A255 Robot Service Manual

UMS-14-504

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Revision	Revision History	Date
001	Original Issue	10-94
002	Chapter 4: Corrections	12-94
003	Chapter 3: DIP Switch, C&A Boards	02-95
004	Chapter 4: Hiroshi Connectors	05-95
005	Chapter 6: Metalon Grease	11-95
006	Chapter 7: Mechanical Drawings	11-95
007	Chapter 5: Troubleshooting	07-95
008	Conversion to MS Word, Updates Chapter 3: Electronics Description Chapter 5: Diagnostics and Troubleshooting Chapter 6: Service Repair Checks Chapter 8: Mechanical Drawings	09-96
008a	Updates, pages numbered sequentially Chapter 1: Safety and Operation Checks, Safety Checks for Working ithin the Robots Workspace Chapter 3: Front Panel Display Board Connectors, T265 Track Connectors, Encoder Connector Board, Power Supply Connectors, Power Filter Board Connectors Chapter 5: Serial Teach Pendant Problems, AC Power Problems Chapter 6: Soft Start Board Check, Zero Cross Relay Check Chapter 7: Calibration, Fan Filters, A265 Track Maintenance	03-97
009	Pages numbered by chapter	03-97
010	Chapter 1: Service tools required. Chapter 2: Positional Gain, Home Command, Homing Errors. Chapter 3: A255 Controller Electronics, Auxiliary Board Connectors, Controller AC Power System, Linear Amplifier Module. Chapter 4: Teach Pendant Connector,GPIO Connector,Motor Power Connector, Arm Signal Schematic. Chapter 5: Finger Position Feedback Continuity Test, Air Gripper Problems. Chapter 6: RE 1.6 Check External E-Stop Wiring, Controller Board Servo Loop Signal Checks, removed Clean or Replace Air Filters. Chapter 7: Mechanical Maintenance Schedule, Establish Communication With the Robot, Cleaning. Removed: Inspect, Clean and Redistribute Grease in the Harmonic Drive, Wrist Centering, and Centering of the Stator Relative to the Shaft. Chapter 8:Mechanical Drawings.	01-01

Table 1-1 Revision History

Preface

This manual contains specifications, drawings, and service procedures for the CRS Robotics A255 robot system. It is not an installation manual, but is intended to be used as a guide for maintaining, servicing, and troubleshooting your A255 robot system. This service manual is not a self-teaching vehicle. It is intended for use only by personnel who have completed the CRS Robotics training course. Please refer to the following CRS literature for information on installation and programming.

- RAPL-II Programming Manual
- A255 Robot System User Guide
- Robcomm-II for Windows
- Robcomm-II for DOS

The specifications contained herein are subject to change. This manual is periodically reviewed and revised to accurately reflect and incorporate improvements and engineering changes made on the equipment covered in the manual. CRS Robotics is not responsible for errors or omissions that may appear in the drawings or specifications of this manual.

Training courses are offered at our facility in Burlington, Ontario or can be conducted at your facility. For additional information contact the Customer Support Group.

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How to Use This Service Manual

Use the table of contents as your main navigational aid for finding topics in this manual. Included with the table of contents is a list of figures and tables. Each chapter is divided into sections according to numbering levels.

The chapters are divided into the following sections:

Preface — **Reference Information**
Revision History, the User, Related Documentation; and a Table of Contents

Chapter 1 — **Introduction**
Arm Nomenclature, Safety Summary, Serial Number, and Tools Required

Chapter 2 — **Controller Operation**
Start-Up Logic, Watchdog Circuitry, Interactive Communication, Servo Motor Logic, Homing Procedure, and Software Diagnostics

Chapter 3 — **Electronics Description**
Electronic Components, Connector Details, and Relevant Schematics for all Circuit Boards.

Chapter 4 — **Arm and External Controller Connectors**
System Connectors, Details of Arm Wiring, and Tracing Information

Chapter 5 — **Diagnostics and Troubleshooting**
Diagnostic Procedures Grouped by Possible Problem Areas

Chapter 6 — **Service Repair Checks**
Service Checks and Electrical Repair Procedures

Chapter 7 — **Mechanical Checks and Adjustments**
Mechanical Service and Repair Procedures for all User-Serviceable Components.

Chapter 8 — **Mechanical Drawings**
Component Drawings for the A255 Robot Arm.

Before attempting to follow a procedure or example, read the entire section first.

Throughout this service manual, warnings are marked by an "!" icon in the left margin. Failure to comply with these warnings can result in injury to persons, damage to the robot, tooling, or work pieces, loss in memory, or errors in the system.

Contents

4 Wiring and Connectors

5 Diagnostics and Troubleshooting

6 Service Repair Checks

7 Mechanical Checks and Adjustments

8 Mechanical System Drawings

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CHAPTER 1

1 Introduction

1-1 Robot Arm Schematic

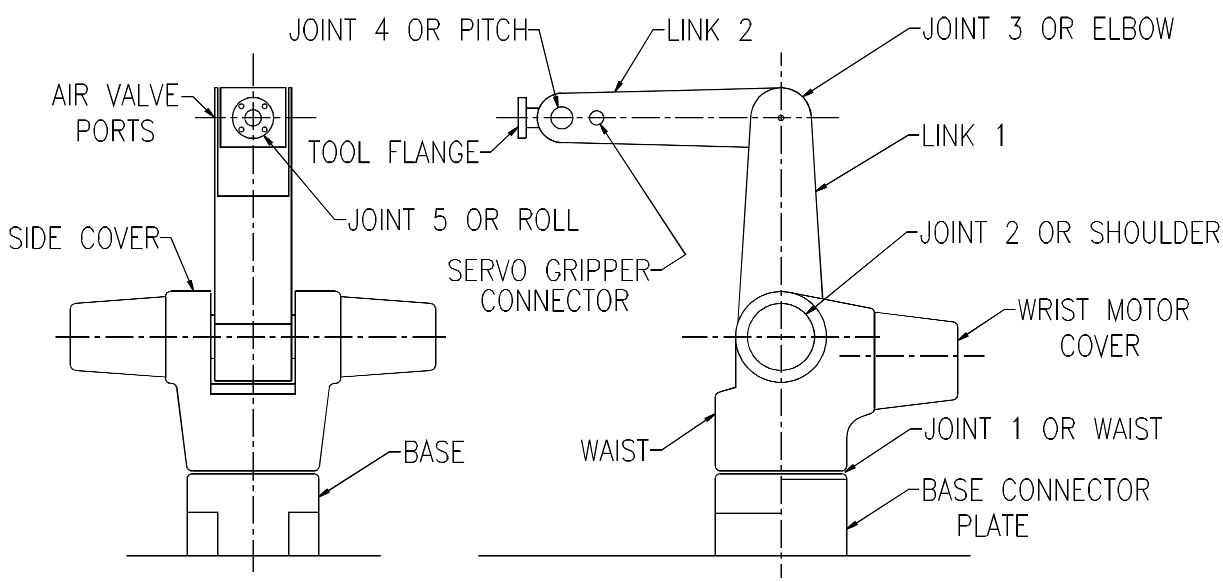


Figure 1-1 Profile of the robot in the "READY" position viewed from the front and the side

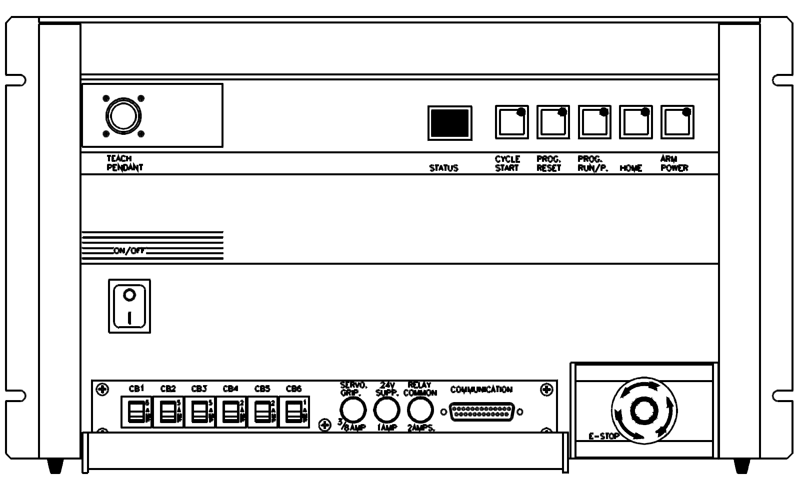


Figure 1-2 C500 Controller

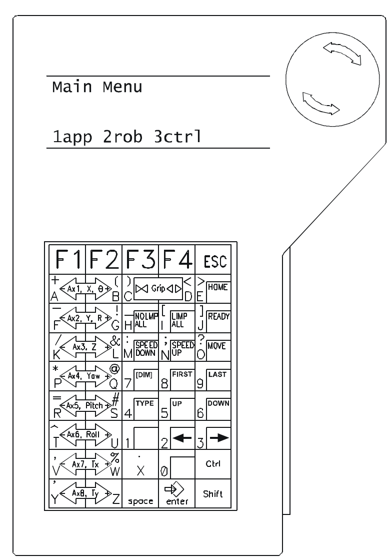


Figure 1-3 Serial Teach Pendant

1-2 Safety Summary

Failure to comply with the following precautions may result in serious injury to personnel and/or damage to CRS Robotics equipment.

The following information should be mandatory reading for all personnel who enter the area within reach of the robot arm.

This service manual is not a self-teaching vehicle. It is intended for use only by personnel who have completed the CRS Robotics training course.

1-2-1 General Safety Rules

Follow these safety rules to ensure proper operation of the robot arm:

1. Always turn off all electrical and pneumatic supply to the system before replacing components or making service adjustments unless you are specifically instructed to do otherwise. In such cases be aware that the robot under servo power is capable of unexpected motions. Maintain a safe space around the arm at all times.
2. Always maintain unobstructed air flow to the controller cooling fan ports. Overheating may cause malfunction.
3. Always remove power to the arm and controller before connecting or disconnecting cables.
4. Enclose the robot work area within a safety barrier to prevent accidental injury.
5. Before entering into the robot’s workspace, visually inspect the robot to determine if any conditions exist that can cause malfunctions and injury to persons.
6. If the teach pendant controls are used, test them to ensure that they are functioning correctly. If any damage or malfunctions is found, complete the required repairs before allowing personnel to enter the robot workspace.
7. When performing repairs on the robot arm, ensure that you have total control of the robot or robot system.
    - Ensure that the robot is off-line; the arm is not stopped in a RAPL program, or running a RAPL program.
    - Ensure that the robot does not respond to any remote signals.
    - Ensure that all safeguards and e-stops are functional.
8. Ensure that the suspended safeguards are returned to their original effectiveness prior to initiating robot operation.

1-2-2 Safety and Operation Checks

Ensure that you have followed all the instructions supplied within this manual.

BEFORE applying power to the arm, verify that:

- ☐ The robot is properly installed, mounted, and is stable, (refer to *A255 Robot System User Guide* for details).
- ☐ The electrical connections are correct and that the power supplies (voltage, frequency and interference levels) are within the specified ranges, (refer to *A255 Robot System User Guide* for details).
- ☐ If you have modified your system, added hardware, software, or serviced your robot, recheck all the changes or additions.
- ☐ User memory is intact. Errors should not appear in your programs, location, or variable files.
- ☐ Safeguards are in place.
- ☐ The physical environment (humidity, atmospheric conditions, and temperature) is as specified, (refer to *A255 Robot System User Guide* for details).

AFTER applying arm power, verify that:

- ☐ The start, stop, and function keys on the teach pendant and controller front panel function as intended.
- ☐ E-stops, safety stops, safeguards, and interlocks are functional.
- ☐ At reduced speed the robot operates properly and has the ability to handle the workpiece.
- ☐ Under normal operation, the robot functions properly and has the capability to perform its intended task at the rated speed and load.

1-2-3 Safety Checks For Working Within the Robot's Workspace

Before entering within the robot's workspace perform the following checks and safety precautions.

- ☐ Visually inspect the robot to determine if any conditions exist that can cause malfunctions or injury to persons.
- ☐ If the teach pendant controls are used, test them to ensure that they function correctly. If any damage or malfunction is found in the teach pendant, complete the required repairs before allowing personnel to enter within the robot workspace.
- ☐ While programming or teaching locations, the robot system must be under the sole control of the programmer.
  - When possible, program the robot with all personnel outside the safeguarded area.
  - When programming the robot and teaching locations within the safeguarded area, ensure that robot motion is reduced to at least 25% speed.
- ☐ While servicing the robot arm, the robot system must be under the sole control of the service person.
  - Ensure that the robot is off-line. The arm must not be stopped in, or running, a program.
  - Ensure that the robot does not respond to any remote signals.
  - Ensure that all safeguards and e-stops are functional.
  - Always remove power to the arm and controller before connecting or disconnecting cables.
  - Ensure that suspended safeguards are returned to their original effectiveness prior to initiating robot operation.
- ☐ When power to the robot arm is not required, it should be turned off.

1-3 Serial Number Location

When calling CRS or your local CRS representative, have your robot and controller serial numbers ready for reference.

The CRS Robotics serial number plates are shown in the figures below.

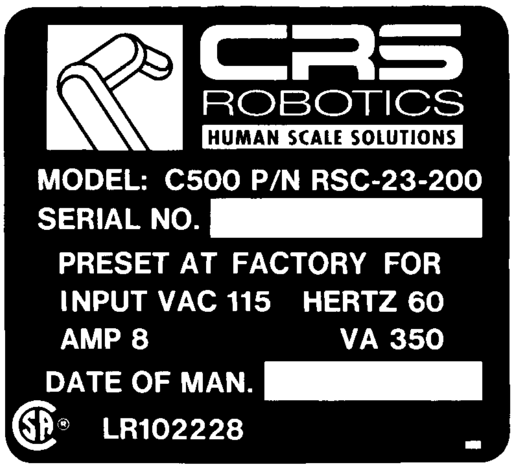


Figure 1-4 Controller Serial Number Plate

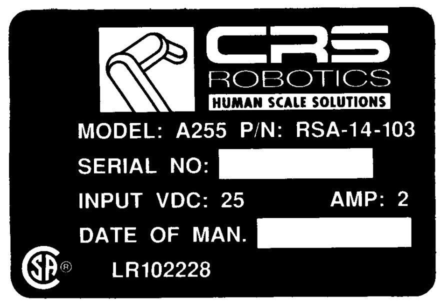


Figure 1-5 Arm Serial Number Plate

The arm serial number plate is located at the rear of the base, adjacent to the electrical and pneumatic connections.

The controller serial number plate is located on the back panel, at the bottom center.

1-4 Service Tools Required

Pliers

- Needle-nose pliers
- Diagonal cutting pliers
- Line-man pliers
- Slip-joint pliers
- 6" Vice grip pliers

Electronic equipment

- Anti-static grounding wrist strap
- Digital multi-meter with 10 Amp current capacity with probes and clips
- Trim-pot adjuster
- Fine adjustable wire stripper
- Soldering iron
- "AMP Service Tool II" or other field crimping tool
- AMP pin extractors, #91067-2, #305183-R

Wrenches

- 6" adjustable
- All SAE allen (hex) keys 0.05" to $^{5}/_{16}$" - ball type end
- Tee-handled allen keys - $^{3}/_{32}$, $^{7}/_{64}$, $^{5}/_{32}$, $^{3}/_{16}$
- 0.035" allen key (for encoder adjustment)
- Metric $^{1}/_{4}$ socket set from 3 mm to 14 mm

Screw-drivers

- #0, 1, 2 Phillips
- Small to large slot
- #0, 1, Robertson (square socket)

CHAPTER 2

2 Controller Operation

2-1 Introduction

Most service procedures for the A255 system require the use of a computer connected to the controller front panel serial communications port. Operate the PC in interactive, immediate mode using a terminal emulator (see sections 2-7 and 2-10).

2-2 Power-Up Sequence

The A255 Robot runs on RAPL-II (Robot Automation Programming Language) multi-tasking operating software, programmed into the C500 controller unit. RAPL-II goes through an initialization sequence whenever the controller main power is turned on and whenever the robot computer or transputer is reset (see Figure 2-1 Initialization Sequence and Figure 2-2 Initialization Sequence (Continued). RAPL-II will also re-initialize automatically when a "brown-out" or short duration power outage occurs.

If an AUTOEXEC program exists (v2.40 or later) and has been specified to run, its instructions execute before communication to the operator is established (see @@SETUP command in the RAPL-II Programming Manual). Table 2-1 lists the system's serial default values.

There are two types of power-up:

1. **Normal Start** is used for normal operation of the robot. Normally, either the serial teach pendant (STP) or the override plug must be connected at the controller's front panel in order to power up the arm.

To power up the robot:

- Switch the main power switch to the ON position. The power turns on and the display reads "A1." During the normal power-up sequence, one or more of the status lights on the panel buttons may flash, depending on resident programs.
  - Upon power-up, RAPL-II's default communication is to the STP, but communication can be changed over to a separate terminal or computer connected at the controller's front panel serial communication port.

