2. ROBOT DIAGNOSTICS SOFTWARE

2.1 INTRODUCTION

The firmware (v.3.xx or later) provides customers with a robust and in-depth diagnostics software package. This feature allows users to diagnose and locate problems on the major components of the controller. The diagnostics software also assists technicians in calibrating robots after parts replacement.

To start the diagnostics mode, press CTRL+D on the teach pendant (notation means simultaneously). The teach pendant serves as the console for the controller and is easily handled because of its small size.

After pressing CTRL+D, the teach pendant displays:

DIAGNOSTICS

ESC-QUIT HERE-GO

Press the HERE button to continue, or ESC to cancel.

Table 2.1 -Teach Pendant Keys

Keys Recognized	Action
HERE	Continues or accepts
ESC	Quits or cancels or aborts
>>>	Increments the step or current value
<<<	Decrements the step or current value
Θ ON/OFF	Toggles the servo or selects the Theta axis
R ON/OFF	Toggles the servo or selects the R axis
Z ON/OFF	Toggles the servo or selects the Z axis
A	Selects all axes
Y	Yes
N	No

2.2 MAIN MENU

The diagnostics mode is divided into 11 steps. The main menu displays the current step and its title. Use the >>> or <<< buttons to select the next or previous step. When the desired step appears on the teach pendant, press HERE to enter the step. After each step, you must press HERE (or ENTER) to go back to main menu.

2.3 STEP #1 (NVSRAM TEST)

NVSRAM TEST performs the following four tests.

2.3.1 NVSRAM Format Test.

If the NVSRAM is *not* yet formatted the diagnostics software displays NVSRAM NOT READY. Refer to the FRMT 313 command in Section 15.4.

2.3.2 Parameter File Test.

Result	Reason
Par File Not Open	No parameter file on NVSRAM. Download parameter file (see EQT)
Par Check-Sum OK or BAD	If OK, no action. If BAD, re-download parameter file.

2.3.3 Coordinate File Test

Result	Reason
Cor File Not Open	No coordinate file on NVSRAM. Download coordinate file (see EQT)
Cor Check-Sum OK or BAD	If OK, no action. If BAD, re-download coordinate file or send SAV command.

2.3.4 Macro File Test

Result	Reason
Mac File Not Open	No macro file on NVSRAM. Download macro file (see EQT).
Mac Check-Sum OK or BAD	If OK, no action. If BAD, re-download macro file and send SMCR.

2.4 STEP #2 (GALIL & I/O TEST)

2.4.1 GALIL Board Test

The diagnostics software attempts to communicate with the GALIL board in this test. If there is an error in communication, the diagnostics software displays “GALIL failed.” Otherwise, it displays **“**GALIL passed.”

NOTE:	**Step #2 locks up all other tests after Step #2**

If this test fails, remove the GALIL board and check the jumper setup as described in Section 7.2. If the jumpers are OK, replace the GALIL board.

2.4.2 I/O Board Test

2.4.2.1 Test Ports B, C, D, and E

The diagnostics software tries to communicate with ports B, C, D, and E. If a port fails, the diagnostics software displays “Port X,,, BAD” (“X” representing the port designator) and returns to the Main Menu. Otherwise, it displays “Port B,C,D,E OK” and continues.

If the Port test fails, try it again. If it fails a second time, check the jumpers as described in Section 6.5. Replace the I/O board if the jumpers are found to be OK.

2.4.2.2 Test Controller Internal Connection Based on Port G Information

The diagnostics software displays:

Testing Input G
VALUE:
XXXXXXXX
Generate Error

NOTE:	**The order of . XXXXXXXX changes here. It is now from right-to-left. Thus, the digit at the left of the row is the least significant, and the digit at the right is the most significant**

Disconnect the controller internal cables, one at a time, while observing how the input bit(s) change.

Input port G should correctly be set to all zeros when all the cables are connected (including the Robot signal cable).

Table 2.2 gives a description of each bit when set to 1, and the associated corrective action.

Table 2.2 - Input G Corrective Actions

Bit No.	Description	Corrective Action
0-2	Internal amplifier inputs or robot signal cable.	Check I/O to GALIL cable, I/O to amplifier board, and the signal cable. If all cables are OK, replace the I/O board. If a problem persists, replace the robot interface board.
3	amplifier board under power indicator	Check green LED on amp. board. If “ON” (board under power), check I/O to amp. board cable and I/O board. If “OFF” (board has no power), and there is voltage to amp. board (P3 pin# 2 & 3 should be 32V to 36V), replace amp. board. If no voltage, check motor power supply (torroidal transformer) and relay.
4	Motor power supply indicator	Check I/O to power supply cable and I/O board.
5	Robot interface Board Power Supply Interface indicator. Usually accompanied by bit #3	Check the Power Supply board (located above switcher). If the LED lights, check I/O to power supply cable and I/O board. If LED is not ON, check relay input for 5V.
6	Switcher indicator	None. This condition happens about 30 ms before the controller shuts down.
7	Bus Power Good indicator	None. This condition is never observed by the diagnostics software.

2.4.2.3 Test External Input

At this point, you are testing the external (user) input ports (the STOP port & EMO ports). The diagnostic software displays:

```
Testing Ext. Input
Press Switches
IO Read: XXXXXXXX
EMO ON/OFF  STOP ON/OFF
```

With all external switches and sensors connected to this port, try to activate and deactivate the sensors, and turn the switches ON and OFF. The value following the "IO Read" must correspond to your sensors or switches. The values following the "EMO" and "STOP" interface ports must also correspond.

Replace the I/O board if this test fails.

2.4.2.4 Test External Outputs

This test allows you to activate and deactivate your external devices connected to the external outputs of the EQUIPE Controller.

The diagnostics software displays:

```
Testing Ext. Output
Enter Bit# to toggle
IO Read: XXXXXXXX
```

Use the numerical keypad of the teach pendant to toggle the outputs. Only 0 through 7 are valid.

Replace the I/O board if this test fails.

2.5 STEP #3 (ENCODER READ TEST)

This step verifies that the controller gets the proper encoder feedback from the robot.

The diagnostics software displays:

T:	**XXXXXXX**
R:	**XXXXXXX**
Z:	**XXXXXXX**
Move Axes	

Try to manually move one axis at a time and see if the number counts down or up. When you are moving in the positive direction, the number should count up. Otherwise, it counts down.

NOTE:	**Make sure the robot signal cable is properly connected.**

If the test fails (the display doesn't change when the axis is moved), use the test-motor to test the encoder.

- If the test succeeds with the test-motor, replace the failing motor and encoder.
- If the problem doesn't go away, replace the robot interface board.
- If, after replacing robot interface board, problem persists, replace the GALIL board.
- The last resort is to replace the flex-PCB.

2.6 STEP #4 (LIMIT & HOME TEST)

The limit & home test tests the limit and home switches. The teach pendant displays the following:

T:	**[-]**	**[H]**	**[+]**
R:	**[-]**	**[H]**	**[+]**
Z:	**[-]**	**[H]**	**[+]**
Act. Limit Switches			

NOTE:	**Square brackets indicate that the characters inside may or may not appear on screen.**

The symbols [**–**], [H], and [**+**], when displayed on screen, respectively indicate the negative limit switch, home switch, and positive limit switch are activated. By moving the axes to their limits (negative or positive), you must see changes on the display that correspond to the direction of movement of the limit switches.

You must also note on all ATM or VAC models (except ATM1X4) activating the negative limit switch on an axis triggers the Home switch of that axis. The Limit switch and Home switch for the Radial axis on ATM1X4 is located at a different place.

NOTE:	**Make sure the robot signal cable is properly connected.**

Two conditions can be easily detected by this test:

- The limit switch is OFF all the time.

Action:

Check the signal cable, robot internal interface board, and flex-PCB.

- The limit switch is ON all the time.

Action:

Unplug the signal cable. If the limit switch goes OFF, replace the limit switch assembly. Otherwise, replace the signal cable or GALIL card.

2.7 STEP #5 (AMP. BOARD SETUP)

NOTE:	**Do NOT perform Step #5 unless you are certain it is necessary. Equipe recommends replacing defective amplifier boards with factory calibrated boards.**

This step assists users in setting up the amplifier board. All amplifier boards are factory calibrated before they are installed in a robot. In most cases, there is no need to re-calibrate the boards.

If it is necessary to set up an amplifier board, this step assists you in doing so after you follow the proper hardware set-up procedure described in Chapter 9, “Amplifier Board.” The present step replaces Steps 5 through 7 of Section 9.3, “Amplifier Board set Up.”

The display shows the sequence of activities (screens) before it is ready to work as shown in Fig 2.1.

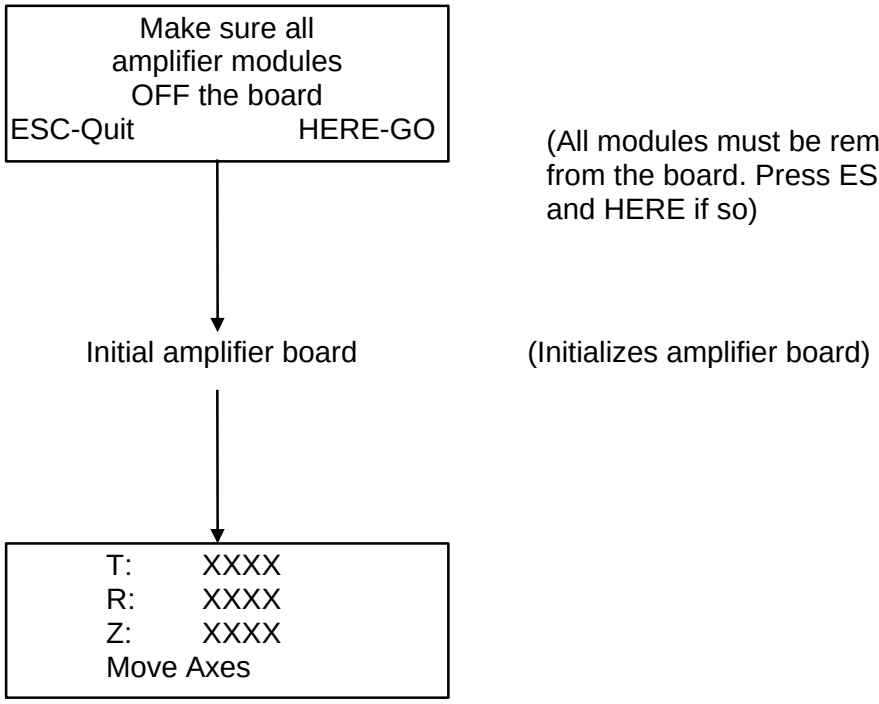


Figure 2.1 Amp. Board Setup

Do not take action at the second screen (Move Axes) because the diagnostics software issues the Move command. Since no amplifier modules are installed, the Robot will not move. Instead, the counters (XXXX) on all axes will count up to 2047. Before making any adjustment on the board, you must wait until these counters indicate 2047.

2.8 STEP #6 (AMP. MODULE SETUP)

NOTE:	Do NOT perform Step #6 unless you are certain it is necessary.

All amplifier modules are shipped from our factory pre-calibrated. They are interchangeable. Therefore, the user can replace an amplifier without any calibration if ordered from us.

When it is necessary to re-calibrate an amplifier module, follow the procedure in Section 9.4, “Amplifier Module Set Up.” In conjunction with this step, ignore Section 9.4 steps 5 through 10 and use the >>> or <<< buttons to increment or decrement the torque limits respectively (steps 14 and 15 of Section 9.4). To toggle the servo ON, use the toggle buttons. All axes are initially in the servo-OFF condition.

The diagnostics software displays:

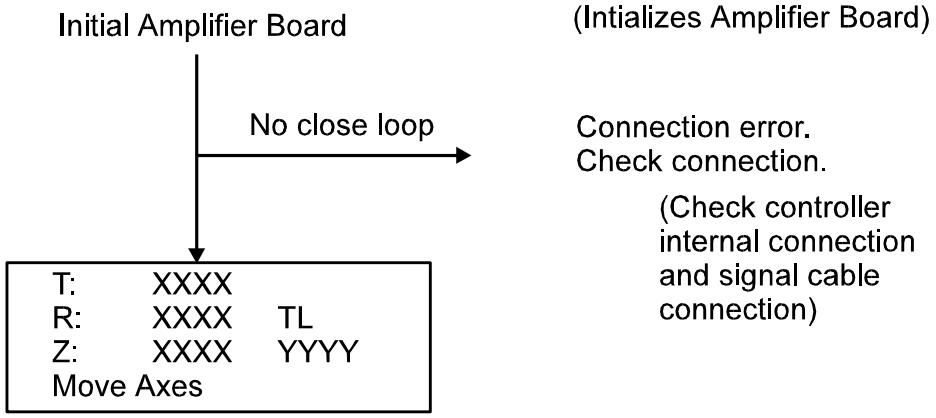


Figure 2.2 - Amp. Module Setup

Where XXXX indicates the current torque sent to the corresponding motor.

