to remove the top cover the ST8000 while it is operating and adjust the INTENSITY control.

```
**                                                          **
**   CAUTION:  VOLTAGES IN EXCESS OF 1500 VOLTS DC ARE      **
**             PRESENT IN THE CRT SECTION OF THE ST8000.     **
**             USE EXTREME CARE AND INSULATED TOOLS WHEN     **
**             ADJUSTING CONTROLS IN THE CRT SECTION.        **
**                                                          **
```

Locate the INTENSITY control on the CRT board below the ST8000 CRT and adjust as required. Use an insulated screw driver! The FOCUS and ANTISTIG controls may also be adjusted if desired, but shoud not require changing for most situations. Refer to the ST8000 maintenance manual for further CRT circuit adjustments.

CHAPTER FIVE
ST8000 HF MODEM SPECIFICATIONS

INPUT DATA:

Data Rate:	10 to 1200 baud
Frequency:	400 - 4000 Hz
Impedance:	8 or 600 ohms, bal. or unbal. 10K ohms, unbalanced
Dynamic Range:	-65 to +10 dBm (580 uV to 2.5 V)

RECEIVE PROCESSING:

Mode:	Hard-limiting FM (-65 dBm threshold) AGC controlled AM (-65 dBm threshold)
Input Filters:	4 filters: 6-pole 1/3, 1/2, 1 Octave tunable, tracked to center frequency of selected Mark and Space tones; 600 - 3500 Hz fixed tuned.
Tone Filters:	Matched 4-pole tunable filters, set to selected Mark and Space frequencies from 500 to 3500 Hz in 1 Hz increments. M/S filter bandwidths set in 16 steps, automatically tracked with Baud and Shift selected.

DATA PROCESSING:

Detectors:	Matched full-wave active detectors. Outputs for Mark Only, Space Only, M/S differential, or Digital Multi-Path Correction.
LP Filters:	Matched separate Mark and Space 7-pole linear phase tunable low-pass filters. Cut-off frequencies set by Input Baud rate control.
Antispace:	Prevents "open loop" on interference.
Print Squelch:	Adjustable Print Squelch threshold; returns to Mark-hold with no signal (LOS).
Diversity:	Exclusive HAL Infinite Resolution Diversity control for two receiver system.
Regeneration:	Dual digital UART regenerator for ASCII or Baudot data; also provides code and speed conversion (45 - 1200 bd).
Clock Recovery:	Recovered receive data clock output.

TUNING FEATURES:

Control:	Frequencies derived from quartz crystal synthesizers. Set Mark, Space, Shift, and Center frequencies, Input or Output Baud in 1 Hz or 1 Baud increments.
Modes:	BAUD - set Input or Output Baud rate SP/SH - set Space or Shift frequency MARK/Fo - set Mark or Center frequency TRACK - Maintain Shift and set Mark, Space, and Fo frequencies.
Memories:	Eight - non-volatile and programmable. Each memory stores Mark, Space, Fo, Shift, Input Filter, M/S Bandwidth, LP Filter Frequency, Input Baud, Output Baud, and M/S AFSK transmit frequencies.
Memory Modes:	TX/RX variable, RX variable, TX memory, TX/RX memory.
Remote Control:	Separate ASCII serial I/O input allows control of all demodulator parameters.

TRANSMIT FEATURES:

AFSK Tones:	100 to 4000 Hz in 1 Hz increments. Track receiver tones or fixed by memory selection.
AFSK Level:	-40 to +10 dBm (rear panel control) (7.8 mV to 2.5 V rms at 600 ohms).
Impedance:	8 or 600 ohms, balanced or un-balanced, transformer coupled or DC isolated output.
PTT Control:	Relay closure to ground; internal KOS, terminal KOS, RS232C RTS, or manual front panel switch control; +/- 50V, 0.5A max.
FSK Output:	Logic voltage to drive direct FSK input on transmitter. Polarity and voltage level selectable (open collector, +5V, or +8V for Mark or Space).

DISPLAYS:

Tuning:	1.50 x 2.00 inch rectangular CRT; crossed-ellipse Mark/Space and Spectra Tune 500-3500 Hz spectral display of received signals; CRT beam turned off on LOS (Loss Of Signal).
Frequency:	Three 4-digit displays show Mark or Fo, Space or Shift, and Input or Output Baud.
LED:	Mark, Space, LOS, Print On, A or B Diversity, TX on, and Power on.