To change communication to a computer running terminal emulation software (e.g. Robcomm):

- Select F2 (comm) at the STP Terminal screen.

To change communication over to the controller's front panel:

- Choose F1 (PANL) at the STP Terminal screen.

To change communication back to the STP:

- Press the STP's Shift+Esc keys.

2. **Diagnostic Start** is used for servicing and testing the robot system. This start-up requires a diagnostic jig (part number SEC-23-520) to be plugged into the controller back panel SYSIO connector before the ON/OFF button is pressed.

   When powered-up, the front panel display reads "D1." Control of the robot in diagnostic mode is from the front panel communication port at 38400 baud. A diagnostic start initiates if the controller does not contain RAPL firmware.

Tip: If there is a detectable boot-up error during a normal start, the controller display reads "D1." If this occurs, try turning the power off and on again.

Any power-up sequence resets the robot's arm position arrays to unknown values so that re-homing is necessary before normal operation can resume (see Homing Procedure, section 2-14).

2-3 Default Power-up Parameters

Unless otherwise specified in an AUTOEXEC program (see @@SETUP command in the RAPL-II Programming Manual), the A255 power-up routine automatically sets the various system parameters to default values. Table 2-1 lists these default settings.

Parameter	RAPL-II Version 2.40	
	STP	Comport
Baud Rate	19,200	38,400
Parity	None	None
Data Bits	8	8
Stop Bits	1	1
Xon/Xoff	Yes	No
RTS/CTS	No	No
Echo	No	No
Device After Power Up	Active	(ACI mode)
Device After Diagnostic Start	Not Active	Active
ACI Mode	No	Yes

Table 2-1 Serial Default Values

2-4 Initialization Logic Sequence

The Controller “display” characters (“D1” etc.) indicate the states the system enters at various points in the initialization sequence.

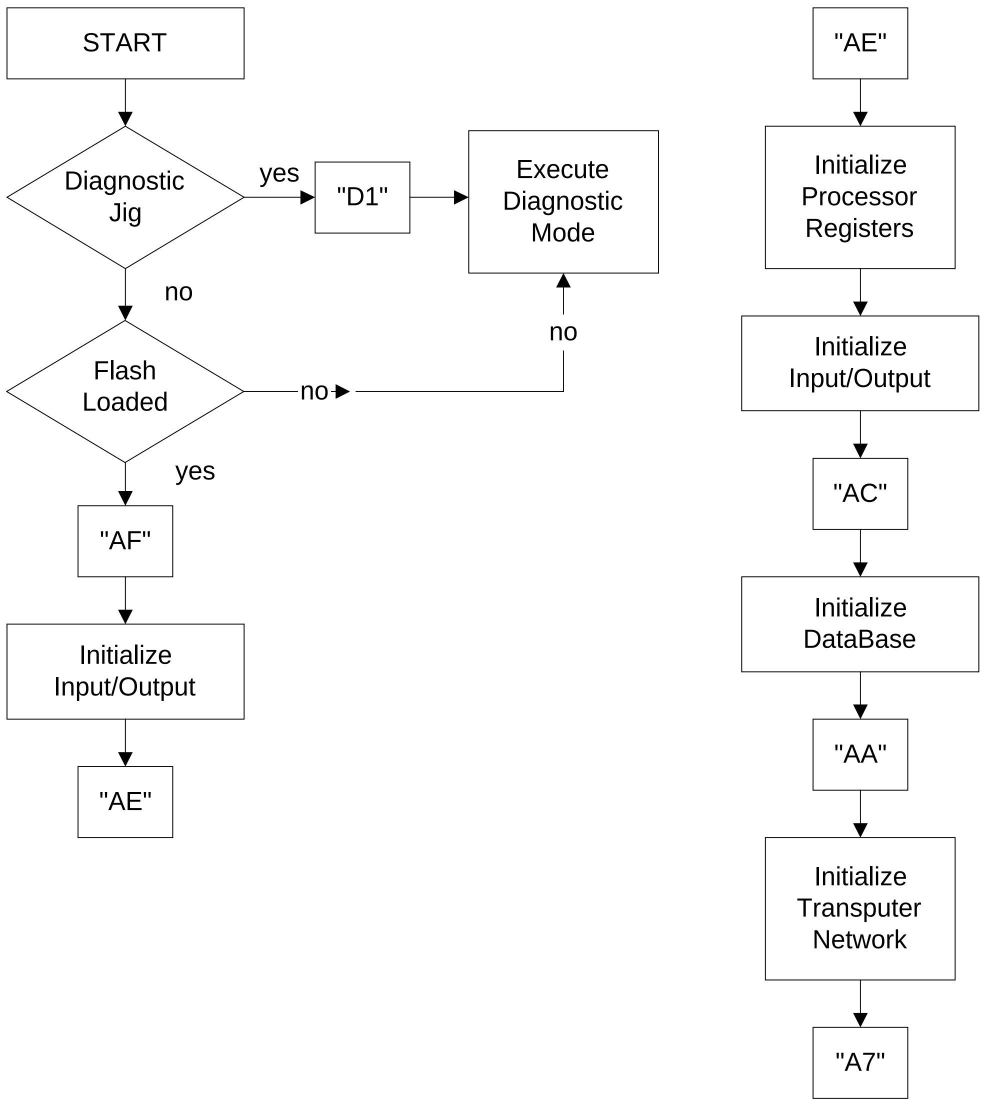


Figure 2-1 Initialization Sequence

2-4 Initialization Logic Sequence (Continued)

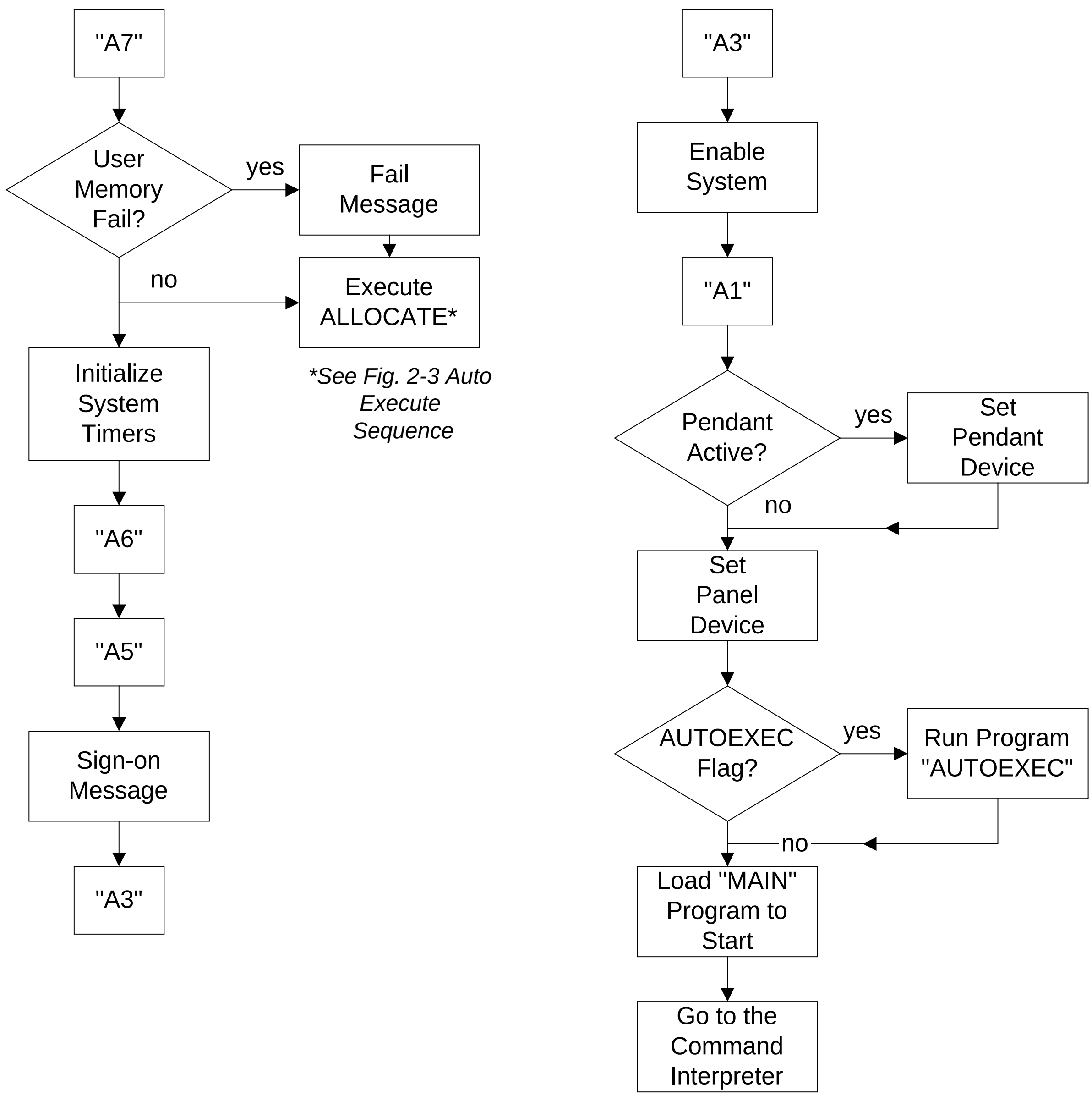


Figure 2-2 Initialization Sequence (Continued)

2-5 User Memory Allocation

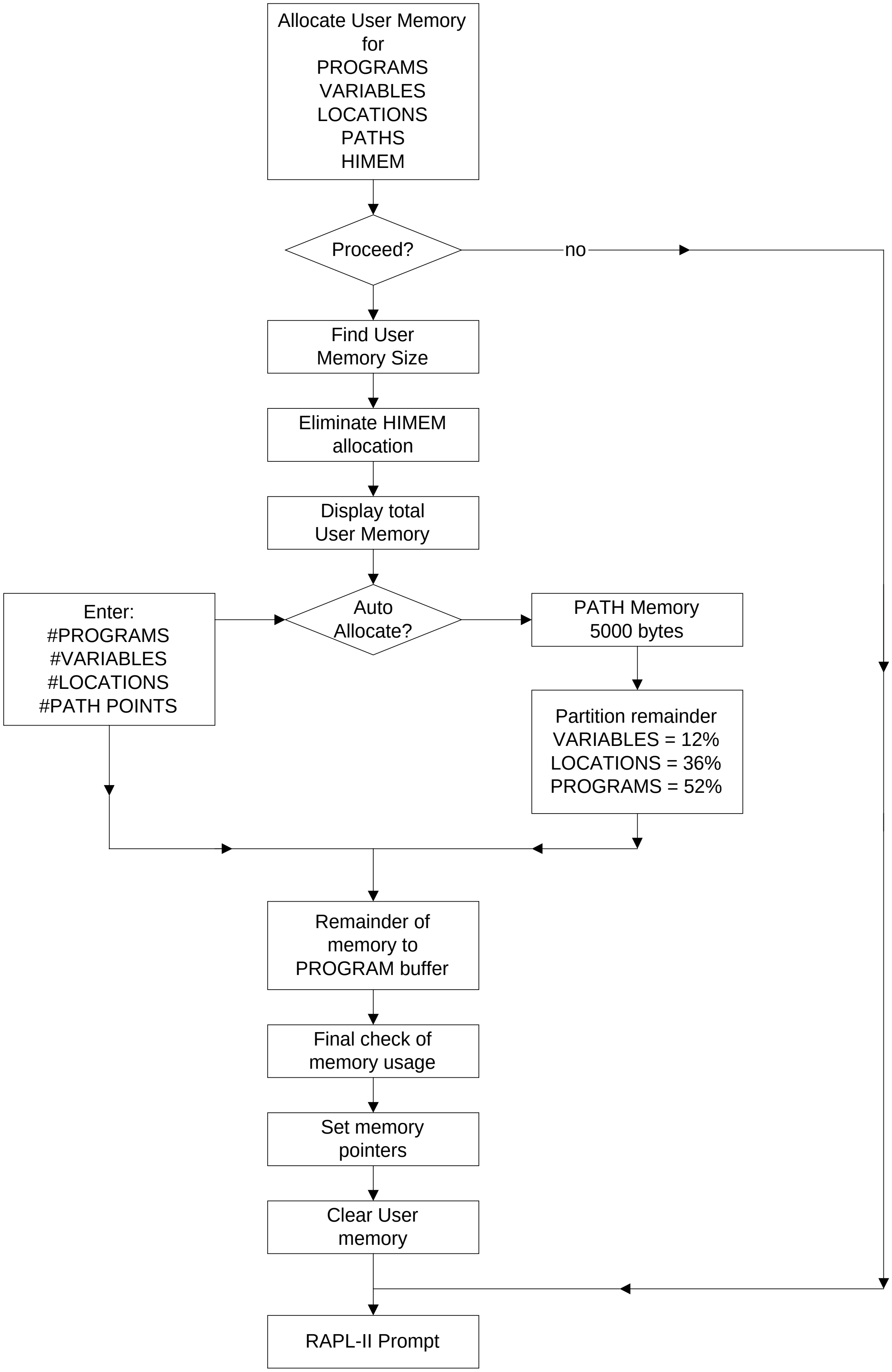


Figure 2-3 Auto Execute Sequence

2-6 Command Processing Loop

Once the controller is initialized it uses command processing logic to decide where the next command will come from. Note that the operational mode of the controller is maintained.

- If a computer using Robcomm is connected to the controller, then the system expects its next command to come from the computer keyboard in interactive mode.
- If the controller has been initialized by pressing the Reset+Run buttons on the front panel, then the system expects to take commands from the AUTOEXEC program and a front panel LED begins flashing.
- If manual mode is selected, it displays with the appropriate prompt.

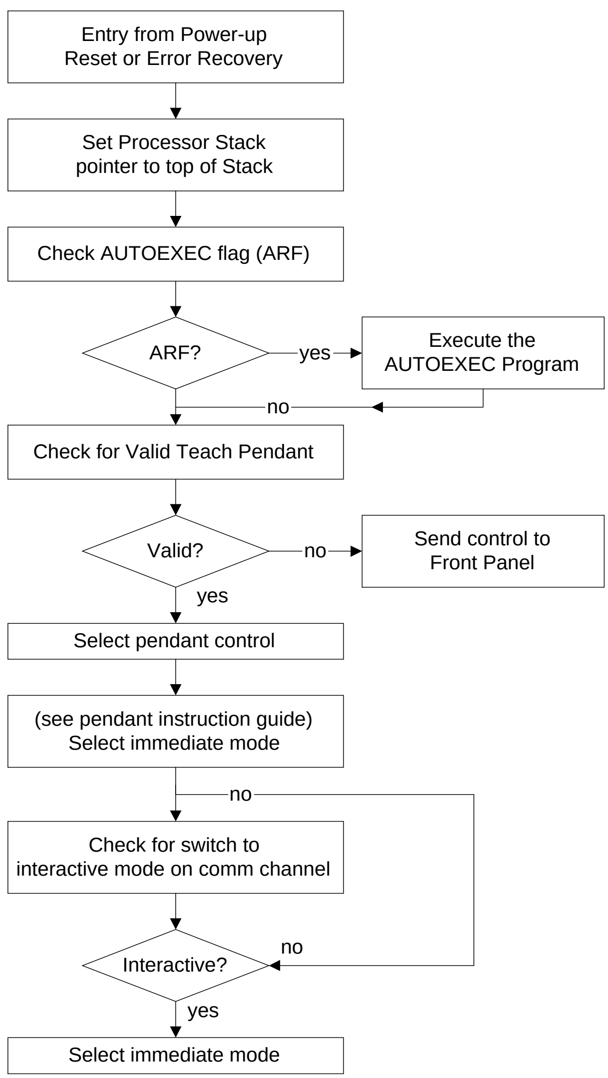


Figure 2-4 Command Processing Loop

2-7 Immediate Mode

Most service procedures for the A255 system are performed in immediate mode from an "interactive" PC computer connected to the controller front panel serial communications port. To terminate from the STP (Serial Teach Pendant) to interactive communication at power-up, choose F2 (comm) at the STP Terminal screen control (see Requirements for Interactive Communication section 2-10). The interactive computer displays the double prompt ">>" when it is the default input device operating in immediate mode.

In the immediate mode sequence, the controller expects to receive a command from the default input device, which is scanned for incoming data. As data is received it is interpreted and the command executes. If the command cannot execute, an error message displays. Immediate mode finishes by returning the program back to the command processing loop.

If the input device's display properly echoes command characters, and the operation does not proceed as expected; a software flag or error may be preventing the action. Consult the *Teach Pendant* user guide.