YYYY indicates the current torque limit setting (use >>> or <<< to change torque limit).

The three toggle buttons (T ( ), R, and Z) can be used to toggle the servo ON and OFF. Each button toggles all servos.

2.9 STEP #7 (SERVO TEST)

NOTE:	**Perform Step #7 ONLY after you pass Step #3 (Encoder Read Test), Step #5 (Amp. Board Setup), and Step #6 (Amp. Module Setup) successfully.**

Step #7 tests the continuous action of the amplifier modules.

The display and buttons are the same as in Step #6, Amp. Module Setup.

With the robot connected to the controller, perform the following steps:

1. Start with a torque limit (TL) of 300.
2. Toggle the servo ON using one of the toggle buttons
3. Manually move one axis at a time. You must feel that the motor applies a counter-directional force smoothly and continuously without any jerking motion.
4. Repeat step 3 on a different axis.

WARNING:	**Do NOT apply too high a force because the belts may slip.**

2.10 STEP #8 (HOME TEST & SET)

Each robot motor is factory-set set such that the distance between the home switch and encoder index is always between 1/3 and 2/3 of a motor revolution. This is important to maintain repeatability of the HOME position of each axis at a given mechanical calibration.

The homing procedure moves an axis to its home switch and then in the opposite direction to find the index of the encoder (index of encoder is one encoder revolution mark, see Chapter 12, “Motor and Encoder” for further discussion). Consider the following:

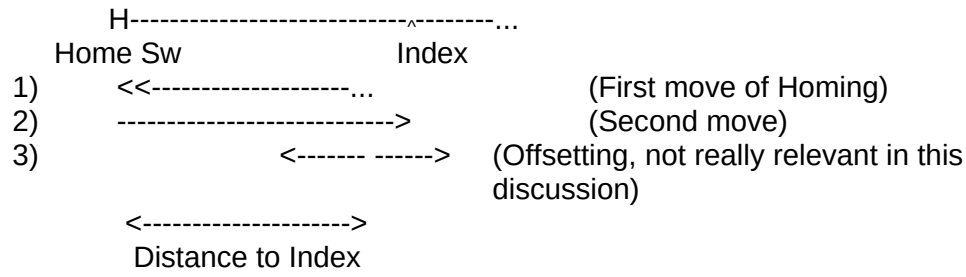


Figure 2.3 - Home Test & Set

If the distance to index is too short, there is a good chance that the controller doesn’t see the first occurrence of the index signal (because it occurs too fast after the home switch signal). Thus, the motor is required to move one more revolution to generate the signal. At some distance, this doesn’t happen all the time and thus creates 2 different home positions, where the second home is seen as too far a distance.

NOTE:	**This procedure should ONLY be performed after replacing parts that require detaching belts such as pulleys, motors, belts, etc. Occasionally, it is also necessary if belt slipping is suspected. For** ATM1X4**, perform step #9 (next step).**

The Home Test & Set (Step 8) determines the distance to index, evaluates it, and assists users to make the correction. The operation is as follows:

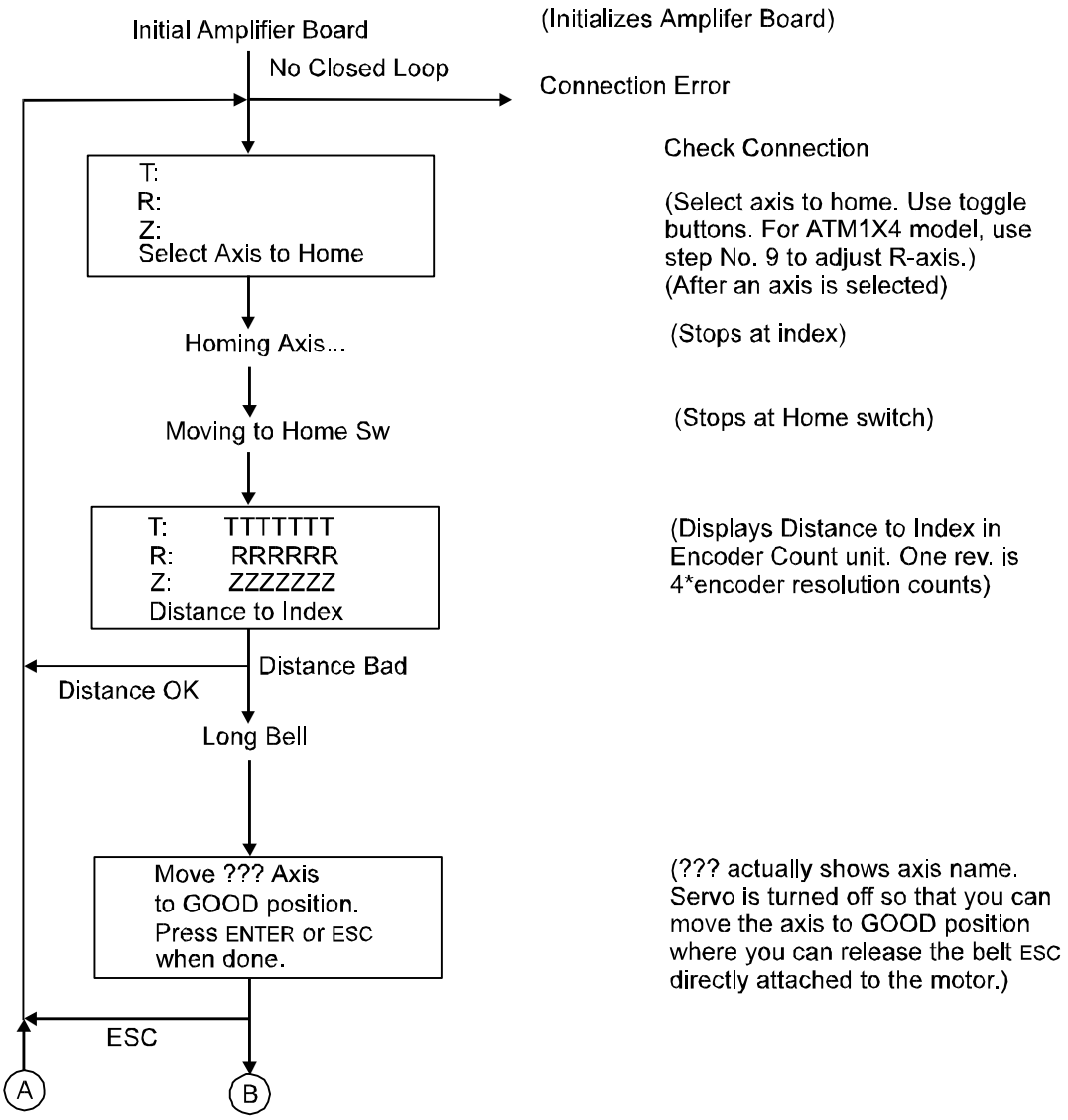


Figure 2.4 - Home Test & Set Operation

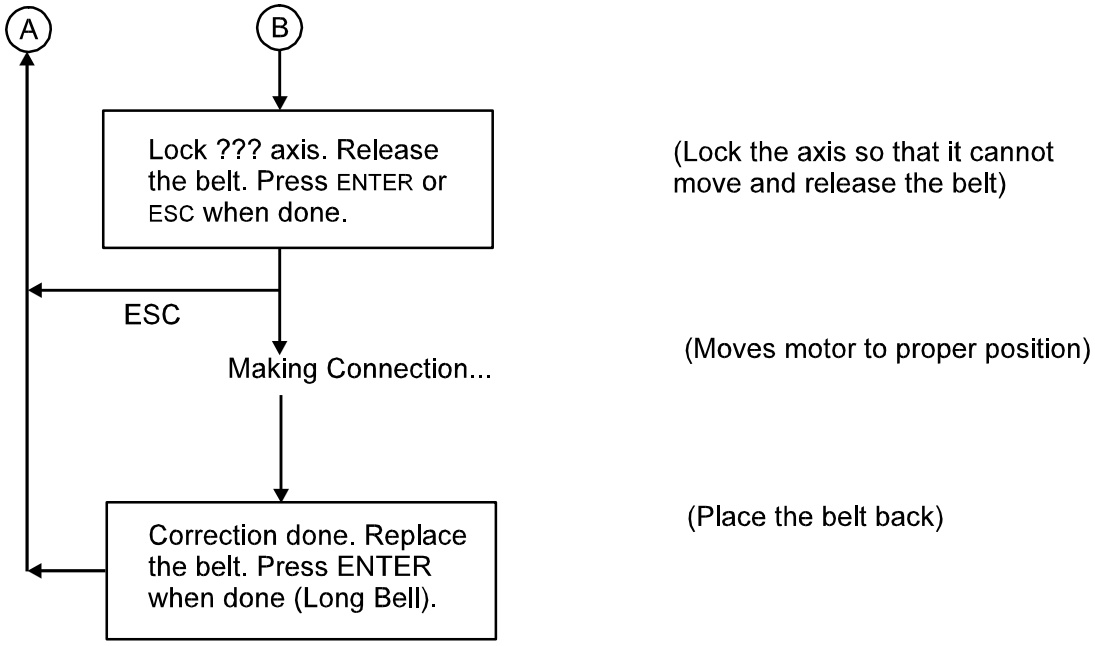


Figure 2.4 - Home Test & Set Operation (continued)

2.11 STEP #9 (R-HOME TEST & SET)

Step #9 consists of three sub-steps. The first two sub-steps are necessary only if you wish to constrain the physical position at home switch and at index.

For example, when you want to have the R-axis retracted the maximum of 5.0 inches from its center (5.0-in. center-to-center) when performing the first home motion, and a maximum of 0.5-inch forward for the second motion. The Center Overlapping Position (COP) is the position where upper link is overlapping exactly in the middle of the lower link. All comments through out Step #9, are based on this example.

Finally, Step #9 performs the home offset test.

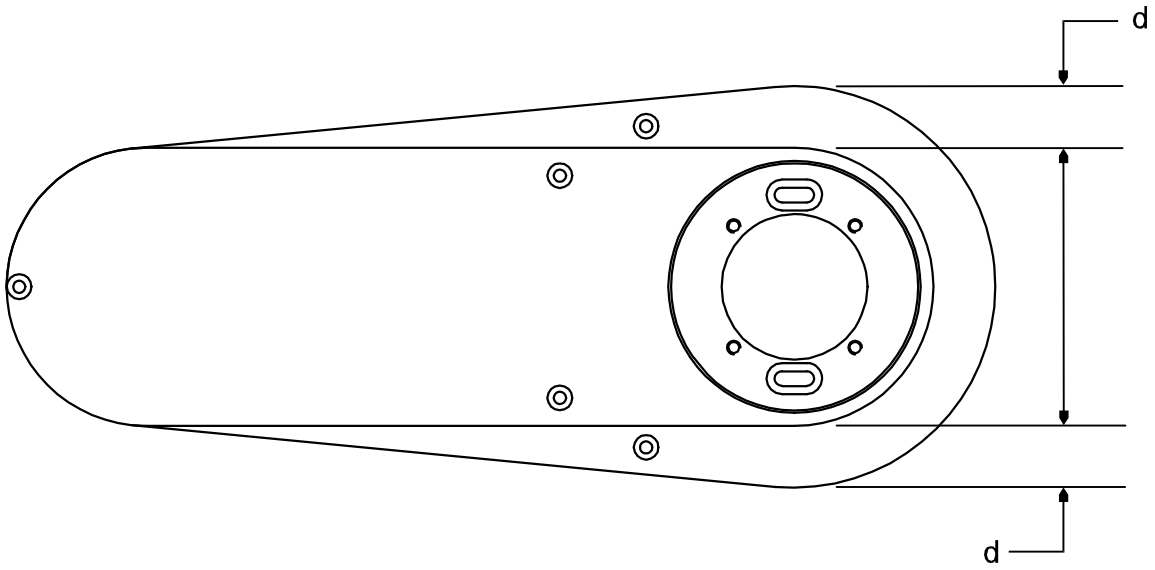


Figure 2.5 - Center Overlapping Position (COP)

