

CHAPTER 6 MAINTENANCE

6.1 GENERAL

The ST-8000A includes internal test features that greatly simplify diagnostic testing of the modem. The tests are the Power-On Self Test (POST), and Built-In-Test (BIT procedures). POST is automatically run each time AC power is applied to the ST-8000A. As explained in sections 3.3.4 and 4.5, multiple BIT routines may be run at any time, accessed either from the front panel keypad or via remote control commands.

This chapter describes POST, BIT, and additional bench-top tests which the user may distinguish between ST-8000A and other system failures.

6.2 DEPOT MAINTENANCE

The recommended maintenance plan for the ST-8000A MODEM is depot maintenance. This plan is:

1. The user should stock spare ST-8000A MODEMS to be used as maintenance replacements.
2. The user should periodically exercise POST and BIT on each ST-8000A in use.
3. Should any ST-8000A fail POST or BIT tests, it should be immediately replaced by a functioning spare unit.
4. The user may optionally choose to conduct further tests to be sure that the failure was not in other portions of the system (cables, for example).
5. A "failed" ST-8000A should be immediately returned to the HAL factory in Urbana, Illinois for repair.
6. User maintenance beyond the "complete unit" level is not recommended. The user should not attempt field diagnostics or replacement of internal parts or assemblies of the ST-8000A.

6.3 ROUTINE MAINTENANCE

As noted above, it is recommended that the user periodically observe the POST results and periodically exercise the BIT routines. The full BIT routine requires from 38 to 63 seconds to run. A daily review of POST and exercise of BIT is suggested.

The POST and BIT are the only routine maintenance procedures required, with the exception of the AC power fuse. Fuse elements are stressed each time AC power is turned ON. It is recommended that the rear panel fuse be replaced each 6 to 12 months of operation as part of routine maintenance.

A routine dusting and inspection of system blowers and filters (if used) is highly recommended. The ST-8000A includes no blowers and cooling is via convection through ventilation holes in the bottom and top covers of the cabinet. These ventilation holes should be kept clean and clear of obstructions.

It may also be desirable to periodically wipe the front panel with a damp, dust and lint-free cloth (gently). Avoid scratching the RED display "windows" and do not spray cleaning fluids directly onto the front panel surface.

6.4 POWER-ON SELF TEST (POST)

Each time the ST-8000A AC power is turned ON, a Power-On Self Test (POST) is performed. POST results are viewed on the front panel display. Correct operation is indicated by:

1. ALL DISPLAY SEGMENTS AND LED INDICATORS TURN ON (1 Second):

The front panel indicators show:

8888.8	(MARK)
8888.8	(SPACE)
8888	(BAUD)
8	(CHAN)

All LED indicators turn ON.

This tests the front panel indicators and their driving circuits.

2. THE FOLLOWING MESSAGE APPEARS (1 Second):

```
          HAL      (MARK)
          8000A    (SPACE)
          1.7      (BAUD) [Firmware Version No; may vary]
All LED indicators turn OFF.
```

This test confirms that the microprocessor is operating correctly and that the firmware EPROM has passed an internal sum-check. If an error is detected, the ST-8000A displays "FAIL" in the BAUD display and runs POST again.

6.5 BUILT-IN-TESTS (BIT)

6.5.1 Purpose

The ST-8000A includes a "Built-In-Test" (BIT) feature that may be used at any time to rapidly test key circuits of the FSK Modem. The intended use of the BIT feature is for in-field confirmation of ST-8000A operability. Field operators may invoke BIT at any time. If all steps of BIT pass, the operator may proceed with operation with a high confidence that the ST-8000A is fully operational. If any Built-In-Test step fails, the ST-8000A should be replaced and returned to HAL Communications for repair.

6.5.2 BIT Activation

The ST-8000A BIT feature is not automatically invoked. BIT use requires active operator entry of either a series of front panel keypad keys or transmission of unique commands from a Remote Control terminal connected to the ST-8000A rear panel REMOTE Port (connector J4). The BIT feature can not be accidentally invoked by any received data combination, data obtained via either the Audio I/O Port (connector J2), or Data I/O Port (connector J1). BIT is not automatically invoked upon ST-8000A AC power ON.