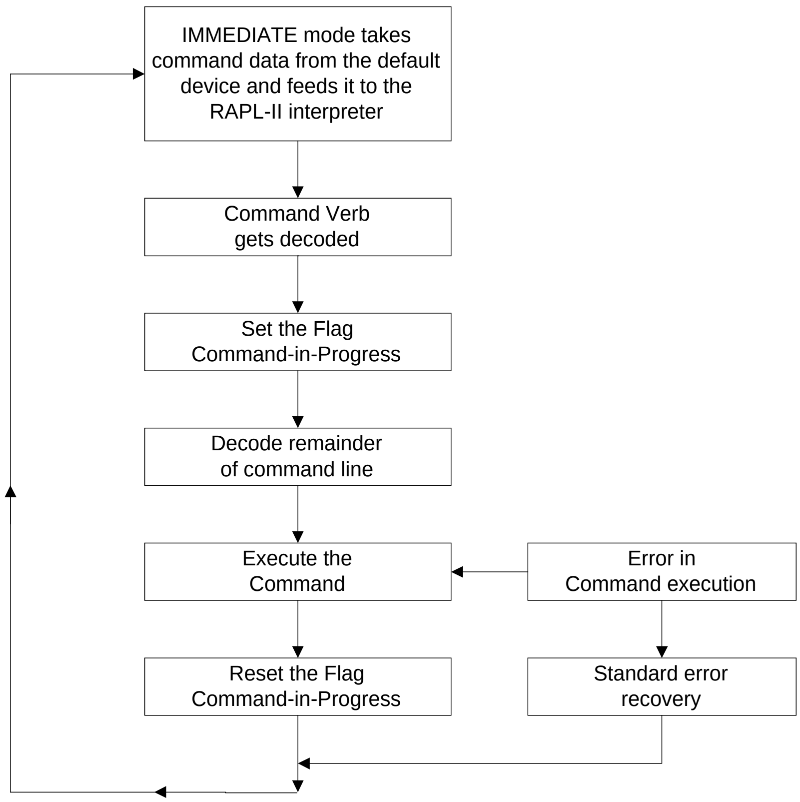


Figure 2-5 Immediate Mode

2-8 Auto Execute Sequence

The auto execute sequence permits the controller to operate in a stand-alone mode, with minimal need for user interaction at power-up. This feature simplifies normal production operation of the robot system. Auto execute mode is configured by a software setting in the @@SETUP command (see the RAPL-II Programming Manual).

2-9 Requirements for Arm Power

Robot arm power has the highest priority of all normal controller operations. If the arm power signals fail, the controller cannot maintain control of the robot motors. As a safeguard, arm power requires a continuous "watchdog" signal from the processor to the arm power circuitry.

Each time the robot is powered up, the circuitry in the auxiliary board monitors the watchdog signal. Its source is a 80286 processor in the controller board. The signal resembles a TTL level square wave with a frequency of 500 Hz. This signal feeds to the servo control transputer. Its software mirrors the signal which feeds through the main encoder feedback gate array devices. The watchdog signal then feeds from the controller board to the auxiliary board.

On the auxiliary board, the watchdog signal feeds to a monostable device which generates an enable signal when the watchdog frequency is present. If the watchdog signal disappears, the circuit changes state within 10 msec and deactivates the arm power circuit, thereby reducing the chance of damage to the robot and its surroundings.

Note: Software commands such as HALT ON, prevent arm motion even though arm power is not disabled.

Tip: If initialization settings are omitted for any robot axis, the watchdog enables the omitted axis, however, the system software prevents the axis from accepting commands.

For example, if your A255 robot is mounted on a track, the track remains limp until the track parameter is correctly set (see @@SETUP command in the RAPL-II Programming Manual).

2-9-1 Arm Power Checks

In the A255 robot system, any signal that permits arm power to be turned on must pass through the following logical "checks" before power can be applied see (Figure 2-1 Initialization Logic Sequence).

1. The controller computer system must be operational. The controller board sends a watchdog square wave which is monitored by circuitry on the auxiliary board. If the signal disappears, then the arm power shuts off. A display of “A1” on the front panel indicates normal status.
2. The front panel e-stop push button contacts must be closed (red mushroom button pulled out).
3. The teach pendant e-stop circuitry must be closed (red mushroom button pulled out), or an override plug installed in place of the teach pendant. The teach pendant circuitry can be bypassed with the four position dip switch on the auxiliary board. The same switch enables the system input/output (SYSIO) e-stop circuitry.
4. The circuit breakers (on the controller front panel) must not be tripped.
5. The fuses for the linear amplifier power supply, and the PWM Amp power supply, must have continuity.
6. If the SYSIO is used, a dip switch should be open, this causes the signal to pass through the remote front panel connector (see the C500 Operation Manual, “Installing a Custom E-Stop”). Ensure that the e-stop (arm power off) switch on the installed remote panel is closed.

Note: Step 7 only applies to the A255 robots with Track axes.

7. Each of the PWM amplifiers sends a complimentary signal called “norm 1,2,3” when arm power is enabled. If this signal is missing, the PWM Amps will not enable. The signal may be missing because either the power supply, or the Amp signal cables are missing, or the PWM fuse is blow.
8. The RAPL-II command DISABLE ARM stops the watchdog signal. The ENABLE ARM command resumes it.

2-10 Requirements for Interactive Communication

You can program the robot system's RAPL-II software through interactive communication with the A255 controller. There are two ways of interactive communication. You can use either a "dumb" terminal, or preferably, a PC computer using terminal emulation software (e.g. Robcomm-II). For communication parameters, see section 2-3 Default Power-up Parameters.

Terminal emulation requires the connection of the "dumb" terminal or an external computer to the robot controller at the DB25 serial communication port on the controller front panel (behind the flip-down door). See “Installing a Serial Device”, in the C500 Installation Manual.

Upon power-up, the Serial Teach Pendant (STP), if connected, becomes the active device by default.

To terminate STP communication to the interactive device:

- Choose F2 (comm) from the STP Terminal screen.
- Start Robcomm and choose Terminal Mode
- Press Ctrl+C when the terminal screen appears
- Press Enter to obtain the double prompt ">>,". This indicates interactive mode.

2-10-1 Interactive I/O

All interactive serial I/O(s) use standard ASCII characters.
RAPL-II, the robot system language, accepts only upper-case characters for commands, however, you can use lower-case characters in messages, comments, etc.

Tip: For optimum screen display set the interactive computer for full Duplex operation; do not use Auto-Line-Feed.

Certain control codes have special meaning to RAPL-II and are handled differently than standard alphabetic characters. These codes are listed in Appendix C of the RAPL-II Manual.

Important Codes

<Ctrl-C> and <Ctrl-X> which, when received, cause an immediate halt of arm motion and program execution, and result in causing communication to reset.

Characters received by the controller's I/O device pass through a "ring-buffer”. When a character is received at the default device, an interrupt issues to the processor. This causes the processor to temporarily halt lower priority activities and place the character in the buffer. This buffer consists of 139 bytes of memory.

The buffer has the following structure:

```
SIZE, IPTR, OPTR, BYTE0, BYTE1, BYTE2, .., BYTE136.
```

The first byte (SIZE) tells RAPL-II the size of the buffer. IPTR (inpointer) is a byte value that points to the last character received into the buffer. This number increments by a count of one each time a character is received. If this number goes to the value of SIZE and another character is received, it "wraps around" to 0 again (hence the Ring-buffer designation).

OPTR (outpointer) is a byte value that points to the last character processed by RAPL-II. When RAPL-II has handled all pending higher-priority tasks, it looks at the respective values of IPTR and OPTR, and if they are different, it interprets the character at the OPTR position and increments OPTR by one. As long as there is a difference between the two pointers, the process of character interpretation continues. The special control codes mentioned above are not interpreted in this fashion, but process immediately.

Note: If RTS/CTS is enabled, be sure that the system hardware does not prevent the controller from completing the power-up sequence.

If RTS/CTS is enabled with a two wire system, the controller will not boot up until the RTS/CTS has been disabled.

If RTS/CTS is enabled with a three wire cable, the controller will not boot up unless the external device is powered up.

2-11 Host Interface Communication (ACI Operation)

Upon power-up, communication between the robot controller and a host (interactive) computer is in Advanced Communications Interface (ACI) mode. The ACI mode transmits software data across the communications link, for example, when loading a program. To ensure the reliability of data transmission, ACI uses error checking and signal retry protocol. In the event of a transmission error during data communication, ACI retries the transmission for a specified number of times. If the error occurs more than the legal number of retries for that error, ACI terminates the transmission and sends an error signal to each end of the link.

2-11-1 Communication Errors Reported at the Host End

At the host computer, the reporting of an error is dependent upon the host software. If you are using the Robcomm-II software package with a PC, error messages read as shown in Table 2-2. For consistency, any host software package written for ACI use, should use these same error codes.

Error	Source
04	An enquiry sequence was ignored 32 times. *The host computer output may not be connected to the correct port of the controller.*
12	A header was tried 4 times with no success
16	A header was responded to with neither an ACK nor a NAK. *The baud rate is probably too high for reliable communication, due to processor load or environment. Lower the baud rate and retry.*
20	A data block read was attempted from the slave 4 times, with an LRC failure all times.
22	A data block write was attempted to the slave 4 times, with a NAK returning all times.
24	Invalid response to a data block write to the slave: neither an ACK nor a NAK returned. *The baud rate may be too high for reliable communication, due to processor load or environment. Lower the baud rate and retry.*
27	Invalid EOT response from the slave.
28	Invalid STX read in a data block read from the slave.
32	Invalid ETB read in a data block read from the slave.
34	Invalid ETX read in a data block read from the slave.
40	Time-out on receiving a character. *Either the baud rate does not match, the wiring is incorrect, the slave requested is not on the receiving end, or the requested slave does not have its ACI enabled. Check each possibility.*
50	Time-out on transmitting a character
61	Bad baud rate selection

Table 2-2 ACI Communication Error Source Codes (Robcomm-II End)

Tip: For a repeated ACI error, lower the communication baud rate for both ends of the communication link. Use the baud rates specified in Table 2-1 Serial Default Values.

2-11-2 Communication Errors Reported at the Controller End

At the controller end of the data communication link, error messages are interpreted in the RAPL-II system language. For the purpose of debugging the communication, display such errors at the host computer by issuing the @@RS status display command. This command displays the number of retries, communication failures, and successful cycles. Error numbers read as shown in Table 2-3. Do not mistake these errors for RAPL-II robot operation error codes, or RAPL-II parser error codes.

Error	Source
1	ENQ sequence retry error - not used
2	No SOH to lead off the header
3	Bad buffer index in header sequence - serious software failure!
4	Retry failure - Header
5	No ETX or ETB read to end data read sequence
6	LRC check failure in data transfer
7	LRC failure in header
8	Data block transfer retry failure
9	Time-out on receiving a character
10	Bad character read instead of STX in data block read
11	Retry failure - data block write
12	Bad character (other than ACK or NAK) read in data write acknowledge
13	Time-out on transmission of character - will turn off ACI
14	Bad target ID match in header
15	Bad target ID match in Enquiry
16	Bad character was received, other than the final EOT
17	Bad read of ETX character at end of header block
18	Time-out on receipt of header SOH character
19	Time-out on receipt of header ETX character
20	Time-out on receipt of data block STX character
21	Time-out on receipt of data block ETB/ETX character
22	Time-out on receipt of data block ACK/NAK character
23	Time-out on receipt of final EOT
24	Master sent premature EOT
25	Software error in ENQ sequence
26	Bad special read code
27	Bad special write code
28	Bad special code of some kind

Table 2-3 ACI Communication Error Source Codes (RAPL-II End)

2-12 Digital I/O Operation

The I/O Enable line is a signal path from the controller board to the auxiliary board. During normal operation, the controller board issues a Watchdog signal to relay circuitry on the auxiliary board.

The I/O Enable signal does not begin until the robot computer completes its start-up initialization routine. This prevents random I/O changes from occurring before the robot system and the user programs are operating properly. For example, if RAPL-II fails to boot properly because a transputer poke test failed, then the I/O line does not enable until this fault is corrected.

When the controller power is turned off, all output signals go low. All outputs re-enable only when the robot controller is powered up normally. After power has been restored, the outputs remain in the off state until commanded otherwise with the OUTPUT command.

Any equipment using a digital output as a trigger should be designed to stop safely in the off state. If, for instance, a pneumatic press or cylinder is controlled from the robot I/O, the cylinder should stroke to the safe end of travel when the power is turned off.

Lock all outputs in the software by issuing the DISABLE OUTPUT command. This prevents their states from changing when an OUTPUT command issues. The intent of this command is to permit testing of software without operating external machinery. Use the ENABLE OUTPUT command to unlock outputs.

An external 24 Volt regulated power supply is recommended for most applications. You may use the internal 24 Volt supply of the opto-isolators if the 1 Amp rating is sufficient. This is accommodated on the 50 pin connector on the rear panel of the controller (pins 1 and 2 POS and 49 and 50 NEG).

Refer to the “Arm Power Problems” section in the C500 Operation Manual:

- If the I/O subsystem introduces noise, or any other disturbance on the 24 Volt line. This may cause a controller crash with possible undetermined results.
- If a robot installation shows excessive signs of controller failure, the I/O subsystem may be at fault.

Note: Use the relay contacts for handling AC power up to 120 VAC, 0.6 Amps. Ensure that the outputs are individually fused with 0.5 Amp fast blow fuses.

2-13 Servo Operation

The servo system operates as illustrated and described below.

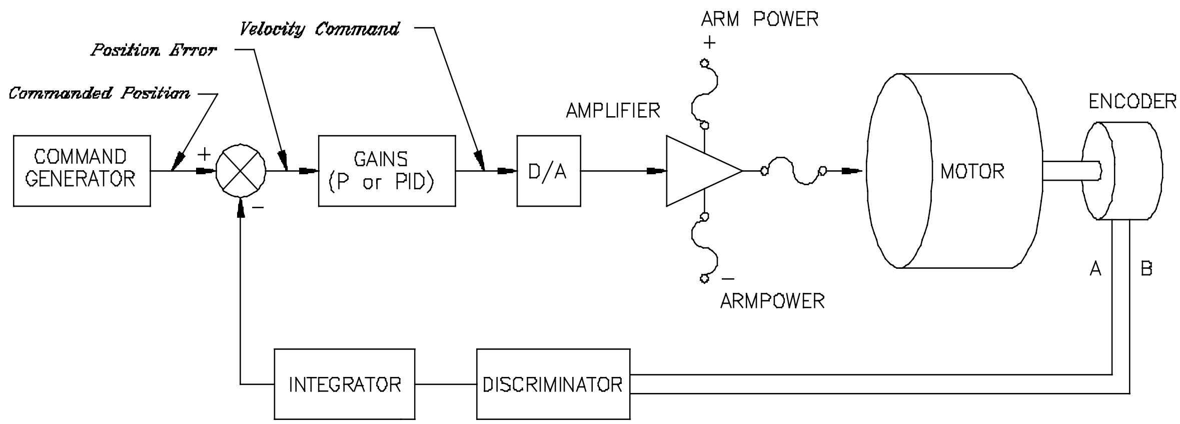


Figure 2-6 Servo Block Diagram

2-13-1 COMMAND INTERPRETER

The COMMAND INTERPRETER (not represented in the drawing) is a software process that interprets RAPL-II commands issued from the interactive device or the stored program. It determines the position profile for each robot axis of motion.

To determine the position profile for each robot axis of motion:

1. Determine the final destination point of the motion command.
2. Calculate end point joint angles from the Cartesian representation of the final destination. This is called the "world-to-joint" transformation.
3. Determine the motor pulse positions for the end point destination. From this end point information, determine which motor must travel the furthest.
4. Determine the time required for the move, based on the programmed speed, the acceleration limits, and the distance to be traveled for the motor with the furthest to go.
5. From the time required for the move, determine speed and position profiles for all other axes so that each motor starts and finishes at the same time.

2-13-2 COMMAND GENERATOR

The COMMAND GENERATOR is the first functional block of the servo. It is a software process that issues the position instruction to each servo (one for each axis) on a time basis. The time of each position update varies depending upon the mode of operation, but typical intervals range from 10 to 30 msec. For A255 robots, the servo loop is always updated at 1 msec intervals.

Command generation time periods are subject to change in all RAPL-II versions. For diagnostic purposes, it is sufficient to ascertain that a command generation cycle is operating. The timer pulses relating to command generation can be found on chip U-11 (an 82C59 programmable interrupt controller), and pin #18. To observe this signal, use an oscilloscope with a time scale of 5 msec. per division, and a voltage scale of 1 Volt per division. This pulse should be operating at a stable period at all times. The pulse refers to the action of requesting and acknowledging a time-based interrupt. When the signal goes to logic high, it indicates that the timer (8254) is requesting an interrupt. When the signal goes low, it is an indication that the software has acknowledged the interrupt and the timer has been restarted.

Tip: If the timer pulse signal is always low, a timer chip (U12, 82C54) failure may have occurred.

If the signal remains high, the software has not acknowledged the interrupt. The cause of this problem is not apparent, but it is most likely due to a software failure.

2-13-3 POSITION COMMAND

For each time increment of the command generation loop, a new position is issued to each motor. The new positional value is called the position command. This is the position the computer "wishes" the motor to go to when the command is given. It is up to the servo to ensure that the motor arrives at that position.