INPUT/OUTPUT CONNECTIONS:

TERMINAL DATA:	Shielded DB-25S socket.
	RS232C: TXD, RXD, RTS, CTS, CD, DSR, recovered RXC
	MIL-188C: TXD, RXD
	TTL: TXD, RXD
	Misc: Terminal KOS, Motor Control, FSK output.
DIVERSITY:	Shielded DE-9S socket to connect second ST8000 in two-channel diversity system.
REMOTE CONTROL:	Shielded DB-25P plug for serial remote control of all front panel parameters.
RECEIVE AUDIO:	Stereo 1/4" phone jack for audio input.
TRANSMITTER:	4-pin shielded mic. connector; transmit audio and PTT or transmit FSK and PTT.
POWER:	IEC AC power connector; shielded and filtered.

PHYSICAL DATA:

Cabinet Finish:	Natural aluminum with irridite finish; black vinyl front panel.
Cabinet Style:	19" rack mounting standard, table-top feet with tilt-bail included.
Size:	3.50 H x 14 D x 19 W (rack mtg). (8,9 x 35.6 x 48.3 cm) 4.125 H x 14 D x 17 W (table case) (10.5 x 35.6 x 43.2 cm)
Weight:	15 lbs (6.8 kg) net, 20 lbs (9.1 kg) shipping.
Power:	100-120 or 200-240 VAC, 44-440 Hz; 20 Watts.

The ST8000 has been tested and verified by HAL Communications to be in accordance with Subpart J of Part 15 of FCC Rules concerning RFI emission. The following text is required by that FCC regulation:

> "This equipment generates and uses radio frequency energy and if not installed and used properly, that is, in strict accordance with the manufacturer's instructions, may cause interference to radio and television reception. It has been type tested and found to comply with the limits for a Class B computing device in accordance with the specifications in Subpart J of Part 15 of FCC Rules, which are designed to provide reasonable protection against such interference in a residential installation. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:
>
> -- reorient the receiving antenna
> -- relocate the computer with respect to the receiver
> -- move the computer away from the receiver
> -- plug the computer into a different outlet so that computer and receiver are on different branch circuits.
>
> "If necessary, the user should consult the dealer or an experienced radio/television technician for additional suggestions. The user may find the following booklet prepared by the Federal Communications Commission helpful:
> 'How to Identify and Resolve Radio-TV Interference Problems', vailable from the U.S. Government Printing Office, Washington, DC 20402, Stock No. 004-000-00345."

The following FCC text applies when the ST8000 is used with peripheral equipment:

> "WARNING: This equipment has been verified to comply with the limits for a Class B computing device, pursuant to Subpart J of Part 15 of FCC Rules. Only peripherals (computer input/output devices, terminals, printers, etc.) certified to comply with the Class B limits may be attached to this computer device. Operation with non-certified peripherals is likely to result in interference to radio and TV reception."

LIMITED WARRANTY

HAL Communications Corp. of Urbana, Illinois, hereby warrants to the original retail purchaser only that the product herein described and sold shall be free from defects in materials and workmanship for a period of one year from the date of sale to the original retail purchaser.

In the event of a defect in materials or workmanship during the warranty period, HAL Communications Corp. will, at its own expense, repair the defective unit and replace any defective parts. Cost of shipping the unit to HAL Communications Corp. shall be paid by the purchaser, as well as costs of removal and reinstallation of the unit. HAL Communications Corp. will bear the shipping costs incurred in returning the unit to the purchaser (48 contiguous states only).

To obtain service under this warranty, the original purchaser should do the following:

1. Notify, as soon as possible, the Customer Service Department of the original selling dealer or HAL Communications Corp., Box 365, Urbana, Illinois, 61801, either in writing or by telephone, of the existence of a possible defect.
2. At the time of notification, identify the model and serial number, date and place of purchase, and the possible defect.
3. Hold the unit until written return authorization is received.
4. Return the unit, freight prepaid, upon the receipt of the written return authorization with a copy of the original bill of sale for the equipment.

Correct installation, use, maintenance, and repair are essential for proper performance of this product. The purchaser should carefully read the technical manual.

This warranty does not apply to any defect which HAL Communications Corp. determines is due to any of the following:

1. Improper maintenance or repair, including the installation of parts or accessories that do not conform to the quality and specifications of the original parts;
2. Misuse, abuse, neglect, improper installation, or improper operation (including operation without a proper safety ground connection);
3. Accidental or intentional damage.

All implied warranties, if any, are limited in duration to a period of one year from the date of purchase by the original retail purchaser. (Some states do not allow limitations on how long an implied warranty lasts, so the above limitation may not apply to you.)

HAL Communications Corp. disclaims any liability for incidental or consequential damages arising out of the use of, or inability to use, this product. (Some states do not allow the exclusion or limitation of incidental or consequential damages, so the above limitation or exclusion may not apply to you.)

This warranty gives you specific legal rights, and you may also have other rights which vary from state to state.