ST-7000

HF Demodulator for Packet Radio

870-07000

August, 1988 Printing

ST-7000 HF DEMODULATOR FOR PACKET RADIO

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HAL COMMUNICATIONS CORP.

ST-7000

HF Demodulator for Packet Radio
Operator's Manual

CHAPTER 1

UNPACKING AND INSPECTION

When unpacking the ST-7000, carefully inspect the shipping carton and the cabinet for shipping damage. Any evidence of shipping damage should be immediately reported to your shipping carrier. Be sure to save all packing materials if damage is found - the shipping carrier will want to inspect them. Before discarding the packing materials check that you have all parts and accessories listed below. If any are found missing, notify HAL Communications Corp. immediately.

Be sure to fill-out and mail the enclosed Warranty Card to HAL Communications.

1	900-07000	ST-7000 HF Demodulator

The following accessories are included with the ST-7000:

1	770-05000	Spare 0.5A fuse
1	800-01002	115VAC to 12VDC Power Supply
1	960-07232	5-pin TTL I/O Cable
3	355-00054	5-pin DIN to Phono Cable
1	870-07000	ST-7000 Preliminary Operator's Manual

The following accessories are available at extra cost:

855-00006	RS232C Cable
333-20250	DB25 Connector
333-51228	DB25 Connector Shell
310-00064	5-pin DIN Connector
327-05000	5-pin TTL Connector

You may also be interested in the following related HAL products:

RPC-2000	Radio Packet Controller Board (for PC-XT & DS-3200)
DS-3200	Radio Data Terminal (100% PC-XT Compatible)

CHAPTER 2

INSTALLATION

The ST-7000 is a modem (MOdulator/DEModulator) device that connects between your packet controller (also called "TNC") and an HF receiver-transmitter. The packet controller is NOT included in the ST-7000. Proper installation of the ST-7000 requires (a) DC power connection, (b) HF radio connection, and (c) packet controller connection.

The rear panel of the ST-7000 is shown below in Figure 2.1. All connections to the ST-7000 are made to one or more of these connectors.

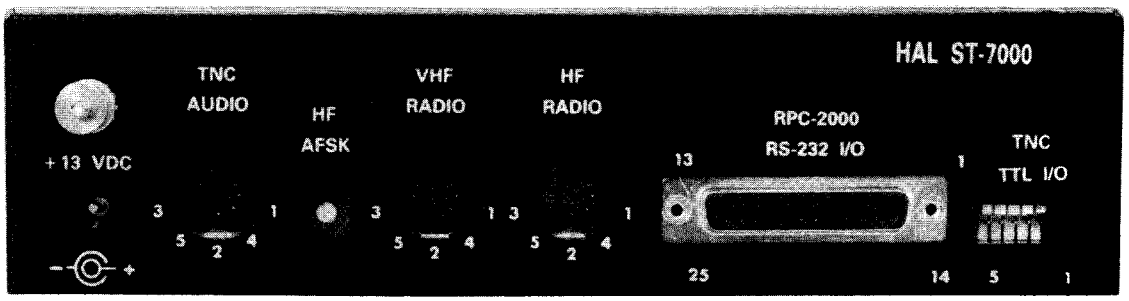


FIGURE 2.1 ST-7000 REAR PANEL

Many of the I/O connections available on the ST-7000 will require changing of internal jumpers. Therefore, when making the first installation, REMOVE the ST-7000 top cover before starting. There are NO hazardous voltages inside the ST-7000, but use care to avoid damaging components or accidently shorting out circuits with stray wires while power is applied to the ST-7000. To remove the top cover:

1. Remove all cables connected to the ST-7000 rear panel.
2. Remove the two screws at each side of the cabinet (4 screws total).
3. Lift from the front and swivel the top so that it lies upside down behind the ST-7000.
4. Unplug the ground jumper wire and set the top cover aside.
5. Preliminary tests will be made with the cover OFF. The cabinet cover may be re-assembled after all jumpers and connections are set.

Location of the internal jumpers is shown in Figure 2.2.

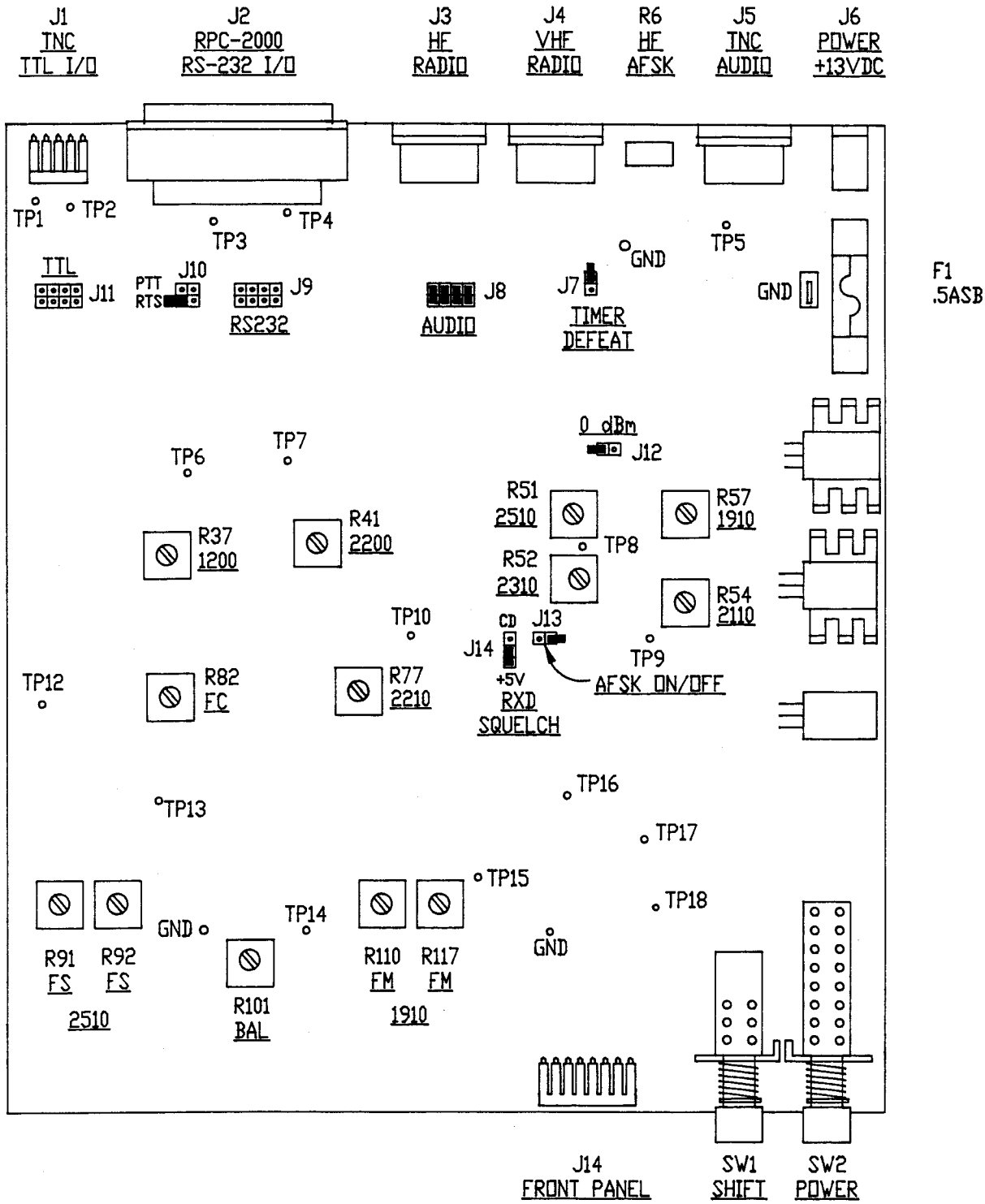


FIGURE 2.2 ST-7000 INTERNAL JUMPER LOCATIONS

2.1 DC Power:

The ST-7000 requires a minimum of 13 VDC @ 225 ma power. This is supplied by the enclosed accessory DC Power Supply or from other sources of DC power. The connector on the HAL DC Power Supply is already set-up for the ST-7000. If using your own DC power source, be sure to observe correct polarity. The ST-7000 DC connector uses the center pin as the positive terminal. BE CAREFUL! Other devices with similar appearing DC connectors may use a different polarity as well as a different diameter center pin. If you accidently reverse the power supply polarity, it should not damage the ST-7000 circuits, but it will blow the fuse inside the ST-7000! Any DC power supply used with the ST-7000 should supply 13.5 to 15 VDC at 0.250 A.

2.2 HF Radio Connection:

The HF Radio equipment is connected to the "HF RADIO" 5-pin DIN connector on the rear panel. If you are preparing your own cables, pay close attention to the pin numbers marked on the rear panel. The "industry standard" pin numbering on these connectors does NOT go in a logical progression! Connections are as follows:

PIN	USE
1	Transmit tones to HF transmitter audio input
2	GROUND
3	Push-to-Talk (PTT) to transmit/receive control
4	Audio output of HF receiver
5	Not used
Shell	GROUND (Cable shields)

An accessory cable (P/N 355-00054) is supplied that conveniently converts the 5-pin DIN connections to individual "RCA-style" phono plugs. Some HF radio equipment (notably Ten-Tec) have rear panel phono connectors to which this adapter cable may be directly connected. Other radio connectors may require that you either make your own complete cable set OR adapt the phono connector to one that matches the connector on your radio. For HF radio connections, the following color code applies to the HAL adapter cable.

HF RADIO CONNECTIONS
DIN to PHONO Adapter Cable

CABLE COLOR	USE	ST-7000 HF RADIO PIN NO.
RED	TONES TO HF TRANSMITTER	1
BLACK	Push-To-Talk (PTT)	3
WHITE	AUDIO FROM HF RECEIVER	4
YELLOW	-- not used --	5

NOTE: Ground (pin 2) is connected to ALL phono connectors

A typical ST-7000 to HF Transceiver connection is shown in Figure 2.3. A detailed discussion of the requirements for each connection is given in the sections following Figure 2.3.

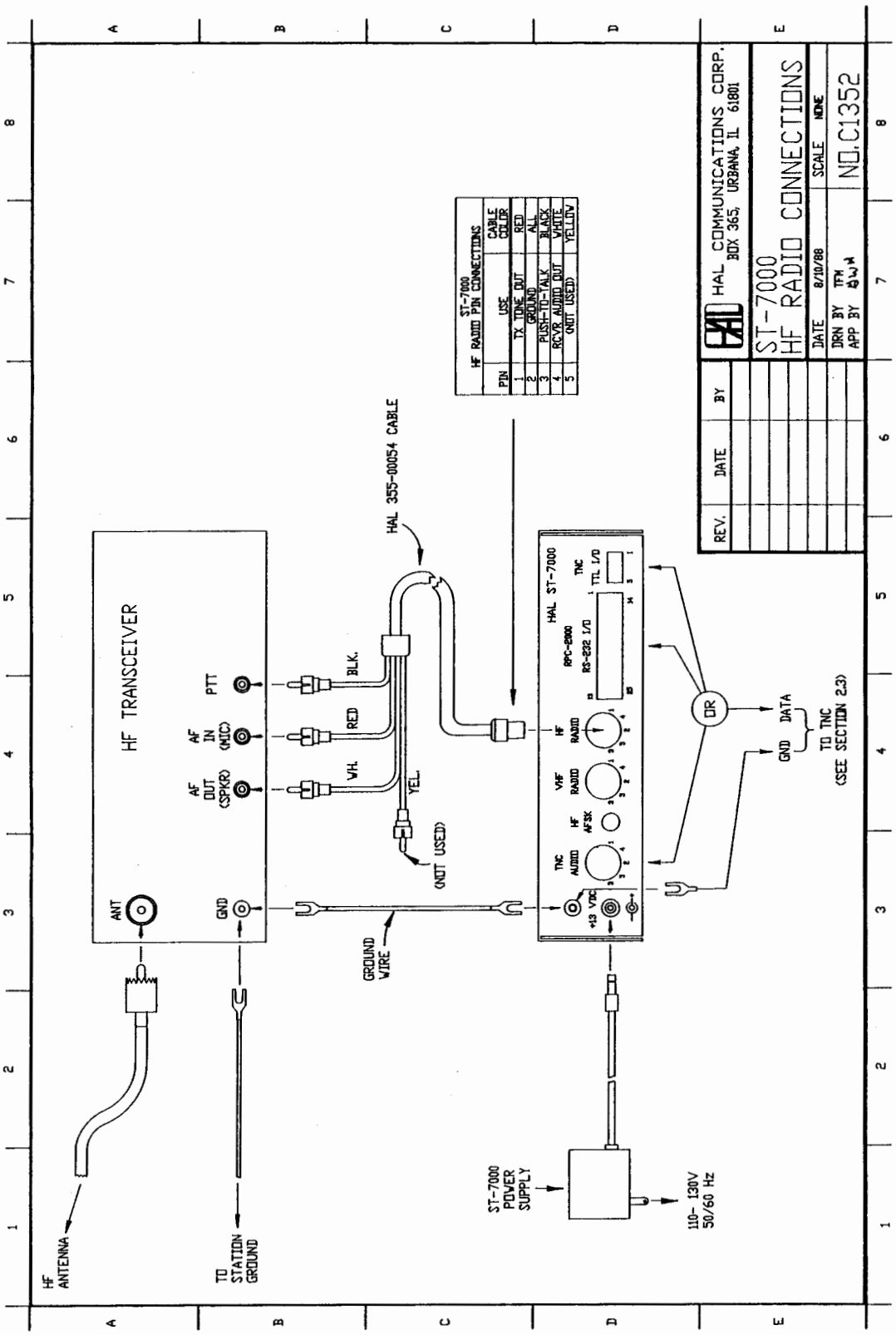


FIGURE 2.3 HF RADIO CONNECTIONS

2.2.1 HF Receive Audio:

The ST-7000 is designed to work equally well from either an 8 ohm or 600 ohm audio output on your receiver. The simplest connection is direct to the receiver speaker output terminals. Set the receiver volume control to a comfortable speaker level and the ST-7000 AGC circuit will do the rest. If you have a constant level 600 ohm audio output, by all means use it. Some radios have a phone patch output on the rear panel - if so, use it. The ST-7000 may also work with some "recorder" outputs provided on some receivers. However, the output impedance and voltage level output may not provide sufficient audio signal for the ST-7000 and may cause reduced performance during signal fades. Be sure to use shielded cables between the ST-7000 and the receiver audio output connector.

2.2.2 HF Transmit Audio:

The ST-7000 is set at the factory for a level of -20 dBm (80 mV) to the transmit audio output connector. This level may be reduced to as low as a few millivolts (-50 dBm) by adjustment of the "HF AFSK" screw-driver control on the rear panel. Conversely, if your transmitter system requires a higher level output, internal jumper J12 may be installed to increase the maximum level output to 0 dBm (800 mV). With J12 in place, the "HF AFSK" control will adjust over the -30 to 0 dBm range (25 to 800 mV). The microphone input of most SSB transmitters will require a level of between -40 and -20 dBm (8 to 80 mV). Be sure to use a shielded cable between the ST-7000 and the transmitter audio input.

Use the following procedure to set the "HF AFSK" level control.

1. Turn OFF transmitter VOX and SPEECH PROCESSOR features.
2. Set the transmitter to LSB mode.
3. Set transmit MIC LEVEL to "0".
4. Set ST-7000 to "200" SHIFT and turn ON ("HF" position).
5. Set ST-7000 HF AFSK to maximum (full CW as viewed from rear).
6. Be sure transmitter is connected to a load (antenna or dummy load).
7. Turn transmitter to XMIT.
8. Slowly increase MIC LEVEL until 50% of full transmitter power output is noticed. Note the position of the MIC LEVEL knob.
9. Turn transmitter OFF.
10. If 50% transmitter power is achieved in first third of the MIC LEVEL rotation, change the setting of "HF AFSK" (CCW) and try step 8 again. Keep adjusting MIC LEVEL and "HF AFSK" until 50% transmitter power is achieved at between 1/3 and 1/2 rotation of the MIC LEVEL control.

11. If 50% transmitter power is achieved at greater than 1/2 rotation of the MIC LEVEL control, install jumper J12 inside the ST-7000. Be sure to turn OFF the ST-7000 before removing its cover. The jumper for J12 is installed at the factory with just one pin covered. Unplug the jumper and re-install it to short out the pins at J12. After installing the J12 jumper, go back to step 8 and adjust MIC LEVEL.

12. If installing J12 still does not give adequate MIC LEVEL settings, turn everything OFF and inspect your cables - something is WRONG!

13. Set the MIC LEVEL control to the desired transmitter output level. Since most transmitters are designed for SSB voice (50% duty cycle), using less than full power for data is a prudent move and may greatly prolong the life of your transmitter. The difference between 1/2 power and full power is only 1/2 an S-unit on the other station's receiver, hardly worth the risk to your transmitter!

2.2.3 HF PTT Connection:

The ST-7000 Push-to-Talk (PTT) output is a relay contact switched to ground. The relay can adequately switch PTT control lines that have up to 50 VDC at a maximum current of 0.25 amperes. This should switch virtually ANY transmitter or transceiver available. A shielded cable is recommended but not required for the PTT connection. Often, a two-conductor shielded cable can be used to carry both transmit audio and PTT signals from the ST-7000 to the transmitter microphone input jack.

The ST-7000 HF PTT output includes a 20 second safety timer for packet radio. This timer prevents long key-down periods, even if your TNC or computer malfunctions. This safety feature helps prevent transmitter burn-out in a malfunctioning packet radio system. The timer resets after each packet is sent and the TNC PTT control line returns to receive state.

However, the ST-7000 may also be used as an RTTY or AMTOR FEC modem. In this case, long key-down transmitter periods are common and internal jumper J7 may be installed to defeat the PTT safety timer. To defeat the timer, move the jumper plug so that it shorts the two pins at J7. The jumper plug is positioned at the factory to cover one but not both pins of J7 (PTT safety timer ON).