2-13-4 POSITION ERROR

After a position command is given, it is compared to the actual position of the motor as determined by the encoder and the feedback side of the servo. The difference between the commanded and the actual position is called the position error, hence:

POSITION ERROR = POSITION COMMAND - ACTUAL POSITION

2-13-5 POSITIONAL GAIN

The positional error feeds into the servo through a gain stage. It is here that the digital computer determines the value of the command which passes to the motor. The output of this stage is called the command signal.

The A255 controller uses a PID control gain with a proportional gain of 12, an Integral gain of 0.05, and a differential gain of 100. The PID calculates the command signal as in the following example:

The proportional term is constant:

5 pulses x 12 (gain) x 10 Volts/2047 pulses = 0.29 Volts

But the integral term changes with time. At the first instant:

5 pulses x 0.05 (gain) x 10 Volts/2047 pulses = 0.0012 Volts

At the second instant:

0.0012 + (5 pulses x 0.05 (gain) x 10 Volts/2047 pulses) = 0.0024 Volts

At the third instant:

0.0024 + (5 pulses x 0.05 (gain) x 10 Volts/2047 pulses) = 0.0036 Volts

The integral term keeps adding voltage as long as there is a static error. This is why a static error eventually command a full voltage output unless the error is removed. When the robot is performing a function that requires a slight collision or binding, the integral action can become quite severe.

Tip: When testing the D/A (digital to analog) output, full output can generate by a relatively small error if the motor is unable to move to correct it. This makes setting the maximum output level quite simple.

2-13-6 Command Signal

The command signal is the output from the digital computer to the D/A converter on the controller board, where it becomes the input for the "velocity loop" of the servo. Its function is to control the speed of the motor.

2-13-7 D/A Converter

The D/A Converter (digital to analog) is part of the circuitry on the controller board's servo axis circuit. Its function is to convert the digital signal from the computer to an analog voltage.

The relationship between the digital and analog values is controlled by two trim-pots on the controller board next to the 60 pin box headers. The gain trim pots are located in a row nearest the header. Axis one is R29. The nominal output value of this device is -10.0 VDC to +10.0 VDC.

- Change the output peak value by adjusting the GAIN potentiometer.
- Setting a lower value for the maximum DC voltage output degrades the performance of the arm.

Test

To properly test maximum output of the servo axis circuit:

1. Disconnect the arm from the controller.
2. Unplug the circuit breaker monitor cable (J11 & J12 on the auxiliary board).
3. Disconnect the Vcom output from the Controller, refer to Table 6-11 Chip Pins.
4. Issue a command for the motor in question to move 50 pulses. The PID loop issues full voltage for the motor.
5. Set the gain to the desired setting using the trim pot.

Warning! Do not omit to reconnect the circuit breaker monitor cable after the above adjustment is completed.

You can adjust the D/A Converter OFFSET so that a digital value of "zero" at the input can be set to generate a non-zero output. This affects the servo balance which in turn affects LIMP performance and positioning accuracy in a static condition. The adjustment is set at the factory so that each servo is balanced between digital and analog "zero".

2-13-8 Power Amplifier

Output from the D/A is routed to the power amplifier where the signal is amplified to the level required to drive the motor. The maximum amplifier input signal is 10 VDC. The maximum voltage gain is approximately 2.8 for all axes. Each amplifier channel is adjusted to reflect the optimum combination of gain and stability.

2-13-9 Motor

The robot uses DC servo motors which respond to the incoming electrical energy as follows: speed is proportional to voltage and torque is proportional to current.

2-13-10 Encoder

The A255 encoders are incremental optical kit-type units mounted directly on the motor shafts. The encoders use optical quality plastic disks with 1000 lines per revolution for positional feedback. Each disk has one reference marker pulse per revolution which is aligned during the homing procedure.

Encoder disks are mounted on each motor shaft. As a disk rotates with the shaft, its grating of etched lines passes a fixed grating of the same resolution. This permits light from an LED to alternatively pass and not-pass through the two gratings to a photocell which converts the light into a voltage. This signal is wave-shaped into a square wave whose frequency is directly related to the motion of the shaft. The encoders use two stators which are out of phase by 90 degrees and are used to determine the direction of rotation. The disk and stator signals are labeled channels A and B. A schematic of the optical encoder operation is shown in Figure 2-7.

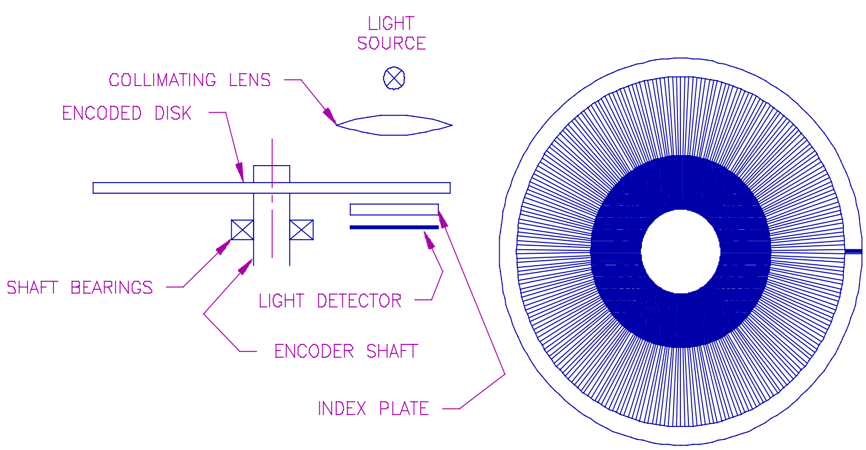


Figure 2-7 Optical Encoder Schematic

2-13-11 Discriminator/ Hardware Counter

Signals from the encoder pass through the wiring to the axis circuitry. The single ended encoder signals are terminated and translated to TTL levels, and are fed into the gate array devices which discriminate the quadrature signals. There, a logical discriminator circuit interprets the two channels and, from phase information, determines the direction of motion. The outputs from this circuit is a fast 12-bit up-down counter register accessed by the servo control transputer chip.

Tip: Use a scope to view the TTL quadrature signals on test points at JP25 for each axis. Pin 1 to 8 is channel A1 to channel A8, pin 9 to 16 is channel B1 to B8, and pin 17 to 24 is channel Z1 to Z8. See Figure 3.1 Controller Board.

2-13-12 Integrator

The integrator is a software counter that reads the value in the hardware counter on the axis circuit each time the position loop closes. The hardware counter rolls over whenever the value exceeds the12 bit limit or counts down from 0. The integrator reads the new value and subtracts the value read last time to determine the incremental count. This strategy means that as long as the hardware counter does not change by more than ½ of its value between reads, the count will always be correct.

2-13-13 Actual Position

The actual position of the robot axes is determined by the encoder count value.

2-13-14 Example of Servo Operation

The following are examples of Servo-Operations:

1. When a robot operator enters a command in RAPL-II, the command interpreter determines the position versus time profile for each motor controlled by the system.
2. The command generator issues these commands on a time base. If the command is in the joint-interpolated mode, this time increment (called a tick, as in tick of the clock) is 0.001 second.
3. When robot motion begins, the commanded position changes with each time interval (tick). The command interpreter assures that the motion does not exceed a set acceleration limit. The default acceleration value is a .2 pulse-per-tick change per .001 seconds. In other words, if the motor is commanded to move at a rate of 20 pulses in one tick, at the next tick the servo cannot demand a change of more than 20.2 pulses. Since a pulse cannot be partial, this means that an additional pulse cannot be added until 5 ticks later.

   Note: The "pulses per tick" is a unit of velocity, and hence "pulses per tick per tick" is a unit of acceleration.

4. Consider the case of a motor whose current commanded position is 18000 pulses, and in the next interval a 20 pulses change in position is demanded. If the current position is actually 17981 pulses, there is an error of 19 pulses. This error value passes through the gain stage and becomes a velocity command of approximately 190 pulses per tick (assuming a proportional gain of 10). The D/A converts this to a voltage of approximately 0.928 VDC. The amplifier increases the voltage to 6.50 VDC (Gain of 7) and sends this to the motor. The motor moves in response and by the next time the integrator reads the encoder count, it sees 18000 pulses.

5. However, by this time, the new commanded position issues for 18020 pulses, a change of 20. As a result, a position error of 20 passes through to the motor as a voltage of 6.84 VDC which causes the motor to move faster than before so that, next time, the integrator sees 20 pulses change. However by then, the new command changes so the motor continues to move.

6. Conversely to the above case of a simple motion condition, assume the commanded position stays the same, but the arm is deformed by an external load. The encoder then reads the change from the actual position and the positional error builds up. The result is the same: the motor receives a voltage which tries to restore the actual position to equal the commanded position.

2-14 Homing Procedure

The homing procedure positions the robot so that the encoder disks on all the motors are aligned to their zero pulse positions. This home position then enables accurate self-referencing of the robot's movements.

Whenever the robot's main power switch is turned off and on again, or whenever the robot's computer is reset, the robot controller does not know the current position of the robot arm. In order to perform a previously programmed motion, the controller must know the actual locations of all the arm joints. Positioning the arm so that the controller knows the joint locations is known as homing the arm. There are a number of concepts involved in homing which are explained in the following terminology.

2-14-1 Home Command

With the homing command, you can home the robot system, without having to precisely position the A255 robot arm manually. Versions of RAPL-II (the robot system software) from 2.38 and up use the simple "HOME" command. The following table lists the commands.

Command for V2.38 and Up	Function
HOME	Home the arm
HOMESEQ	Home an axis
HOMEZC	Home-Seek zero cross (axis)
@@CAL	Calibrate the arm
@@CALSEQ	Calibrate an axis
@@CALZC	Calibrate-Seek zero cross (axis)

Table 2-4 RAPL-II Software HOME and CALIBRATION Commands

The procedure to home the robot is called the "Home sequence command". Similarly, the calibration procedure which uses the arm's proximity switches is called the "Calibration sequence command" (This applies only to the A465 robot arm).

2-14-2 Zero Position

The zero position is a specific arm pose which is used as a starting point for calculating joint angle measurements for all Cartesian locations. In this pose, all arm axes positions register zero. This pose is also called the CALRDY position because the @CALRDY command can be used to move the arm to that position.

The Zero Position is initially set at the factory and involves manually moving the arm so that it is positioned at certain measurements and then setting the joint position registers to zero while at that pose. This is called the Calibration Procedure, or calibration from scratch, and is described in detail in section 5 of the RAPL-II manual under the @@CAL command.

2-14-3 Zero-Cross Pulse

The zero-cross pulse is a signal sent out from each encoder once every rotation. It provides a reference point to determine the precise encoder shaft angle. The signal is read by the axis position registers. The Zero-Cross Pulse is also known as an Index Pulse and Marker Pulse.

2-14-4 Calibration Position

To recover the arm position after power off, the arm must be re-aligned to the controller software's mathematical representation of its position. This is done at a specific arm pose called the Calibration Position. The Calibration Position is represented as being at the end of one full encoder rotation of each joint, called the Home Range. The Home Range is determined by the encoder Marker Pulse within the range of the home alignment strip on the robot arm.

2-14-5 Calibration Array

The Calibration Position is factory installed in the controller memory as a series of numbers called the Calibration Numbers or Calibration Array. The Calibration Array is also supplied on the calibration back-up diskette, and can be re-loaded by the Robcomm-II utilities from the Memory/Calibrate menu path. The Calibration Array is protected against tampering by the use of a checksum byte. Each time the robot system is homed, the checksum is re-calculated and compared to the stored value. If there is a difference, an error appears on the screen:

056 CAL CHKSUM

When this occurs, the array must be reloaded from the calibration back-up disk. If reloading the Calibration Array from disk does not resolve a homing checksum error, then the system must be re-calibrated from scratch (see the RAPL-II Programming Manual, @@CAL command). In this case the Calibration Array stored on the diskette is no longer valid.

2-14-6 Home Range

The Home Range for each joint is the full rotation of the encoder disk leading up to the Zero Cross Pulse that defines the Calibration Position.

Before the homing procedure, you must move each joint to within the range indicated by the home alignment marks on the robot arm, see Figure 2-8 Alignment Test Strip.

The home command moves the joints to seek the Zero-Cross Pulse.

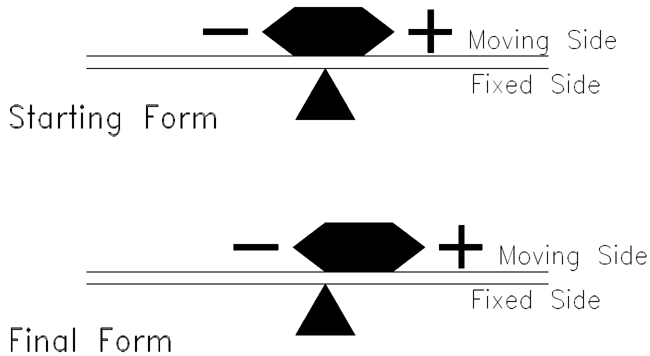


Figure 2-8 Alignment Test Strip

2-15 Homing Errors

In order to achieve correct homing, the following systems and components must be intact and operating correctly:

1. Encoder Zero-Cross pulse
2. Zero-Cross pulse wiring
3. PID logic
4. Calibration memory integrity

Any failure will lead to an error during the HOME sequence. The type of error points to the cause of the problem.

The following errors can occur during the HOME sequence:

- RAPL-II error 029 – Illegal Transform
- RAPL-II error 047 - Memory Checksum
- RAPL-II error 056 - Calibration Checksum

2-15-1 HOME Sequence Errors

RAPL-II Error 029 – Illegal Transform

When homing the robot starting from Manual mode, the HOME sequence command temporarily de-activates the teach pendant while the computer controls the arm. At the end of the sequence, manual mode re-activates. If the arm is homed from a start-up (as is normally the case), then only Joint Manual mode (signified by the J> prompt) can be activated. An illegal transform error can result.

However, if for some reason the robot is re-homed, it is possible that the arm may be in World or Tool Manual mode (signified by the W> or T> prompts). When the sequence is complete, some joints may be out of their legal software ranges. When manual mode re-activates, a transform illegal error may issue.

Note: Any attempt to put the arm into one of the above manual modes immediately after completion of the HOME sequence command results in an error. Saving the final position and immediately trying to move back to it also results in an error.

Tip: Good programming practice for any automatic start programming is to issue the NOMANUAL command before the HOME sequence command. After completion of the sequence, move to a known legal position (for example, READY) before continuing.

RAPL-II Error 056 - Calibration Checksum

This error indicates that memory containing the arm calibration registers is corrupt.

To recover the calibration:

- Use the Memory/Calibrate/Send menu item to send the contents of the file called SRS_#### to the robot. You can locate this file on the distribution disk that is sent with each system in the directory “CAL”. This should eliminate the error.

  If the above mentioned files do not exist, a re-calibration from scratch is necessary. Follow the instructions for the @@CAL command in the RAPL-II Manual, section 5. After issuing the CALIBRATION sequence command, save the calibration data to disk. Any memory loss should be treated as a potential hardware problem and investigated thoroughly. See section 2-17-5 “WHERE Commands” for more information on memory checksums.

2-16 Gripper Operation

The controller may be set up to operate either an air gripper (standard), or a servo gripper (optional). A magnetic gripper can also be used in place of the servo gripper.

2-16-1 Air Gripper

The A255 arm contains a 2-way air solenoid valve for the operation of a small gripper or other small air-powered devices attached to the end of the tool flange. The valve operates from a 12 VDC circuit on the auxiliary board. The TTL output signal from the CPU is buffered by a 75461 driver chip located on the auxiliary board (U2).

From here, the output signal leaves the auxiliary board at a five pin Molex connector (J7). It is then passed into the Robot Feedback connector at pins 53 and 54 (see Table 4-5 Robot Feedback (CPC57 Connector). It goes into the arm at the base connector and passes through the arm internal wiring harness to the solenoid valve.

Tip: If the two air solenoid wires (S/A G+ and S/A G-) are shorted out while the controller power is ON, then the current flow will destroy the driver on the auxiliary board.

2-16-2 Servo Gripper

The servo gripper is an analog servo device which requires the correct configuration during boot up. For proper operation, select the servo gripper from the @@SETUP menu. For more information on the servo gripper, refer to the Servo Gripper Operation manual.

2-17 Software Diagnostics

Several software procedures can be used to determine errors in the use of CRS robot systems. These procedures require the use of Robcomm-II software to correctly diagnose and repair the errors.

Software detectable errors include:

- Memory Checksums
- ERROR Messages
- The STATUS command
- The @@DIAG command
- The "Where" commands W1, W3, and W5

Possible sources of these errors:

- RAPL-II programs
- Current default settings
- Motor servo system
- Controller hardware system
- Battery backed-up memory

2-17-1 RAPL-II Memory Organization

RAPL-II, the robot system software, contains three sections of RAM that you can service and repair. If the contents of any of this memory is altered because of electrical interference or other "unauthorized" means, operation of the system may not proceed as expected.