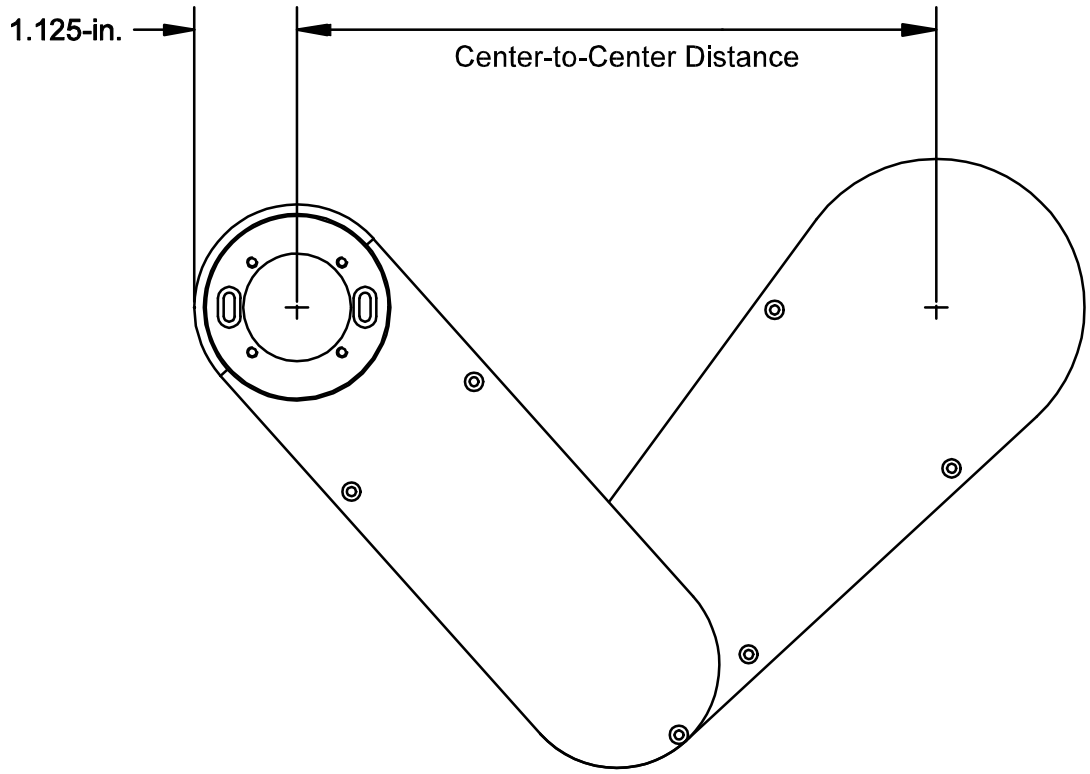


Figure 2.6- Center-to-Center Distance

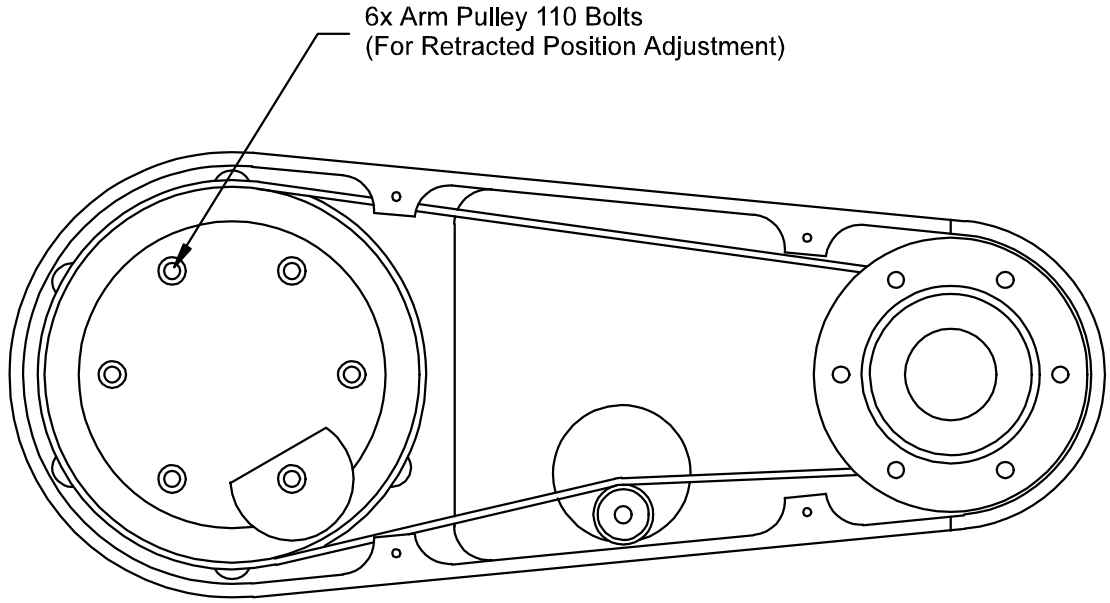


Figure 2.7 - Top View of Lower Link

The sub-steps are as follows:

2.11.1 Adjust the Physical Position at the Home Switch.

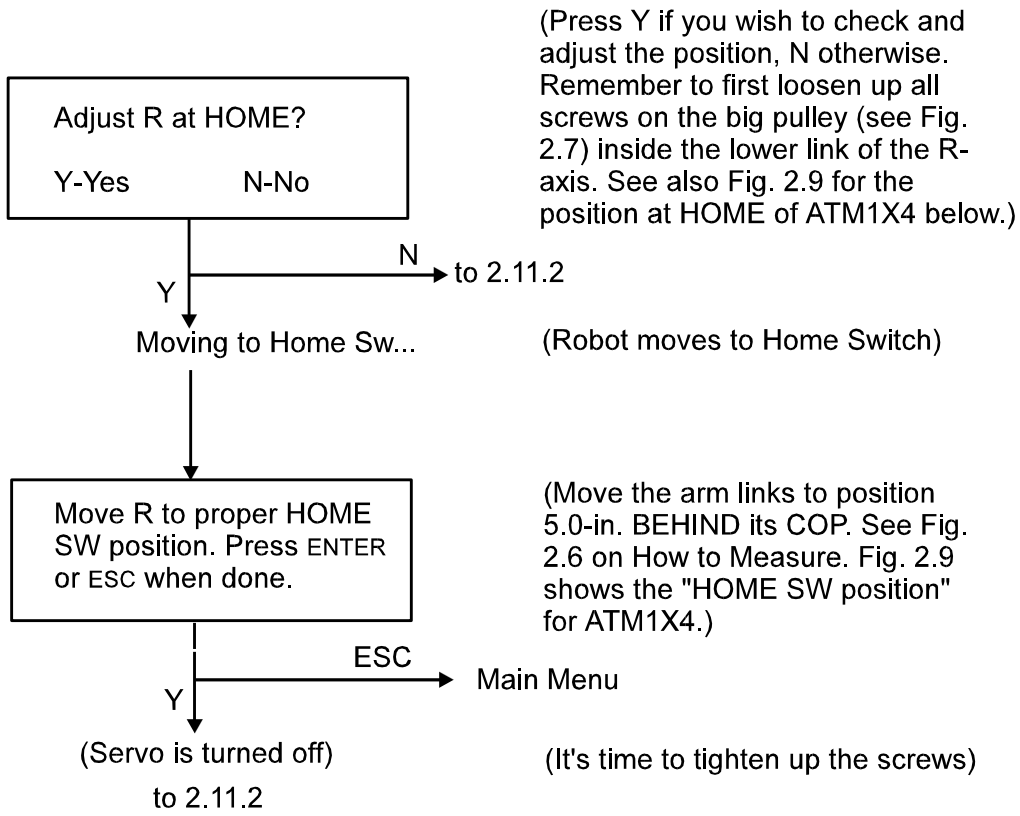


Figure 2.8 - Adjust the Physical Position at the Home Switch

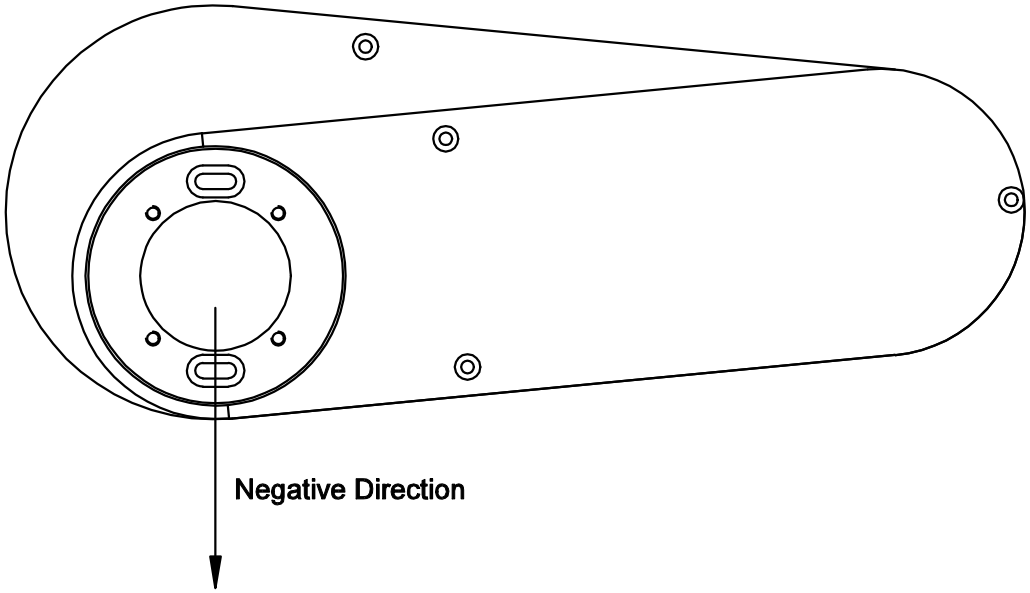


Figure 2.9 - Position of R-Axis at HOME for ATM1X4

2.11.2 Adjusting the Physical Position at Index

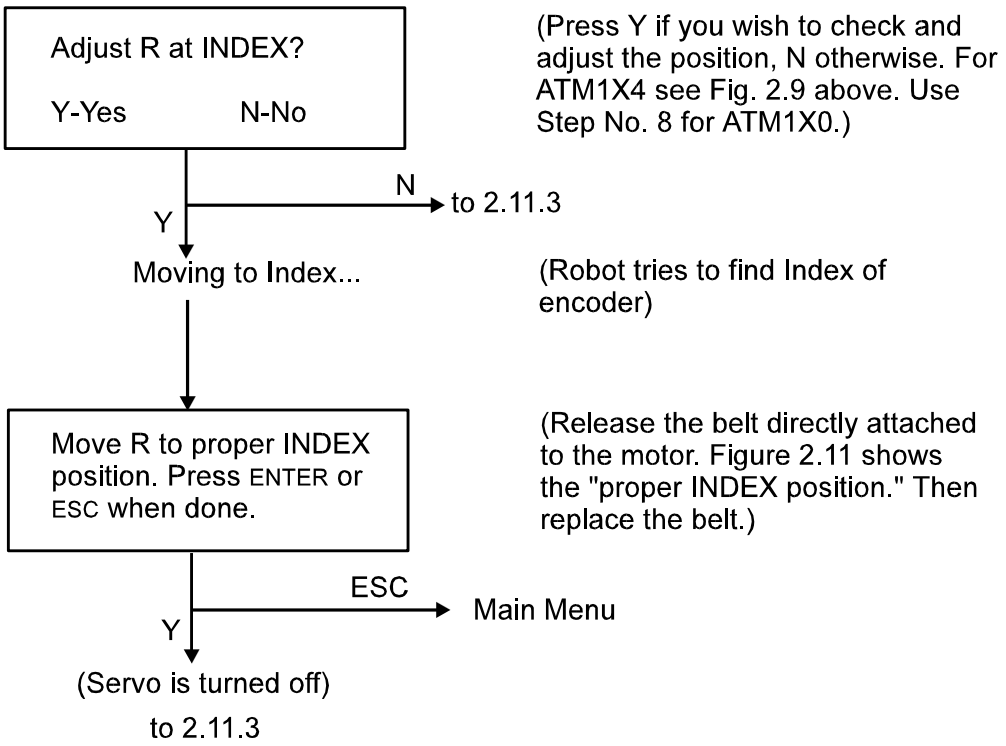


Figure 2.10 - Adjusting the Physical Position at Index

As a reminder, Step #9 will change the distance to index discussed earlier. You may want to make sure it is still within the recommended distance by repeating Step #8. If the distance to index is not appropriate, it is simply that the combination of the physical positions of the home switch and Index is not achievable. Try a different combination.