2.2.4 HF GROUND Connection:

The ST-7000 MUST be adequately grounded to the HF transmitter and receiver. Grounding is done in TWO steps - (1) an audio ground obtained through the shielded cables between the HF RADIO connector and the transmitter/receiver audio connections, and (2) an RF ground between cabinets. The importance of a good RF ground cannot be over-emphasized! Use a short length of 1/4" shield braid directly between the transmitter/receiver cabinet and the ST-7000 rear panel ground screw. An earth ground for the entire radio station is a good safety feature but does NOT replace the need for a separate RF ground connection.

2.3 Packet Controller Connections:

The ST-7000 includes three different I/O interface connectors and jumper sets for connection to your packet controller (TNC). Choice of which interface is used is left to the operator. If you need to use the same packet controller for HF and VHF, use the TNC AUDIO interface. If you choose to dedicate a packet controller specifically for HF use, a slight improvement in performance may be gained by using the TTL or RS232 interface connections, but at the loss of the VHF-Audio "pass-through" feature. The factory settings are for an AUDIO interface and its use is described first.

2.3.1 TNC AUDIO Interface:

This interface connection makes use of a separate modem contained inside the ST-7000. This modem converts the processed HF packet data into the tone standards used for VHF packet radio - 1200 Hz and 2200 Hz. This interface allows use of virtually ALL currently available packet controllers with NO internal modifications to the packet controller itself.

A "standard" 5-pin DIN audio connector is used for the TNC AUDIO interface. Pin connections correspond to those pins used on the popular TNC-2, MFJ-1274, and KPC controllers. However, connectors and standards change - BE SURE TO CHECK YOUR MANUAL! Connections to the TNC AUDIO connector are:

Pin	Use
1	Transmit audio output from TNC
2	GROUND
3	PTT output from TNC
4	Receive audio input to TNC
5	Not used by ST-7000
Shell	GROUND (not used on some TNC devices)

Use shielded cables to connect between the ST-7000 and the TNC. Be sure to make an RF ground connection between the ST-7000 cabinet and the TNC cabinet. No adjustments are necessary for the TNC AUDIO interface connection. Internal jumpers at ST-7000 location J8 are set at the factory. If your unit has been changed from factory settings, check to be sure that:

1. ALL four (4) jumpers are installed at jumper field J8.
2. NO jumpers are installed at fields J9, J10, and J11.
3. If jumpers are not installed at J9, J10, or J11, connection of external cables to either the TTL or RS232 I/O connectors will NOT affect ST-7000 operation.

Two DIN to Phono adapter cables (P/N 355-00054) are supplied to assist in making the TNC Audio connection. In general, use of the adapter cable greatly simplifies installation, even if some of the connectors must be changed or further adapted. For TNC Audio connections, the following color code applies to the HAL adapter cable.

TNC AUDIO CONNECTIONS
DIN to PHONO Adapter Cable

CABLE COLOR	USE	ST-7000 TNC AUDIO PIN NO.
RED	TX TONES from TNC	1
BLACK	Push-To-Talk (PTT) from TNC	3
WHITE	AUDIO to TNC AF INPUT	4
YELLOW	-- not used --	5

NOTE: Ground (pin 2) is connected to ALL phono connectors

A typical ST-7000 to TNC AUDIO connection is shown in Figure 2.4. Note that connections to a VHF Radio are also shown. These connections will be discussed further in section 2.4.

2.3.2 TTL TNC I/O Connections:

The ST-7000 may also be used in a direct connection to an external modem connector on your packet controller. The connector and pin arrangement is identical to that used on the PK232 controller. Cable 960-07232 furnished in the accessories may be used to make a direct connection to the PK-232. Note that internal jumpers in the PK-232 MUST be changed to use its external modem connection. Other TNC's may or may not support direct TTL external modem connections. Be sure to check your manual before making this connection. The connector and pin numbering may be different; some jumpers inside your TNC may have to be changed. The connections to the TTL TNC I/O connector are:

Pin	Use
1	Received HF data to TNC
2	Transmit data from TNC
3	HF Carrier Detect data to TNC
4	GROUND
5	Push-to-Talk (PTT) from TNC

Shielded wire is recommended for this cable connection. Be sure to run a separate RF ground between the TNC and ST-7000 cabinets. The following jumpers MUST be set inside the ST-7000 to use the TTL TNC I/O connection:

1. Plug-in four jumper plugs at jumper field J11. If your ST-7000 is "factory fresh", unplug the four plugs from jumper field J8 and move them to field J11.

2. REMOVE ALL jumper plugs in fields J8, J9, and J10.

3. External cables connected to ST-7000 TNC AUDIO or RS232 rear panel connectors will have NO effect.

TTL TNC connections are shown in Figure 2.5.

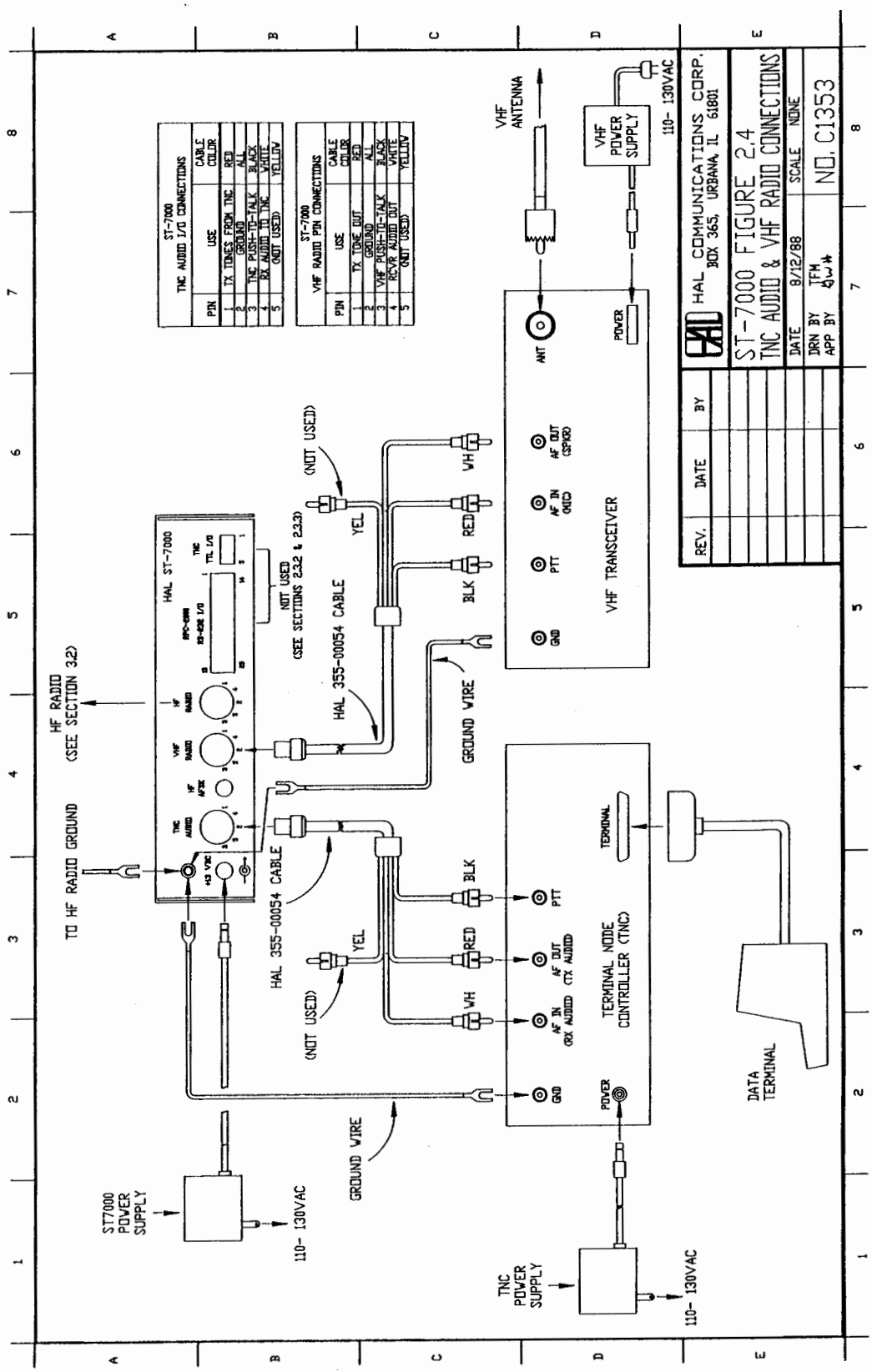


FIGURE 2.4 AUDIO TNC INTERFACE CONNECTIONS

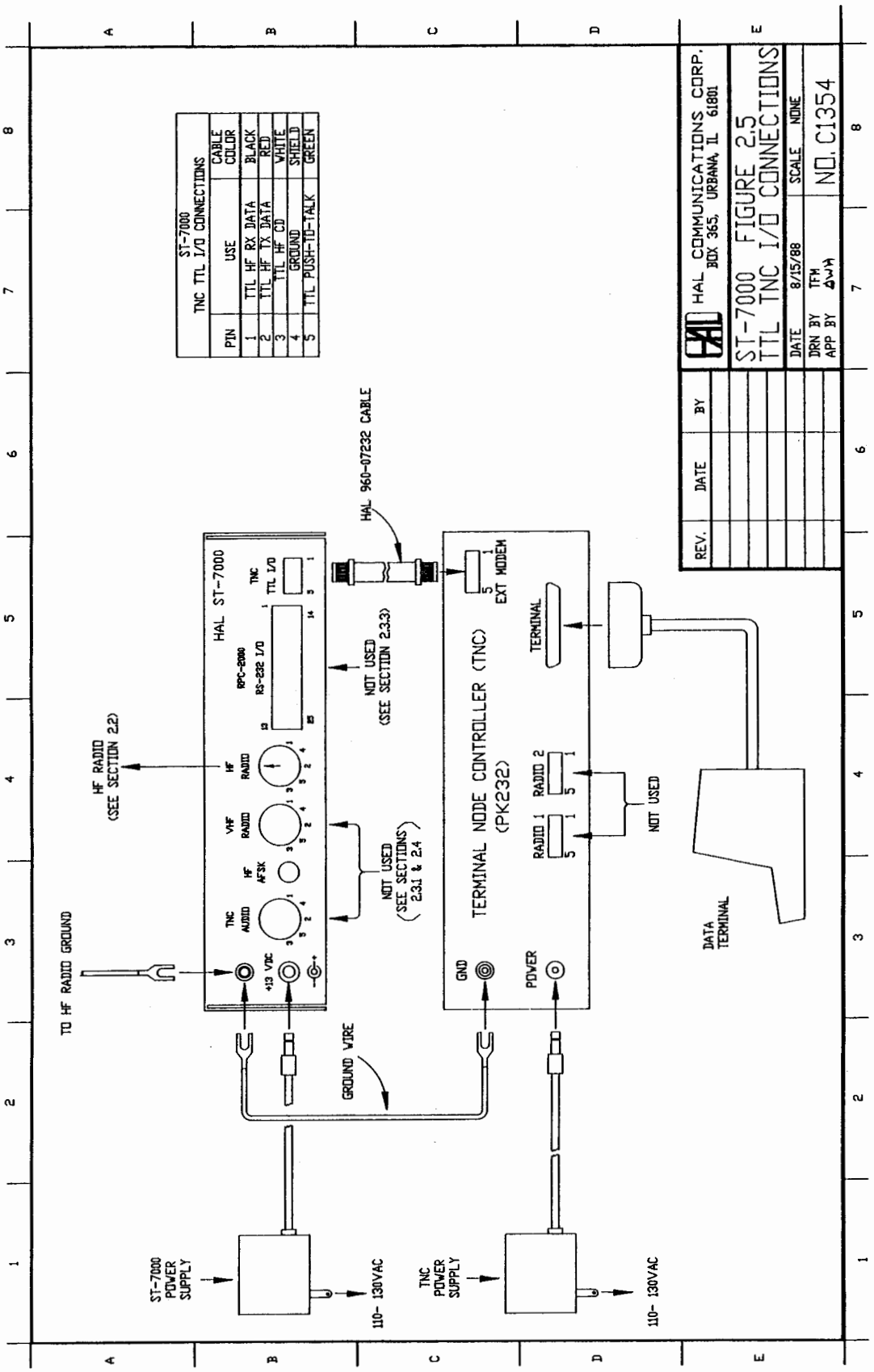


FIGURE 2.5 TTL TNC INTERFACE CONNECTIONS

2.3.3 RPC-2000 RS232 I/O Connections:

This connector is provided specifically for connection to the HAL RPC-2000 Radio Packet Controller, but may be used with ANY TNC that has an RS232C external modem interface. The pin connections are:

Pin	Use
1	Chassis Ground
2	Transmit data (TXD) from TNC
3	HF Receive data (RXD) to TNC
4	Request To Send (RTS) from TNC (+V = transmit)
5	Clear To Send (CTS) to TNC (constant +8V)
6	Data Set Ready (DSR) to TNC (constant +8V)
7	Signal Ground
8	HF Carrier Detect (CD) data to TNC
19	Push-to-Talk (PTT) from TNC (ground = transmit)

Other pins = NO CONNECTION IN ST-7000

TWO different transmit/receive control inputs are provided RTS and PTT). The RPC-2000 provides BOTH, but other TNC's may provide just one or the other. This connector is designed so that a full 25-wire RS232 cable may be used between the ST-7000 and the RPC-2000. For other TNC devices, be sure to consult your manual and connect only those pins that are required.

Two jumper fields are provided for RS232 I/O - a 4 position field (J9) for TXD, RXD, CD, and PTT plus a 2 position field (J10) to choose whether TNC RTS (pin 4) or TNC PTT (pin 19) is used to control the ST-7000 HF PTT circuit. To use the ST-7000 with the RPC-2000, use the following jumpers:

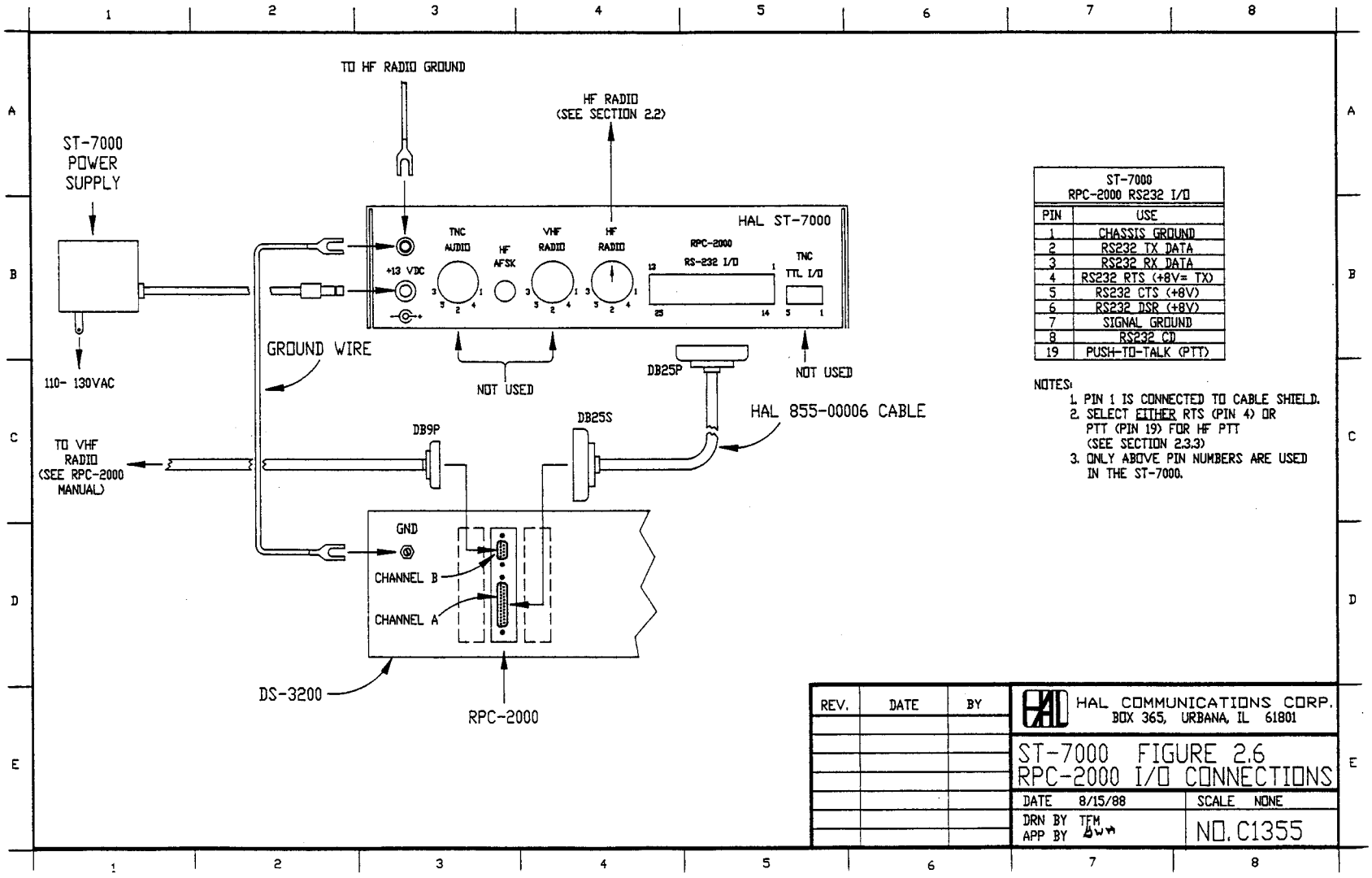
1. Install four jumper plugs at field J9 (aligned front-to-back in the ST-7000 cabinet).

2. Install one jumper plug in the RTS position of field J10 (aligned left-to-right in the ST-7000 cabinet).

3. Be sure that ALL jumper plugs are removed from fields J8 and J11.

4. Connection of external cables to the TTL I/O or TNC AUDIO connectors on the ST-7000 will have NO effect.

Also, be sure to provide a good RF ground connection between the DS-3200 or host PC for the RPC-2000 and ST-7000 cabinets. Use of the ST-7000 to RPC-2000 RS-232 Interface is shown in Figure 2.6.