"Repair" procedures for corrupted memory are listed below according to memory type. There are three types of memory:

1. System (or Parameter) Memory
2. User Memory
3. Calibration Memory

System (or Parameter) Memory

System memory contains the parameters used for normal system operation. All servo parameters, communication parameters, peripheral axis parameters, memory allocation information, etc. are stored here. Parameter memory is located in battery backed-up RAM and is normally retained during power-off.

System memory also contains space that RAPL-II uses for calculations during operation. This "scratch-pad" memory is battery backed-up, but clears each time the system power is removed.

Any instance of memory damage can potentially affect system memory. Corruption of parameter memory is the most serious as it can affect robot arm performance which can result in damage to equipment or personal injury.

User Memory

User memory contains user-written programs, and all the locations and variables used by the robot during operation. This memory section is partitioned and cleared by the RAPL-II allocate (ALLOC) command. The NEW command clears user memory without the re-partitioning procedure. Information stored in user memory is maintained when power is removed from the system.

User memory damage is detected through the use of checksums. There is one checksum for each program, location, and variable used in the program (see section 2-17-2 Memory Checksums). If a user memory item is damaged, access to that item is denied and an error message issues. This prevents user memory damage from affecting robot operation.

The memory check procedure at start-up detects if user memory is scrambled by checking for valid memory pointer addresses (see section 2-17-5 “WHERE” command). If a memory failure is detected, then start-up displays the message:

*** USER MEMORY CHECK FAILED ***

Start-up then queries you whether you want to continue. If you answer "YES," then start-up automatically executes the ALLOC command. As previously stated, this command clears, resets, and re-partitions the user memory. Using the "NO", permits you to examine damaged memory, with a DIR, LLOC, or LVAR command. The individual component can then be fixed selectively. If those commands indicate widespread memory corruption, then an ALLOC may be the final resort.

Calibration Memory

This memory contains calibration information for the particular robot arm run by the controller. It may also contain calibration information for any extra axes that have been installed in the controller. Calibration memory is maintained when power is removed from the system.

Calibration memory is vital for robot operation. It is also protected by checksums. If the checksum indicates a problem with any calibration memory item, then the homing procedure cannot be performed and an error message: "056 CALIBRATION DATA CHK" issues.

To restore the correct values, you must either re-calibrate the robot or re-load the values from disk using the Robcomm for Windows Setup/Calibration/Send command.

2-17-2 Memory Checksums

All C500 controllers contain battery-backed RAM to preserve all user data and system parameters, even while the controller is unplugged. Each controller board is supplied by a lithium battery, capable of maintaining memory contents for 10 years.

This memory, like any other electronic component, is susceptible to the effects of voltage transients. Although the computer electronics are isolated from the primary AC voltage source, these transients can be introduced by other means, such as internal and external wiring problems that affect the voltage supplies or data buses.

The RAPL-II system provides a series of checks which protect against the system being used with the memory damaged. Each area of the user memory is provided with a checksum. A checksum is a byte whose value is the sum of the bytes that it is responsible for auditing. For user memory, the programs, paths, variables and locations each have their own checksums which are constantly maintained whenever the contents of this data is changed.

Every time data is used, its checksum value is confirmed. It is confirmed by summing the data contained in the memory item and comparing it with the checksum stored for that item. If a discrepancy exists, an error issues. For instance, when the GOSUB command is used to call a program to be executed, it first checks the sum of the data in the program against the checksum stored in the program table for that entry. A failed check prevents the program from executing. Similarly, the MOVE command checks the location it uses before proceeding. A checksum error message "047 CHKSM ERR" reports if there are any problems, and program execution terminates.

Checksum errors can also display when listing the user data. For instance, the LISTV, LVAL, LISTL, LLOC, DIR, LISTP and LPROG commands indicate if a checksum error is present.

If there is an error in a single data element, then that item can be deleted and re-created. If, however, a program becomes corrupted in many places, then the best solution is to delete it and re-load the program from disk using Robcomm-II.

The robot calibration position is maintained with its own checksum. Before the robot is allowed to HOME, the integrity of the calibration is confirmed. If there is an error, then homing stops and the robot is not permitted any complex moves until the error is cleared. Calibration data can then be loaded using the Robcomm-II for Windows Setup/Calibrate/Send command.

When the user memory is partitioned by the ALLOC (allocate) command, pointers to the various elements of the RAPL-II user memory are assigned values in a certain order. Each time the controller is turned on, those pointers are examined for consistency. If there is evidence of a loss of integrity, then an error displays and the user is forced to proceed with an allocation sequence:

*** USER MEMORY CHECK FAILED ***

Warning! Any checksum error should be a rare occurence. Always treat memory failures as possible symptoms of serious problems.

Some areas of the RAPL-II memory are not protected by checksums, so there is no guarantee that the memory corruption is located only in that area that has been flagged by a checksum error.

If you find a memory problem:

1. Note the event
2. Execute a re-start to initialize all parameters memory
3. Re-allocate memory
4. Reload the application software.

If memory problems persist, then typically a hardware fault is responsible and more detailed troubleshooting is necessary.

2-17-3 RAPL-II Error Messages

RAPL-II monitors robot operations for error conditions. When an error is detected, RAPL-II stops robot motion and program execution, if any, displays an error message on the interactive device, or on the teach pendant if it is plugged in and enabled. All possible errors are listed in Appendix B of the RAPL-II Manual along with a description.

Some errors, such as "056 CALIBRATION DATA CHK", are very serious and prohibit robot operation until the source of the error is corrected. However, most errors require only a minor change before continuing operations.

Entering a valid RAPL-II command clears the RAPL-II error flag. The number of the last RAPL-II error displays in the status screen.

See the RAPL-II Programming Manual, Appendix B for the description of RAPL-II errors.

2-17-4 The @@DIAG Command

The @@DIAG command is a powerful diagnostic tool that permits various chip-level tests of various controller board functions. To enter diagnostic mode, type the RAPL-II password using the PASSWORD command and then enter the @@DIAG supervisor level function.

Once the diagnostic mode is entered, a warning is issued to turn off the robot arm power. If you fail to do so, the system performs the action for you. For a description of the @@DIAG command, refer to the RAPL-II Programming Manual (R-UMI-17-555). Once the diagnostic mode is complete, the controller must be turned off.

2-17-5 "WHERE" Commands

The RAPL-II commands W0, W1, W2, W3, W4, W5, WE1, WE3, are commands that view the state of the RAPL-II actual position and position command registers. As such, they are extremely useful for first level diagnostic purposes. For instance, if it is suspected that an encoder is malfunctioning, then it can be tested using the W1 command which continuously displays the actual position of the robot while physically moving the arm. If a display item changes and is proper and consistent with the motion that you apply to the arm, then the encoder operation can be confirmed.

See the RAPL-II Programming Manual, section 4, for a complete description of these commands.

CHAPTER 3

3 Electronics Description

3-1 A255 Controller Electronics

The A255 controller box is divided into three main compartments for electronic hardware. The upper compartment houses the robot control electronics. The lower compartment contains the AC power supply, main power start-up circuitry, and the power filter board. A bulkhead separates the two. In the remaining space, beside the upper and lower compartments, are the robot motor amplifiers.

You can lift out the controller board/auxiliary board assembly by removing the four Phillips head mounting screws on the bulkhead. This allows you to access the power supply in the lower compartment. Note the locations of the various connectors while unplugging them.

Once you have removed the controller board/auxiliary board assembly, you can remove the motor amplifier sub-assembly along with the capacitor bank mounted together with it. Six M4 nuts with lock washers secure the sub-assembly to the floor of the chassis.

Table 3-1 below lists all the A255 controller's electronic modules. These modules are described in detail in the sections that follow.

Qty.	Part Number	Description	Location
1	SMC-23-203 or SMC-23-303*	Controller Board/Auxiliary Board	Upper Compartment
	* for auxilliary board serial numbers greater than 6800		
2	SEC-13-903 or SEC-920-001**	Linear Amplifier or PWM Amplifier**	Amplifier Section
	** for PWM amp serial numbers greater than PWMXXXX		
1	MA0933-120-00	Computer Power Supply	Lower Compartment
1	SEC-23-203	Capacitor Bank	Lower Compartment
1	SMC-23-101A	Transformer Assembly	Lower Compartment
1	SEC-23-204	Encoder Connector Board	Rear Panel
1	SMC-23-202	Fuse Panel Assembly	Front Panel
1	SEC-23-300	Front Panel Display Board	Front Panel
1	SEC-23-422	AC Current Softstart Board	Lower Compartment

Table 3-1 A255 Controller Electronic Modules

3-2 Controller Board

The controller board (Figure 3-1) is the controller's upper large printed circuit board. The controller board is responsible for the communications, data processing, and memory functions of the robot system.

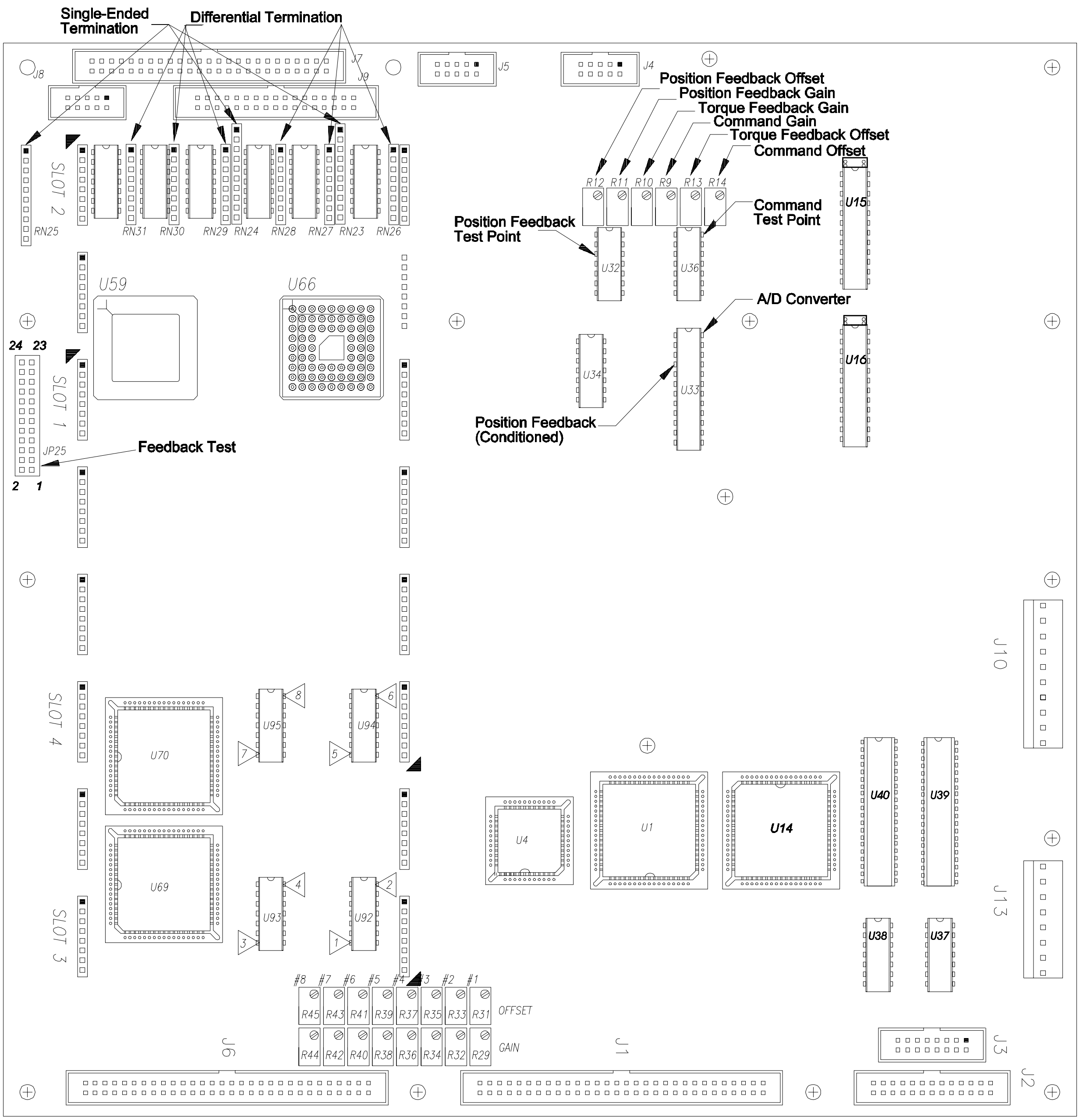


Figure 3--1 Controller Board

3-2-1 Controller Board Components

The controller board contains the following components:

CPU

An Intel 80286 16-bit microprocessor and Intel 80287-2 math co-processor, running at a master clock frequency of 11.05 MHz.

Transputer

Inmos 4 serial port crossbar linked multiprocessor, running at 20 MHz for servo loop control. An optional second transputer is supported for high speed kinematics applications. Each transputer has 128 Kbytes of fast SRAM.

TRAM

Four tram sites are supported for optional equipment such as vision, force, and network. The tram linkspeed is 10 Mbit/sec or 20 Mbit/sec. The default is 20 Mbit/sec. Tram link is J4 tram network UP (in) and J5 tram network DOWN (out) on the controller board.

RTS/CTS

The loopback is jumper selectable only with serial teach pendant communication (device 0). This is selectable on the controller board at JP6.

PIC

The programmable interrupt controller (PIC) is used to support the multi-tasking operating system.

PIT

The programmable interval timer (PIT) is used to generate fixed time intervals. The PIT has 3 timers which are used as follows:

- Timer 0 generates a time 1 ms (watchdog).
- Timer 1 generates a time of 10-40 ms.
- Timer 2 generates a time base of 20 ms.

UARTs

The Universal Asynchronous Receiver/Transmitter (UART x 2) controls two serial channels with the RS-232 format having a programmable baud rate at startup of between 9600, 19200, and 38400 baud. Device 0 is dedicated to the Serial Teach Pendant (STP) and Device 1 is dedicated to the Advanced Communication Interface (ACI). RS 422 is supported with an internal converter (optional).

RAM

256 Kbytes of Random Access Memory is provided for user programming and computer "scratch-pad" space. The RAM chips have an external lithium battery which will retain the memory contents for up to 10 years.

Flash ROM

512 Kbytes RAM is in use for system firmware with 512 Kbytes available for user memory backup.

3-2-2 Socketed Components

The following tables list and describe socketed components.

Label	Description
U1	CPU 80286 Handles external serial communication and is interfaced with two transputer nodes.
U4	80287 Co-processor for accelerating floating point operations
U14	FPGA1 Field Programable Gate Array
U32	Quad op Amp for servo gripper position feedback.
U33	Servo gripper A/D converter
U36	LM324 quad op Amp for torque feedback
U37 & U38	DS14c88 & DS 14c89 RS232 drivers.
U39 & U40	Serial I/O UARTs
U15 & U16	Locations of the EPROM memory chips 27512 which contain the power-on diagnostics.
U59 & U66	T400 transputer and optional T805 transputer
U69 & U70	FPGA2 Field Programmable Gate Array
U92	VCom Output for axes 1 and 2
U93	VCom Output for axes 3 and 4
U94	VCom Output for axes 5 and 6
U95	VCom Output for axes 7 and 8

Table 3-2 C500 Controller Board Socketed Components

JP25 Test Strip (Condition Signals)

Pin	Signal
1	1A
2	2A
3	3A
4	4A
5	5A
6	6A
7	7A
8	8A
9	1B
10	2B
11	3B
12	4B

Pin	Signal
13	5B
14	6B
15	7B
16	8B
17	1Z
18	2Z
19	3Z
20	4Z
21	5Z
22	6Z
23	7Z
24	8Z

Table 3-3 JP25 Test Strip (Condition Signals)

3-2-3 Controller Board Connectors

Figure 3-2 below shows the controller board's connector locations. See legend (Table 3-3) and pin-outs in tables that follow.