During the time that BIT sequences are running, the ST-8000A is not available for coding or decoding of Radio or Wire-Line data (data via connector J2). BIT activation causes the following changes inside the ST-8000A:

1. Demodulator audio input is disconnected from J2 (pins 10 & 12) and connected to the modulator output, forming an internal audio loopback. The internal audio loopback connection includes three calibrated attenuator settings to test demodulator operation. The loopback test levels used are 0 dBm, -20 dBm, and -45 dBm.
2. The modulator data input signal (TXD) is disconnected from Data I/O connector J1 (pin 20). This signal is used internally by BIT to confirm modulator and demodulator

operation.

The ST-8000A operator may start the BIT sequence in two different ways: (1) via front panel keypad key entry; and (2) via Remote Control port command entry. These two entry techniques are detailed in the following sections.

6.5.2.1 BIT Entry via Front Panel Keypad:

To start BIT from the front panel, perform the following steps:

1. Turn ST-8000A AC Power ON.
2. Wait until normal MARK, SPACE, BAUD, and CHANNEL numbers are displayed on the front panel.
3. In sequence, press and release first the 2nd, then the BIT, and finally the ENTER keypads. A three-key sequence is required to prevent accidental BIT activation.

Built-In-Tests will now be run in the sequence described in Section 6.5.4. Once the BIT sequence has started, the operator has two additional options:

4. To RESTART BIT at Step #0, press BIT.
5. To cancel BIT and return the ST-8000A to normal operation, press CLEAR. BIT steps are immediately disabled and the ST-8000A is returned to the operational parameters in use prior to activating BIT.

6.5.2.2 BIT Entry via Remote Control Commands:

To start BIT using Remote Control commands, perform the following steps:

1. Turn ST-8000A AC Power ON.
2. Wait until normal MARK, SPACE, BAUD, and CHANNEL numbers are displayed on the front panel.
3. Select the unit using the "Cxx" ("xx" = Channel No.) and R1 commands.
4. Enter the Remote Control command T1.

Built-In-Tests will now be run in the sequence described in Section 6.5.4. Once the BIT sequence has started, the operator has two additional options:

5. To RESTART BIT at Step #0, re-enter the T1 Remote Control command.

6. To cancel BIT and return the ST-8000A to normal operation, enter the T0 (DISABLE) Remote Control command. BIT steps are immediately disabled and the ST-8000A is returned to the operational parameters in use prior to activating BIT.

6.5.3 BIT Test Result Indications

During the time that the Built-In-Test feature is running, the front panel "CH" (Channel), "BAUD", "SPACE", and "MARK" indicators are used to show the BIT status and results.

Immediately upon activation of BIT, the MARK display will show "8000A" and the SPACE display will show "-bit-". These characters remain on the MARK and SPACE displays throughout the duration of BIT.

The "CH" (Channel) display indicates the number of the BIT sequence in process. There are a total of thirteen (13) BIT sequences, indicated by "0" through "9" and "A", "B", and "C".

The "BAUD" display shows "FAIL" and flashes if any step fails and "PASS" after all 13 BIT steps pass. The "BAUD" display is normally blank during the operation of BIT if no failures occur.

If BIT has been activated by Remote Control command, descriptive text for each step is printed on the remote control terminal, followed by "PASSED" or "FAILED" as each test step is completed.

6.5.3.1 BIT Step Successful:

As each BIT step is run, the number of that step is shown on the "CH" display. Successful completion of that BIT step is indicated by changing of the "CH" display to the next step number (or letter). The BAUD display remains blank during each successful step, but shows "PASS" when all 13 steps have been successfully completed.

If BIT has been activated via the Remote Control port, the characters "PASSED" are printed following the description of the test conducted. Successful completion of all 13 steps of the BIT are indicated by printing "ST-8000A PASSED ALL TESTS" on the Remote Control terminal. Except for BIT "Test B" (see 4.12), messages are output to the Remote Control terminal only when BIT has been activated via Remote Control.

6.5.3.2 BIT Step Failure:

If any test should fail, the following sequence is observed:

1. The word "FAIL" appears on the BAUD display.
2. The failed BIT step number appears on the CH display.
3. The ST-8000A halts at this BIT step and will not proceed further.

Procedure after BIT step failure differs slightly between front panel activation and Remote Control activation of BIT.