ST-7000 RPC-2000 RS232 I/O	
PIN	USE
1	CHASSIS GROUND
2	RS232 TX DATA
3	RS232 RX DATA
4	RS232 RTS (+8V= TX)
5	RS232 CTS (+8V)
6	RS232 DSR (+8V)
7	SIGNAL GROUND
8	RS232 CD
19	PUSH-TO-TALK (PTT)

NOTES:
1. PIN 1 IS CONNECTED TO CABLE SHIELD.
2. SELECT EITHER RTS (PIN 4) OR PTT (PIN 19) FOR HF PTT (SEE SECTION 2.3.3)
3. ONLY ABOVE PIN NUMBERS ARE USED IN THE ST-7000.

REV.	DATE	BY

HAL COMMUNICATIONS CORP.
BOX 365, URBANA, IL 61801

ST-7000 FIGURE 2.6
RPC-2000 I/O CONNECTIONS

DATE 8/15/88 | SCALE NONE

DRN BY TFM
APP BY

NO. C1355

FIGURE 2.6 RS-232 TNC INTERFACE CONNECTION

2.4 VHF RADIO Connections:

The VHF radio connector works ONLY if the TNC AUDIO I/O interface is also used. It has NO effect if TTL or RS232 I/O is used. The connector and pin-out are identical to that used for a connection to popular TNC models. If such a connector is already in use in your VHF to TNC connection, you may just unplug the cable from the TNC and plug it into the ST-7000 VHF RADIO connector. If you use a different connector, check your manuals and prepare a cable as follows:

Pin	Use
1	Audio input to VHF Radio transmitter
2	GROUND
3	Push-to-Talk to VHF Radio
4	Audio output from VHF Radio receiver
5	Not used
Shell	GROUND (may not be used on some TNC's)

To use the TNC with the VHF radio, set the ST-7000 front panel switch to VHF position (button out = ST-7000 OFF) and change the TNC HBAUD to 1200 baud. No ST-7000 circuits are used on VHF - the switch connects the VHF RADIO connector to the TNC AUDIO connector. Connections and color coding of the DIN to Phono adapter cable are shown in Figure 2.4.

This completes connection of the ST-7000 to the radio system. Temporarily remove all connectors from the ST-7000, re-install the ST-7000 top cover, and then restore the connections to the ST-7000. Be sure to reconnect the ground wire between the ST-7000 circuit board and rear panel.

CHAPTER 3
OPERATION

Operation of the ST-7000 is very simple. It is virtually a matter of hooking it up, turning it ON, and tuning a signal. First, a brief review of the controls and indicators:

3.1 CONTROLS AND INDICATORS

Refer to Figure 3.1 for the following discussion.

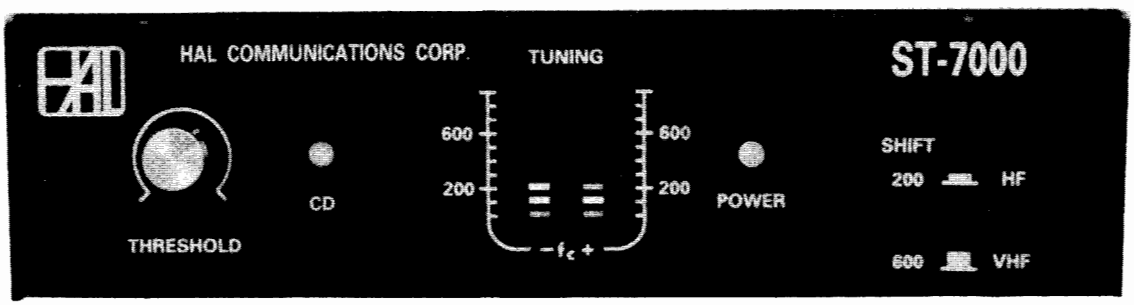


FIGURE 3.1 ST-7000 FRONT PANEL

3.1.1 HF/VHF Switch:

The HF/VHF switch serves the dual function of ST-7000 power switch and HF/VHF radio switch if the TNC AUDIO interface connection (2.3.1) is also used. If either the TNC TTL or RS232 TNC interface connections are used, the HF/VHF switch only controls the power to the ST-7000. Power is turned ON when the button is pushed IN (HF position), as indicated by the RED POWER front panel lamp. If the TNC AUDIO interface connection is used and a VHF radio is connected to the ST-7000 (Sections 2.3.1 and 2.4), this switch also diverts the TNC audio signals to the VHF radio when the ST-7000 is turned OFF (button OUT = VHF position).

3.1.2 SHIFT Switch:

This switch selects either 200 Hz or 600 Hz switch. The present "HF Standard" is 200 Hz shift, so you will want to use this position to get started (button in). However, when talking with another station who also has a HAL ST-7000, switch to 600 Hz shift and see the difference! The ST-7000 200 Hz shift performance is good, but the 600 Hz performance is even better! Both receiver filters/detectors and transmit tones are switched by the SHIFT switch - you are always transceive. Although polarity makes no difference to packet radio

signals, care has been taken to assure that receive and transmit data polarities are identical - you may also use the ST-7000 for 300 baud Baudot or ASCII RTTY (or 100 baud AMTOR).

3.1.3 THRESHOLD Control:

This control sets the signal/no-signal detection threshold for the Carrier Detect circuit. It operates in a similar fashion to a squelch control on a VHF radio. Tune the receiver to an unoccupied frequency and rotate the control clockwise (CW) until the CD LED comes on. Now, "back" the control CCW until the CD light goes OFF. Tune to an active HF packet channel and confirm that the CD LED flashes ON and OFF as bursts of packet signals are heard. The setting of THRESHOLD will change with receiver volume control setting unless you have a constant audio output connection on your receiver. Practice setting this control.

3.1.4 Tuning Indicator:

The ST-7000 tuning indicator is a unique device, unlike any other ever offered. A total of 20 LED segments are arranged in two parallel bars. A fully lit LED segment corresponds to approximately 50 Hz change in the audio frequency of the received tone(s). Picture the two parallel bars as the vertical "legs" of the letter "U". The lowest audio frequency (approximately 900 Hz) will light the top left LED segment. As you tune to increase the tone frequency, the illuminated LED segment moves down the left bar and then back up the right bar to the highest frequency (approximately 3000 Hz). The "center" of the display (1/2 way between the bottom dots of the two rows) corresponds to the 1900 Hz center frequency of the ST-7000. A packet radio signal will appear as a band of dots, the width of which is proportional to the shift and data rate. The dots actually correspond to the frequency spectra of the received signal. Correct tuning of the receiver is achieved when the signal is centered on the ST-7000 input filters - centered on the tuning display. Therefore, you need only tune until an equal vertical deflection is obtained on the two parallel bars.

When correctly tuned, a 200 Hz shift signal will illuminate the bottom three bars in both vertical lines - approximately to the "200" marks on the front panel. A 600 Hz shift signal will have a balanced deflection near the "600" marks on the front panel. With a little practice, it becomes VERY easy to precisely tune an HF packet signal on the display. Use some patience when tuning - a given packet burst may appear "biased" to one side or the other - this is because of the bit-stuffing and NRZI format used for packet data. With just a little practice, you can easily tune to within 20 Hz or closer. Watch some HF packet signals on a busy channel. You will be amazed at the frequency error of some stations. The ST-7000 itself is very forgiving of minor tuning errors (50 Hz on 200 Hz shift, 100 Hz on 600 Hz shift), but strive to be as accurate as possible when tuning. The resolution of the tuning indicator is a lot better than the 50 Hz bar spacing might lead one to believe since each segment partially illuminates as its "center frequency" is approached. Resolution of 20 Hz or better is quite easy to achieve. If absolute frequency accuracy is required on a net frequency, a crystal in the transmitter/receiver is still the best approach. Examples of correct and incorrect tuning are shown in Figure 3.2.

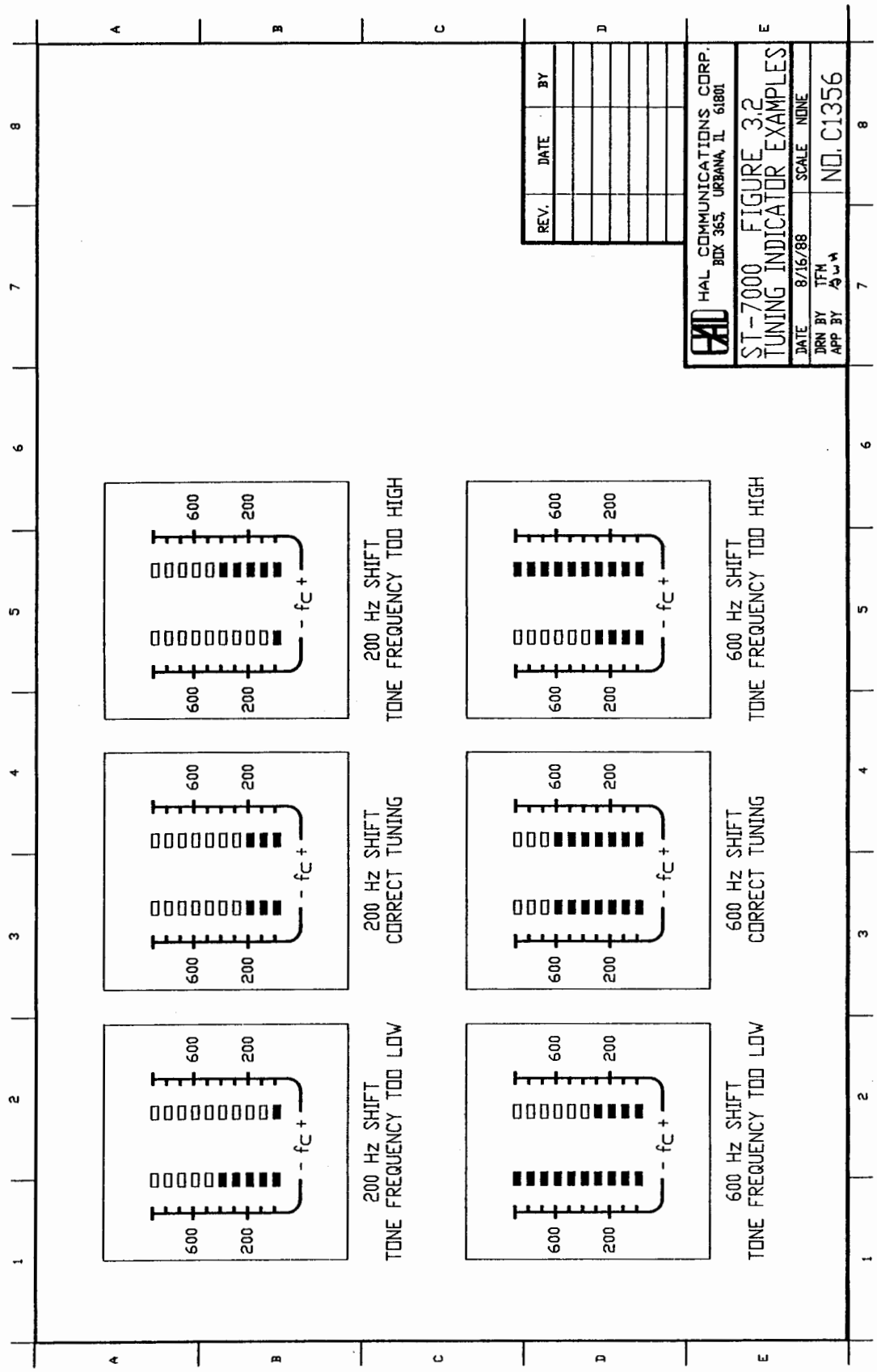


FIGURE 3.2 TUNING INDICATOR EXAMPLES

3.2 USE OF THE ST-7000

3.2.1 GENERAL CONSIDERATIONS

The ST-7000 is very forgiving of most operator errors. Close attention should be paid to the setting of the THRESHOLD control. Setting it too "tight" (too far CCW) will require a very strong signal to trigger CD. This will NOT affect your reception, but may cause you to transmit on top of someone else. Setting THRESHOLD too "loose" (too far CW) will cause excessive lighting of the CD LED and prevent you from transmitting when you could have. Both situations contribute to reduced data through-put, so careful operator attention is advisable.

3.2.2 HF PACKET OPERATION

The ST-7000 is a modem designed to meet the requirements of noisy and crowded HF communications conditions. Signal fades are often easily compensated for by the modem. However, some receiver adjustments can greatly improve your HF performance.

In particular, if your receiver has a narrow IF filter and passband tuning, be sure to use them. The ST-7000 receiver demodulator is designed to operate with receive tones centered at 2210 Hz. For 200 Hz shift, the tones are 2110 and 2310 Hz; for 600 Hz shift, the tones are 1910 and 2510 Hz. This tone frequency is chosen to be compatible with HF radios that provide an "RTTY offset" of the passband to favor standard RTTY tones of 2125 and 2295 Hz (center at 2210 Hz). Some HF transceivers such as the TS-940 allow split-mode operation - different modes for transmit and receive. If so, use "LSB" for transmit and "RTTY" for receive. Other radios such as the Ten-Tec Paragon and the TS-430 have a full-range passband tuning adjustment. In this case, use "LSB" mode and set the passband tuning to favor the RTTY tones. Passband tuning may be set to approximately the correct value by simply observing the ST-7000 tuning indicator. To do this, tune the receiver to an unused frequency, select the narrow filter, and adjust passband tuning until the noise is "centered" on the ST-7000 tuning indicator. Now, tune-in an HF Packet signal and refine the passband tuning adjustment as required.

Receiver AGC should be used with the ST-7000. Choice of "FAST" or "SLOW" response will vary with atmospheric conditions; "FAST" is preferred if static levels are high. Set receiver volume level to a comfortable listening level. Setting too high a volume level into the ST-7000 may cause reduced performance. If your receiver has a constant level, 0 dBm audio output, use it - this is the ideal input audio level for the ST-7000. A good receiver noise blanker may help in conditions of high static or over-the-horizon radar interference. Avoid advancing the noise blanker control too high as this will distort the data signal and degrade performance.

As mentioned in Chapter 2, ST-7000 performance will be somewhat better if the TTL or RS232 TNC connections are used. This is because the TNC AUDIO interface modem must be keyed ON/OFF by the HF Carrier Detect signal. Keying of the audio tone to the TNC in turn allows the TNC's CD system to operate as is required for CSMA (Carrier Sense Multiple Access) to work. Careful attention

to the setting of the ST-7000 THRESHOLD control is advisable when TNC AUDIO interface is used. Otherwise, your TNC may never "hear" a signal to be received ("tight" THRESHOLD setting) or may never be allowed to transmit ("loose" THRESHOLD setting).

When the TTL TNC I/O interface is used with the PK-232, the PK-232 THRESHOLD and CD LED will NOT affect HF operation - these features are now controlled by the ST-7000. Conversely, if the PK-232 is used with the TNC AUDIO interface, both the PK232 THRESHOLD and PK 232 CD lamp function, but now indicate the condition of the regenerated TNC audio tones, not the HF channel. When using the PK-232 with the TNC AUDIO interface, choose HBAUD = 300, but set VHF ON.

For ALL TNC devices, be sure to set HBAUD = 300 when communicating on HF!

3.2.3 HF RTTY AND AMTOR OPERATION

Although the ST-7000 is designed primarily for 300 baud HF packet operation, it also works very well for HF RTTY and AMTOR. Any of the "TNC" interface connections may be used with an RTTY or AMTOR terminal, but the TTL and RS-232 may be the most convenient connections for most equipment.

The ST-7000 may be used for any data rate and will out-perform most RTTY demodulators, even at slower data rates of 75 or even 45 baud. However, the filters in the ST-7000 are optimized for the bandwidths required for 300 baud data and use at slower rates is a compromise condition when compared to a matched performance modem such as the HAL ST-8000. AMTOR may also be used with the ST-7000 with very good results. The ST-7000 tuning indicator works equally well at all data rates, but will show a slightly increased deflection for both 200 and 600 Hz shift indications.

Use of a 300 baud data rate is NOT restricted to only HF Packet - 300 baud Baudot or ASCII are also legal and usable. If a signal link is of good quality, the "through-put" of a straight 300 baud ASCII RTTY signal will be 2 to 4 times greater than that of HF packet, but <u>without</u> error correction. Baudot may also be used at 300 baud with an equivalent words-per-minute rate of 400 WPM!

Several additional features and internal jumpers are provided to optimize RTTY and AMTOR operation of the ST-7000. These features are described in the following sections.

3.2.3.1 HF PTT CONTROL

The ST-7000 HF PTT output includes a 20 second "safety timer" that prevents a transmitter key-down condition if the TNC or data terminal malfunctions. Since RTTY and AMTOR FEC modes require long periods of transmitter-ON condition, this feature must be defeated for these modes. To do this, change the internal jumper plug so that it shorts across the pins at location J7. The transmitter will now stay "on the air" for as long as the input PTT line is held in transmit state. NOTE - you may want to remove this jumper when returning to HF packet operation to regain the safety timer feature.

3.2.3.2 HF RX DATA SQUELCH

ST-7000 demodulated HF receive data is normally passed directly through to the RXD input of the "TNC" or data terminal. For HF Packet use, this is a normal condition and the front panel THRESHOLD control sets only the state of the output CARRIER DETECT (CD) signal (indicated by the CD front panel lamp). When operating RTTY, this means that noise or interference will produce a continuous stream of "garbage" characters on the data terminal screen. The operation of the ST-7000 THRESHOLD cicuit can be converted to that of an RTTY "Autostart" or "Autoprint" control. To do this, move the plug at internal jumper location J14 so that it shorts the rear two pins of J14 together (factory position jumpers the front two pins of J14). The received data flow to the TTL, RS-232, or TNC audio outputs will now be controlled by the THRESHOLD control (CD lamp ON = RX data ON). The THRESHOLD control still also controls the CD lamp and the CD output signal.

3.2.3.3 HF TRANSMIT TONE ON/OFF

Some HF RTTY systems require that the transmit tones be turned OFF when receiving and ON when transmitting. The normal condition of the ST-7000 is that the transmit tones are always ON. However, installation of a jumper plug at location J13 allows ON/OFF control of the transmitter tones by the terminal or TNC PTT signal. Thus, if internal jumper J13 is installed to short the two pins, the transmitter tones will be ON only when transmitting and OFF whenever the TNC or data terminal PTT signal is in the receive state. This feature will allow use of the transmitter VOX circuit to select between transmit and receive and a separate PTT connection to the transceiver may not be required. However, unless the TNC or data terminal also has a delay time between PTT control and the start of data, the first RTTY data pulse will be shortened and probably lost due to the switching time of the PTT relay in the transceiver. Use of VOX for RTTY, AMTOR, or Packet transmit/receive control is NOT recommended.