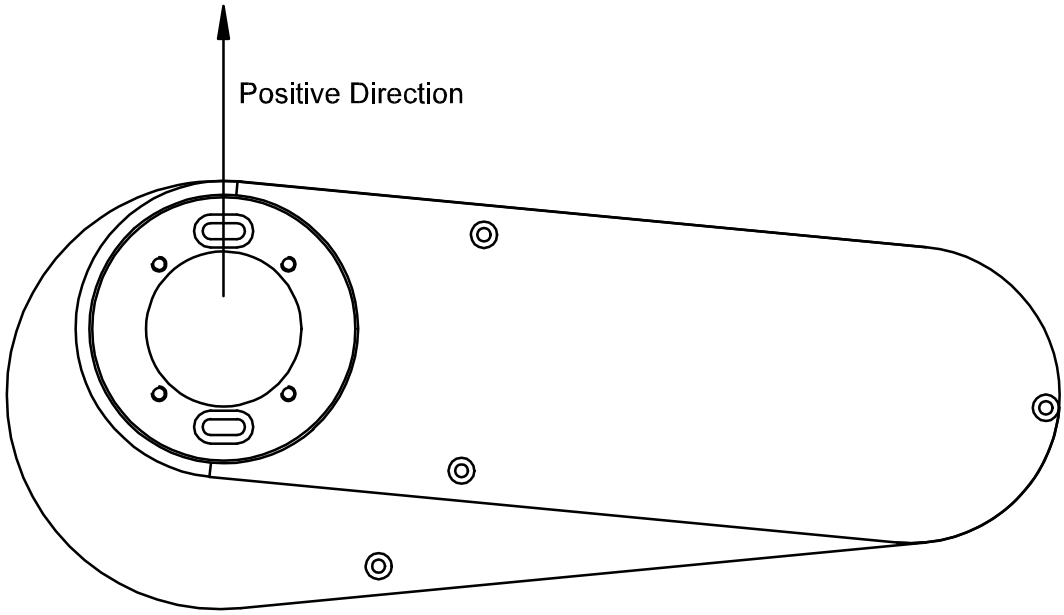


Figure 2.11 - Position of R-axis at Index for ATM1X4

2.11.3 Set the Home Offset

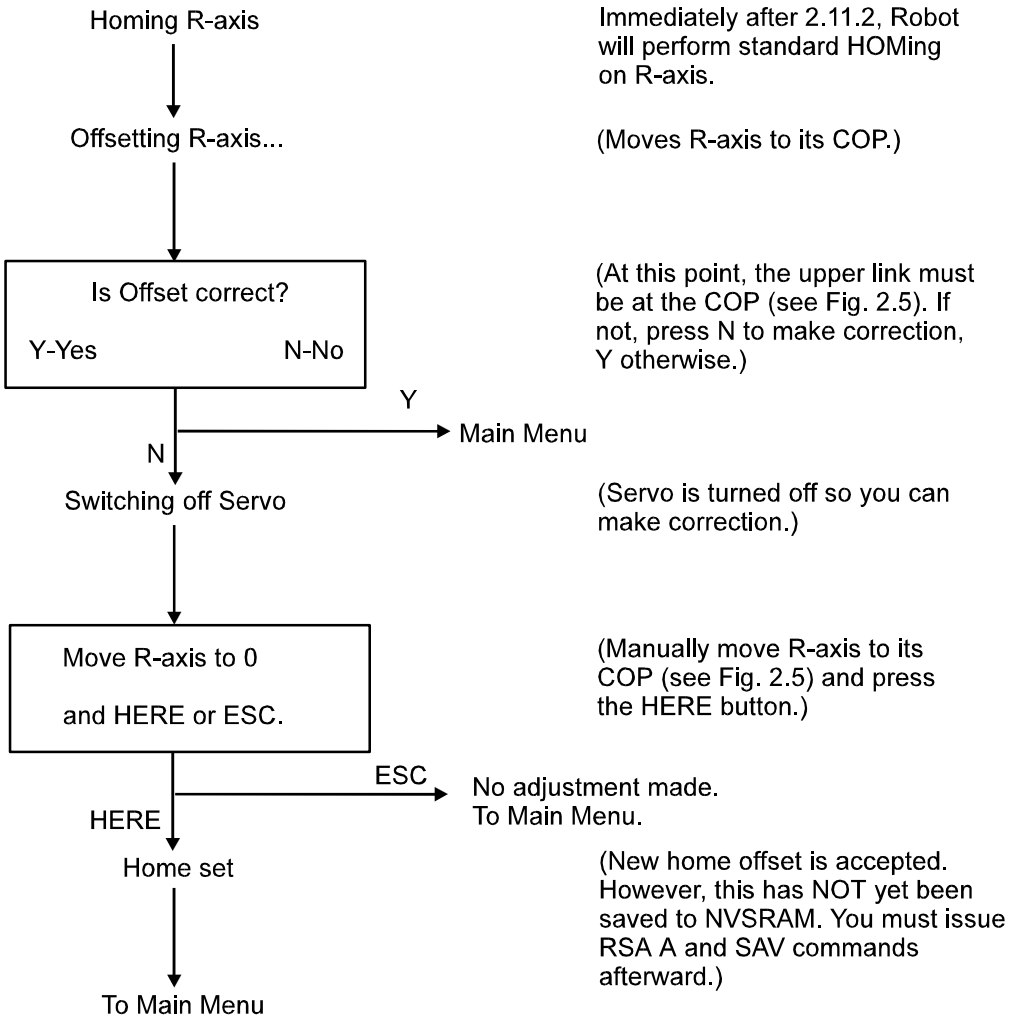


Figure 2.12 - Set the Home Offset

2.12 STEP #10 (SCALING FACTOR TEST)

The scaling factor test is used to verify scaling factor on each axis. This is particularly useful to check whether the Mechanical Ratio Field (MRF) in the parameter file is correct.

Before executing this test, make sure you HOME the R-axis (use Test #9 or send a HOME R command if in the terminal mode). As mentioned earlier, the R-axis is not a linear axis. In order for the scaling factor algorithm to work, it must know precisely the Zero position of the R-axis.

The diagnostics software displays:

```
T:    TTTTTTT
R:    RRRRRR
Z:    ZZZZZZZ
Move Axes
```

Where TTTTTT is the position of Theta in 0.01°, RRRRRR is the Radial position expressed in 0.001-in., and ZZZZZZ is the Z-axis position expressed in 0.001-in. units.

With some type of measurement device, move the axis you want to check. Measure the physical movement and compare the result with the reading of the Teach Pendant.

NOTE:	**It is important only to measure the displacement of the axis rather than to measure the absolute position. Consequently, you must pay attention to the initial physical position and initial reading on the Teach Pendant.**

2.13 STEP #11 (VAC. VALVE/SENSOR)

This step tests the vacuum valve(s) and vacuum sensor(s) attached to the robot. For models with one vacuum valve and one sensor, only position #1 is relevant.

	#1	#2
Vac Sensor	On/Off	On/Off
Vac Valve	On/Off	On/Off
Press '1' or '2'		

(Vacuum Sensors)
(Vacuum Valves)
(Use numerical key 1 or 2 to toggle vacuum valve)

Turn the vacuum valve ON (open the valve) and place and remove an object on the end-effector. The vacuum valve indicates ON and OFF respectively.

- If it stays ON all the time ,it is set too sensitive; decrease the sensitivity.
- If it stays OFF all the time, it is not set sensitive enough; increase the sensitivity.

Refer to Chapter 4, "Error Recovery through Software Servo Adjustment" to adjust the sensitivity.

3. STATUS MESSAGES AND TROUBLE SHOOTING

The commands for the different status messages are sent from the terminal mode over the RS-232 to the Controller. The basic status commands include:

STAT	Send status word
RNCS	Read NVSRAM check-sum
RLS	Read limit switches
INPUT #	Read input port #

These are the main commands used in trouble shooting the robot.

Response from STAT, RNCS, RLS, and INPUT instructions are in hexadecimal format.

3.1 COMPREHENSIVE STATUS MESSAGE

Sending the STAT command over the RS232 results in the controller returning a 16-bit status word indicating the controller status.

Table 3.1- STAT Bit Assignments

Bit No.	Meaning When Set (to 1)	Cleared By
0	Previous command not executed	Any
1	Previous command invalid	Any
2	Vacuum sensor is activated	
3	Vacuum switch is ON	
4	Motor error on one or more axes	SVON (see Section 3.9)
5	One or more limit switches are triggered	RLS (see Section 3.7, 3.8.2)
6	One or more axes are not homed yet	HOME
7	Prealigner error (Initialization only)	
8	Running macro	
9	One or more axes are moving	
10	Servo OFF on one or more axes	SVON (see Section 3.9)
11	Error on COM2	AST 2
12	Not used (always 1)	
13	NVSRAM error	RNCS
14	Controller error	Any
15	Error on COM1	AST 1

3.2 HEXADECIMAL FORMAT

Status bits are sent by the Controller in hexadecimal format. The following is an explanation on how to evaluate the status message.

STAT returns four characters. Each character can be from 0-9 and A-F. Each character is represented by four status bits (and each bit is either a 0 or 1). Table 3.2 describes the hexadecimal translation of each character to four status bits.

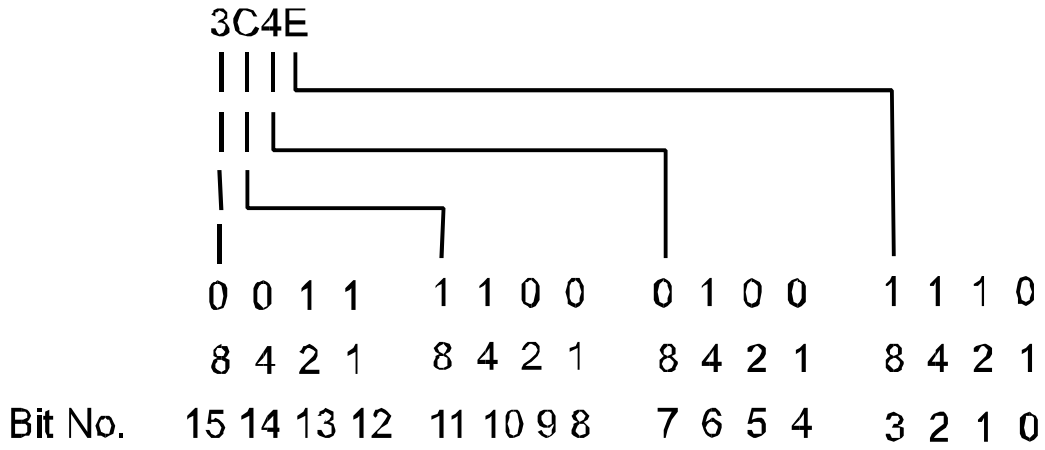
Table 3.2 - Hexadecimal Character Translation

Character	Bits 8 4 2 1
0	0 0 0 0
1	0 0 0 1
2	0 0 1 0
3	0 0 1 1
4	0 1 0 0
5	0 1 0 1
6	0 1 1 0
7	0 1 1 1
8	1 0 0 0
9	1 0 0 1
A	1 0 1 0
B	1 0 1 1
C	1 1 0 0
D	1 1 0 1
E	1 1 1 0
F	1 1 1 1

Thus, character 0 means all bits are set to 0, and character F means all bits are set to 1.

The four characters returned by the STAT command can be translated as follows:

For example, the STAT command returning 3C4E can be translated to:



This means Bit Nos. 1, 2, 3, 6, 7, 10, 12, and 13 are set to 1, which, if you refer to the STAT Bit Assignment table (Table 3.1), indicates that:

Bit	Meaning
1	Previous command was invalid
2	Vacuum sensor is activated
3	Vacuum switch in ON
6	One or more axes are not yet homed
7	Not used (always 0)
10	Servo is OFF on one or more axes
12	Always 1 (ignore)
13	NVSRAM error

3.3 CAUSE AND RECOVERY FOR STAT MESSAGES

The setting of each status bit is caused by one or more reasons. Under some circumstances the cause is fatal and needs immediate action to recover, and under other circumstances the cause is harmless and does not need any direct action. See Table 3.3 for cause and recovery.

Table 3.3 Cause and Recovery for STAT

Bit No.	Cause	Recovery
0	If the command has valid syntax, this bit means that the command is inappropriate for the current condition. Example: executing SVON while axes are moving.	Make sure to set the proper condition before executing the command.
1	The previous command is unknown or has invalid syntax. The setting of this bit always sets bit #0 to 1.	Check command list and the syntax of the command.
2	Vacuum sensor is ON (object detected). 1 on this bit must always be accompanied by 1 on bit 3 (vacuum switch must also be ON). If this bit is always 1 regardless of presence of object or status of bit 3, it indicates that vacuum sensor is too sensitive.	Re-adjust the vacuum sensor (see Chapter 4)
3	Turns the vacuum switch ON/OFF. For example, the GET or PUT command changes the value of this bit.	None.
4	One or more axes have a position error condition. Excessive force has been applied to the force generated by the motor. An obstacle in Robot's path could be one of the reasons. Another possible cause is if the Servo Error Limit (ER) is too small. The setting of this bit will always set bit 10 to be 1.	Clear the obstacle, send the SVON command, and continue. If ER is too small (usually in the range of 100-200), change the setup and increase (see Section 15.3).
5	One or more limit switches are triggered. There are two limit switches (positive and negative) for each axis. The RLS command shows information that is more detailed about limit switches.	Send the RLS command. Determine which limit switches are ON or triggered, and move away from the switches (see Sections 3.7 and 3.8.2).
6	One or more axes are not homed. With this condition, the controller will not allow any move command on the axes. Power up or disconnection of the signal cable sets this bit to 1.	Get Controller ready to Home and then HOME the Robot.
7	Not used.	N/A
8	A macro is running. The bit is set to 0 after the macro executes the last ENDM command.	None.