If BIT has been activated via the front panel keypad and a step fails:

- 4a. Upon failure of a step, the ST-8000A remains locked in that BIT step. Pressing the front panel "BIT" or "CLEAR" keypads will not restart BIT or reset to normal operation. Cycling the AC Power switch OFF and back ON will restore the ST-8000A to normal operation. The parameters set before activation of BIT are restored.

If BIT has been started with Remote Control command T1 and a step fails:

4b. The ST-8000A remains locked in the failed BIT step. It will respond to a T0 command. This restores the ST-8000A to normal operations at the parameters set before activation of BIT. This feature allows operator access to the Remote Control command menus (T9). As in the case of front panel BIT access, cycling of the AC power switch OFF and back ON will restore normal ST-8000A operation.

5. The phrase "FAILED" is continuously sent to the remote control terminal. "FAILED" is repeated until ST-8000A AC Power is turned OFF or until the remote control command T0 is entered.

Although a BIT step failure may be by-passed, a failure has nonetheless occurred. Continued operation of a failed ST-8000A is not recommended. However, should a failure occur, BIT activation should be repeated to confirm the failure mode.

6.5.4 ST-8000A BIT Steps

A total of 13 BIT steps are conducted, "0" through "9" and "A" through "C". The following is a description of each of these steps.

6.5.4.1 Microprocessor Alive Test (Test 0):

When BIT is invoked, the letters "8000A" appear in the MARK numerical display, "-bit-" appears in the SPACE numerical display, the BAUD display is cleared and CHANNEL is set to "0". Also, the MARK and SPACE level indicators and all LED's are cleared.

If BIT is activated via remote control, the following message is sent to the remote control terminal:

```
HAL ST-8000A HF MODEM  
BUILT-IN-TEST (BIT) SUMMARY  
-----
```

When this step passes, BIT automatically proceeds to "Test 1". "Test 0" requires approximately 0.5 seconds to complete.

6.5.4.2 Internal Clock Test (Test 1):

BIT "Test 1" tests the Programmable Interval Timer (8254) and its generated clocks. This step verifies the internal timing clock, the Low-pass filter clock and the Transmit Sync clock. Operation of other clocks are confirmed during "loop-back" steps ("Test 6" through "Test A").

If BIT is activated via remote control, the following message is sent to the remote control terminal:

```
1.. Timer Frequency Test .... PASSED (or repeated FAILED)
```

When this step passes, BIT automatically proceeds to "Test 2". "Test 1" requires approximately 0.5 seconds to complete.

6.5.4.3 ROM Checksum Test (Test 2):

BIT "Test 2" checks the firmware ROM (A2U4) for errors by calculating a sum-check of the entire ROM contents. "Test 2" fails if the sum-check value does not agree with the factory calculated correct value.

If BIT is activated via remote control, the following message is sent to the remote control terminal:

2.. EPROM Memory Test PASSED (or repeated FAILED)

When this step passes, BIT automatically proceeds to "Test 3". "Test 2" requires approximately 0.5 seconds to complete.

6.5.4.4 Random Access Memory (RAM) Test (Test 3):

BIT "Test 3" checks the Random Access Memory (RAM, A2U3). Test patterns are written to the RAM and verified. "Test 3" fails if any single read value does not match the value written. Front panel displays will flicker when the RAM configuration is restored.

If BIT is activated via remote control, the following message is sent to the remote control terminal:

3.. RAM Memory Test PASSED (or repeated FAILED)

When this step passes, BIT automatically proceeds to "Test 4". "Test 3" requires approximately 1.0 seconds to complete.

6.5.4.5 EEPROM Test (Test 4):

BIT "Test 4" verifies EEPROM (A2U2) operations. EEPROM sections used by the main program are tested. Previous EEPROM data is saved in RAM and replaced after the test is completed. "Test 4" fails if the read operation does not match the write operation.

If BIT is activated via remote control, the following message is sent to the remote control terminal:

4.. EEPROM Memory Test PASSED (or repeated FAILED)

When this step passes, BIT automatically proceeds to "Test 5". "Test 4" requires approximately 1.5 seconds to complete.

6.5.4.6 Front Panel Indicator Test (Test 5):

BIT "Test 5" requires operator observation. At the start of "Test 5", all segments and LED's are turned ON for 2.5 seconds. The operator must visually verify that this does occur. All LED indicators and display segments are then turned OFF for 2.0 seconds. The operator must also visually verify that all segments turn OFF.