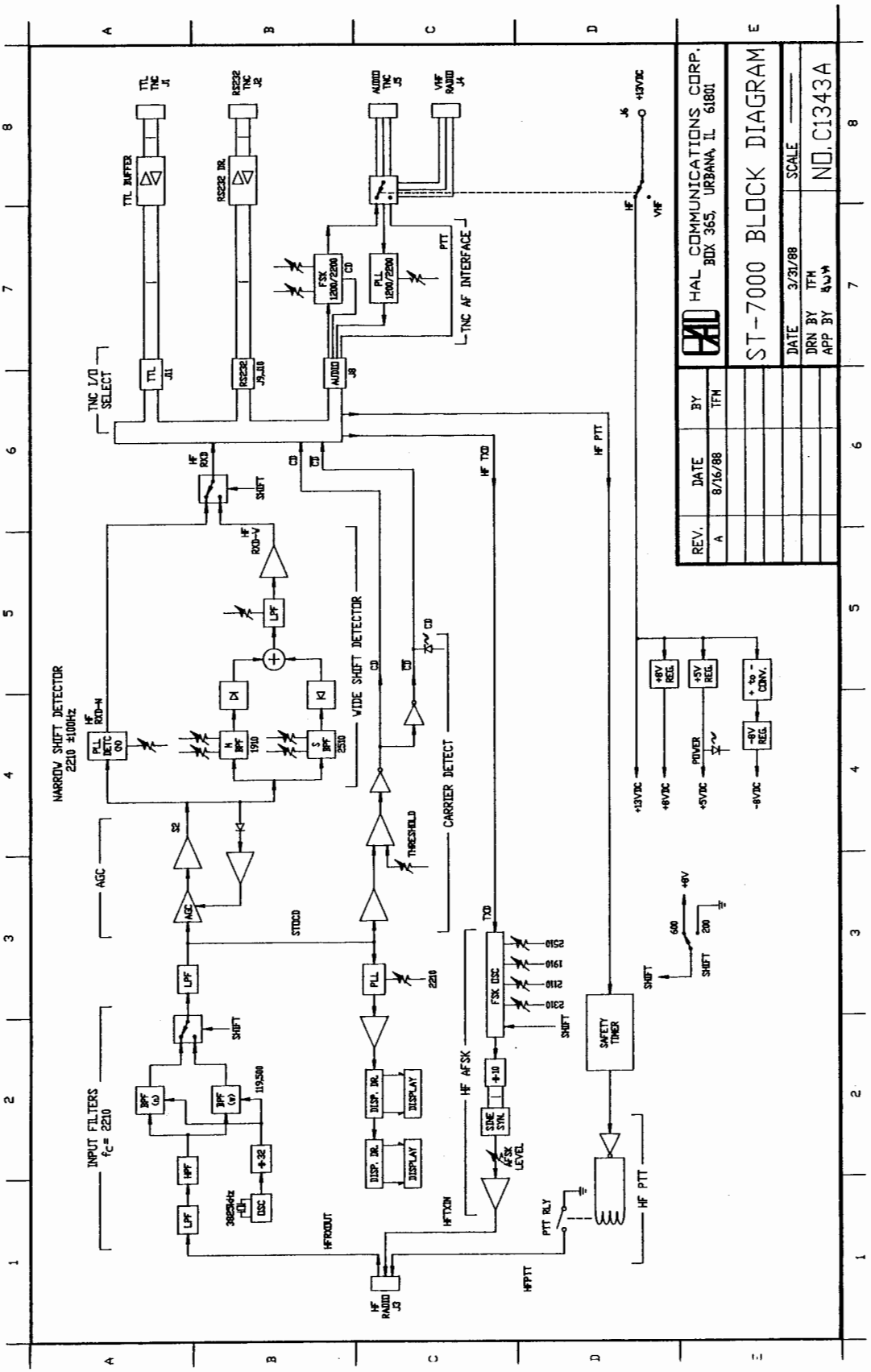


FIGURE 4.1 ST-7000 BLOCK DIAGRAM

CHAPTER 4
THEORY OF OPERATION

The ST-7000 is a full-performance data MOdulator-DEModulator (MODEM), designed specifically for 300 baud HF data use. The circuitry used follows the tradition of previous HAL MODEMS, particularly the popular ST-6000 and ST-8000 models. A block diagram of the ST-7000 is shown in Figure 4.1.

There are, in fact three modems included in the ST-7000: (1) a 200 Hz shift HF modem, (2) a 600 Hz shift HF modem, and (3) a 1000 Hz shift VHF modem to provide an audio interface to all Terminal Node Controller (TNC) devices. In addition, the ST-7000 includes I/O circuitry for connection to TTL and RS-232 data level-compatible TNC's or data terminals. The ST-7000 does NOT contain any digital data processing circuitry to convert one data code to another, decode characters, or change data rates. The received signal is detected, filtered, and conditioned, but passed through to the TNC or data terminal at the same data code and rate as that sent by the received station. Similarly, the data code and rate of a transmit signal is not changed by the ST-7000.

The ST-7000 also includes a unique tuning indicator that greatly reduces tuning errors when communicating with other HF data stations. The ST-7000 transmitter ON/OFF control (Push-To-Talk, or PTT) includes a relay output and a safety timer. Power to the ST-7000 is supplied by an external DC power supply. This voltage is then internally regulated to provide stable operating voltages for the ST-7000 circuits. The entire ST-7000 is housed in a metal (aluminum) shielded enclosure to minimize RF interference from the radio transmitter. All input and output signal lines are filtered at their rear panel connections to further reduce susceptability to RF interference.

The following sections will discuss each portion of the ST-7000 circuit. Each section will refer to a schematic diagram located at the end of this Chapter. Parts placement is shown in Figures 4.14 and 4.15.

4.1 AF INPUT FILTERS (Figure 4.2; A1693)

Receive audio input from the HF Radio (J3, pin 4) drives the input of the ST-7000 at R3 and R4. Diodes D1 and D2 are only for protection against higher than normal input audio voltages to the ST-7000 and are NOT used for signal amplitude limiting. The ST-7000 is an "AM-type" demodulator, with an AGC amplitude control that will be discussed in the next section.

Active filter stages U4a and U4b provide input signal filtering, primarily limiting harmonics to prevent aliasing of the following Switched-Capacitor Filters (SCFs).

Integrated circuits U7 and U8 are Switched-Capacitor Filters (SCFs) that set the input bandpass of the ST-7000 HF receive demodulator. Each SCF filter is a 6-pole Chebyshev ANSI Class II bandpass filter with ultimate attenuation exceeding 50 dB. The center frequency of each filter is set by its clock input (pin 3). The clock for the SCF circuits is obtained from the 3825 kHz crystal oscillator, divided by U2 to produce the 119.5 kHz clock frequency required. Filter U8 has a -3 dB bandwidth of 750 Hz and is selected when 200 Hz shift is to be received. Filter U7 has a -3 dB bandwidth of 1400 Hz and is selected when 600 Hz shift is used. Switch U12a is controlled by the front panel SHIFT switch and selects which of the two SCF filter outputs is used.

4.2 RECEIVE AUDIO AGC (Figure 4.3; A1694)

The output of switch U12a (S1) drives active low-pass filter stage U17b. This filter removes any clock noise produced by the SCF filters (U7 or U8). The output of this filter drives the following AGC circuit and the front panel THRESHOLD and TUNING INDICATOR circuits (STOCD at TP17).

Stages U18, U17d, and U17c form an Automatic Gain Control (AGC) circuit. The AGC circuit has a dynamic range of greater than 50 dB and produce a regulated audio voltage amplitude of approximately -10 dBm at its output (S2). U18 is the gain controlled stage and U17d provides additional loop gain (20 dB). The audio output is detected by D12 and filtered and amplified by U17c. The output control voltage is applied to the control input of U18 (pin 2; TP18).

The output of the AGC circuit (S2) drives three circuits: (1) 600 Hz Shift Mark Filter, (2) 600 Hz Space Filter, and (3) 200 Hz Detector.

4.3 MARK FILTER - 600 HZ SHIFT (Figure 4.4; A1695)

The output of the AGC circuit (S1) is divided by resistor network R119 and R118 and applied to the input of a two-stage, 4-pole Mark bandpass filter (U16). U16a and U16c form the first 2-pole bandpass filter, U16b and U16d form the second 2-pole bandpass filter. Both filters are tuned to 1910 Hz (600 Hz shift Mark frequency) with resistors R110 and R117. The composite 4-pole filter has a -3 dB bandwidth of 370 Hz.

The output of the Mark filter (TP15) is detected by the active detector circuit of U15a. The positive voltage detected output (S3) is later combined with that of the Space detector to produce 600 Hz shift data output.

4.4 SPACE FILTER - 600 Hz SHIFT (Figure 4.5, A1969)

The Space filter is identical to the Mark filter except that it is tuned to 2510 Hz, the Space frequency for 600 Hz shift. The input to the Space filter is also obtained from divider R119, R118 (S21, Figure 4.4). The Space filter is also a composite 4-pole filter, tuned to 2510 Hz with resistors R91 and R92. The bandwidth of the composite filter is also 370 Hz.

The output of the Space filter (TP13) is detected by the active detector circuit of U15b. The negative voltage detected output (S4) is later combined with that of the Mark detector to produce 600 Hz shift data output.

4.5 200 HZ DETECTOR AND SHIFT SWITCH (Figure 4.6, A1697)

Continuing the discussion of 600 Hz shift first, the outputs of the Mark and Space detectors (S3 and S4) are combined at the input of U15d, an active low-pass filter. The post-detection low-pass filter is a 3-pole design with the first pole set by C64 and R96/R106. The final 2-poles are set by C65 and C66. Resistor R101 allows adjustment of DC balance of the Mark/Space differential input to the LP filter.

The filtered 600 Hz shift detected data is restored to bi-polar, saturated data by slicer stage U15c. Transistor Q8 converts the bi-polar data to TTL levels which then drive the shift data selector switch U12c.

The detector for 200 Hz shift is the Phase-Locked-Loop (PLL) IC, U10. The input for the PLL detector is obtained from the output of the AGC amplifier (S2, Figure 4.3). The PLL detector design is optimized for 2210 Hz center frequency and 300 baud data. Only the data detection feature of the PLL is used. The TTL-level data output of the PLL detector (TP12) drives shift switch U12c. Center frequency of the PLL detector is set with resistor R82.

IC switch U12c selects the outputs from either the 200 Hz detector (U10) or the 600 Hz detector (Q8). This data output (TP10) then passes through a second IC switch (U12b). Stage U12b allows ON/OFF received data (RXD) control by the front panel THRESHOLD (CD) circuit for RTTY operation. This control is jumper selectable by jumper J14. For HF packet operation, this ON/OFF RXD control is not required and jumper J14 is set so that switch U12b is always ON pin 9 jumpered to Vcc). For RTTY operation where "autoprint" data control is desired, jumper J14 may be moved so that the CD signal from the THRESHOLD circuit (front panel board) will now control switch U12b.

4.6 HF TRANSMIT TONE GENERATOR (Figure 4.7; A1698)

TTL-level HF transmit data from the TNC or data terminal drives transistor Q9 which in turn drives the AFSK oscillator U9 (TP9). This oscillator operates at a frequency that is ten times the desired frequency output. The output frequencies are set by resistors R50, R53, R55, and R56 as follows:

SHIFT	STATE	CONTROL	FREQUENCY (TP8)
200	MARK	R52	23,100 Hz
200	SPACE	R54	21,100 Hz
600	MARK	R51	25,100 Hz
600	SPACE	R57	19,100 Hz

NOTE: Adjustments will be discussed in Chapter 5. For either shift, the lower frequency tone must be set before setting the higher frequency tone!

The output of oscillator U9 drives the ten-step sine-wave synthesizer circuit (U13 and U5b). The effect of the synthesizer is to divide all input frequencies by 10, thus producing the desired output AFSK tone frequencies. Stages U5b and U5a provide low-pass filtering to smooth the synthesized sine-wave. Control R8, HF AFSK LEVEL adjusts the audio output voltage to the HF transmitter (HFTXIN; J3, pin 1).

Two internal jumper options are provided for the HF AFSK circuit. Jumper J13 allows ON/OFF control of the HF transmit tones by the TNC or data terminal PTT signal. With jumper J13 installed, the transmit tones are ON only when the TNC or data terminal PTT is in transmit state; the tones are OFF when in receive state. Jumper J13 is factory installed so that these pins are NOT jumpered and the transmit tones are always on. As explained in section 3.2.3.3, use of transmit tone ON/OFF control to control the transmitter VOX circuit is not recommended for most installations.

Jumper J12 allows changing the range of HF AFSK tone output level by 20 dB. With J12 NOT jumpered (standard factory setting), the AFSK output level may be adjusted from a maximum of -20 dBm (approximately 80 mV) down to -50 dBm (approximately 2.5 mV). With the jumper plug installed to short-out pins at J12, the maximum output level is increased to 0 dBm (approximately 800 mV) and may be adjusted down to -30 dBm (approximately 25 mV). Most HF transmitters will require an output of approximately -30 dBm and jumper J12 will normally not be required. See section 2.2.2 for the proper set-up procedure for the HF AFSK output level.

4.7 RS232 AND TTL I/O INTERFACE (Figure 4.8; A1699)

The ST-7000 I/O interface may be set for RS232, TTL, or TNC Audio tone interface. Each interface requires setting of 4 or 5 (RS232) jumpers in jumper fields J8 (AUDIO), J9 and J10 (RS232), or J11 (TTL). ALL voltage levels of the HF modem section of the ST-7000 are TTL; conversion or buffering is provided before these signals are connected to the rear panel connectors. Only one set of these jumpers may be installed at one time. The RS232 and TTL interface are shown in this schematic diagram.

The RS-232 interface is selected by placing jumper plugs in all four positions of jumper field J9. This connects the ST-7000 RXD, TXD, PTT, and CD signals from the HF modem circuits to the RS232 drivers and receivers. The PTT signal has two jumper options which may be set via field J10 for either RS-232 RTS (Request To Send) control (+V = transmit), or for PTT control (GND = transmit). Circuits U3a and U3b provide TTL to RS-232 output level conversions for the RXD and CD signals. Transistors Q4 and Q5 provide input level conversion from RS-232 to TTL voltages. All active signals on the RS-232 rear panel connector are filtered to avoid RF interference to the ST-7000. The pin arrangement of the RS-232 connector conforms to industry standards as shown in section 2.3.3 of this manual. Push-To-Talk (PTT) input, a non-standard RS-232 signal, is connected to pin 19, normally unused and a direct connection to the HAL RPC-2000 and PCI-2000 products. Pins 5 and 6 (CTS and DSR) are connected to +8V to assure compatibility with devices that may use these signals.

TTL I/O interface is selected by placing jumpers in all four positions of field J11. Sections of integrated circuit U1 provide buffering and polarity conversion for the RXD, TXD, and CD signals. The PTT signal is jumpered directly to the ST-7000 PTT circuit. The 5-pin connector (J1) and pin arrangement exactly matches that of the PK232 external modem connector. All active signal pins of J1 are filtered to minimize RF interference to the ST-7000.

4.8 TNC AUDIO MODEM (Figure 4.9; A1700)

When the TNC AUDIO I/O interface is selected, it is necessary to provide a second send-receive modem to convert the ST-7000 TTL-level data signals to the VHF-audio tones used by the TNC. This modem matches the standard 1000 Hz shift modem tones used by so-called "VHF" TNC's - 1200 Hz Mark and 2200 Hz Space.

The 1200/2200 Hz transmit output tones of the TNC (from J5, pin 1) drive PLL detector stage U11 where they are detected and converted to a TTL transmit data signal (TTXD). This TTL transmit data signal is then passed to jumper field J8 (next section) where it may be selected for use by the ST-7000. Control R77 sets the center frequency of this detector (1700 Hz).

Processed HF data is passed through jumper field J8 and then to Q2 (TRXD). The output of Q2 (TP6) then drives AFSK oscillator U6 that generates 1200 (Mark) or 2200 Hz (Space) tones. This tone output at -10 dBm (250 mV) then passes to pin 4 of J5, the TNC AUDIO I/O connector. This provides the 1000 Hz shift audio to the TNC. In addition, the Carrier Detect (CD) signal is passed through jumper field J8 to Q3. This signal then turns the U6 oscillator output ON when an HF carrier is detected and OFF when no HF signal is present. This allows the carrier detect circuitry of the audio TNC to function correctly. The two tone frequencies are set by controls R41 (2200 Hz) and R37 (1200 Hz).

4.9 TNC AUDIO INTERFACE AND PTT (Figure 4.10; A1701)

Continuing the discussion of the TNC audio interface, TTL level RXD and TXD data signals to and from the TNC audio modem (Figure 4.9) are selected in jumper field J8 as described in the previous section. The TNC audio modem signals are then passed through the HF/VHF (ON/OFF) switch (S2). When this switch is in the HF (ON) position, the TNC audio modem receive and transmit signals are connected to the TNC AUDIO I/O rear panel connector (J5). When switch S2 is in the VHF (OFF) position, ALL TNC AUDIO I/O signals are diverted to the same pins on the VHF RADIO rear panel connector (J4). Thus, a VHF radio may be connected to J4 using the same cable formerly used to connect directly to the TNC. When the ST-7000 is turned OFF (VHF position), the TNC may be used directly on VHF; when ON (HF position), the TNC is connected through the ST-7000 to the HF radio.

NOTE: Although this TNC AUDIO I/O interface allows use of the same 1200/2200 Hz "VHF" TNC tones for both HF and VHF, you must still change "HBAUD" from 1200 to 300 when switching from VHF to HF.

In the HF (ON) position of S2, the PTT signal from the TNC AUDIO I/O connector is passed through jumper field J8 to the HF PTT circuit of the ST-7000.