Bit No.	Cause	Recovery
9	One or more axes are moving. Any Move command will cause this bit to set to 1.	None.
10	Servo OFF condition on one or more axes. Bit 10 is set to 1 when SVOF is issued or a motor error condition is generated.	Send SVON command.
11	Error on COM2. Several things can cause this condition. Send AST 2 command to see the type of error.	Normally sending AST 2 clears this bit.
12	Not used.	N/A
13	NVSRAM error. It is set to 1 by any of the following: ☐ NVSRAM is not installed. ☐ NVSRAM is not formatted. ☐ The parameter file is corrupted. ☐ The coordinate file is corrupted. ☐ The macro file is corrupted or is an incompatible version.	☐ Install NVSRAM. ☐ Format NVSRAM with FRMT command. ☐ Re-download the parameter file. ☐ Re-download the coordinate file or re-teach coordinates and send the SAV command. ☐ Re-download the macro file and send the SMCR command.
	To determine the reason for the error and the recovery for NVSRAM problems, enter the RNCS command in the terminal mode and evaluate the response. See Section 3.4, “RNCS status message” below.	
14	Internal motion controller communication error.	Send another STAT. If it doesn’t clear the bit, replace the GALIL board and/or call EQUIPE for service.
15	Error on COM1. See AST 1 for the cause of this condition.	Normally sending AST 1 clears the bit.

3.4 NVSRAM STATUS USING RNCS STATUS MESSAGE

Sending the RNCS command from the terminal mode gives the status of the NVSRAM chip on the CPU board. The NVSRAM chip stores all the variable information of the robot and the system. On the NVSRAM chip contains the following files:

- Parameter file
- Coordinate file
- Macro file

The controller can determine, using check-sum, if these files have been corrupted. It can also verify the functionality of the NVSRAM chip in general. By sending the RNCS command during trouble-shooting you will receive the following information:

16-Bit Status Word Bit Number	**Explanation (if set to 1)**
0	Check-sum error on parameter file
1	Check-sum error on coordinate file
2	Check-sum error on macro file
3 through 14	Not used—always 0
15	NVSRAM is not formatted or does not exist

For example, if the NVSRAM is not formatted, non-functional, not in place, or after installing a new NVSRAM (unformatted), the RNCS command returns status: 8007. This means that bits 0, 1, 2, and 15 are set to 1:

3.5 NVSRAM—RNCS RECOVERY

To recover from a NVSRAM failure requires downloading the files that should also be stored on the host computer. It is therefore good practice to:

1. Upload a copy of the parameter files of each robot upon initial receipt.
2. Make sure that after all stations have been taught, you upload the parameters and store them in a file on your host system.
3. Upload all macros to the host computer.

These steps should be done on a periodic basis, and most definitely prior to shipment to ensure that the latest files have been saved. Some users write their host software to do this automatically.

NOTE:	**Use EQT to upload and download data (see Chapter 14).**

Table 3.4 - RNCS Cause and Recovery for RNCS

Bit No.	Cause	Recovery
0	Check-sum error on the parameter file.	Re-download the parameter file using WRIP from the command line.
1	Check-sum error on the parameter file.	Reset the controller using the RES command. Re-download coordinates using the SPO command for each station. Restore speed and acceleration using the RSA command, and then save the parameters using the SAV command.
2	Check-sum error on the macro file.	Re-download macro files and save the macros to the NVSRAM by sending the SMCR command.
15	NVSRAM not functioning.	Reformat the existing NVSRAM chip and re-download all of the above. If a problem still exists, reformat and re-download all the above.

3.6 FORMATTING NVSRAM

The EQUIPE controller system may require the NVSRAM to be formatted twice depending on the condition of the NVSRAM to be formatted. If working with a new (blank) NVSRAM, the controller will perform low-level formatting of the NVSRAM. The user must then send another format command to perform the high-level formatting of the NVSRAM. Table 3.5 describes the procedure for formatting the NVSRAM.

Table 3.5 - NVSRAM Formatting Procedure

Step	Command Sent	Controller Response	Controller Activity
1	FRMT 313	0006 >	Low-level formatting, and resetting (continues during the following steps)
2	FRMT 313 (2nd)	0000 >	High-level formatting
3	RES	>	Resetting
4	WRIP	>	Downloads the parameter file. Use the EQT program to initiate download.
5	RES	>	Resets (will properly initialize coordinates to their default value)
6	RSA A	>	Restores Speed and Acceleration
7	SAV	>	Saves parameters and coordinates (creates coordinate file consisting default value)
8	Download Macro	N/A	Uses the EQT program to download the macro file
9	SMCR	>	Saves the macro file (it takes approx. 30 sec. before sending the prompt)

If the controller responds with something other than 0006 or 0000 for the FRMT 313 command, refer to the FRMT command in Section 15.4 for the response interpretation.

3.7 LIMIT SWITCH STATUS USING THE RLS STATUS MESSAGE

This section and section 3.8 discuss problems with the limit switch that are generally caused by software or mechanical position setup. Before proceeding, you must first determine if limit switch hardware is functional by performing diagnostic step #4 (Limit & Home Test).

If the robot fails due to a limit switch being triggered (bit #5 from the STAT command) first troubleshoot to determine which limit switch was activated by using the RLS command. Then determine whether this actually caused this condition.

Limit switch status RLS has the following bit assignments:

Table 3.6 - Limit Switch Status RLS Bit Assignments

Bit No.	Active Limit Switch (if set to 1)
0	Positive Theta
1	Positive Radial
2	Positive Z
3	Negative Theta
4	Negative Radial
5	Negative Z
6–7	Always 0
8	Positive Theta triggered
9	Positive Radial triggered
10	Positive Z triggered
11	Negative Theta triggered
12	Negative Radial triggered
13	Negative Z triggered
14–15	Always 0

If a limit switch is still ON, its bit will still be set to 1 (bits 0 - 5).

The triggered group of limit switch status words (bits 8 - 13) indicates that the limit switch is momentarily triggered. It does not reflect the current limit switch status, rather what caused the Robot to stop its motion. These bits are cleared after the RLS command is issued.

3.8 LIMIT SWITCH—RLS RECOVERY

The limit switches prevent over-travel of the robot into the hard stops of each axis of motion, and are normally activated just prior to contact with the hard stops. The limit switches signal the motion control card to kill power to the motor to prevent the robot axes from being driven into the hard stop. In normal operation, the robot should not move into the limit switch area.

When a limit switch is triggered during the robot's operation, the robot will stop its motion and return an error message. In this situation you should:

- Send the RLS command to determine which switch was triggered (above).
- Send RLS command again to see if switch is still active.

3.8.1 Limit Switch Remains ON After RLS Command

If a switch is still active after the second RLS command, the robot is probably at its travel limit. Physically move it away from this limit, then send the RLS command again to see if it is cleared. If so, this indicates that the robot was probably instructed by software to go too close to the limit.

This can occur even during teaching, if the position taught was beyond the limit. This can also be caused by:

- Robot overshoot (where the robot goes slightly beyond its taught position as it decelerates at the end of a motion in a given axis and then comes back to its designated position)
- A stroke being entered for a Z motion in a pickup place is too large (where the taught position was within the robot's range, but now the stroke requires the robot to enter the area of the limit switch).

To resolve these problems you must:

- Change the taught position (which may require physically moving station within system to a position farther away from limit)
- Change (reduce) the stroke and/or vertical offsets (if this occurs at the first or last slot of a cassette and it is the vertical axis which is shutting down
- Decrease the speeds and accelerations to minimize robot overshoot on deceleration.

3.8.2 Limit Switch Goes OFF After RLS Command

If the second RLS command clears all bits (while the robot position has changed), this indicates a problem in the limit switch assembly. The robot may need to be serviced. Call EQUIPE for assistance.

3.9 TROUBLESHOOTING TABLE

Table 3.7 - Hex to Binary Conversion

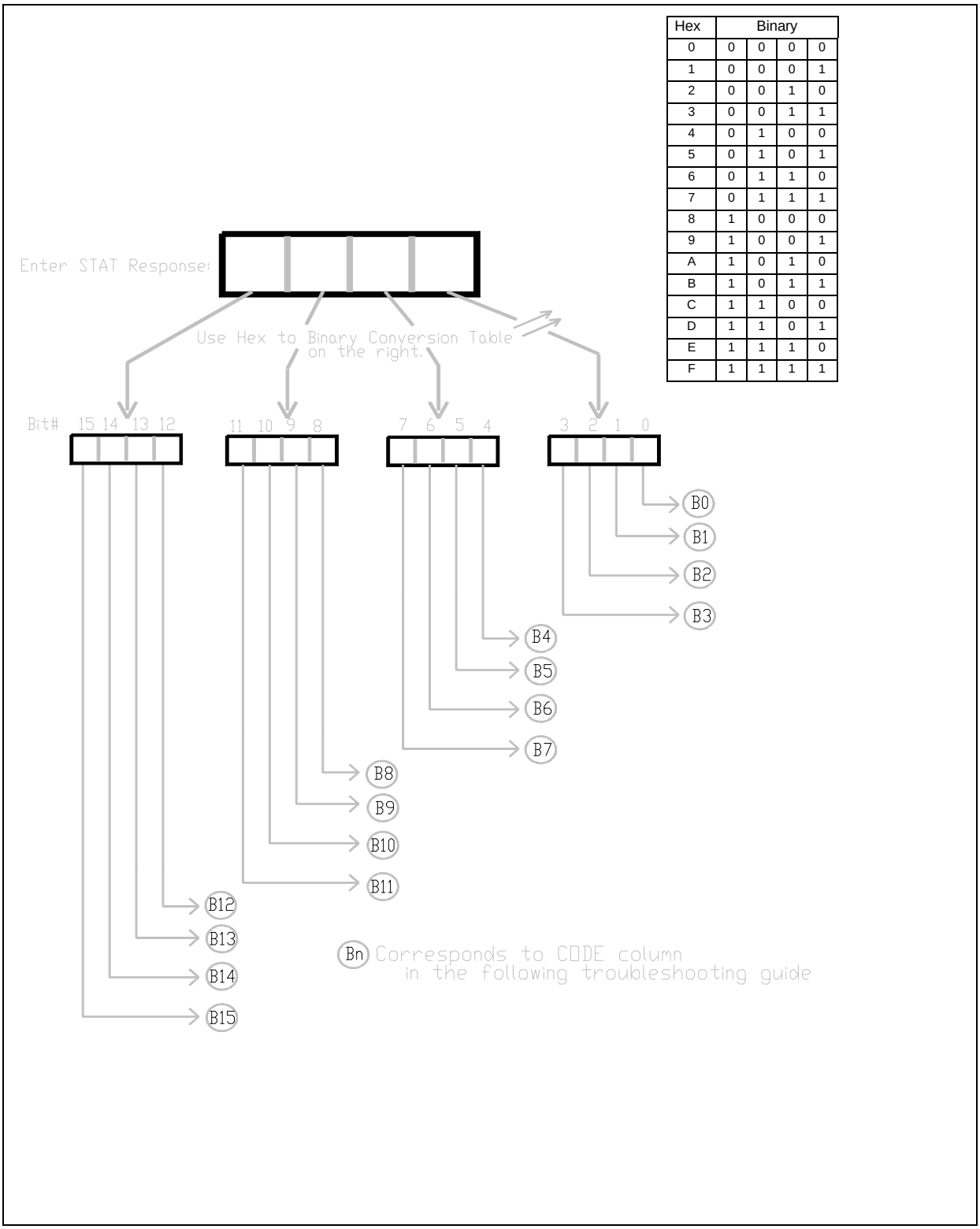


Table 3.8 - Troubleshooting Table

Trouble	Symptom	Possible Cause	Code	Corrective Action
No communication	Exhaust fan not running	No AC power		Check power cord and fuses
	No BEEP from CPU	EPROM's improperly installed		Order new EPROM's and place them properly. Sockets are 32-pin JEDEC standard. Ensure correct jumper setup (see Technical Manual Section 4.2).
		Loose board(s)		Remove all but amplifier board and replace them on the bus while securing their connection.
		Bad CPU board		Replace CPU board.
	LED's on amplifier board not lit	Bad EPROM's or EPROM's improperly installed		Order new EPROM's and place them properly. Sockets are 32-pin JEDEC standard. Ensure correct jumper setup (see Section 4.2 of Technical Manual).
		Loose board(s)		Remove all but amplifier board and replace them on the bus while securing their connection.
	Other	Wrong RS232 cable		Check RS232 cable (see Section 6 of Owner's Manual).
		Wrong BAUD rate		Try different BAUD rate on host computer/terminal (see SBR).
Axis can't servo-on	SVON command responded with "?"	Unsecured connection(s) of signal cables(s)	B0, B10	Check external signal cable. Send INPUT G command (see Section 6 of Owner's Manual).
		Other		Send ABM command. Try to servo-on again.
		If ABM is responded by "/"	B0, B10, B14	Replace GALIL board.