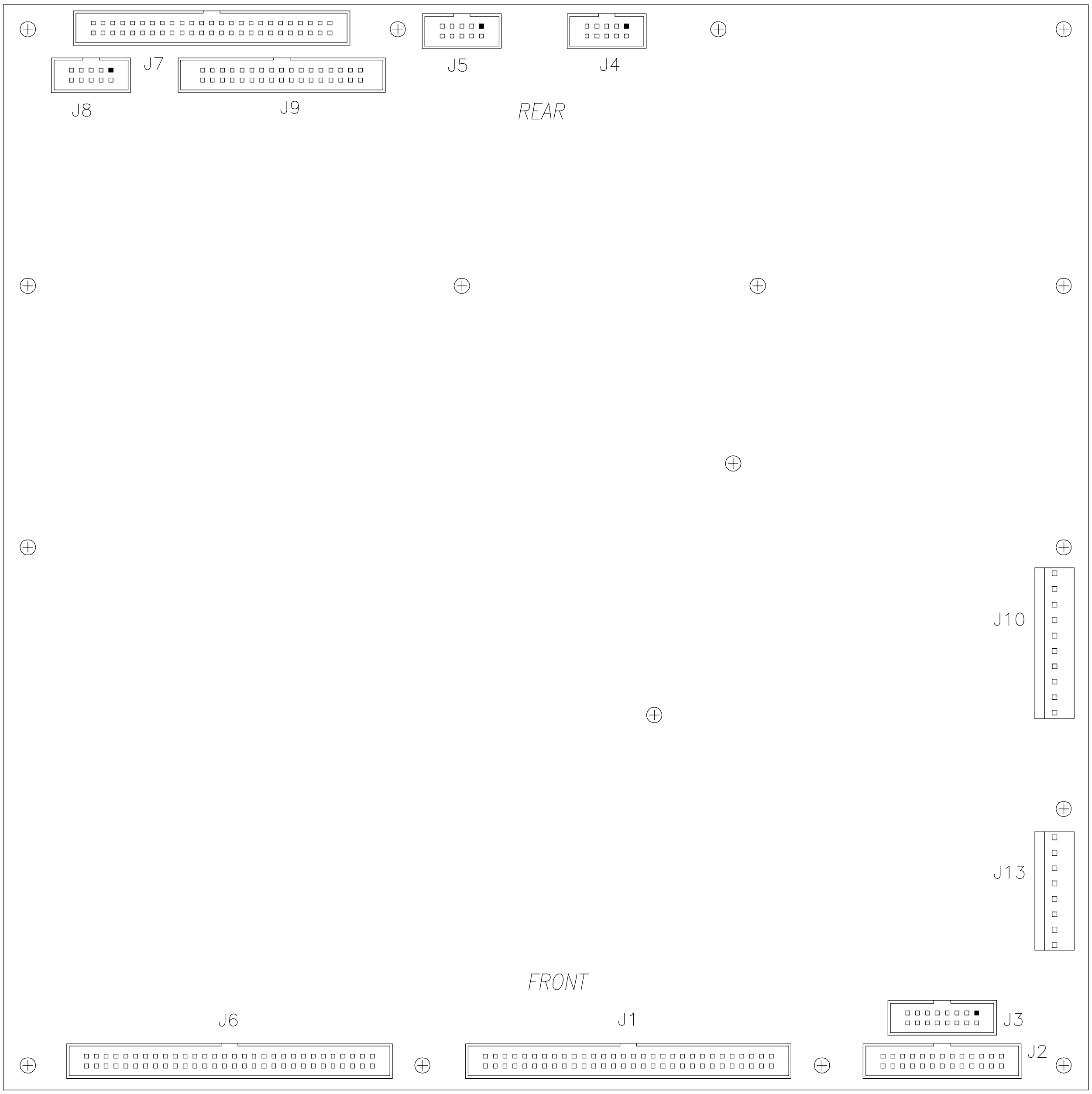
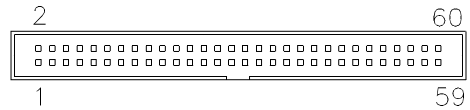


Figure 3-2 Controller Board Connector Locations

Label	Description
J1	Aux Board Connector #1 Interconnect
J2	Communication Port
J3	Teach Pendant Connector
J4	Transputer Network UP
J5	Transputer Network DOWN
J6	Aux Board Connector #2 Interconnect
J7	Encoder Connector
J8	Encoder Power Connector
J9	Amp Expansion
J10	Power Supply
J13	Aux Board Power Connector

Table 3-4 Controller Board Connectors Legend

CB-J1



Connector Name AB-2 I/O Board Interconnect
Connector Type 60 Pin Ansely Header
Destination AB-J2
Via SCC-23-001

Pin #	Function	Signature	Description
1	Hex0	TTL	Display Data (LSB)
2	Hex1	TTL	Display Data
3	Hex2	TTL	Display Data
4	Hex3	TTL	Display Data
5	Hex4	TTL	Display Data
6	Hex5	TTL	Display Data
7	Hex6	TTL	Display Data
8	Hex7	TTL	Display Data (MSB)
9	N/C		
10	Error	TTL	Error signal
11	ACReset	OC	Reset signal from AC indicators
12	ManEn	TTL	Manual Enable signal
13	WDI	TTL	Arm power watchdog
14	ArmPowerReq	TTL	Arm power request
15	RunPauseReq	TTL	Run/Pause request
16	BlankOn	TTL	Blank Display signal
17	HomeReq	TTL	Home Request
18	IOEnable	TTL	IO watchdog
19	ProgramReset	TTL	Program reset
20	RP0	TTL	Run/Pause Status 0
21	N/C		
22	RP1	TTL	Run/Pause Status 1
23	CyStReq	TTL	Cycle start request
24	HomeAck	TTL	Home acknowledge
25	ArmPowOn	TTL	Arm Power On Ack
26	ProgRstAck	TTL	Program reset acknowledge
27	JingIns	TTL	Jig installed Diagnostic Boot-Up
28	CyStAck	TTL	Cycle start acknowledge
29	GPO1	TTL	General Purpose user output #1
30	GPI1	TTL	General Purpose user input #1
31	GPO2	TTL	General Purpose user output #2
32	GPI 2	TTL	General Purpose user input #2
33	GPO3	TTL	General Purpose user output #3
34	GPI 3	TTL	General Purpose user input #3
35	GPO4	TTL	General Purpose user output #4
36	GPI4	TTL	General Purpose user input #4
37	GPO5	TTL	General Purpose user output #5
38	GPI5	TTL	General Purpose user input #5
39	GPO6	TTL	General Purpose user output #6

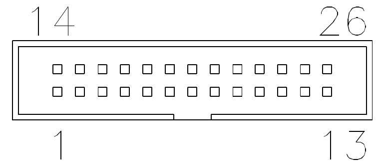
Table 3-5 AB-2 I/O Board Interconnect

CB-J1 (Continued)

Pin #	Function	Signature	Description
40	GPI6	TTL	General Purpose user input #6
41	GPO7	TTL	General Purpose user output #7
42	GPI7	TTL	General Purpose user input #7
43	GPO8	TTL	General Purpose user output #8
44	GPI8	TTL	General Purpose user input #8
45	GPO9	TTL	General Purpose user output #9
46	GPI9	TTL	General Purpose user input #9
47	GPO10	TTL	General Purpose user output #10
48	GPI10	TTL	General Purpose user input #10
49	GPO11	TTL	General Purpose user output #11
50	GPI11	TTL	General Purpose user input #11
51	GPO12	TTL	General Purpose user output #12
52	GPI12	TTL	General Purpose user input #12
53	GPO13	TTL	General Purpose user output #13
54	GPI13	TTL	General Purpose user input #13
55	GPO14	TTL	General Purpose user output #14
56	GPI14	TTL	General Purpose user input #14
57	GPO15	TTL	General Purpose user output #15
58	GPI15	TTL	General Purpose user input #15
59	GPO16	TTL	General Purpose user output #16
60	GPI16	TTL	General Purpose user input #16

AB-2 I/O Board Interconnect (Continued)

CB-J2

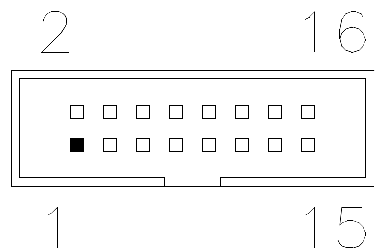


Connector Name	Communications Port Connector
Connector Type	26 Pin Ansely
Destination	Front Panel Chassis-Mount DB25 Connector
Via	SCC-23-107

Pin #	Function	Signature	Description
1			not used
2	RX	RS-232C	Receive signal
3	TX	RS-232C	Transmit signal
4	CTS-	RS-232C	Clear To Send
5	RTS-	RS-232C	Ready To Send
6	DTR-	RS-232C	Data Terminal Ready
7	Gnd	Gnd	Digital ground
8	N/C		
9	ACIEn-	RS-232C	ACI Enable
10	NC	N/A	No Connect
11	+12 V	Power	+12 Volt Supply to the serial port
12	NC	N/A	No Connect
13	NC	N/A	No Connect
14	NC	N/A	No Connect
15	NC	N/A	No Connect
16	NC	N/A	No Connect
17	NC	N/A	No Connect
18	-12 V	Power	-12 Volt Supply to the serial port
19	NC	N/A	No Connect
20	DSR-	RS-232C	Data Set Ready
21	NC	N/A	No Connect
22	NC	N/A	No Connect
23	NC	N/A	No Connect
24	NC	N/A	No Connect
25	+5 V	Power	+5 Volt Supply to the serial port
26	NC	N/A	No Connect

Table 3-6 Communications Port Connector

CB-J3

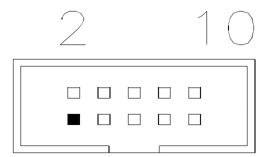


Connector Name Teach Pendant Connector
Connector Type 16 Pin Ansely
Destination Front Panel Chassis-Mount Cannon 10 Pin
Connector
Via SCC-23-514

Pin #	Function	Signature	Description
1	Inst-	TTL	Teach pendant installed
2	TX	RS-232C	Transmit signal to the teach pendant
3	RX	RS-232C	Receive signal from the teach pendant
4			
5			
6			
7	Gnd	Power	Return from the teach pendant
8	Liveman-	contact	Pendant live-man switch pair
9			
10	LiveMan+		Pendant live-man switch pair
11	TPEStop+	ESTOP	Teach pendant emergency stop switch pair
12	TPEStop-	ESTOP	Teach pendant emergency stop switch pair
13			
14			
15	+5 V	Power	+5 Volt Supply to the teach pendant 100 mA max

Table 3-7 Teach Pendant Connector

CB-J4

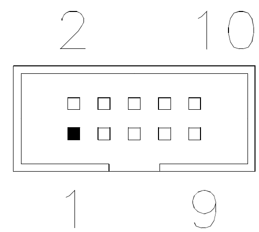


Connector Name Transputer Up Connector
Connector Type 10 Pin Ansely (Staggered Nomenclature)
Destination Rear Panel Chassis-Mount Connector (Optional)
Via SCC-23-008

Pin #	Function	Signature	Description
1	URst+	RS-422	Reset from master
2	URst-	RS-422	Reset from master (complementary)
3	UErr+	RS-422	Error to master
4	UErr-	RS-422	Error to master (complementary)
5	UAna+	RS-422	Analyze from master
6	UAna-	RS-422	Analyze from master (complementary)
7	LI0+	RS-422	Link 0 input
8	LI0-	RS-422	Link 0 input (complementary)
9	LO0+	RS-422	Link 0 output
10	LO0-	RS-422	Link 0 output (complementary)

Table 3-8 Transputer Up Connector

CB-J5

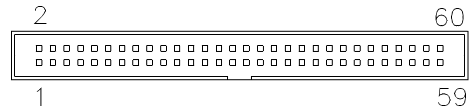


Connector Name Transputer Down Connector
Connector Type 10 Pin Ansely (Staggered Nomenclature)
Destination Rear Panel Chassis-Mount Connector (Optional)
Via SCC-23-008A

Pin #	Function	Signature	Description
1	DRst+	RS-422	Reset to slave
2	DRst-	RS-422	Reset to slave (complementary)
3	DErr+	RS-422	Error from slave
4	DErr-	RS-422	Error from slave (complemetary)
5	DAna+	RS-422	Analyze to slave
6	DAna-	RS-422	Analyze to slave (complementary)
7	LI1+	RS-422	Link 1 input
8	LI1-	RS-422	Link 1 input (complementary)
9	LO1+	RS-422	Link 1 output
10	LO1-	RS-422	Link 1 output (complementary)

Table 3-9 Transputer Down Connector

CB-J6



Connector Name AB-1 Connector
Connector Type 60 Pin Ansely (staggered nomenclature)
Destination AB-J1
Via SCC-23-001

Pin #	Function	Signature	Description
1	Vcom1	Analog	Command voltage for axis 1
2	Vcom5	Analog	Command voltage for axis 5
3	Vcom2	Analog	Command voltage for axis 2
4	Vcom6	Analog	Command voltage for axis 6
5	Vcom3	Analog	Command voltage for axis 3
6	Vcom7	Analog	Command voltage for axis 7
7	Vcom4	Analog	Command voltage for axis 4
8	Vcom8	Analog	Command voltage for axis 8
9	HSW1	OC	Homing switch for axis 1
10	PSW1	OC	Positive Travel switch for axis 1
11	NSW1	OC	Negative Travel switch for axis 1
12	TSW1	OC	Thermal switch for axis 1
13	HSW2	OC	Homing switch for axis 2
14	PSW2	OC	Positive Travel switch for axis 2
15	NSW2	OC	Negative Travel switch for axis 2
16	TSW2	OC	Thermal switch for axis 2
17	HSW3	OC	Homing switch for axis 3
18	PSW3	OC	Positive Travel switch for axis 3
19	NSW3	OC	Negative Travel switch for axis 3
20	TSW3	OC	Thermal switch for axis 3
21	HSW4	OC	Homing switch for axis 4
22	PSW4	OC	Positive Travel switch for axis 4
23	NSW4	OC	Negative Travel switch for axis 4
24	TSW4	OC	Thermal switch for axis 4
25	HSW5	OC	Homing switch for axis 5
26	PSW5	OC	Positive Travel switch for axis 5
27	NSW5	OC	Negative Travel switch for axis 5
28	TSW5	OC	Thermal switch for axis 5
29	HSW6	OC	Homing switch for axis 6
30	PSW6	OC	Positive Travel switch for axis 6
31	NSW6	OC	Negative Travel switch for axis 6
32	TSW6	OC	Thermal switch for axis 6
33	HSW7	OC	Homing switch for axis 7
34	PSW7	OC	Positive Travel switch for axis 7

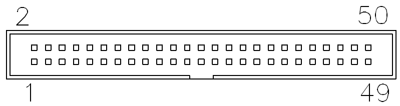
Table 3-10 AB -1 Connector

CB-J6 (Continued)

Pin #	Function	Signature	Description
35	NSW7	OC	Negative Travel switch for axis 7
36	TSW7	OC	Thermal switch for axis 7
37	HSW8	OC	Homing switch for axis 8
38	PSW8	OC	Positive Travel switch for axis 8
39	NSW8	OC	Negative Travel switch for axis 8
40	TSW8	OC	Thermal switch for axis 8
41	TPEStop+	Switch	Teach pendant E-Stop pair
42	TPEStop-		Teach pendant E-Stop pair
43	LiveMan+	Switch	Teach pendant liveman switch pair
44	Liveman-		Teach pendant E-Stop pair
45	Brake+	Switch	Brake relay source
46	Brake-		Switch Brake relay return (normally open)
47	ArmOn+	Switch	Arm Power relay source
48	ArmOn-	Switch	Arm Power relay return (normally open)
49	AnalogIn1		
50	AnalogIn2		
51	AEEStop+	Switch	Auxiliary E-Stop switch pair. Used for exp Amp connector. Can be bypassed on the auxiliary board with a switch.
52	AEEStop-		
53	N/C		
54	N/C		
55	N/C		
56	N/C		
57	N/C		
58	N/C		
59	N/C		
60	N/C		

AB -1 Connector (Continued)

CB-J7



Connector Name Encoder Connector
Connector Type 50 Pin Ansely (staggered nomenclature)
Destination Encoder Feedback Connector
Via SCC-23-110

Pin #	Function	Signature	Description
1	A1+	RS-422	Axis 1 Channel A input
2	A1-	RS-422	Axis 1 Channel A input (complementary)
3	B1+	RS-422	Axis 1 Channel B input
4	B1-	RS-422	Axis 1 Channel B input (complementary)
5	Z1+	RS-422	Axis 1 Channel Z input
6	Z1-	RS-422	Axis 1 Channel Z input (complementary)
7	A2+	RS-422	Axis 2 Channel A input
8	A2-	RS-422	Axis 2 Channel A input (complementary)
9	B2+	RS-422	Axis 2 Channel B input
10	B2-	RS-422	Axis 2 Channel B input (complementary)
11	Z2+	RS-422	Axis 2 Channel Z input
12	Z2-	RS-422	Axis 2 Channel Z input (complementary)
13	A3+	RS-422	Axis 3 Channel A input
14	A3-	RS-422	Axis 3 Channel A input (complementary)
15	B3+	RS-422	Axis 3 Channel B input
16	B3-	RS-422	Axis 3 Channel B input (complementary)
17	Z3+	RS-422	Axis 3 Channel Z input
18	Z3-	RS-422	Axis 3 Channel Z input (complementary)
19	A4+	RS-422	Axis 4 Channel A input
20	A4-	RS-422	Axis 4 Channel A input (complementary)
21	B4+	RS-422	Axis 4 Channel B input
22	B4-	RS-422	Axis 4 Channel B input (complementary)
23	Z4+	RS-422	Axis 4 Channel Z input
24	Z4-	RS-422	Axis 4 Channel Z input (complementary)
25	A5+	RS-422	Axis 5 Channel A input
26	A5-	RS-422	Axis 5 Channel A input (complementary)
27	B5+	RS-422	Axis 5 Channel B input
28	B5-	RS-422	Axis 5 Channel B input (complementary)
29	Z5+	RS-422	Axis 5 Channel Z input
30	Z5-	RS-422	Axis 5 Channel Z input (complementary)
31	A6+	RS-422	Axis 6 Channel A input
32	A6-	RS-422	Axis 6 Channel A input (complementary)
33	B6+	RS-422	Axis 6 Channel B input
34	B6-	RS-422	Axis 6 Channel B input (complementary)