The ST-7000 HF PTT circuit uses a relay to control the HF transmitters send-receive circuit. This relay output eliminates the interface problems that have been noted with transistor keying of the widely differing PTT control line voltages and currents used on popular transmitters. The safety timer prevents transmitter damage that might otherwise occur if a TNC or data terminal malfunctions and locks in the TX-ON condition. This failure mode is common with some TNC devices, especially if power to the TNC is temporarily interrupted or if some TNC devices are turned OFF. The period of the safety timer is approximately 20 seconds, a long time for all HF 300 baud packets, but sufficiently short to prevent transmitter damage.

For RTTY and FEC AMTOR use of the ST-7000, this timer must be defeated by placing a jumper plug across jumper J7. When jumper J7 is in place, there is NO safety timer period and the transmitter will remain ON for as long as the TNC or data terminal remains in the TX ON state.

The HF Radio connects to J3. All signal connections are filtered to minimize RF interference to the ST-7000.

4.10 POWER SUPPLIES (Figure 4.11; A1702)

The ST-7000 is powered by an external DC power supply (supplied with the ST-7000). This unregulated DC power is then regulated and converted to produce three voltages: +8 V, +5 V, and -8 V. Integrated circuits VR4 and VR5 are positive to negative voltage converters that change the nominal +12 VDC input to -12 VDC. Regulator VR3 then provides the required regulated -8 VDC output.

The THRESHOLD and TUNING INDICATOR circuits are contained on a separate circuit board mounted to the front panel. Connector J15 provides signal and power connections to this circuit board.

4.11 TUNING INDICATOR (Figure 4.12; A1691)

The filtered HF audio receive signal (STOCD) from U17b (Figure 4.3) passes through connector J15 on the main circuit board to the input of PLL detector U2. This PLL detector, unlike the 200 Hz detector, is designed to produce a linear, wide frequency-range output - an FM detector, rather than a data detector. The center frequency is set to 2210 Hz with control R20. The output (junction of R18 and C2) is a smoothly varying voltage that changes as the frequency of the signal changes. This voltage is amplified and offset by U1c and drives the LED BAR circuits (U3, U4, DS2 and DS3). The displays (DS2 and DS3) are arranged in two vertical lines so that a very low frequency lights the top bar of the left display and a very high frequency lights the top bar of the right-hand display. A frequency near the center of the ST-7000 tuning range (2210 Hz) will partially light the two lower bars of each display. Therefore, as an FSK signal is tuned, it is only necessary to adjust receiver tuning so that an equal vertical deflection on the two bars is obtained.

4.12 THRESHOLD CIRCUIT (Figure 4.13; A1692)

The THRESHOLD or CD circuit also uses the filtered output receive signal from U17b (Figure 4.3). This signal is amplified in U1a, detected in D2, and then compared to a voltage produced by the front panel THRESHOLD control (R6). When the detected HF received signal amplitude exceeds the level set by R6, a "carrier detected" output signal is generated by U1b. This signal is converted to TTL level and set to required polarities by Q1 and Q2. The CD lamp is also driven by Q2. Note that the THRESHOLD circuit is an amplitude sensing circuit and therefore does require some operator adjustment whenever the receiver volume control is also adjusted.

This completes the circuit description of the ST-7000.

4.13 ST-7000 CIRCUIT BOARD ARRANGEMENT (Figure 4.14 and 4.15)

The ST-7000 circuitry is contained on two circuit boards: (1) the large "main" circuit board attached to the bottom of the cabinet, and (2) the smaller "display" circuit board attached to the front panel. Parts placement on these two circuit boards is shown in Figures 4.14 and 4.15.