Trouble	Symptom	Possible Cause	Code	Corrective Action
	SVON command OK but no power to motor(s)	Unsecured connection of external power cable (usually no servo to any motors)		Secure cable connections
		Bad amplifier module(s) (usually only one of the two motors)		Replace amplifier module on the failing axis (use Diagnostics step #7 to determine the failing axis).
Axis can't HOME	Axis moves but stops at its negative hardstop and looses servo	Limit switch is not working	B4, B10	Perform diagnostics step #4 to determine the failing limit switch. Replace limit switch assembly. If problem persists, replace flex-PCB.
	Axis moves but stops at random position and retains servo	Intermittent false-positive signal generated by home switch	B5	Send RLS to determine which axis. Replace limit switch assembly.
	Axis moves but stops at random position and looses servo	Servo is too weak	B4, B10	Check servo parameters (GN, TL, and ER). Increase associated parameters.
	Axis moves but stops at certain position range and looses servo	Mechanical friction is too high	B4, B10	Check all transmissions along the axis. Make sure belts are not too tight and bearings move smoothly.
	Axis moves but stops at its positive hardstop	Home switch is active all the time	B5, B9	Send RLS to determine which axis. Replace limit switch assembly.
	Axis doesn't move at all	Positive and Home switches are active all the time	B5, B9	Send RLS to determine which axis. Replace limit switch assembly.
Robot stops during normal operation	Axis stops at random position but retains servo	False -positive signal generated by limit switch	B5	Send RLS to determine which axis. Replace limit switch assembly.
	Axis stops at random position and looses servo	Speed is too fast for error limit setup	B4, B10	Increase error limit setup (see Section 9 of Owner's Manual on SAD and SSP).
		False -positive signal generated by limit switch	B4, B5, B10	Send RLS to determine which axis. Replace limit switch assembly.

Trouble	Symptom	Possible Cause	Code	Corrective Action
	Axis stops when it comes in contact with an object (e.g., wafer)	Mechanical friction is too high	B4, B10	Check all transmissions along the axis. Make sure belts are not too tight and bearings move smoothly.
	Robot stops when it comes in contact with an object (i.e., wafer)	Excessive electrostatic discharge or EMI/RFI to Robot	B14	Re-route each-grounding and proper shielding.
		Robot hits the object	B4, B10	Re-teach robot.
Robot not repeatable	Axis position drifting over time	Worn-out belts		Inspect belts, and replace if necessary.
		Loose transmission shaft		Inspect shaft by rotating pulley manually while servo is on.
		Bad Encoder		Use oscilloscope to test the Encoder output signal (see Section 10 of Technical Manual). If Encoder is OK, replace the flex-PCB.
	Axis position slightly different from the last time stations were taught and the difference is consistent from one station to another	Slipped belt(s)		Inspect belts for loose adjustment. Perform Diagnostic step #8 to ensure the distance from the home switch and encoder index is within the allowable range. For the R-axis, also perform step #9 to re-calibrate the Home offset. Then re-teach the stations.
		Encoder index set too close to home switch		Reset index. (See Section 2-10)
	Axis position different after every HOME sequence	Intermittent limit switch problem	B5	Send RLS to determine which axis. Replace limit switch assembly.
Robot loses taught stations after power-on cycle	After power-on cycle, robot does not move to previously taught stations	NVSRAM failure	B13	Try to reformat NVSRAM (see Section 3.5 and 3.6). If successful, re-download PAR and Macro files, and then re-teach stations. Otherwise, try with new NVSRAM. Ensure correct jumper setup (see Section 6.1).

Trouble	Symptom	Possible Cause	Code	Corrective Action
Robot moves erratically	Robot performs normally but an axis jumps unpredictably to its hardstop (negative or positive)	Bad Encoder		Perform Encoder test (Diagnostics step #3). Replace Encoder if required.
		Bad amplifier module (especially after Controller box passes warm-up period)	B4, B10	Perform Encoder test (Diagnostics step #3) to make sure it is NOT an Encoder problem. If the Encoder is OK, replace the amplifier module.
		Excessive noise to GALIL board or bad GALIL board	B14	Send GALIL command. You must receive "." response. Press ENTER several times. If you receive ">" response, replace GALIL board. If problem persists, re-route grounding and proper shielding.
		Interrupted Encoder signal		Replace flex-PCB.

CODE indicates bit(s) from STAT response that are set to 1. This can be used to confirm the symptom you have observed.

4. ERROR RECOVERY THROUGH SOFTWARE SERVO ADJUSTMENT

This chapter describes servo adjustment as the subset of PID (proportional, integral, and derivative) parameter adjustment. The intent is to use a simple procedure to solve common servo problems.

Before proceeding with this procedure, make sure that diagnostics steps # 5 through #7 have been successfully performed. The software adjustment will *not* fix a hardware mis-adjustment.

Adjustment methodology is based on symptom-to-corrective action progression. You must identify the symptom that causes the servo problem before you can proceed.

Table 4.x - Software Servo Corrective Action

Symptoms	Corrective Action	Example
An axis keeps shutting off at random positions.	RGN Axis (Controller returns a number)	**RGN Z** (return value is 50) **GN Z,55**
	Increase the value by 5 units. Continue normal operation. If the axis still keeps shutting off, RER Axis (Controller returns a number)	**RER R** (return value is 150)
	Increase the value by 50 units. Continue normal operation. If the axis is still shutting off, continue increasing the ER value. However, the increase should not exceed 200 units from its original value.	**ER R,200**
Unstable axis. An axis jerks at certain speeds.	RGN Axis (Controller returns a number)	**RGN Z** (return value is 50) **GN Z,55**
	Increase the value by 5 units. Continue normal operation. If the axis is still jerking, RKI Axis	**RKI T** (return value is 10)
	Decrease KI value by 2. Continue normal operation. If the axis is still jerking, keep decreasing the KI value. The minimum value for KI is 1. Do not set KI to 0.	**KI T,8**
Unstable axis. An axis oscillates while stationary.	RGN Axis (Controller returns a number)	**RGN Z** (return value is 55)
	Decrease the value by 5 units.	**GN Z,50**

The commands in bold are sent to the Controller through the host terminal or the Teach Pendant in Terminal Mode.

5. VACUUM SENSOR ADJUSTMENT

Equipe robots use up to two SMC Series NZSE1-T1-14 or NZSE2-T1-15C vacuum switches. This switch can sense up to –30 in. Hg. Robots are factory set detecting wafer presence using –20 in. Hg. vacuum. The switch will need to be reset if vacuum pressure is different at the installation site.. The switch is located in the lower arm link. The covers to the arm must be removed for sensor adjustment. The switch can be accessed by removing the screws and removing the arm cover.

The NZSE1-T1-14 vacuum switch has two potentiometers. The blue potentiometer is marked "SET" and controls setpoint adjustment. The yellow potentiometer is marked "HYS" and controls hysteresis. The total range of potentiometer adjustment is 3 revolutions. The NZSE2-T1-15C has only one potentiometer for setpoint adjustment.

A red LED located at the bottom of the switch indicates when the switch is activated. This corresponds to the I/O being activated. To adjust the vacuum sensor sensitivity:

1. Connect vacuum line to the robot and install end-effector
2. Open vacuum valve.
3. With no object on the end-effector, turn the potentiometer counterclockwise until the LED indicator turns on. Record this position as position A.
4. With an object on the end-effector, turn potentiometer clockwise until LED is turned OFF. Record this position as position B.
5. The final position will be position C, which is mid way between positions A and B.

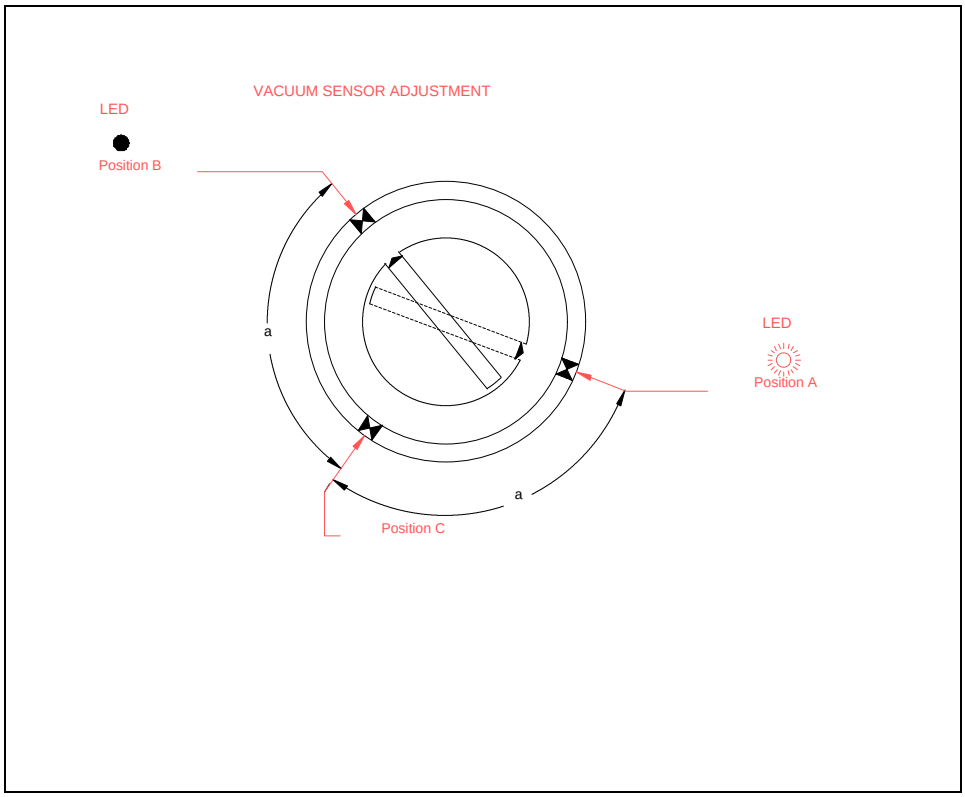


Figure 5.1 - Vacuum Sensor Adjustment

6. 386 COMPUTER

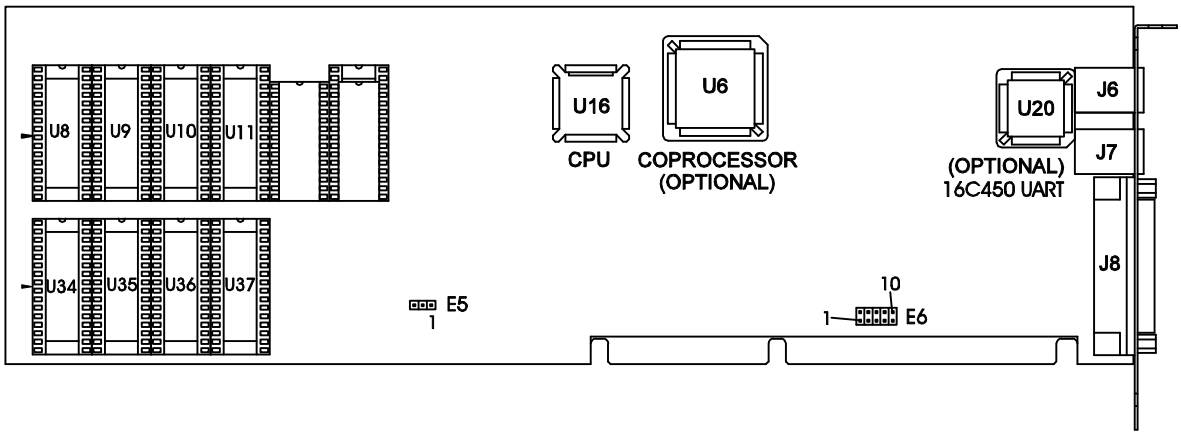


Figure 6.1 - CPU Component Side

The controller utilizes an IBM 386 compatible single board computer (SBC) to run the overall control software. Software is installed on the EPROM's that emulates a read-only floppy disk (Promdisk). Upon power-up the promdisk acts as a system disk and loads the control software.

A NVSRAM is set up as read/write floppy disk and stores data files such as parameters, station information, and macros. During initialization, the control software reads all three data files, checks for data integrity (by performing check-sum) and initializes its internal data based on these data files.

In case of an error, the NVSRAM status error is set and control software uses its default data. The user is urged to trouble-shoot the problem (use the STAT and RNCS commands). The default data set is used by the software so that it can maintain communication for further troubleshooting.

CAUTION:	**DO NOT use the default data set for normal operation.**

Jumpers are set to allow SBC to work with 27C512 EPROM and DS1230 NVSRAM (Dallas Semi) or bq4011YMA (Benchmark).