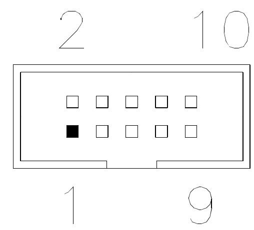
Table 3-11 Encoder Connector

CB-J7 (Continued)

Pin #	Function	Signature	Description
35	Z6+	RS-422	Axis 6 Channel Z input
36	Z6-	RS-422	Axis 6 Channel Z input (complementary)
37	N/C	N/A	No Connect
38	Shield		No Connect
39			
40			
41	SGPos	Analog	Servo gripper position
42	SGTor	Analog	Servo gripper torque (not used)
43	AirGrip-	Power	Solenoid return
44	Gnd	Power	
45			
46	Gnd	Power	
47	+12 V	Power	+12 Volt supply to the servo gripper/Air Gripper Solenoid
48	Gnd	Power	
49	+12 V	Power	+12 Volt supply to the servo gripper/Air Gripper Solenoid
50	Gnd	Power	

Encoder Connector (Continued)

CB-J8

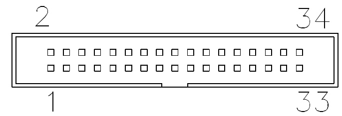


Connector Name	Encoder Power Connector
Connector Type	10 Pin Ansely (staggered nomenclature)
Destination	Encoder Connector
Via	SCC-23-210

Pin #	Function	Signature	Description
1	+5Enc	5 Volts	Isolated encoder supply
2	Gnd		Ground: Encoder power supply return
3	+5Enc	5 Volts	Isolated encoder supply
4	Gnd		Ground: Encoder power supply return
5	+5Enc	5 Volts	Isolated encoder supply
6	Gnd		Ground: Encoder power supply return
7	+5Enc	5 Volts	Isolated encoder supply
8	Gnd		Ground: Encoder power supply return
9	+5Enc	5 Volts	Isolated encoder supply
10	Gnd		Ground: Encoder power supply return

Table 3-12 Encoder Power Connector

CB-J9

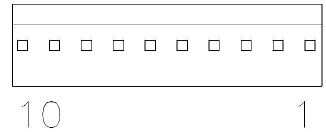


Connector Name Amp Expansion Connector
Connector Type 34 Pin Ansely (staggered nomenclature)
Destination Amplifier Expansion Connector
Via SCC-23-511 (Optional)

Pin #	Function	Signature	Description
1	A6+	RS-422	Axis 6 Channel A input
2	A6-	RS-422	Axis 6 Channel A input (complementary)
3	B6+	RS-422	Axis 6 Channel B input
4	B6-	RS-422	Axis 6 Channel B input (complementary)
5	Z6+	RS-422	Axis 6 Channel Z input
6	Z6-	RS-422	Axis 6 Channel Z input (complementary)
7	Brake-	Switch	Brake relay source (≈12 Ω snubber to ground)
8	Brake+	Switch	Brake relay return (normally open)
9	A7+	RS-422	Axis 7 Channel A input
10	A7-	RS-422	Axis 7 Channel A input (complementary)
11	B7+	RS-422	Axis 7 Channel B input
12	B7-	RS-422	Axis 7 Channel B input (complementary)
13	Z7+	RS-422	Axis 7 Channel Z input
14	Z7-	RS-422	Axis 7 Channel Z input (complementary)
15	ArmOn+	Switch	Arm Power relay source
16	ArmOn-	Switch	Arm Power relay return (normally open)
17	A8+	RS-422	Axis 8 Channel A input
18	A8-	RS-422	Axis 8 Channel A input (complementary)
19	B8+	RS-422	Axis 8 Channel B input
20	B8-	RS-422	Axis 8 Channel B input (complementary)
21	Z8+	RS-422	Axis 8 Channel Z input
22	Z8-	RS-422	Axis 8 Channel Z input (complementary)
23	AEE-stop+	switch	Auxiliary E-Stop switch pair
24	AEE-stop-		
25	+12 VDC		
26	+12 VDC	logic power	
27	Vcom6	Analog	Command voltage for axis 6
28	Vcom7	Analog	Command voltage for axis 7
29	Vcom8	Analog	Command voltage for axis 8
30	Gnd	Ground	Logic Ground
31	Vcc	+5 VDC	Logic supply to encoders
32	Gnd	Ground	Logic Ground
33	Vcc	+5 VDC	Logic supply to encoders
34	Gnd	Ground	Logic Ground

Table 3-13 Amp Expansion Connector

CB-J10

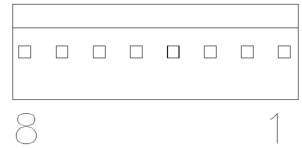


Connector Name Power Supply Connector
Connector Type 10 Pin MOLEX
Destination Power Supply - 10 Pin MOLEX
Via SCC-23-106 or SCC-23-606

Pin #	Function	Signature	Description
1	+5 V	Power	+5 Volt supply to the controllerboard
2	+5 V	Power	+5 Volt supply to the controllerboard
3	Gnd	Power	Return for +5 V, +12 V, -12 V and +24 V
4	Gnd	Power	Return for +5 V, +12 V, -12 V and +24 V
5	Key	N/A	Key for the connector
6	+12 V	Power	+12 Volt supply to the controllerboard
7	-12 V	Power	-12 Volt supply to the controllerboard
8	Gnd	Power	Return for the isolated +5 Volt supply
9	ISO +5 V	Power	Isolated +5 Volt supply for the encoders
10	+24 V	Power	+24 Volt supply for the isolated I/O

Table 3-14 Power Supply Connector

CB-J13



Connector Name	Aux Board Logic Power Input Connector
Connector Type	8 Pin Molex
Destination	Auxiliary Board
Via	SCC-23-005 or SCC23-105

Pin #	Function	Signature	Description
1	+5 V	Power	+5 Volt supply to the auxiliary board
2	Key	N/A	Key for the connector
3	+5 V	Power	+5 Volt supply to the auxiliary board
4	Gnd	Power	Ground
5	Gnd	Power	Ground
6	+12 V	Power	+12 Volt supply to the auxiliary board
7	-12 V	Power	-12 Volt supply to the auxiliary board
8	+24 V	Power	+24 Volt supply to the auxiliary board

Table 3-15 Auxiliary Board Logic Power Input Connector

3-3 Auxiliary Board

The auxiliary board is located in the controller's upper compartment below the controller board. It is responsible for monitoring the robot motor servers and encoders, switching brake/gripper power, and all I/O functions.

3-3-1 Auxiliary Board DIP Switch

One DIP switch is used to set the auxiliary board configuration for various operational modes (Figure 3-3). For the A255, the factory installation settings for 1 and 4 are in the OFF position, while 2 and 3 are in the ON position.

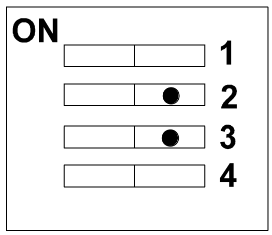


Figure 3-3 DIP Switches 2 and 3 ON

Switch	ON	OFF	Function
1	Bypass	Engage	Teach Pendant E-Stop Contact
2	Bypass	Engage	SYSIO E-Stop Contact
3	Bypass	Engage	Expansion Amp Connector Switch
4	Bypass	Engage	STP Liveman (Rev 1.3 and above)

Table 3-16 Dip Switch Settings for the A255

3-3-2 Diagnostic LED's

A row of LED's reside in auxiliary boards with serial numbers above AB6000 (REV. 1.3 and above). These LED's diagnose problems in power supply, emergency stop lines, the watchdog signal, and linear amplifier rail voltage.

LED	Signal	Override
D59	+5 V power supply	
D60	+24 V power supply	
D61	+12 V power supply	
D62	-12 V power supply	
D63	Front Panel E-Stop	
D64	Teach Pendant E-Stop	S1 #1 (Aux. Board)
D65	Liveman E-Stop	S4 #4 (Aux. Board)
D66	Remote (SYSIO) E-Stop	S2 #2 (Aux. Board)
D67	Expansion Amp E-Stop	S3 #3 (Aux. Board)
D68	Watch Dog Enabled	
D69	+ Linear Amplifier Rail Voltage	
D70	– Linear Amplifier Rail	

Table 3-17 Auxiliary Board Diagnostic LED's

3-3-3 Auxiliary Board Connectors

Figure 3-4 shows the locations for all auxiliary board connectors and socketed components. See the legend (Table 3-18) and pin-outs in the tables that follow.

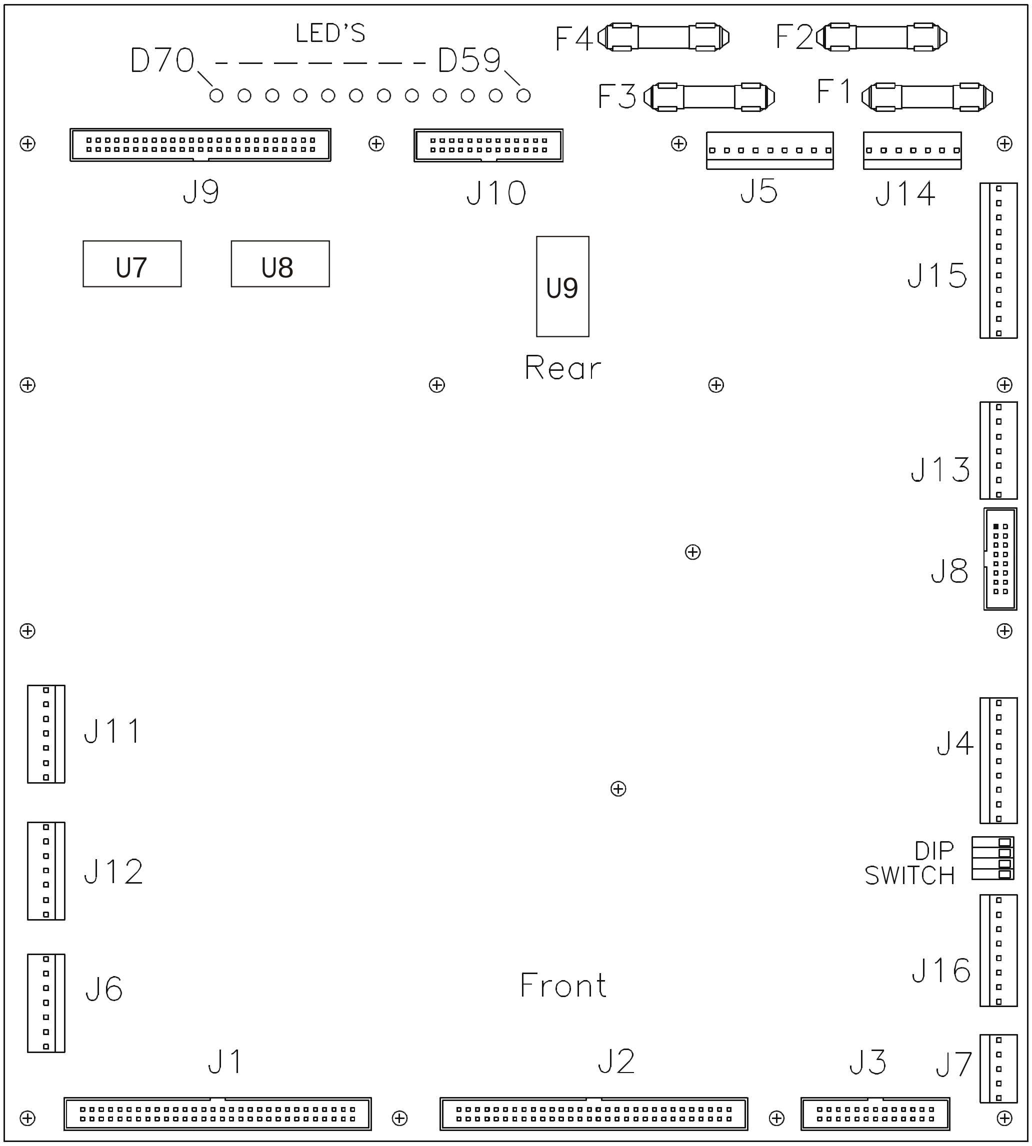
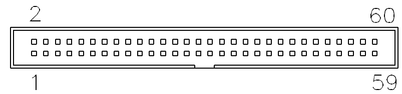


Figure 3-4 Auxiliary Board Connectors and Socketed Components Locations

Label	Description
J1	Controller Board #1 Interconnect
J2	Controller Board #2 Interconnect
J3	Front Panel Control/Display Connector
J4	Linear Amp Vcom Connector
J5	Proximity Switch Signal Connector (not used in A255)
J6	Fuse Connector
J7	Brake/Air Gripper Signal Connector
J8	PWM Vcom and Signal Connector
J9	GPIO Connector
J10	SYSIO Connector
J11	V1-3 Breaker Connector
J12	V4-6 Breaker Connector
J13	Power Supply Output to Linear Amps
J14	PWM Amp Power Supply Connector
J15	High V Power Supply In
J16	Logic Power Supply Input Connector
U7	Output buffer for SYSIO
U8	Output buffer for GPIO
U9	Output buffer for GPIO

Table 3-18 Auxiliary Board Connector and Socketed Components Legend

AB-J1



Connector Name CB-1 I/O Board Interconnect
Connector Type 60 Pin Ansely Header
Destination CB-J6
Via SCC-23-001

Pin #	Function	Signature	Description
1	Vcom1	Analog	Command voltage for axis 1
2	Vcom5	Analog	Command voltage for axis 5
3	Vcom2	Analog	Command voltage for axis 2
4	Vcom6	Analog	Command voltage for axis 6
5	Vcom3	Analog	Command voltage for axis 3
6			
7	Vcom4	Analog	Command voltage for axis 4
8			
9	HSW1	OC	Homing switch for axis 1
10			
11			
12			
13	HSW2	OC	Homing switch for axis 2
14			
15			
16			
17	HSW3	OC	Homing switch for axis 3
18			
19			
20			
21	HSW4	OC	Homing switch for axis 4
22			
23			
24			
25	HSW5	OC	Homing switch for axis 5
26			
27			
28			
29	HSW6	OC	Homing switch for axis 6
30			
31			
32			
33	HSW7	OC	Homing switch for axis 7
34			

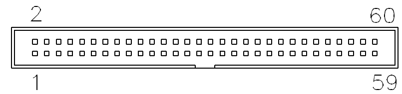
Table 3-19 CB-1 I/O Board Interconnect

AB-J1 (Continued)

Pin #	Function	Signature	Description
35			
36			
37	HSW8	OC	Homing switch for axis 8
38			
39			
40			
41	TPEStop+		Teach pendant e-stop contact pair
42	TPEStop-		
43	LiveMan+		Teach pendant liveman switch contact pair
44	Liveman-		
45	Brakeoff+	Switch	Brake relay source (flow through to exp Amp ctr)
46	Brakeoff-	Switch	Brake relay return (normally open)
47	ArmOn+	Switch	Arm power relay source
48	ArmOn-	Switch	Arm power relay return (normally open)
49	AnalogIn1		Analog channel #3, extra
50	AnalogIn2		Analog channel #4, extra
51	AEEStop+		Auxiliary e-stop contact pair. Used for the exp Amp connector
52	AEEStop-		
53	SGripIn	Analog	Analog signal from servo gripper pre-Amp
54	AmpON	TTL	Confirms arm power is ON & Amps are ON
55	BrakeRel	TTL	Software control of brake release
56	N/C		
57	700.6	TTL	Software control of brake/arm power coordination
58	N/C		
59	700.7	TTL	Software control of brake/arm power coordination
60	N/C		

CB -1 I/O Board Interconnect (Continued)

AB-J2



Connector Name CB-2 I/O Board interconnect
Connector Type 60 Pin Ansely Header
Destination CB-J1
Via SCC-23-001