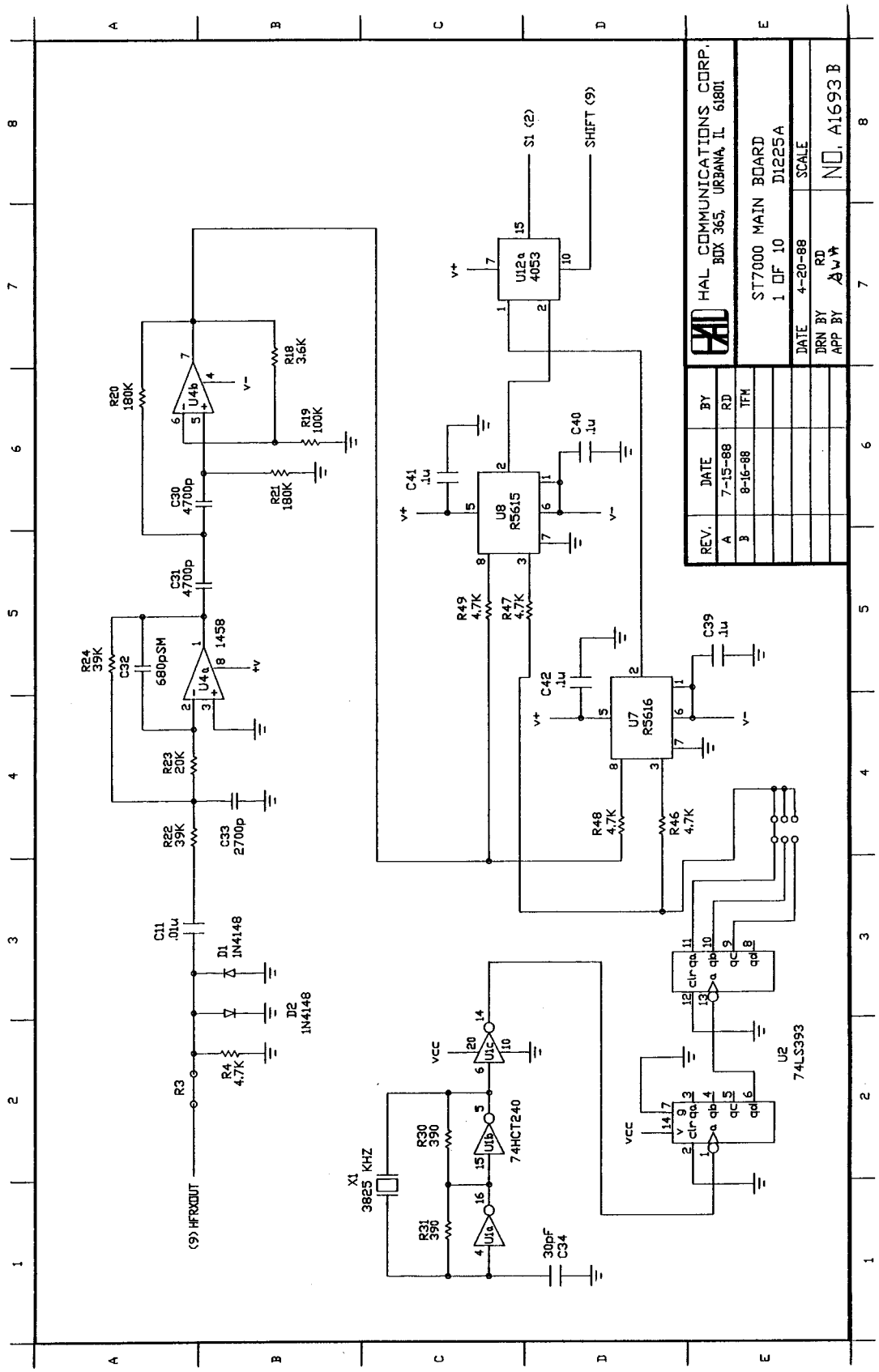


FIGURE 4.2 AUDIO INPUT FILTERS

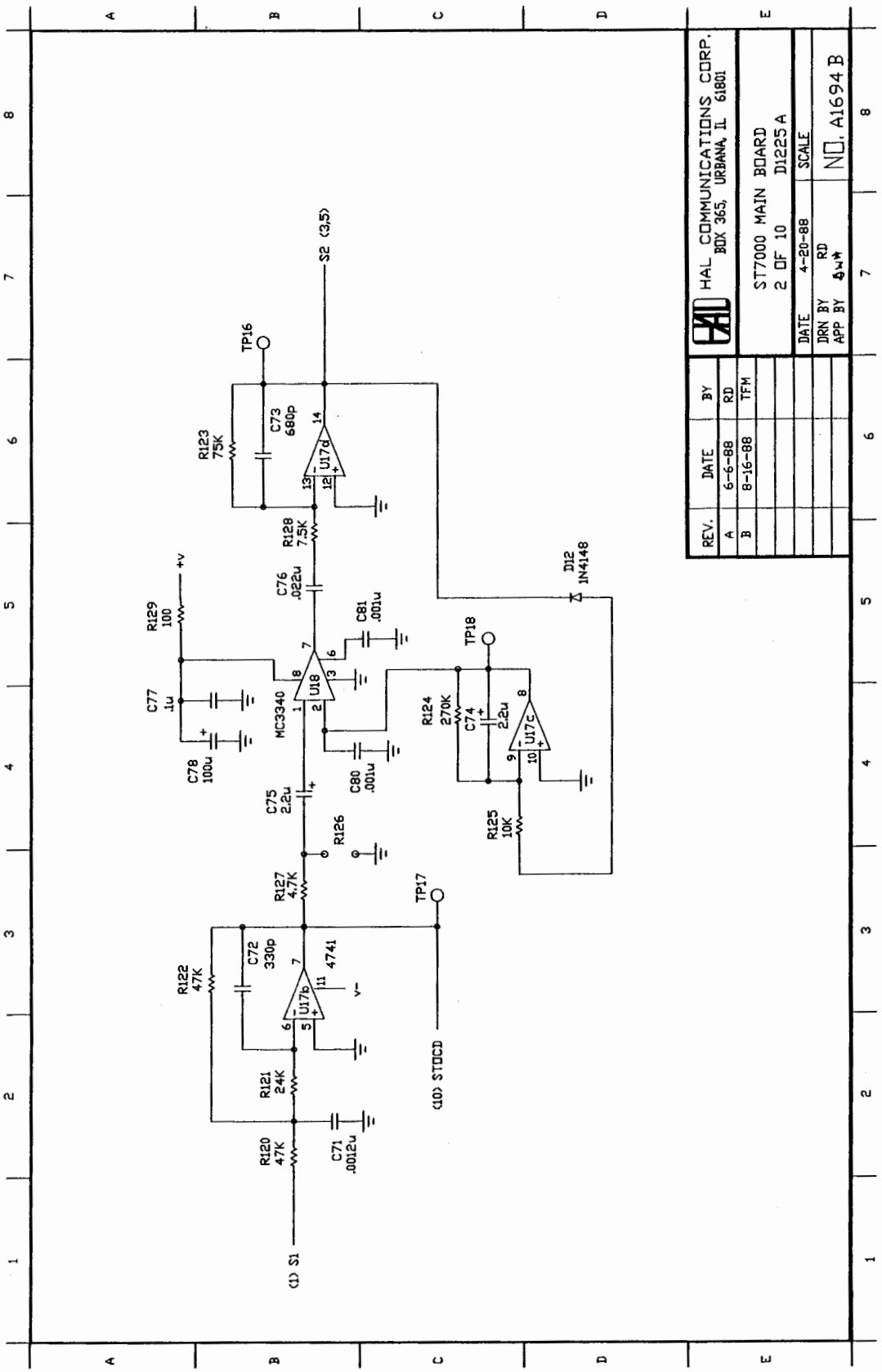


FIGURE 4.3 RECEIVE AGC CIRCUIT

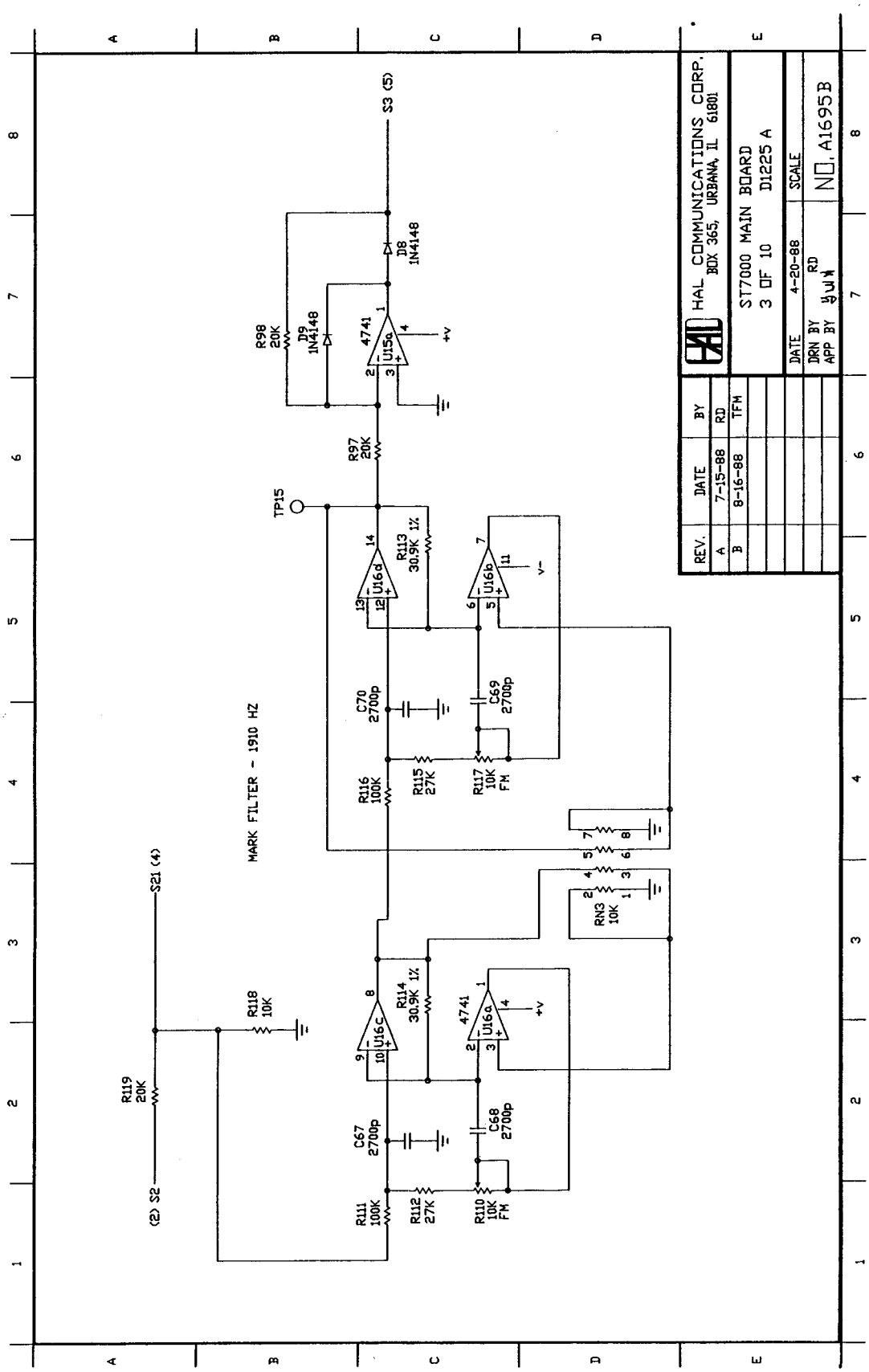


FIGURE 4.4 600 HZ MARK FILTER

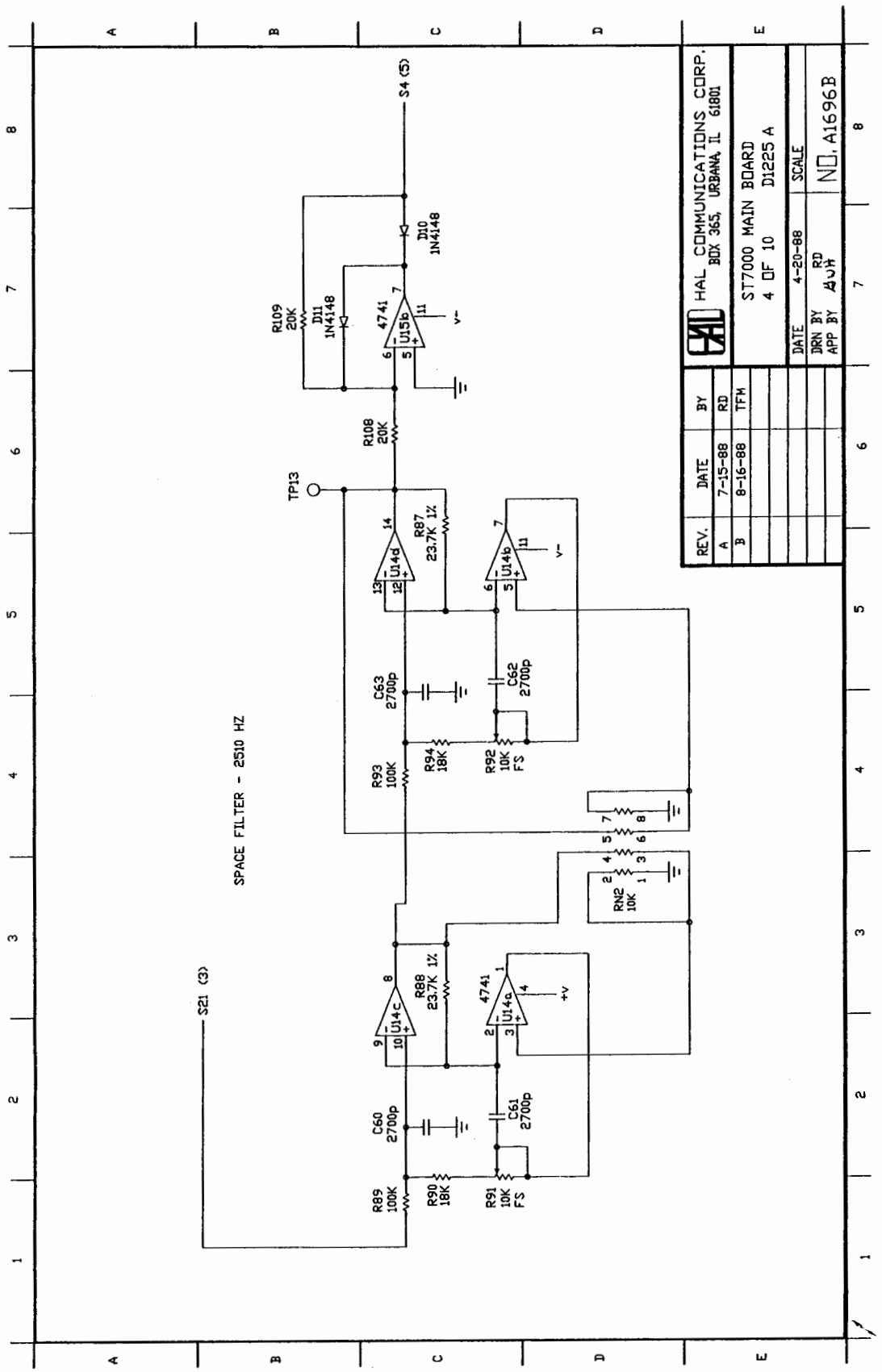


FIGURE 4.5 600 HZ SPACE FILTER

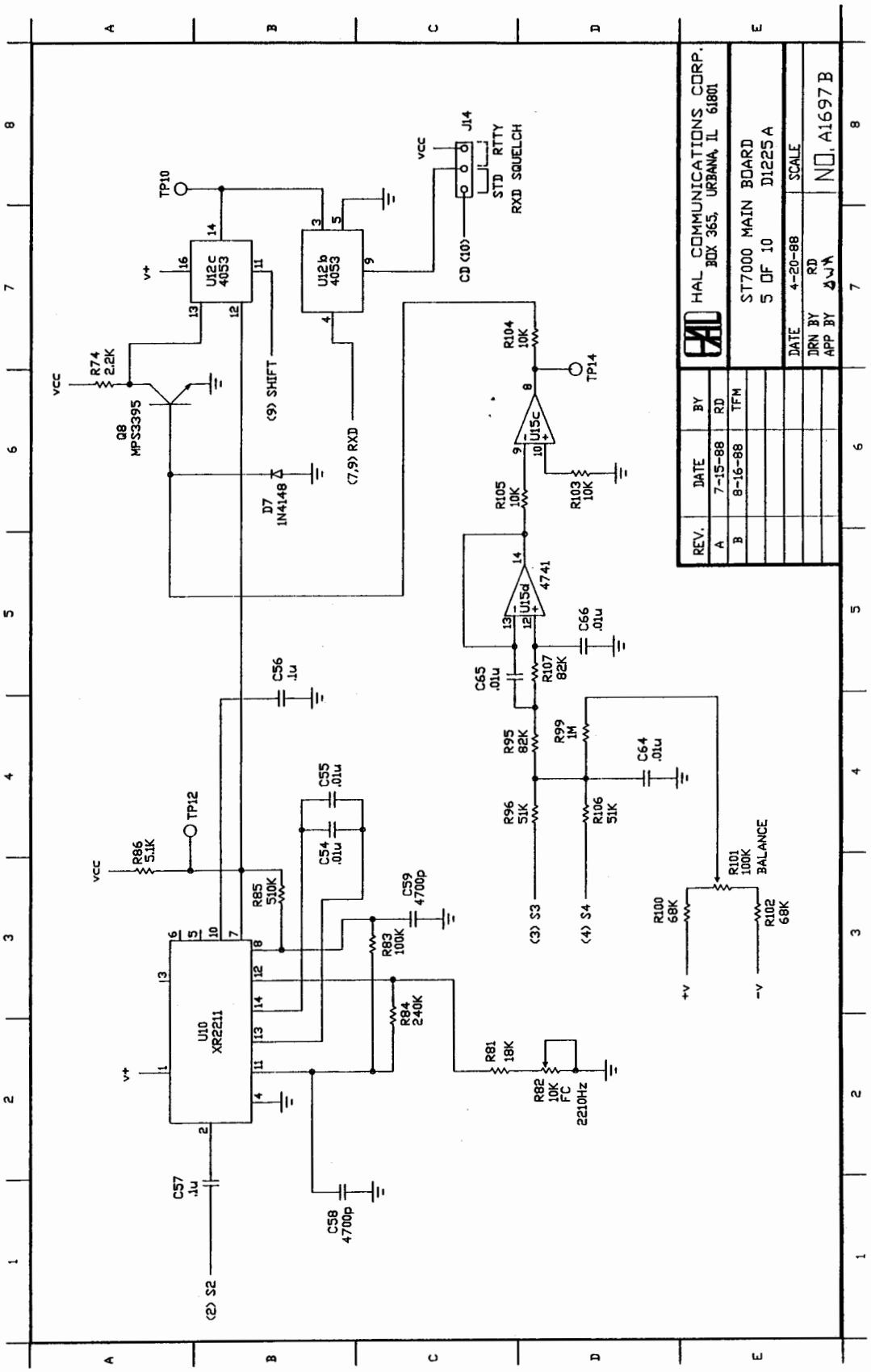


FIGURE 4.6 200 HZ DETECTOR

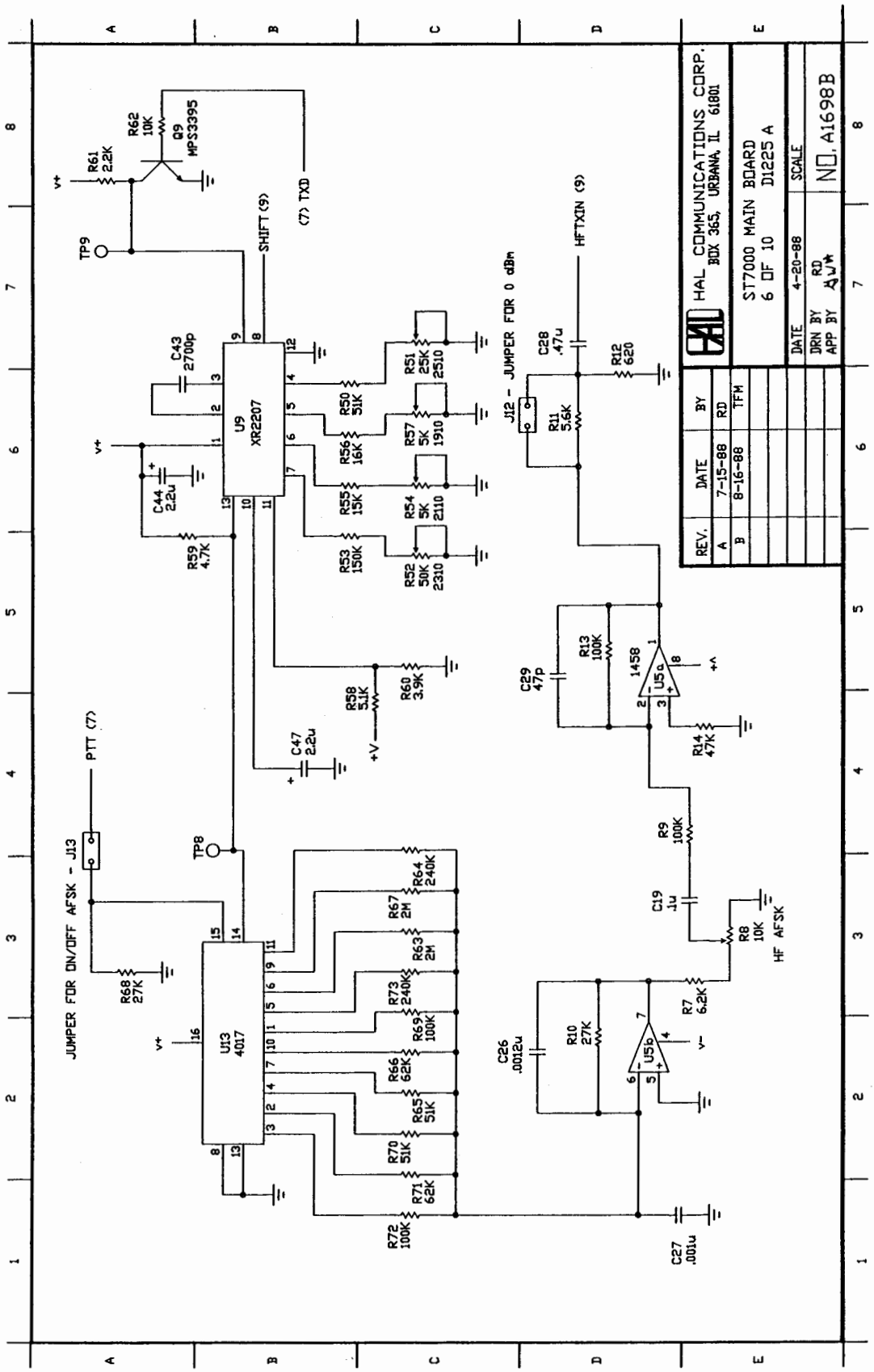


FIGURE 4.7 HF AFSK GENERATOR

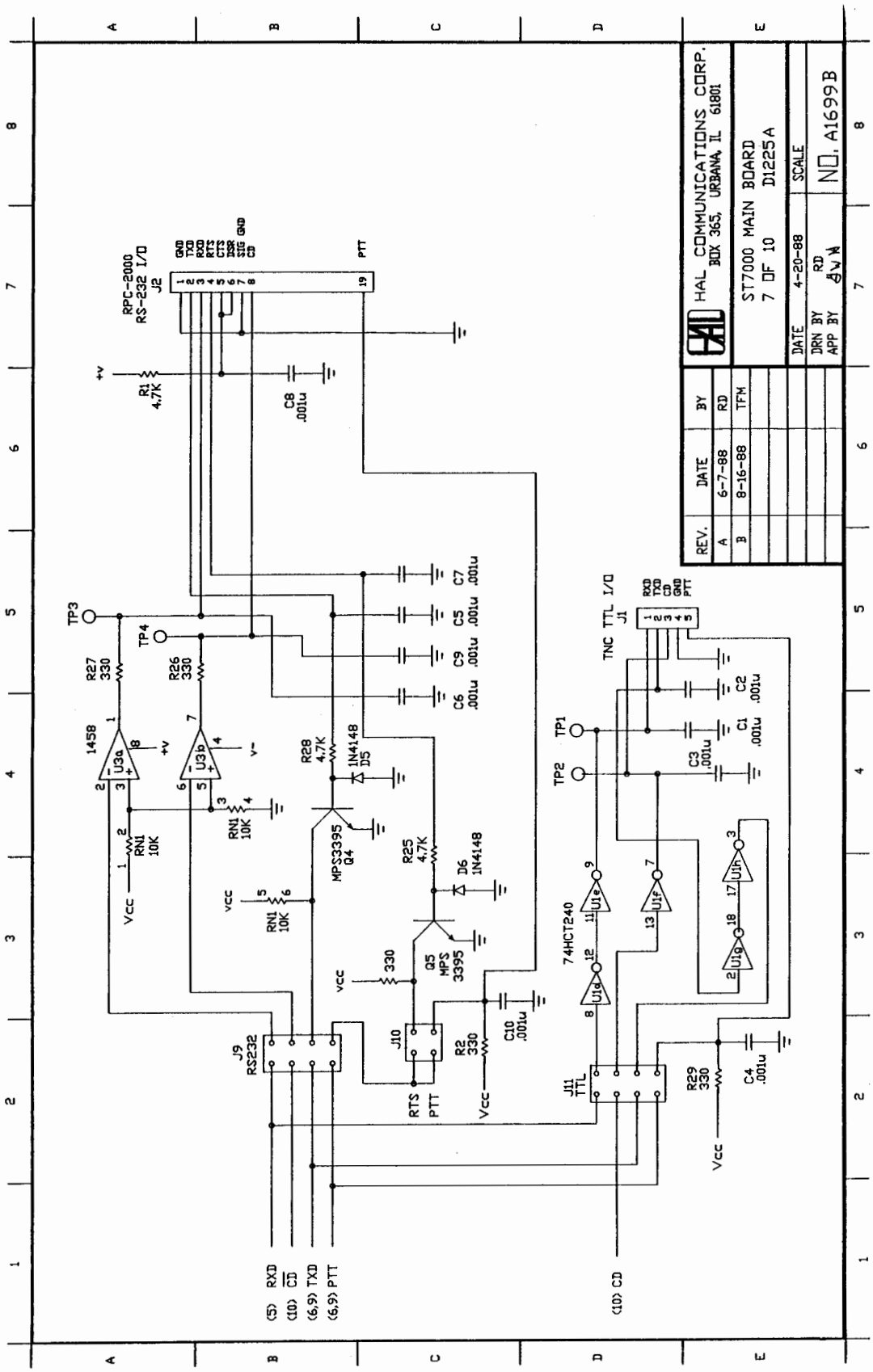


FIGURE 4.8 RS-232 AND TTL I/O INTERFACE

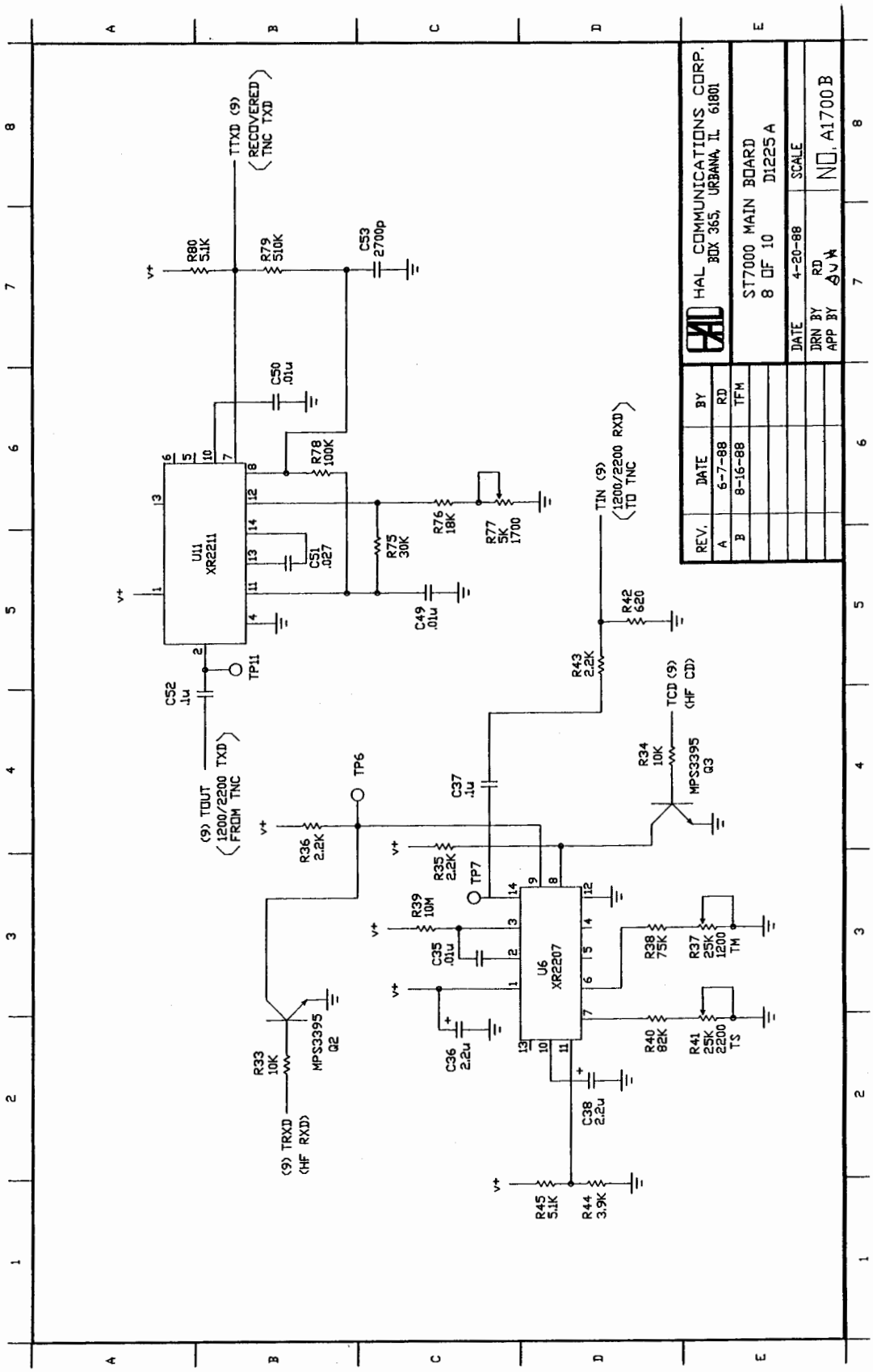


FIGURE 4.9 TNC AUDIO MODEM

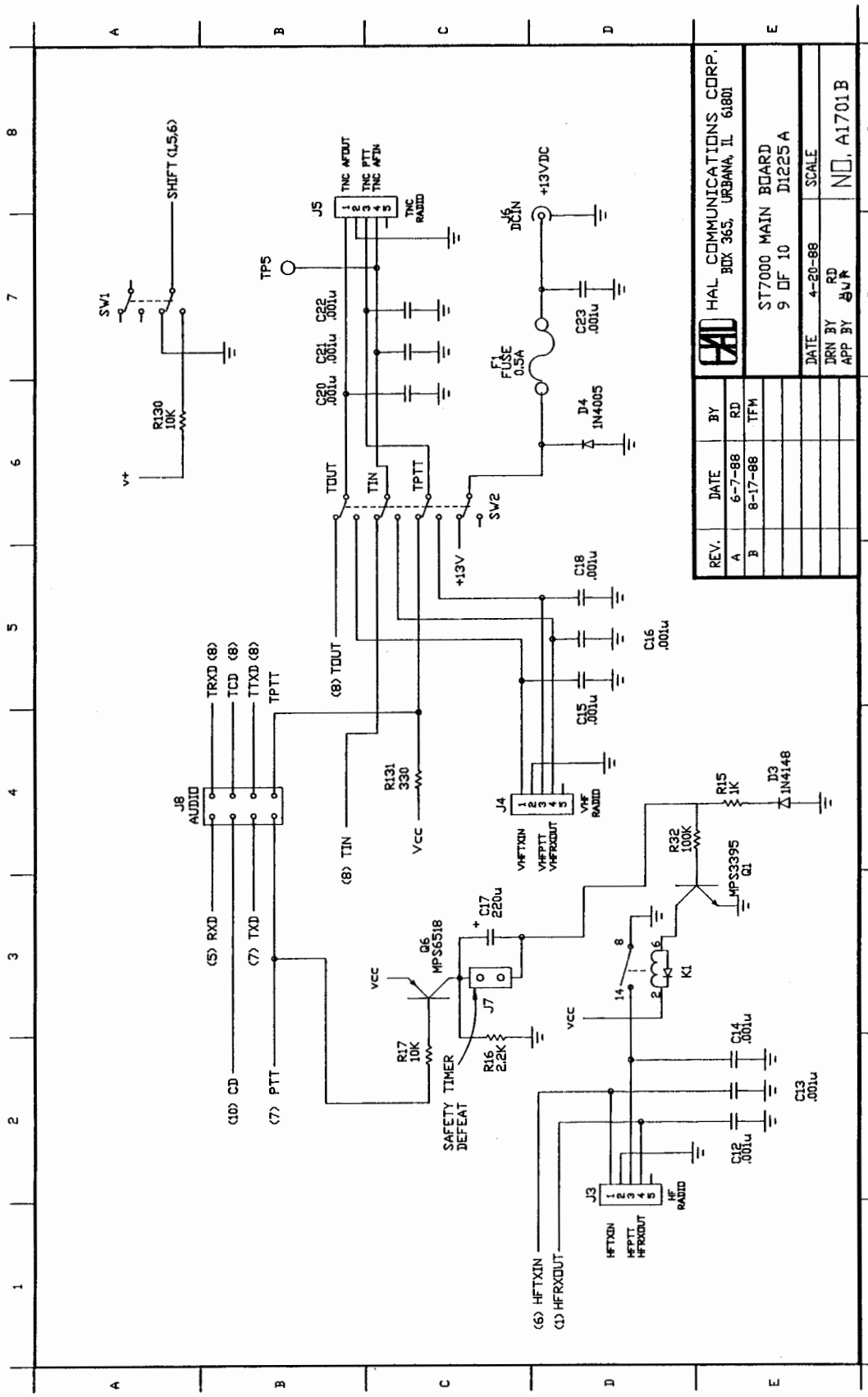


FIGURE 4.10 TNC AUDIO I/O AND HF PTT

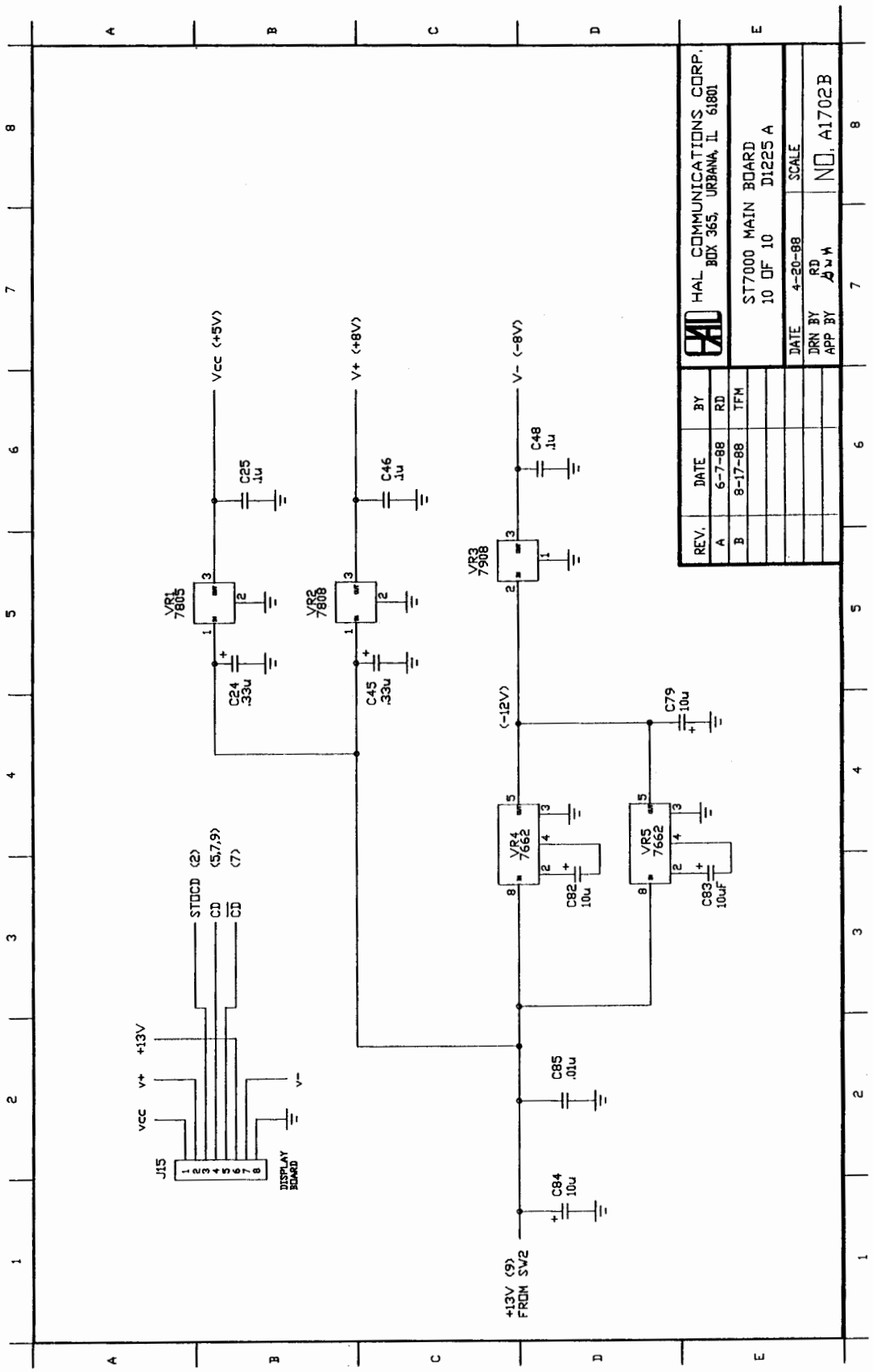


FIGURE 4.11 ST-7000 POWER SUPPLIES

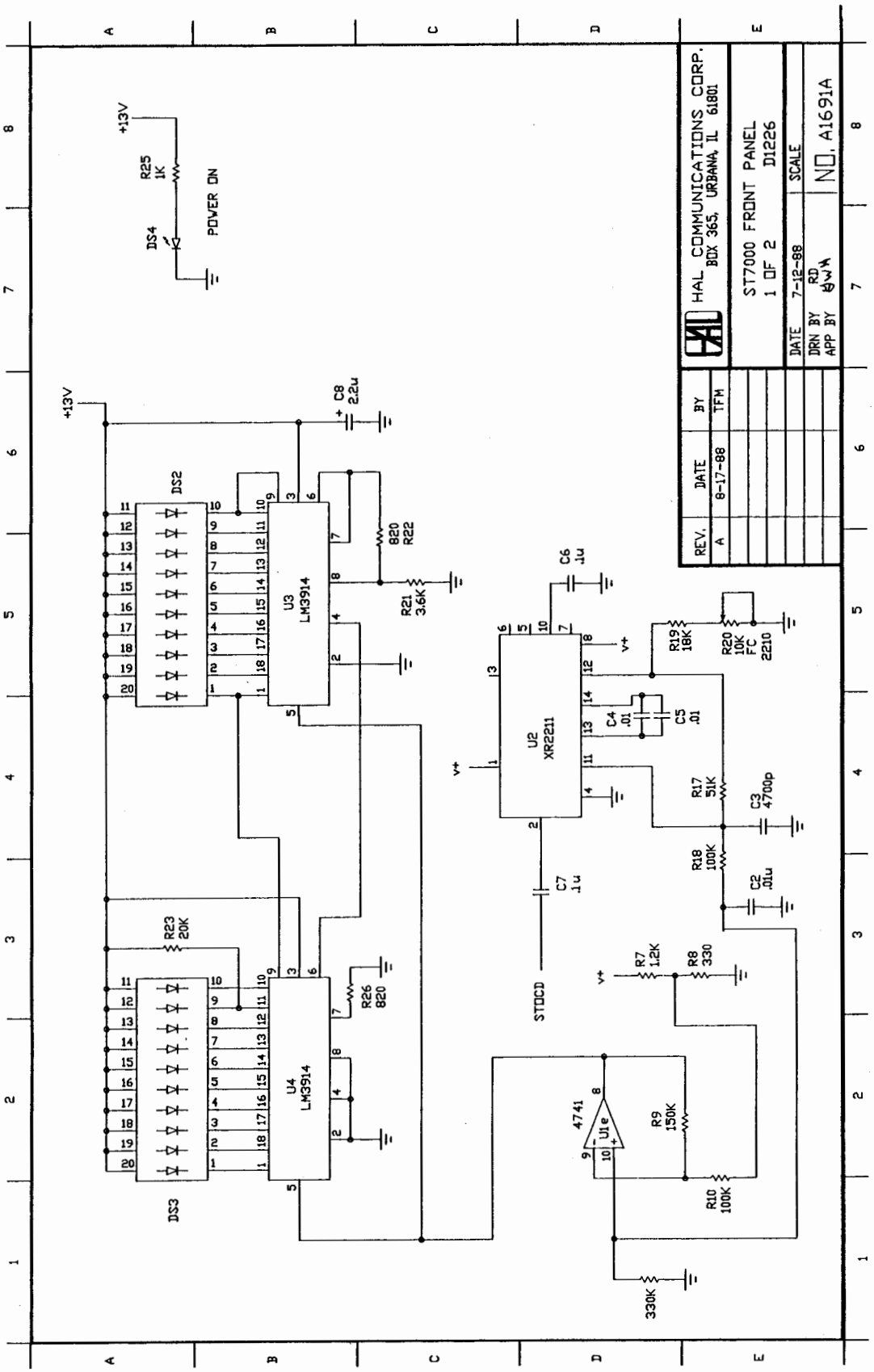


FIGURE 4.12 TUNING INDICATOR

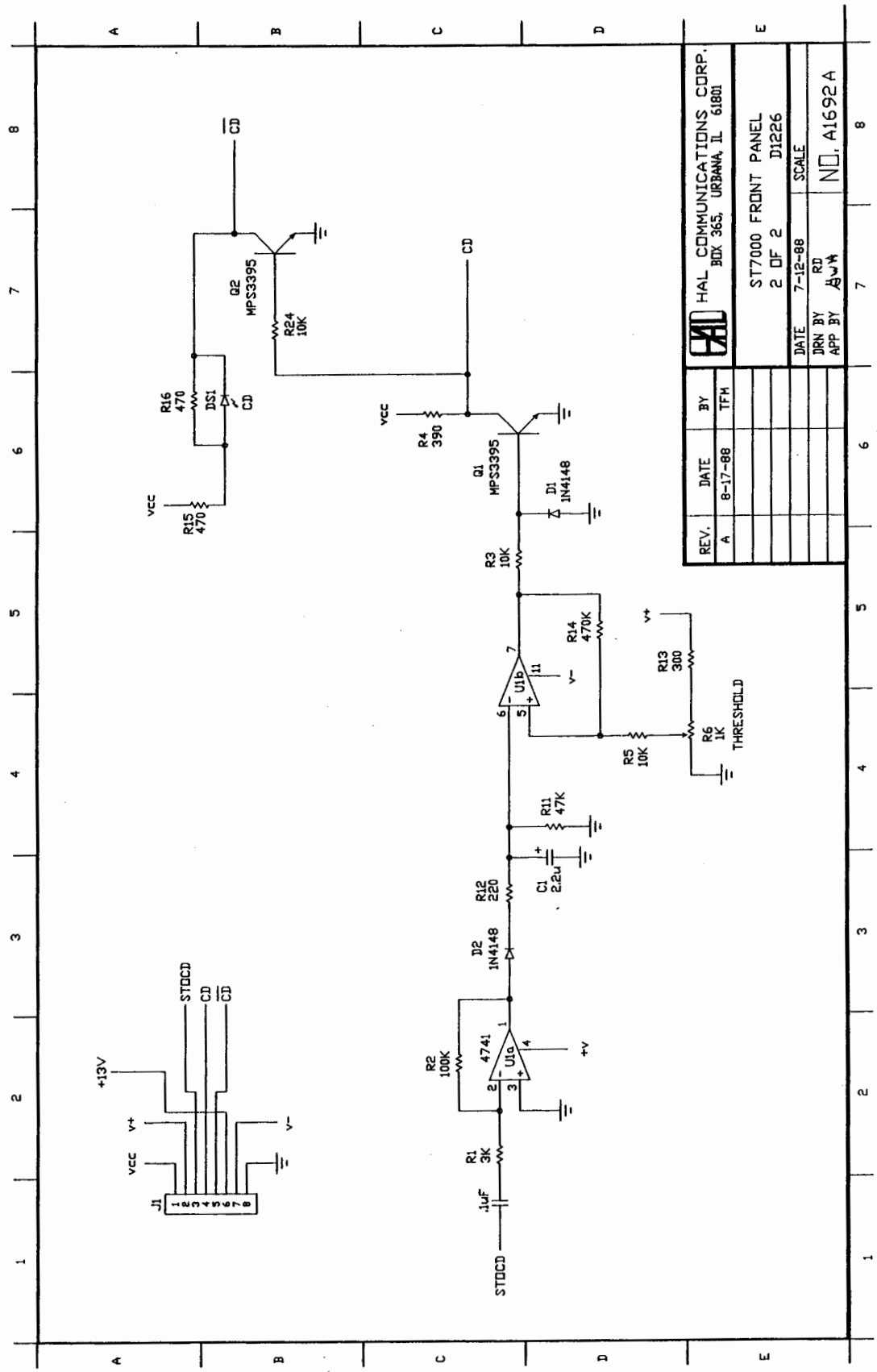


FIGURE 4.13 THRESHOLD AND CARRIER DETECT

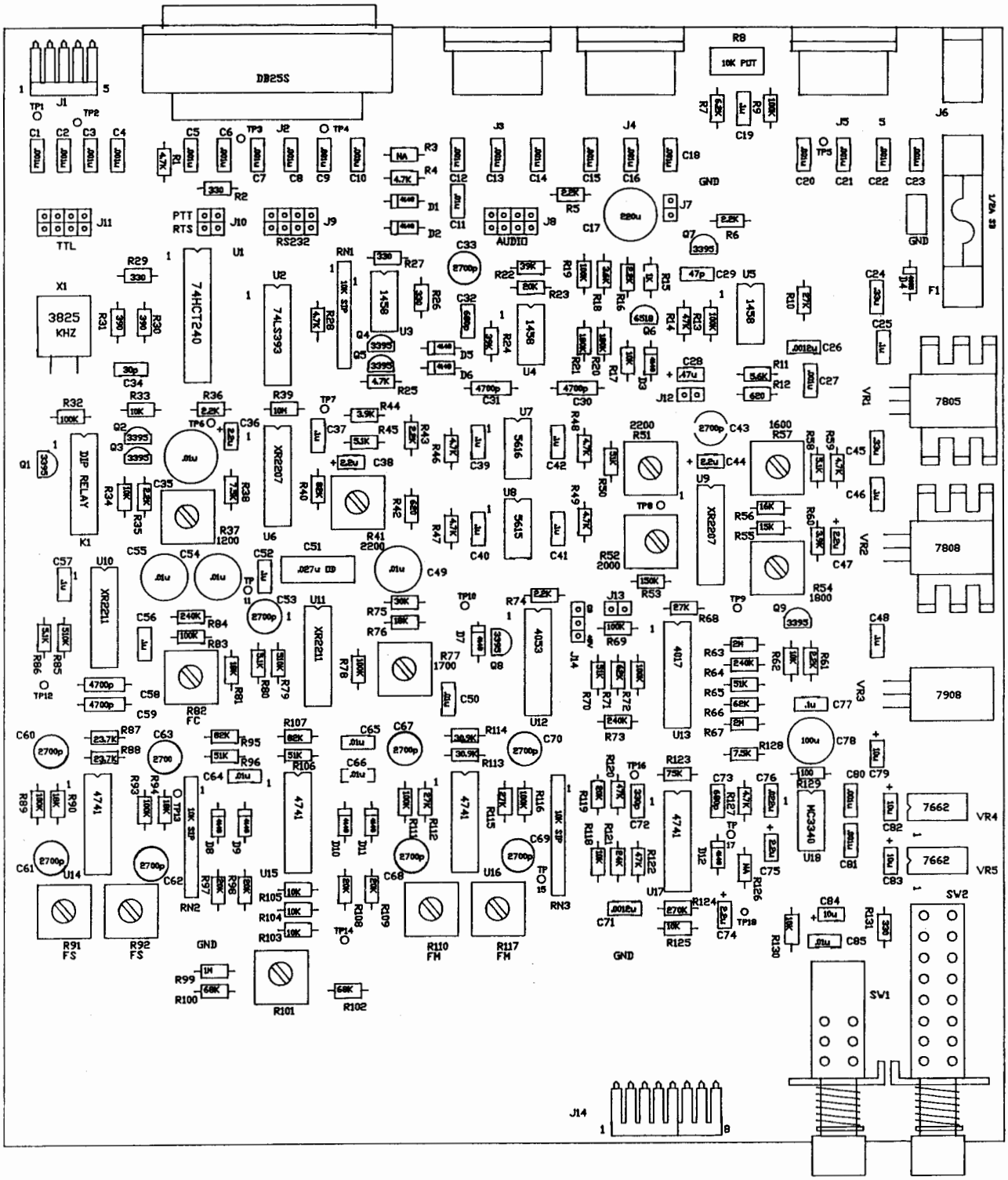