Pass or failure of "Test 5" must be confirmed by operator observation. Test 5 always concludes with "PASSED" on the front panel display. If the operator should miss this test or be unsure of its result, he should re-invoke BIT by pressing the front panel BIT keypad or by re-entering the T1 Remote Control command. Note, however, that this will also cause repeat of BIT steps "Test 0" through "Test 4".

If BIT is activated via remote control, the following message is sent to the remote control terminal:

5.. Display Test PASSED (no failure indication)

BIT automatically proceeds to "Test 6" upon completion of the ON/OFF display test. "Test 5" requires approximately 4.5 seconds to complete.

6.5.4.7 Loopback Data Test, Parameter Set #1 (Test 6):

BIT "Test 6" is a complete test of all low-speed modulator and demodulator signal processing circuits. To do these tests, the modulator output is internally connected to the demodulator input ("loopback") and a known data stream is sent through the modem. The demodulated data stream is bit-by-bit compared with the test data sent. "Test 6" fails if any single bit comparison fails. The parameters used for this test are:

MARK	= 300 Hz
SPACE	= 3000 Hz
BAUD	= 100
MODULATOR LEVEL	= 0 dBm
TEST DATA	= 511 pseudo-random data elements

If BIT is activated via remote control, the following message is sent to the remote control terminal:

```
6.. Loopback Test #1 ..... PASSED      (or repeated FAILED)
```

When this step passes, BIT automatically proceeds to "Test 7". "Test 6" requires approximately 6.0 seconds to complete.

6.5.4.8 Loopback Data Test, Parameter Set #2 (Test 7):

BIT "Test 7" is the second loopback test of the low-speed demodulator. "Test 7" fails if any single bit comparison fails. The test parameters are:

MARK	= 2000 Hz
SPACE	= 2085 Hz
BAUD	= 75
MODULATOR LEVEL	= -20 dBm

TEST DATA = 511 pseudo-random data elements

If BIT is activated via remote control, the following message is sent to the remote control terminal:

7.. Loopback Test #2 PASSED (or repeated FAILED)

When this step passes, BIT automatically proceeds to "Test 8". "Test 7" requires approximately 7.0 seconds to complete.

6.5.4.9 Loopback Data Test, Parameter Set #3 (Test 8):

BIT "Test 8" is the third loopback test of the low-speed demodulator. "Test 8" fails if any single bit comparison fails. The test parameters are:

MARK	= 1000 Hz
SPACE	= 2000 Hz
BAUD	= 300
MODULATOR LEVEL	= -45 dBm
TEST DATA	= 511 pseudo-random data elements

If BIT is activated via remote control, the following message is sent to the remote control terminal:

8.. Loopback Test #3 PASSED (or repeated FAILED)

When this step passes, BIT automatically proceeds to "Test 9". "Test 8" requires approximately 2.5 seconds to complete.

6.5.4.10 Loopback Data Test, Parameter Set #4 (Test 9):

BIT "Test 9" is the first loopback test of the high-speed demodulator circuit. "Test 9" fails if any single bit comparison fails. The test parameters are:

MARK	= 1575 Hz
SPACE	= 2425 Hz
BAUD	= 650
MODULATOR LEVEL	= -20 dBm
TEST DATA	= 511 pseudo-random data elements

If BIT is activated via remote control, the following message is sent to the remote control terminal:

9.. Loopback Test #4 PASSED (or repeated FAILED)

When this step passes, BIT automatically proceeds to "Test A". "Test 9" requires approximately 2.0 seconds to complete.

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6.5.4.11 Loopback Data Test, Parameter Set #5 (Test A):

BIT "Test A" is the final loopback test of the high-speed demodulator. "Test A" fails if any single bit comparison fails. The test parameters are:

MARK	= 1400 Hz
SPACE	= 2600 Hz
BAUD	= 1200
MODULATOR LEVEL	= 0 dBm
TEST DATA	= 511 pseudo-random data elements

If BIT is activated via remote control, the following message is sent to the remote control terminal:

A.. Loopback Test #5 PASSED (or repeated FAILED)

When this step passes, BIT automatically proceeds to "Test B". "Test A" requires approximately 1.5 seconds to complete.