NOTE:	**Do Not modify the jumper set-up.**

6.1 CONNECTORS

Table 6.1 - Connector Configuration

Connector Designation	Connector Component	Connector Type
J2	Keyboard	D-sub 9-pin female
J3	COM2	D-sub 25-pin male
E2	COM2	10-pin header. Connected to J5 on the I/O control board.
E4	Computer hardware reset	2-pin header. Connected to J5 on the I/O control board.
E8	CMOS setup reset	2-pin header. Do not short! A short will reset the CMOS setup and you will need to run CMOS setup again. For the setup, you need to connect the keyboard and add a monitor card and monitor.

6.2 PROPER SETUP OF JUMPERS

Jumpers are used on E5, E6 and E7 to select memory type for promdisk.

Table 6.2 - E5 Jumper Arraignment

2	4	6	8	10	12	14	16
1	3	5	7	9	11	13	15

: Indicates jumper position

Table 6.3 - E6 and E7 Jumper Arraignment

2	4	6	8	10	12	14	16
1	3	5	7	9	11	13	15

: Indicates jumper position

6.3 PROMDISK

EPROM's, use sockets U1, U2, and U3. Control software requires three EPROM's that are labeled 1, 2, and 3. Insert the EPROM's labeled with 1, 2, and 3 into U1, U2, and U3 respectively. Make sure you use the proper software version, see the VER command in the owner's manual.

NVSRAM uses U5 socket. New NVSRAM chips must be formatted before using. To do this use FRMT 313 (see Section 15.4)

6.4 COPROCESSOR

A coprocessor is installed when a prealigner is installed. An Intel 8087-1 coprocessor is installed on U10.

6.5 CMOS SETUP

For the CMOS setup you must add a keyboard and monitor to the system! Refer to the MCSI Manual to set up CMOS. This is a factory procedure and is listed here for reference purposes only.

7. PRE-ALIGNER I/O CONTROL BOARD

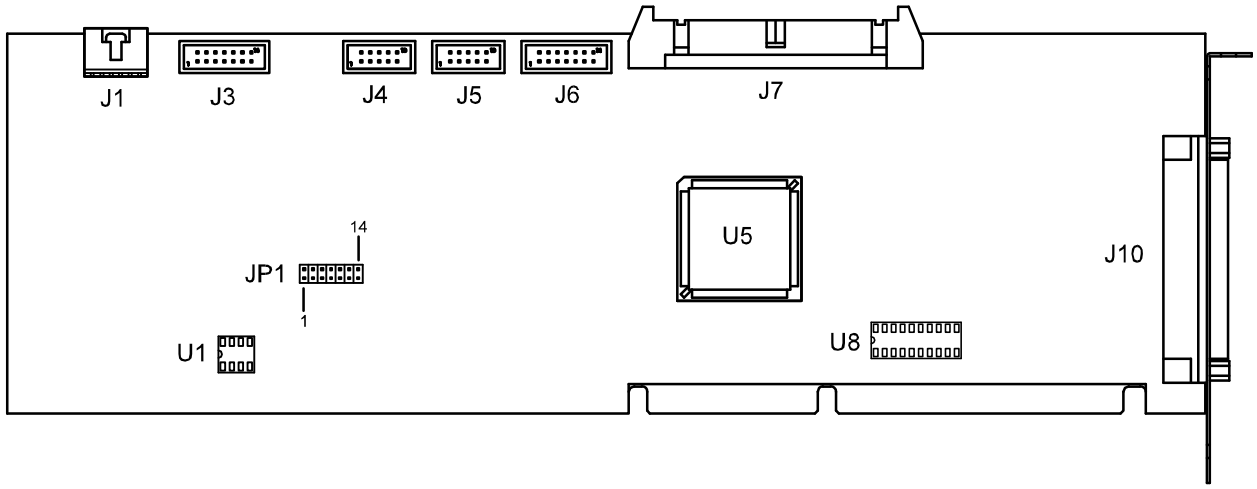


Figure 7.1 - Prealigner I/O Board Component Side

This board provides internal connection and control, external inputs, and external outputs.

7.1 BOARD SETUP

Table 7.1 - JP1 Configuration

2	4	6	8	10	12	14
1	3	5	7	9	11	13

: Indicates jumper position

Table 7.2 JP2 Configuration (all accept Pre-Aligner controller)

2	4	6	8	10
1	3	5	7	9

: Indicates jumper position

Table 7.3 - JP2 Configuration for Prealigner Controller Only

2	4	6	8	10
1	3	5	7	9

: Indicates jumper position

7.2 CONNECTOR DESCRIPTIONS

J1 Not used

J2 Amplifier board control - 14-pin header

Pin	Signal	Pin	Signal
1	Axis #1 motor signal + (out)[1]	2	Axis #1 motor signal - (out)[1]
3	Axis #2 motor signal + (out)[1]	4	Axis #2 motor signal - (out)[1]
5	Axis #3 motor signal + (out)[1]	6	Axis #3 motor signal - (out)[1]
7	Amplifier #1 enable (L) (out)[2]	8	Amplifier #2 enable (L) (out)[2]
9	Amplifier #3 enable (L) (out)[2]	10	+5 VDC
11	Amplifier under power (L) (in)[3]	12	GND
13	NC	14	NC

[1] Input for motor signal from Galil motion controller. Analog signal ranging from –10VDC to +10 VDC. Idle axis is 0 V.

[2] TTL open collector output. Low enable amplifier to work.

[3] Input from amplifier. Collector of phototransistor, emitter is connected to pin12.

J3 Galil output signal - 14-pin header

Pin	Signal	Pin	Signal
1	Axis #1 motor signal + (in)[1]	2	Axis #1 motor signal - (in)[1]
3	Axis #2 motor signal - (in)[1]	4	Axis #2 motor signal - (in)[1]
5	Axis #3 motor signal + (in)[1]	6	Axis #3 motor signal - (in)[1]
7	Signal cable connected (L) (out)[2]	8	NC
9	NC	10	NC
11	NC	12	NC
13	NC	14	NC

[1] Analog input for motor output from Galil motion controller board.

[2] TTL input for signal cable check, it is parallel connection to the Galil input 7 that is connected to the GND inside of the Robot.

J4 Power supply control - 10-pin header

Pin	Signal	Pin	Signal
1	GND	2	Enable motor P/S (L) (out)[1]
3	Enable 24 VDC P/S (L) (out)[1]	4	Fail of switches P/S (L) (in)[2]
5	24 VDC is On (L) (in)[2]	6	Motor P/S is On (L) (in)[2]
7	+5 VDC	8	NC
9	NC	10	NC

[1] TTL Open collector outputs.

[2] TTL input.

J5 Galil output signal - 14-pin header

Pin	Signal
1–10	COM2 IND88-4SBC
11–13	NC
14	Hardware reset of CPU

J6 Not used

J7 Teach terminal - 6-pin phone jack

Pin	Signal
1	GND
2	RX
3	TX
4	CTS
5	RTS
6	+12 VDC

It is COM2 with 12 VDC

J8 User I/O - Dsub 37-pin female

This board provides:

- Hardware Reset
- Stop
- Motor off
- External inputs
- External outputs

All inputs and outputs are optically isolated. Controller Signal GND is on pin 22, and +5 VDC is on pin 4. Inputs are set for 5 V operation. When higher voltages are required, external serial resistors are needed. The output can switch up to 50 VDC @ 200 ma.

Pin	Signal	Pin	Signal
1	NC	20	Res., stop, motor OFF power. in (5V)
2	Reset of Controller (active L)	21	Stop input (active L)
3	Motor of (active L)	22	GND internal
4	+5 VDC internal	23	NC
5	NC	24	NC
6	NC	25	NC
7	Input No. 7	26	Input #6
8	Input No. 5	27	Input #4
9	Input No. 3	28	Input #2
10	Input No. 1	29	Input #0
11	Inputs power input (5 VDC)	30	Output #7 return (negative)
12	Output #7 (positive)	31	Output #6 return
13	Output #6	32	Output #5 return
14	Output #5	33	Output #4 return
15	Output #4	34	Output #3 return
16	Output #3	35	Output #2 return
17	Output #2	36	Output #1 return
18	Output #1	37	Output #0 return
19	Output #0		

Pin 20 is external power 5 VDC for HARDWARE RESET, MOTOR OFF and STOP inputs. Pin 11 is external power 5 VDC for inputs. Do not use internal power from pins 4 and 22 i to supply the optical-isolators.

8. GALIL MOTION CONTROL BOARD

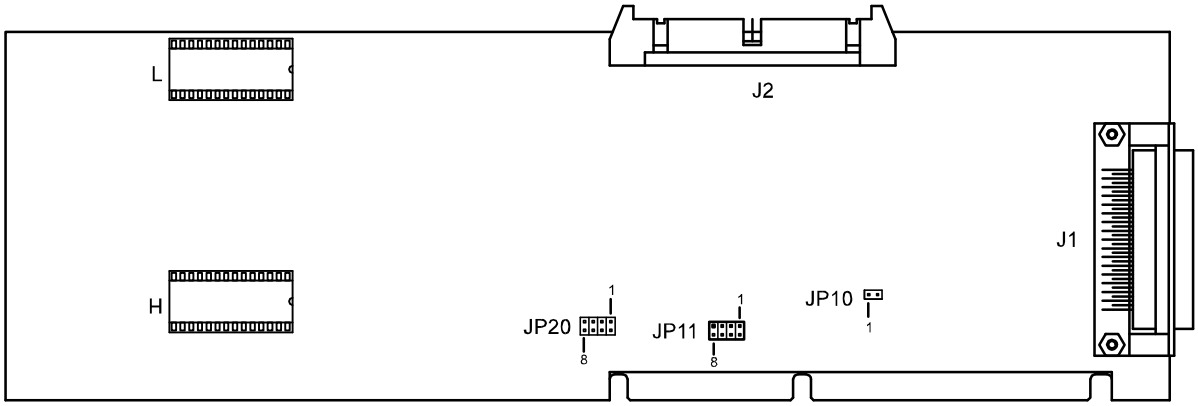


Figure 8.1 - Galil Component Side

The GALIL motion control board is a three-axis servo controller card. It uses encoder feed back, limit switch input, and commands from the XT computer to generate the amplifier control signal.

A red LED illuminates when a Servo Error occurs. A servo error occurs when the difference between the robot's current and commanded positions exceed the range set by the servo error constant. This constant is set by the ER command. For further details see Section 15.3.

8.1 BOARD SETUP

Table 8.1 - JP2

MOF	SM

: Indicates jumper position

Table 8.2 JP3 Address Setup

A2	A3	A4	A5	A6	A7	A8

: Indicates jumper position

JP4 Encoder - no jumpers used

JT No jumpers used

8.2 CONNECTORS

8.2.1 JAUX Motor output

Uses pins 1 through 14, which are connected by a flat cable to the I/O control board. Pins 15 and 16 are cut.

Pin	Signal	Pin	Signal
1	Motor out. Signal T (#1,X) axis[1]	2	GND
3	Motor out. Signal T (#2,Y) axis[1]	4	GND
5	Motor out. Signal T (#3,Z) axis[1]	6	GND
7	Galil in. 8 - Robot connected[2]	8	NC
9	NC	10	NC
11	NC	12	GND
13	NC	14	GND

[1] Motor output signal generates from 0 VDC (servo Off or axis in place) to ±10 VDC
(maximum output for position correction).

[2] Signal cable connected, line is connected to ground inside of Robot.

JD Not used

8.2.2 J10 Robot connector

Connects the Robot through the interface board.

Pin	Signal	Pin	Signal
1	GND	2	+5 V
3	Error output	4	NC
5	NC	6	NC
7	NC	8	GND
9	Z Encoder, index (Z)	10	Z Encoder, index – (Z)
11	Z Encoder, channel B (Z)	12	Z Encoder, channel B – (Z)
13	Z Encoder, channel A (Z)	14	Z Encoder, channel A – (Z)
15	R Encoder, index (Y)	16	R Encoder, index – (Y)
17	R Encoder, channel B (Y)	18	R Encoder, channel B – (Y)
19	R Encoder, channel A (Y)	20	R Encoder, channel A – (Y)
21	Z Switch, positive limit	22	Z Switch, negative limit (Z)
23	Z Switch, home (Z)	24	R Switch, positive limit (Y)
25	R Switch, positive limit	26	R Switch, home (Y)
27	NC	28	+5 V
29	T Encoder, index (X)	30	T Encoder, index – (X)
31	T Encoder, channel A (X)	32	T Encoder, channel B – (X)
33	T Encoder, channel B (X)	36	T Encoder, channel A – (X)
35	T Switch, positive limit	37	T Switch, negative limit (X)
37	T Switch, home (X)	38	GND
39	NC	40	Input F bit 7 (in 8)
41	Input F bit 8 (in 7)	42	Input F bit 5 (in 6)
43	Input F bit 6 (in 5)	44	Input F bit 3 (in 4)
45	Input F bit 4 (in 3)	46	Input F bit 1 (in 2)
47	Input F bit 2 (in 1) Vacuum Sen. #2	48	GND
49	Output A bit 7 (out 7)	50	Output A bit 6 (out 6)
51	Output A bit 5 (out 5)	52	Output A bit 4 (out 4)
53	Output A bit 3 (out 3)	54	Output A bit 2 (out 2)
55	Output A bit 1 (out 1) Vacuum Val. #2	56	Output A bit 0 (out 0) Vacuum
57	NC	58	NC
59	+5 V	60	GND

For all items with ( ), refert o the Galil manual

All inputs are active low.