FIGURE 4.14 ST-7000 MAIN CIRCUIT BOARD

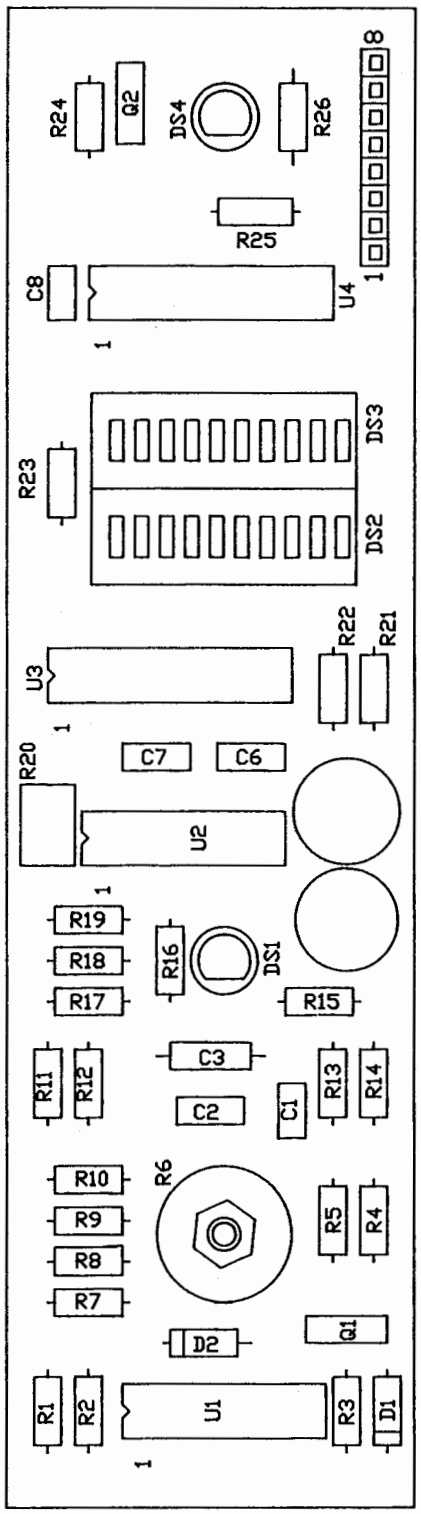


FIGURE 4.15 ST-7000 DISPLAY CIRCUIT BOARD

CHAPTER 5
TEST AND ALIGNMENT

The ST-7000 has been thoroughly tested and aligned at the factory and should require no further adjustment for many years to come. However, the following information is provided should alignment become necessary for any reason. Please carefully note the list of required equipment at the begining of the alignment instructions. This is the test equipment used at the factory to test and align each ST-7000. Care should be taken to assure that any "substitute" piece of test equipment provides equivalent or better performance than that listed. Numerous test points (TP#) are mentioned in the alignment instructions. These correspond to test points so marked on the schematic diagrams and on the circuit boards. A careful reading of Chapter 4, THEORY OF OPERATION is highly recommended before attempting the following steps.