6.5.4.12 Remote Port Test (Test B):

BIT "Test B" is a test of the Remote Control port of the ST-8000A. This test requires that the operator observe the output of a message sent by the ST-8000A to the remote control terminal. This message is always sent to the Remote Control port, even if BIT is accessed via the front panel keypad. This test requires observation to determine "PASS" or "FAIL". The text sent to the remote control terminal is:

```
B.. Remote Port Test .....  
THE QUICK BROWN FOX JUMPS OVER THE LAZY DOG'S BACK 0123456789  
[0.5 second delay]  
THE QUICK BROWN FOX JUMPS OVER THE LAZY DOG'S BACK 0123456789  
B.. Remote Port Test ..... PASSED
```

There is no failure message sent to the remote control terminal for Test B.

BIT "Test B" always proceeds to BIT "Test C". The time required to complete "Test B" varies with the data rate chosen for communications with the remote control terminal (via option switch U2SW3). At 300 baud, "Test B" requires approximately 6.0 seconds. At 9600 or 19,200 baud, "Test B" requires approximately 2.5 seconds.

6.5.4.13 Deadman Timer Test (Test C):

BIT "Test C" tests the automatic reset circuitry. The length of time required for the microprocessor system to reset is verified to be within acceptable limits. Note that BIT "Test C" causes a reset and will flicker the display. If "Test C" passes, the ST-8000A returns to BIT test mode without the loss of any modem parameters. "Test C" fails if the time-out period is outside of acceptable limits.

If BIT is activated via remote control, the following message is sent to the remote control terminal:

```
C.. Deadman Timer Test ..... PASSED      (or repeated FAILED)
```

When this step passes, BIT automatically proceeds to display of the "Final BIT Report". "Test C" requires approximately 2.5 seconds to complete.

6.5.4.14 Final BIT Report:

This concludes the ST-8000A Built-In-Tests. If all tests have been successful, the word "PASS" appears on the BAUD display. If BIT was accessed via remote control, the phrase "ST-8000A PASSED ALL TESTS" is sent to the remote control terminal.

As noted in section 3.2, a failure of any BIT step will result in the display of the word "FAIL" on the BAUD display. If BIT was accessed via the remote control port, the word "FAILED" is also sent continuously to the remote control terminal.

The final report display of "PASS" on the BAUD display remains for approximately 4.0 seconds. After this delay, BIT proceeds to restore operational parameters.

6.5.4.15 Restore Parameters:

At the successful conclusion of all BIT steps, all parameters of the ST-8000A are restored to the same values that were in use prior to entering BIT. All input and output connections are restored and the ST-8000A modem is then "on-line" for normal data modulation and demodulation.

As noted previously, an in-process BIT sequence may be aborted at any time by pressing the CLEAR keypad or entering the DISABLE (T0) command from the remote port. The CLEAR or DISABLE commands immediately restore the ST-8000A to full operation using the previously set parameters.

6.5.5 BIT Execution Times

Wherever necessary, the BIT procedure has included pauses to allow for comfortable viewing of the progression of the individual tests. The following is a list of times for each BIT step. Note that BIT requires a longer time to run when the remote terminal data rate is slow. Table 1 shows approximate BIT step times for front panel BIT activation, and remote control activation at 300 and 9600 baud.

TABLE 6.1
BIT STEP EXECUTION TIMES

TEST	DESCRIPTION	BIT ACCESS METHOD		
		FRONT PANEL	- REMOTE CONTROL 300 BD	-- 9600 BD
"Test 0"	Microprocessor Alive:	0.5 sec.	4.0 sec.	0.5 sec.
"Test 1"	Internal Clock Test:	0.5 sec.	3.0 sec.	0.5 sec.
"Test 2"	ROM Checksum Test:	0.5 sec.	3.0 sec.	0.5 sec.
"Test 3"	RAM Test:	1.0 sec.	3.0 sec.	1.0 sec.
"Test 4"	EEPROM Test:	1.5 sec.	3.0 sec.	1.5 sec.
"Test 5"	Indicator Test:	4.5 sec.	6.0 sec.	4.5 sec.
"Test 6"	Loopback Test #1:	6.0 sec.	7.5 sec.	6.0 sec.
"Test 7"	Loopback Test #2:	7.0 sec.	9.5 sec.	7.0 sec.
"Test 8"	Loopback Test #3:	2.5 sec.	3.5 sec.	2.5 sec.
"Test 9"	Loopback Test #4:	2.0 sec.	3.0 sec.	2.0 sec.
"Test A"	Loopback Test #5:	1.5 sec.	2.5 sec.	1.5 sec.