8.3 GALIL INTERFACE

The GALIL interface provides interconnection between the Galil 60-pin header and the 50-pin D-sub for external cable.

Connector D50 - Robot Signal Connector

Table 8.3 - Galil Interface

Pin	Signal	Pin	Signal	Pin	Signal
1	Shield	18	+5 VDC	34	+5 VDC
2	+5 VDC	19	GND	35	GND
3	GND	20	GND	36	GND
4	Error	21	Z Encoder Index-	37	Z Encoder Index+
5	Z Encoder B+	22	Z Encoder A+	38	Z Encoder B-
6	Z Encoder A-	23	R Encoder Index-	39	R Encoder Index+
7	R Encoder B+	24	R Encoder A+	40	R Encoder B-
8	R Encoder A-	25	Z Switch Limit Neg.	41	Z Switch Limit Pos.
9	Z switch Home	26	R Switch Limit Neg.	42	R Switch Limit Pos.
10	R Switch Home	27	T Encoder Index-	43	T Encoder Index+
11	T Encoder B+	28	T Encoder A+	44	T Encoder B-
12	T Encoder A-	29	T Switch Limit Neg.	45	T Switch Limit Pos.
13	T Switch Home	30	NC	46	Arm Out #1
14	NC	31	Arm in #2	47	NC
15	Arm In #1	32	Vacuum Sensor #1	48	Vacuum Sensor #2
16	Arm Out #3	33	Robot Connected	49	Arm Out #2
17	Vacuum Valve #2			50	Vacuum Valve #1

All inputs are active low.

9. AMPLIFIER BOARD

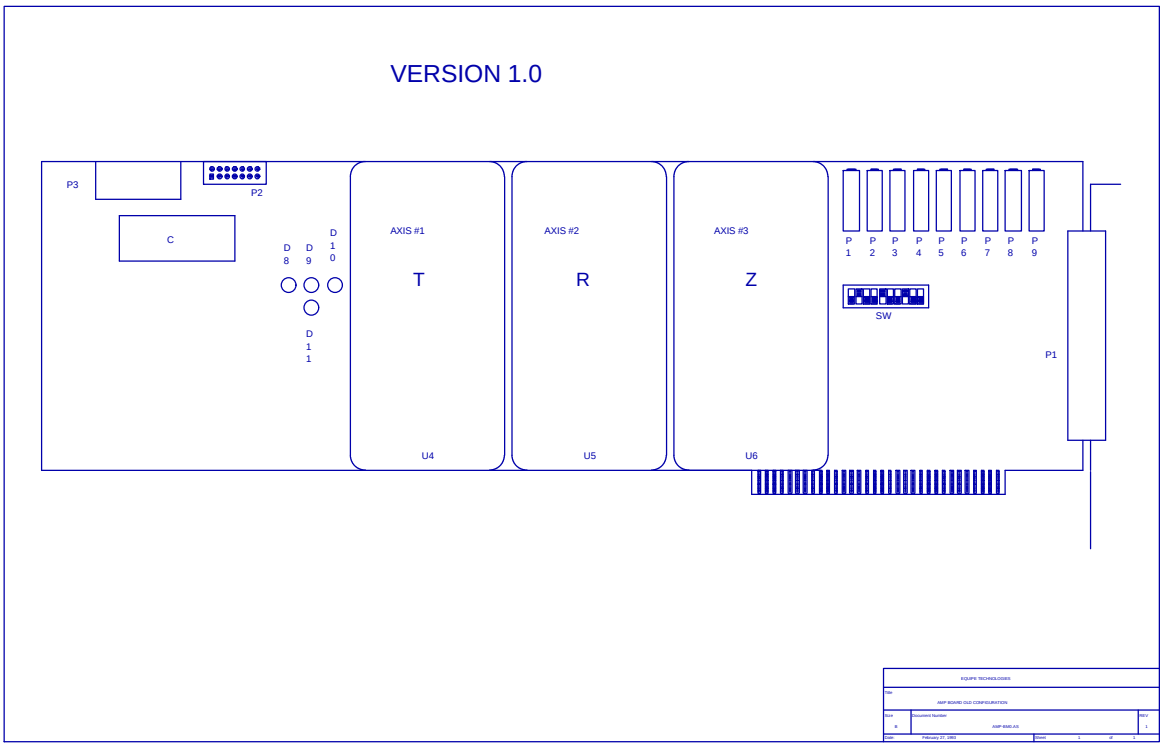


Figure 9.1 - Amplifier Board Component-Side (V. 2.0)

The amplifier board has up to three PWM amplifiers working at 36 Khz. For systems with robot and prealigner, the controller has two amplifiers boards:

- U4 for T (or #1) axis
- U5 for R (Radial or #2) axis
- U6 for Z (vertical #3) axis

The board has no electrical connection to the AT-bus passive backplane in the controller, but the bus connector mechanically holds the board in place. The amplifier board needs the enable signal to work. Upon power up, the board is disabled until it receives this signal.

9.1 LED SIGNALIZATION

- D11 Board is under power when OFF (green)
- D8 T (#1) axis is disabled when ON (red)
- D9 R (#2) axis is disabled when ON (red)
- D10 Z (#3) axis is disabled when ON (red)

9.2 CONNECTORS

9.2.1 P3 Power Input –

Supplies power to the amplifier and Robot.

Pin	Signal
1	NC
2	GND
3	Power for amplifier (35 VDC)
4	+24 VDC for use in Robot
5	GND for 24 VDC

9.2.2 P2 Signal Input

Input for motor signal and control signals from I/O Control board. All control signals are opto-isolated on the board.

Pin	Signal	Pin	Signal
1	Motor signal + T (#1) (in)[1]	2	Motor signal –T (#1) (in)[1]
3	Motor signal + R (#2) (in)[1]	4	Motor signal –R (#2) (in)[1]
5	Motor signal + Z (#3) (in)[1]	6	Motor signal –Z (#3) (in)[1]
7	Enable T (#1) axis (in)[2]	8	Enable R (#2) axis (in)[2]
9	Enable Z (#3) axis (in)[2]	10	+5 VDC input
11	Error positive (out)[3]	12	Error negative (out) [3]
13	NC	14	NC

[1] Analog input (±10 VDC) is driven by Galil motion controller.

[2] TTL input optically-isolated on board. Low enables the amplifier.

[3] Output pins 11 and 12 are shorted by photo-transistor if the board has power.

9.2.3 P1 Output to the Robot

Output drives motors and supplies 24 VDC to the robot. Note: Pin 1 is not marked correctly on the board. Check pin 1 on the connector for the correct call out.

Pin	Signal	Measure[1]
1	+24 VDC	+24 VDC
2	GND	0 VDC
3	Negative motor Z (#3) axis	from +15 to +20 VDC
4	Positive motor Z (#3) axis	from +15 to +20 VDC
5	Negative motor R (#2) axis	from +15 to +20 VDC
6	Positive motor R (#2) axis	from +15 to +20 VDC
7	Negative motor T (#1) axis	from +15 to +20 VDC
8	Positive motor T (#1) axis	from +15 to +20 VDC

[1] Measure between the pin and body of the connector after sending the RES instruction followed by SVON A.

9.2.4 AT AT bus

This connector has no connection to the board at all. This is used only for holding the board in place.

9.3 AMPLIFIER BOARD SETUP

1. Power OFF the controller and disconnect power and signal cables to the robot.
2. Remove the amplifier board from the controller and make sure the setup on the SW switch selector corresponds to the following table.

Table 9.1 - Software Switch Settings

On										
Off										
Switch position	1	2	3	4	5	6	7	8	9	10

: Indicates jumper position

3. Remove the amplifier modules from the board and insert the amplifier board back into the controller. Make connections P2 and P3.
4. Connect the signal cable to the robot and power up the controller.

NOTE:	**Skip steps 5 -through 7 if you use the teach pendant diagnostics.**

5. Check that all four LEDs (D8, D9, D10 and D11) on the board are ON. It takes a couple of seconds after power-up.
6. Send instruction OUTP B,1 to enable the amplifier board. The D8, D9 and D10 LEDs should switch OFF. If they do not, check the connection of the signal cable and internal flat cables in the controller.
7. Activate direct communications with the servo control board by sending the GALIL command. The prompt (**>**) changes to (**:**).
8. Disable on error function (send the OE 0,0,0 command).
9. Switch on the servo on all axes by sending the SH command.
10. Move all axes by hand in the negative direction.
11. Send the TT command and the controller should respond with 2047,2047,2047. If you receive a different number, move the robot some more and try the TT command again.
12. Correct the setup of gain and balance for the amplifier board by using Table 9.2.

NOTE:	**Turning the potentiometer clockwise increases the voltage. Potentiometers P3, P6, and P9 have no influence on the board setup. On the most recent amplifier boards, this setup is fixed and the switch is eliminated.**

Table 9.2 - Setup Table for Amplifier Board 2-02-0003 (ATM Series Robot)

Axis (position)	Gain measure on pin 6*	Balance measure on pin 4*
T (U4)	set 4.0V by pot. P1	set 0.0V by pot. P2
R (U5)	set 4.0V by pot. P4	set 0.0V by pot. P5
Z (U6)	set 7.0V by pot. P7	set 0.0V by pot. P8

* Use the ground lead from the big capacitor (C22) on the amplifier board.

9.4 AMPLIFIER MODULE SETUP

NOTE:	**Skip steps 6, 10, 14 and 15 if you use the teach pendant diagnostics.**

1. Switch OFF the controller and insert the amplifier into position U4 for the T ( ) axis.
2. Insert the board back into the controller and make connections P2 and P3.
3. Connect the X-axis amplifier, the set-up tools to the signal and power connectors, and set the ammeter to the 10-amp range.
4. Switch on the Controller.
5. Check that the amplifier board LEDs are ON. If not, check the cable connections.
6. Send the OUTP B,1 command. The D8, D9, and D10 LEDs should go OFF. If not, check the cable connections.
7. Activate the Galil mode by sending the GALIL command. The prompt "**>**" changes to "**:**".
8. Lower the torque limit by typing *TL 300,300,300*.
9. Disable "servo-off on following error" function by typing *OE 0,0,0*.
10. Switch the servo ON by sending the SH command.
11. Turn the motor shaft and you will feel the counter force of the motor. The motor should be trying to stay in the position it was at the time of sending the SH command.
12. Set the amplifier gain by using the potentiometer on the amplifier (on the side closest to pin no. 8). Clockwise rotation increases the gain. Use the motor current Table 9.3 to set up line TL1024,1024,1024.
13. Move motor half a rotation and check current from Table 9.3 for TL 300,300,300 line and make current correction.

14. Type *TL 1024,1024,1024* and make the setup according to Table 9.3. Check for left and right rotation and select the median.
15. Type *TL 2047,2047,2047* to check the maximum current from the amplifier.

Table 9.3 - Motor Current Table for 10A8 (P/N 2-06-0010)

Torque limit set	Galil max. outp	Motor current	Note
TL 300,300,300	± 1.5 V DC	±.4 ».8 Amp	Just for checking
TL 1024,1024,1024	± 5.0 V DC	± 2.5 Amp	Use for set-up of amp
TL 2047,2024,2047	± 10.0 V DC	± 5.0 Amp	Just for checking (±15%)

10. POWER SUPPLY MODULE

This power supply consists of two separate power supplies. The switching power supply is for the AT–bus +5, –5, +12 and –12 VDC. The linear power supply is for the amplifiers (36 VDC) and 24 VDC for the robot.

NOTE:	**Make sure to select the proper voltage on the power entry module. It is accessible from the back panel.**

The power supply for the motor output is controlled from the I/O Control board.

10.1 CONNECTORS

10.1.1 10-pin header

Connects power supply control signal to I/O control board.

Pin	Signal	Pin	Signal
1	Connect to GND	2	Motor power relay neg.
3	NC	4	Switch power sup. fail
5	Connect to GND	6	GND (input)
7	Motor power relay pos.	8	NC
9	NC	10	NC

10.1.2 5-pin terminal

Connects power to amplifier board

Pin	Power Line
1	NC
2	GND for motor
3	+35 VDC for motor
4	+24 VDC for Robot
5	GND for Robot