NOTE:

The ST-7000 uses CMOS and other Electrostatic Discharge (ESD) sensitive devices. If the circuit boards are not removed from the cabinet, nn extra precautions need be taken. However, if any integrated circuits are removed from their sockets, or if either circuit board is removed from the metal cabinet, use of an electrostatic workstation is highly recommended. A suitable electrostatic workstation included grounded bench and floor mats and grounded wrist bracelets. A suitable ESD workstation is available from 3M and other firms (3M #8031 kit). When contained in its protective metal cabinet, the ST-7000 is no more sensitive to electrostatic discharge than any other electronic instrument. Proper grounding is highly recommended to prevent RF interference to the ST-7000 and to minimize susceptibility to electrostatic discharge.

ST-7000
Test Procedure Fc = 2210 Hz
21 JUL 1988

Test Equipment: 2-channel scope
ACVM (HP400FL or HP3400A)
DCVM (Fluke 77 or 75)
Counter (HP5381, Fluke 1900A, or Fluke 1911A)
Signal Generator (HP3311)
300 baud RS232 Square-wave generator
FSK data Generator (ST-8000 with 300 bd square wave data TXD input).

Nomenclature:

U2-11	=	pin 11 of IC U2
R103-FR	=	Resistor R103, end towards front of cabinet
R89-RR	=	Rear end of R89

( ) 1. Connect DC power supply, turn on ST-7000, confirm that power led is turned ON. Measure and record voltages (+5, +8 and -8v; ± 0.5v).

+5V = _____ +8V = _____ -8V = _____

( ) 2. Connect scope and counter to U2-11 and confirm that 119,531 Hz square wave is present. Measure and record frequency (± 10 Hz).

Frequency = _____ Hz

( ) 3. Set generator to 2210 Hz, -10 dBm and connect to HF Radio (J3-4).

( ) 4. Use scope and ACVM to confirm 2210 Hz signal at -10 dBm level (± 1 dB) at: U4-1, U4-7, U7-2, U8-2, U12-15, and U17-7. Record value at TP17 (U17-7).

V (TP17) = _____ dBm

( ) 5. With scope and ACVM at TP17 (U17-7), measure and record BW Fc of WIDE and NARROW shifts. Typical values:

NARROW: BW = 750 ± 50 Hz; Fc = 2210 ± 100 Hz
WIDE: BW = 1400 ± 100 Hz; Fc = 2210 ± 100 Hz

FILTER	V(2210) (dBm)	V(peak) (dBm)	f(peak) (Hz)	-3dBH (Hz)	-3dBL (Hz)	BW (Hz)	fc (Hz)
NARROW	_____	_____	_____	_____	_____	_____	_____
WIDE	_____	_____	_____	_____	_____	_____	_____

( ) 6. Set generator to 2210 Hz. Use scope and ACVM to confirm and record -2.5 dBm signal (± 1 dB) at TP16 (U17-14).

V (TP16) = _____ dBm

( ) 7. Connect DCVM to TP18 (U17-8) and record AGC voltage and TP16 (U17-14) AC voltage for input levels of 0, -10,-20, -30 and -50 dBm.

Vin (dBm)	V (TP16) (dBm)	V (TP18) (V DC)
0	_____	_____
-10	_____	_____
-20	_____	_____
-30	_____	_____
-50	_____	_____

( ) 8. Set ST-7000 to WIDE shift. Set generator to 1910 Hz and connect scope amd ACVM to TP15 (U16-14). Adjust R110 and R117 for maximum output at TP15. The level should be -0.5 dBm (± 1 dB). Record V(TP15).

V (1910 Hz @ TP15) = _____ dBm

( ) 9. Measure BW and Fc. Typical values are 1910 Hz Fc (± 20) and 370 Hz BW (± 20 Hz).

V(1910) (dBm)	-3dBH (Hz)	-3dBL (Hz)	BW (Hz)	fc (Hz)
_____	_____	_____	_____	_____

( ) 10. Set generator to 2510 Hz and connect scope and ACVM to TP13 (U14-14). Adjust R91 and R92 for maximum output at TP13. The typical levels should be -0.5 dBm (± 1 dB). Record V(TP13).

V (2510 @ TP13) = _____ dBm

( ) 11. Measure BW and Fc. Typical values are 2510 Hz Fc (± 20) and 370 Hz Bw (± 20 Hz).

V(2510) (dBm)	-3dBH (Hz)	-3dBL (Hz)	BW (Hz)	fc (Hz)
_____	_____	_____	_____	_____

( ) 12. Connect data signal generator to ST-7000 input (J3-4). Set tones to 1910 Hz Mark and 2510 Hz Space, 300 bd square wave data signal. Connect scope to TP14 (U15-8). Trigger scope from 300 bd data source. Set generator output to -10 dBm.

( ) 13. Slowly reduce the data generator output to -30 to -50 dBm. Adjust R101 until data at lowest level of data generator is obtained. This level should be of the order of -50 dBm (± 5 dB).

( ) 14. Set generator to -10 dBm, connect scope to TP10 (U12-14), and confirm that 300 bd data signal is present.

( ) 15. Set ST-7000 to NARROW shift. Set data generator tones to 2110 Hz Mark and 2310 Hz Space, 300 bd square wave data signal. Connect scope to TP12 (U10-7). Trigger scope from 300 bd data source. Set generator output to -40 dBm.

( ) 16. Observing scope waveform, adjust R82 for a symmetrical square wave at TP12. Test that waveform is also present with some jitter at -50 dBm.

( ) 17. Set generator to -10 dBm, connect scope to TP10 (U12-14), and confirm that 300 bd data signal is present.

( ) 18. Install jumper plug at J11-1 (TTL, RXD) and J14 +5v position. Use scope to confirm a TTL level 300 bd data signal at TP1 (TTL, I/O). Remove jumper plug when done.

( ) 19. Install jumper plug at J9-1 (RS232, RXD). Use scope to confirm an RS232 level 300 bd data signal at TP3 (RS232, I/O). Remove jumper plug when done.

( ) 20. Install jumper plug at J8-1 (AUDIO, RXD). Use scope to confirm that a 0 to +8v 300 bd data signal is present at TP6 (U6-9). Remove jumper plug when done.

( ) 21. While viewing the front panel tuning display, adjust R20 on the display circuit board for a symmetrical balance from the bottom of each side of the display (3 segments up each side).

( ) 22. Change the data generator to 1910/2510 Hz and confirm that the display is still symmetrical (6 segments up each side). Trim R20 if necessary. Reset the data generator to 2110/2310 Hz when done.

( ) 23. Set data generator output to -20 dBm. Adjust front panel THRESHOLD control and confirm that CD LED is ON at full CW and OFF at full CCW positions. Set THRESHOLD to full CW when done.

( ) 24. Install jumper plug at J11-2. Connect scope to TP2 and confirm the presence of a TTL high when THRESHOLD is adjusted for CD LED OFF and TTL low when CD LED is ON. Remove jumper plug from J11-2 when done.

( ) 25. Install jumper plug at J9-2. Connect scope to TP4 (J2-8) and confirm presence of -V when THRESHOLD is adjusted for CD LED OFF and +V when CD LED is ON. Remove plug from J9-2 when done.

( ) 26. Install jumper plug at J8-2 and J8-3. Set THRESHOLD control to full CW.

( ) 27. Connect scope to TP7 (U6-14) and confirm presence of triangle wave audio signal. Rotate THRESHOLD control and confirm that TP7 signal quits when CD LED is OFF. Return THRESHOLD control to full CW when done.

( ) 28. Install jumper plugs at J8-1 and J8-2. Set 300 bd data source to produce constant MARK output (2110 Hz). Connect counter to R43-FR. Adjust R37 for 1200 Hz (± 5 Hz).

( ) 29. Set 300 bd data source to produce constant SPACE output (2310 Hz). Adjust R41 for 2200 Hz (± 5 Hz).

( ) 30. Set 300 bd data source to square wave and connect scope and ACVM to TP5 (J5-4). Confirm that 1200/2200 Hz AFSK signal is present at approximately -10 dBm level (± 5 dB). Record this level.

V (TP5) = _____ dBm

( ) 31. Connect J5-1 to J5-4 (TNC AUDIO, AF IN to AF OUT). Connect scope to U11-7. Adjust R77 for a symmetrical 300 bd square wave. Remove the jumper plugs from J8 when done.

( ) 32. Confirm that NO jumper plugs are installed at TTL, RS232 or Audio interface fields.

( ) 33. Set the ST-7000 to WIDE shift. Connect scope and counter to TP8 (U9-13). Jumper J11-3 (front pin) to +5V. Adjust R57 for 19,100 Hz (± 10 Hz).

( ) 34. Temporarily disconnect the jumper from J11-3. Adjust R51 for 25,100 Hz (± 10 Hz).

( ) 35. Reconnect the jumper to J11-3 and set ST-7000 shif to NARROW. Adjust R54 for 21,100 Hz (± 10 Hz).

( ) 36. Remove the jumper from J11-3 and +5V; adjust R52 for 23,100 Hz (± 10 Hz).

( ) 37. Install jumper plug at position J9-3 of the RS232 I/O interface plug field. Connect an RS232, 300 bd square wave data source to J2-2 (RS232 I/O connector).

( ) 38. Use scope to confirm that +8V data signal is present at TP9 (U9-9).

( ) 39. Set ST-7000 to NARROW shift. Connect scope and ACVM to U5-1 (R13-RR). Set HF AFSK control to maximum (full CW). Confirm presence of AFSK signal at +0.5 dBm level (± 1 dB). Signal should be 10-step synthesized sine-wave with smoothed steps. Confirm that HF AFSK control can reduce level to -30 dBm. Change to WIDE shift and confirm levels and signals are essentially the same (more m/s amplitude variation is acceptable in WIDE shift). Reset AFSK level to maximum and change to NARROW shift when done.

MAX AFSK LEVEL @ U5-1 = _____ dBm

( ) 40. Connect ACVM to HF TX AUDIO in (J3-1; HF AUDIO). Install jumper plug at J12 and confirm same amplitude levels as in #39.

MAX AFSK HIGH LEVEL @ J3-1 = _____ dBm

( ) 41. Remove plug from J12 and confirm new maximum output level of -20.5 dBm (± 1 dB). Confirm that AFSK level control can reduce level to -50 dBm. Reset AFSK level to maximum when done. "Park" the jumper plug on the left pin of jumper J12 (J12 not jumpered).

( ) 42. Install jumper plug at J11-3. With 300 baud data source still connected to RS232 I/O, jumper J9-3 (REAR) to J1-2 (TTL I/O). Confirm that AFSK data is present at J3-1. Remove jumper wire between J9-3 and J1-2 and jumper at J11-3 when done.

( ) 43. Install jumper at J11-4. Connect continuity tester to J3-3 (HF RADIO, PTT). Connect J1-5 (TTL I/O, PTT) to ground and confirm that relay K1 operates (ground at J1-5 = closed relay). Leave the connection to ground at J1-1 and confirm that the relay opens after 15 to 25 seconds . Remove jumper when done. Leave continuity tester connected to J3-3.

( ) 44. Install jumper at J9-4. Connect jumper in PTT position at J10. Connect J2-19 (RS232 I/O, PTT) to ground and confirm that relay K1 operates (ground at J2-19 = closed relay).

( ) 45. Change the J10 jumper to RTS position. Connect J2-4 (RTS) to +8V and confirm that relay K1 operates (+8V at J2-4 = cloed relay). Remove jumpers from J9 when done. "Park" J10 plug on left pin of RTS J10 when done (J10 NOT jumpered for RTS or PTT). Leave continuity tester connected to J3-3.

( ) 46. Install jumper plug at J8-4. Connect J5-3 (TNC I/O, PTT) to ground and confirm that relay K1 operates (ground at J5-3 = closed relay). Remove jumper plug and continuity tester when done.

( ) 47. Remove all jumper plugs from J11 and J9 fields. Install all four jumper plugs at J8. Confirm that jumper plugs at J10 and J12 are "parked" (plug on left pin of jumper field).

( ) 48. Turn OFF power and assemble cabinet.

( ) 49. Burn-in completed ST-7000.

CHAPTER 6
SPECIFICATIONS

INPUT DATA:	
Data Rate:	300 baud
Frequency:	2210 Hz Center Frequency ± 100 Hz or ± 300 Hz
Impedance:	8 or 800 ohms, unbalanced
Dynamic Range:	-50 to 0 dBm (2.5 mV to 800 mV)
SIGNAL PROCESSING:	
Mode:	AGC controlled AM
Input Filters:	2 filters, 6-pole SCF
Tone Filters:	Matched 4-pole (600 Hz Shift)
AGC Circuit:	50 dB Dynamic Range
DATA PROCESSING:	
Detectors:	Narrow Shift (200 Hz) - Optimized PLL Wide Shift (600 Hz) - matched active detectors
Post Detection:	3-pole active LP filter
Threshold:	Front panel CD control
TRANSMIT FEATURES:	
AFSK Tones:	200 Hz Shift: 2110 / 2310 Hz 600 Hz Shift: 1910 / 2510 Hz
AFSK Level:	-50 to 0 dBm; factory set at -20 dBm
Impedance:	600 ohms, unbalanced
PTT Control:	Relay closure to ground; 50V, .25A maximum
TNC I/O INTERFACE:	
RPC-2000:	RS-232 DB25 Connector with RXD, TXD, CD, RTS, PTT.
TNC TTL:	5-pin TTL with RXD, TXD, CD, and PTT
TNC Audio:	5-pin DIN; 1200/2200 Hz audio and PTT
HF RADIO:	5-pin DIN with RX AUDIO, TX AUDIO, and PTT
VHF RADIO:	5-pin DIN with RX AUDIO, TX AUDIO, and PTT
POWER:	3.5 mm Coaxial Socket; +13.5-15 VDC, 0.25A
DISPLAYS:	
Tuning:	20-segment frequency spectra; ± 20 Hz accuracy
LED:	CD and POWER ON indicators
SWITCHES AND CONTROLS:	
SHIFT:	Select 200 Hz (N) or 600 Hz (W) shift
HF/VHF:	Turn ST-7000 ON (HF) or OFF (VHF); also selects VHF RADIO when TNC AUDIO INTERFACE is used.
THRESHOLD:	Adjust CD HF receive signal level
HF AFSK:	Adjust HF TX tone voltage (rear panel)
PHYSICAL DATA:	
Cabinet:	Black, table mount, aluminum.
Size:	2.1"H x 8.7"W x 8.1"D (5.23x22.1x20.7 cm)
Weight:	3 lb net, 5 lb shipping (1.36 & 2.27 kg)

LIMITED WARRANTY

HAL Communications Corp. of Urbana, Illinois, hereby warrants to the purchaser that the product herein described shall be free from defects in materials and workmanship, and from failure of operation from ordinary use, for a period of one year from the date of sale to the 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. as well as costs of removal and reinstallation of the unit shall be paid by the purchaser. HAL Communications Corp. will pay the shipping costs incurred in returning the unit to the purchaser.

To obtain warranty service, the customer should:

1. Notify, as soon as possible, the Customer Service Department of HAL Communications Corp., Box 365, Urbana, Illinois, 61801, of the existence of a possible defect.
2. At the time of notification, identify the serial number, and the possible defect.
3. HAL Communications will issue a Return Authorization Number at this time.
4. Return the unit, freight prepaid. Include in the shipping carton a reference to the Return Authorization Number and a brief description of the problem.

Correct installation, use, maintenance, and repair are essential for proper performance of this product. The purchaser should carefully read the equipment manual. The purchaser will be billed for labor and shipping charges on any unit determined by HAL to be in working order when received for repair.

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 are limited in duration to a period of one year from the date of purchase by the original retail purchaser. HAL Communications Corp. disclaims any liability for incidental or consequential damages arising out of the use of, or inability to use, this product. This warranty gives you specific legal rights, but there may be additional rights.