"Test B"	Remote Port Test:	2.5 sec.	6.0 sec.	2.5 sec.
	to	6.0 sec.*		
"Test C"	Deadman Timer Test:	3.0 sec.	4.0 sec.	3.0 sec.
	BIT Final Report:	4.0 sec.	5.5 sec.	4.0 sec.
		-----	-----	-----
	Total BIT Time:	38.0 sec.	63.5 sec.	38.0 sec.
	to	41.5 sec.*		

* Time varies with data rate set on remote control port.

6.5.6 Manual Test Selection

The ST-8000A allows manual selection of an individual test included in the BIT. Selection of a single test is accomplished from the REMOTE port with the T9 command. This results in the display of the manual test selection menu. From this menu, any of the BIT steps may be executed.

A front panel keypad test is included in the manual test menu as option "K". When this option is activated, all keys pressed on the keypad are reported on the remote control terminal. While the modem is in this test, no key command operations are performed. This test is provided to isolate suspected keypad problems.

To leave the manual test menu, enter the "X" command on the remote terminal.

6.6 ADDITIONAL FAULT IDENTIFICATION

The ST-8000A BIT tests are extensive and will locate most ST-8000A FSK MODEM failures. However, failures that cannot be tested by the ST-8000A BIT feature include:

1. ST-8000A Demodulator audio input transformer and modulator audio output transformer. The internal BIT audio loopback does not pass through the transformers. "Host Nation" and FCC modem interconnect rules do not permit additional internal connections to the "outside" transformer winding terminals.
2. The system cables that the user may have connected between the ST-8000A and other equipment.

A "suspect" ST-8000A that passes BIT but appears to be malfunctioning may be checked by replacing the unit with another modem with the same internal option settings and the same operational parameters. If the replacement solves the error condition, the replaced unit has a failure. The failure should be

described to include the fact that the BIT did not detect the failure. The failure description should go with the unit when shipped for repair.

If an ST-8000A does not turn ON when the POWER switch is activated, check the fuse. If replacing the fuse does not return the unit to operation, let the unit sit with power OFF for 30 minutes. The ST-8000A power transformer has a thermal circuit breaker on the coil. This safety device opens the transformer primary winding when the temperature exceeds the design limit. Letting the ST-8000A cool for 30 minutes will provide sufficient time for the circuit breaker to reset. The thermal breaker provides fire safety protection required by UL1950 and EN60950. The breaker should not open under normal operating conditions. A unit whose thermal breaker repeatedly trips should be replaced and returned for repair. The reason for the over heating should be determined before the unit is returned to use. If no environmental causes are identified, the unit should be returned to the factory for servicing.

6.7 RETURN TO FACTORY

If it is necessary to return an ST-8000A FSK MODEM to the HAL factory for repair, please follow these procedures:

1. Write a short description of the failure mode. List any failed tests and test steps (POST or BIT). List any possibly related circumstances (lightning storm, dropped unit, high dust or temperatures, etc.). Include a copy of this note inside the package containing the ST-8000A. Include the serial number of the unit on this note.

2. If possible, Locate the original packing materials and re-pack the ST-8000A as shown in Figure 2.1. The connector covers should be replaced prior to wrapping the modem. If the original packing materials are not available, pack the ST-8000A in a fashion as close as possible to the system shown in Figure 2.1. Avoid foam pellets if at all possible. Foam pellets will shift during shipment, possibly exposing the cabinet to damage. "Bubble-wrap" and double-boxing are

recommended.

3. Contact the HAL factory and inform repair personnel that the unit is being returned to the factory. Phone numbers are:

Voice: (217) 367-7373 (M-F, 0800 - 1700 CST/CDT)
FAX: (217) 367-1701 (all times)

4. Include in the package the organization, address, and name to be used when returning the repaired unit.

5. If the ST-8000A is "out-of-warranty" include in the package information concerning how the repairs and return shipment will be paid. If the repair is a "warranty repair", HAL will pay for repair and return shipment to a CONUS address.

4. Ship the packaged ST-8000A postpaid and insured to the HAL factory at the following address:

HAL COMMUNICATIONS CORP.
1201 WEST KENYON ROAD
URBANA, ILLINOIS 61801

ATTN: REPAIR DEPARTMENT

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