Pin #	Function	Signature	Description
1	Hex0	TTL	Display Data (LSB)
2	Hex1	TTL	Display Data
3	Hex2	TTL	Display Data
4	Hex3	TTL	Display Data
5	Hex4	TTL	Display Data
6	Hex5	TTL	Display Data
7	Hex6	TTL	Display Data
8	Hex7	TTL	Display Data (MSB)
9	AirGripIn	TTL	Air gripper activation signal.
10	ErrorAck	TTL	Error signal
11	ACReset	OC	Reset signal from AC indicators
12	ManEn	TTL	Manual Enable signal
13	WDI	TTL	Arm power watchdog
14	ArmPowerReq	TTL	Arm power request
15	RunPauseReq	TTL	Run/Pause request
16	BlankOn	TTL	Blank Display signal
17	HomeReq	TTL	Home Request
18	IOEnable	TTL	IO watchdog
19	ProgramReset	TTL	Program reset
20	RP0	TTL	Run/Pause Status 0
21	N/C		
22	RP1	TTL	Run/Pause Status 1
23	CyStReq	TTL	Cycle start requesy
24	HomeAck	TTL	Home acknowledge
25	ArmPowOn	TTL	Arm Power On Ack
26	ProgRstAck	TTL	Program reset acknowledge
27	JingIns	TTL	JigInstalled
28	CyStAck	TTL	Cycle start acknowledge
29	GPO1	TTL	General Purpose user output #1
30	GPI1	TTL	General Purpose user input #1
31	GPO2	TTL	General Purpose user output #2
32	GPI2	TTL	General Purpose user input #2
33	GPO3	TTL	General Purpose user output #3
34	GPI3	TTL	General Purpose user input #3

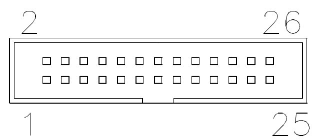
Table 3-20 CB-2 I/O Board Interconnect

AB-J2 (Continued)

Pin #	Function	Signature	Description
35	GPO4	TTL	General Purpose user output #4
36	GPI4	TTL	General Purpose user input #4
37	GPO5	TTL	General Purpose user output #5
38	GPI5	TTL	General Purpose user input #5
39	GPO6	TTL	General Purpose user output #6
40	GPI6	TTL	General Purpose user input #6
41	GPO7	TTL	General Purpose user output #7
42	GPI7	TTL	General Purpose user input #7
43	GPO8	TTL	General Purpose user output #8
44	GPI8	TTL	General Purpose user input #8
45	GPO9	TTL	General Purpose user output #9
46	GPI9	TTL	General Purpose user input #9
47	GPO10	TTL	General Purpose user output #10
48	GPI10	TTL	General Purpose user input #10
49	GPO11	TTL	General Purpose user output #11
50	GPI11	TTL	General Purpose user input #11
51	GPO12	TTL	General Purpose user output #12
52	GPI12	TTL	General Purpose user input #12
53	GPO13	TTL	General Purpose user output #13
54	GPI13	TTL	General Purpose user input #13
55	GPO14	TTL	General Purpose user output #14
56	GPI14	TTL	General Purpose user input #14
57	GPO15	TTL	General Purpose user output #15
58	GPI15	TTL	General Purpose user input #15
59	GPO16	TTL	General Purpose user output #16
60	GPI16	TTL	General Purpose user input #16

CB -2 I/O Board Interconnect (Continued)

AB-J3

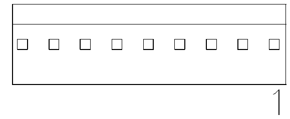


Connector Name	Display/Control Connector
Connector Type	26 Pin Ansely Header
Destination	Front Panel Displays, Switches
Via	SCC-23-012

Pin #	Function	Signature	Description
1	Vcc	+5 V	Logic power
2	+12 V		
3	Digit0	TTL	Hex Display
4	FPESTOP-	Switch	ESTOP
5	Digit1	TTL	Hex Display
6	FPMOMSW+	Switch	Arm Power momentary switch
7	Digit2	TTL	Hex Display
8	FPMOMSW-	Switch	Arm Power momentary switch
9	Digit3	TTL	Hex Display
10	FPRPSW		Run/Pause switch
11	Digit4	TTL	Hex Display
12	FPHOMESW	Switch	Home request switch
13	Digit5	TTL	Hex Display
14	FPPRSTSW	Switch	Program reset switch
15	Digit6	TTL	Hex Display
16	FPCYCSW		Cycle start switch
17	Digit7	TTL	Hex Display
18	HMA	TTL	Home Acknowledge signal
19	BLANK	TTL	Blanking control
20	PRA	TTL	Program reset acknowledge
21	R0A	TTL	Run/Pause state 0
22	CSA	TTL	Cycle start acknowledge
23	R1A	TTL	Run/Pause state 1
24	APA	TTL	Arm power acknowledge
25	Gnd		
26	Gnd		

Table 3-21 Display/Control Connector

AB-J4

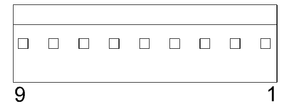


Connector Name Linear Amp Vcom Connector
Connector Type 9 Pin Molex
Destination Linear Amp Module(s)
Via SCC-23-015

Pin #	Function	Signature	Description
1	Vcom1	Analog	Command voltage for axis 1
2	Vcom2	Analog	Command voltage for axis 2
3	Vcom3		Command voltage for axis 3
4	Gnd	Motor Return	
5	Gnd		
6	Key		
7	Vcom4	Analog	Command voltage for axis 4
8	Vcom5	Analog	Command voltage for axis 5
9	Vcom6	Analog	Command voltage for axis 6

Table 3-22 Linear Amp Vcom Connector

AB-J5

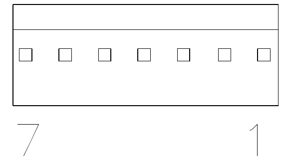


Connector Name Home Switch
Connector Type 9 Pin Molex
Destination CPC-24, Back Panel
Via SCC-23-024

Pin #	Function	Signature	Description
1	HSW1	24 V	Home Switch #1
2	HSW2	24 V	Home Switch #2
3	HSW3	24 V	Home Switch #3
4	HSW4	24 V	Home Switch #4
5	HSW5	24 V	Home Switch #5
6	HSW6	24 V	Home Switch #6
7	HSW7	24 V	Home Switch #7
8	HSW8	24 V	Home Switch #8
9	Key		

Table 3-23 Home Switch/Brake Connector

AB-J6

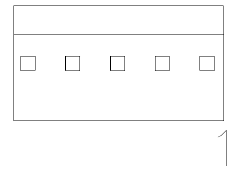


Connector Name Relay/Power Fuse Connector
Connector Type 7 Pin Molex
Destination Fuse Panel
Via SCC-23-021

Pin #	Function	Signature	Description
1	SGBF	Analog/Pwr	Servo gripper control signal, before fuse
2	SGAF	Analog/Pwr	Servo gripper control signal, after fuse
3	24VBF	24 V	Internal 24 V supply, before fuse
4	24VAF	24 V	Internal 24 V supply, after fuse
5	RLYBF	contact	Relay common, before fuse
6	RLYAF	contact	Relay common, after fuse
7	Key		

Table 3-24 Relay/Power Fuse Connector

AB-J7

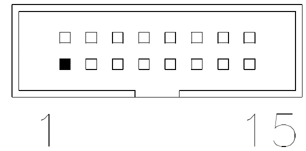


Connector Name Air Gripper/Brake Power Connector
Connector Type 5 Pin Molex
Destination Encoder Connector Board
Via SCC-23-133

Pin #	Function	Signature	Description
1	Servogripper	±15 V	Motor 380 mA max @12 V
2	AirGripOut	12 V	Solenoid 300 mA max @ 12 V
3	Brake Power	35 V	Motor voltage used for brakes fuse @ 2 A
4	Key		
5	Gnd		

Table 3-25 Air Gripper/Brake Power Connector

AB-J8

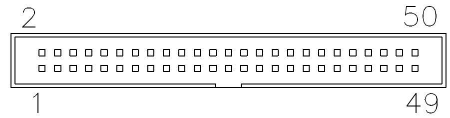


Connector Name V03PWM
Connector Type 16 Pin Ansely Header
Destination PWM, Common Harness
Via SCC-23-013

Pin #	Function	Signature	Description
1	PWMENA	TTL	Global enables for PWM amplifiers
2	Vcom1		Analog ±10 V signal to amplifier
3	PWMENA	TTL	Global enables for PWM amplifier
4	Vcom2		Analog ±10 V signal to amplifier
5	PWMENA	TTL	Global enables for PWM amplifier
6	Vcom3		Analog ±10 V signal to amplifiers
7	PWDIRENA	TTL	Global enables for PWM amplifiers (low true)
8	NORM0	TTL	Amp OK acknowledge returned to AB
9	PWMDIRENA	TTL	Global enables for PWM amplifiers (low true)
10	NORM1	TTL	Amp OK acknowledge returned to AB
11	PWMDIRENA	TTL	Global enables for PWM amplifiers (low true)
12	NORM2	TTL	Amp OK acknowledge returned to AB
13	Gnd		Digital
14	Gnd		
15	Gnd		
16	Gnd		

Table 3-26 VO3PWM

AB-J9



Connector Name General Purpose I/O Connector
Connector Type 50 Pin Ansely Header
Destination Back Panel GPIO
Via SCC-23-023

Pin #	Function	Signature	Description
1	+24 V	24 VDC	Optional Source for 24 V, internal
2	+24 V		
3	IPW	24-40 VDC	Iso Power, externally supplied
4	IPW		
5	GPI1	Opto	General Purpose input #1
6	GPI2	Opto	General Purpose input #2
7	GPI3	Opto	General Purpose input #3
8	GPI4	Opto	General Purpose input #4
9	GPI5	Opto	General Purpose input #5
10	GPI6	Opto	General Purpose input #6
11	GPI7	Opto	General Purpose input #7
12	GPI8	Opto	General Purpose input #8
13	GPI9	Opto	General Purpose input #9
14	GPI10	Opto	General Purpose input #10
15	GPI11	Opto	General Purpose input #11
16	GPI12	Opto	General Purpose input #12
17	GPI13	Opto	General Purpose input #13
18	GPI14	Opto	General Purpose input #14
19	GPI15	Opto	General Purpose input #15
20	GPI16	Opto	General Purpose input #16
21	GPO1	Opto	General Purpose output #1
22	GPO2	Opto	General Purpose output #2
23	GPO3	Opto	General Purpose output #3
24	GPO4	Opto	General Purpose output #4
25	GPO5	Opto	General Purpose output #5
26	GPO6	Opto	General Purpose output #6
27	GPO7	Opto	General Purpose output #7
28	GPO8	Opto	General Purpose output #8
29	GPO9	Opto	General Purpose output #9
30	GPO10	Opto	General Purpose output #10

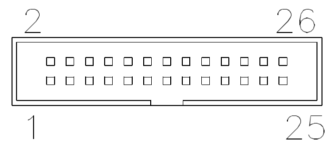
Table 3-27 General Purpose I/O Connector

AB-J9 (Continued)

Pin #	Function	Signature	Description
31	GPO11	Opto	General Purpose output #11
32	GPO12	Opto	General Purpose output #12
33	Shield		
34	N/C		
35	GPO13NC	Relay	General Purpose output #13, Normally closed contact
36	GPO13NO	Relay	General Purpose output #13, Normally open contact
37	GPO14NC	Relay	General Purpose output #14, Normally closed contact
38	GPO14NO	Relay	General Purpose output #14, Normally open contact
39	GPO15NC	Relay	General Purpose output #15, Normally closed contact
40	GPO15NO	Relay	General Purpose output #15, Normally open contact
41	GPO16NC	Relay	General Purpose output #16, Normally closed contact
42	GPO16NO	Relay	General Purpose output #16, Normally open contact
43	RLY		
44	RLY	Relay common	
45	AnalogIn1	Analog	Analog input (0-4.7 V, diode clamped), channel #3 of A/D
46	AnalogIn2	Analog	Analog input (0-4.7 V, diode clamped), channel #4 of A/D
47	IRT	IsoReturn	Return for IPW, externally supplied
48	IRT		
49	Gnd	Digital	Internal ground return for 24 ±10 V
50	Gnd		

General Purpose I/O Connector (Continued)

AB-J10

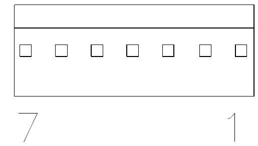


Connector Name SYSIO Connector
Connector Type 26 Pin Ansely Header
Destination Back Panel, DB25
Via SCC-23-022

Pin #	Function	Signature	Description
1	+24 VDC	Power	Optional Source for external I/O, internal supply
2	+24 VDC	Power	Optional Source for external I/O, internal supply
3	IPW	24-40 VDC	Isolated external power
4	IPW		
5	RPS	Opto	Run/Pause Req
6	ERA	Opto	Error signal
7	HMS	Opto	Home Request
8	R0A	Opto	Run/Pause State 0
9	PRS	Opto	Program Reset Req
10	R1A	Opto	Run/Pause State 1
11	CSS	Opto	Cycle Start Req
12	HMA	Opto	Home Ack
13	JigIns	Opto	Jig Installed
14	PRA	Opto	Program Reset Ack
15	APA	Opto	Arm Power Ack
16	CSA	Opto	Cycle Start Ack
17	REMONSW+	Contact	Remote arm ON contact
18	REMONSW-	Contact	Remote arm ON contact
19	REMESTOP+	Contact	Remote E-Stop
20	REMESTOP-	Contact	Remote E-Stop
21	N/C		
22	Shield		
23	IRT	IsoRet	Isolated return for IPW, externally supplied
24	IRT		
25	Gnd	Digital	Internal return for 24 V
26	Gnd		

Table 3-28 SYSIO Connector

AB-J11

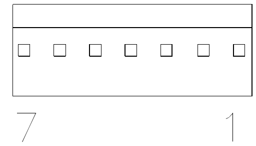


Connector Name Ax1-3 Circuit Breaker Connector
Connector Type 7 Pin Molex
Destination Breakers
Via SCC-23-021

Pin #	Function	Signature	Description
1	Ax1AF	Motor Power	Motor 1 after fuse (breaker)
2	Ax1BF	Motor Power	Motor 1 before fuse (breaker)
3	Ax2AF	Motor Power	Motor 2 after fuse (breaker)
4	Ax2BF	Motor Power	Motor 2 before fuse (breaker)
5	Ax3AF	Motor Power	Motor 3 after fuse (breaker)
6	Ax3BF	Motor Power	Motor 3 before fuse (breaker)
7	Key		

Table 3-29 Ax1-3 Circuit Breaker Connector

AB-J12

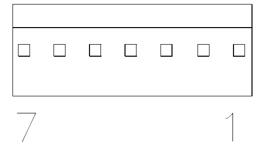


Connector Name	Ax4-6 Circuit Breaker Connector
Connector Type	7 Pin Molex
Destination	Breakers
Via	SCC-23-021

Pin #	Function	Signature	Description
1	Ax4AF	Motor Power	Motor 4 after fuse (breaker)
2	Ax4BF	Motor Power	Motor 4 before fuse (breaker)
3	Ax5AF	Motor Power	Motor 5 after fuse (breaker)
4	Ax5BF	Motor Power	Motor 5 before fuse (breaker)
5	Ax6AF	Motor Power	Motor 6 after fuse (breaker)
6	Key		
7	Ax6BF	Motor Power	Motor 6 before fuse (breaker)

Table 3-30 AX4-6 Circuit Breaker Connector

AB-J13

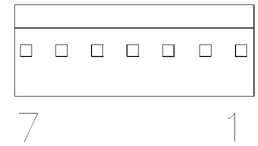


Connector Name Linear Amp Power Supply Out Connector
Connector Type 7 Pin Molex
Destination Linear Amplifier, Power Ctr
Via SCC-23-019

Pin #	Function	Signature	Description
1	Vout+	+35 VDC ±10%	Linear PS+
2	Vout+	+35 VDC	Linear PS+
3	Key		
4	Vout-	-35 VDC ±10%	Linear PS-
5	Vout-	-35 VDC	Linear PS-
6	Gnd	Power Gnd	Return (Ground)
7	Gnd	Power Gnd	Return (Ground)

Table 3-31 Linear Amp Power Supply Out Connector

AB-J14

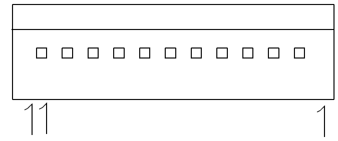


Connector Name	PWM Amp Power Supply Out Connector
Connector Type	7 Pin Molex
Destination	Copley PWM Amp Power Connector
Via	SCC-23-016

Pin #	Function	Signature	Description
1	Vout+	63 V PWM	PWM supply to amplifiers
2	Vout+	63 V PWM	PWM supply to amplifiers
3	Vout+	63 V PWM	PWM supply to amplifiers
4	Key		
5	Ret	Return	PWM supply to amplifiers
6	Ret	Return	PWM supply to amplifiers
7	Ret	Return	PWM supply to amplifiers

Table 3-32 PWM Amp Power Supply Out Connector

AB-J15

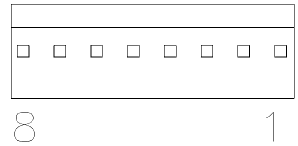


Connector Name High Voltage Power Supply In Connector
Connector Type 11 Pin Molex
Destination Capacitor Power Board (PB)
Via SCC-23-117

Pin #	Function	Signature	Description
1	12 V	12 V	Logic power level, to be used by external arm power control relay
2	APS	TTL	Arm power supply ON signal, to control arm power relay coil
3	PWMNO	PWM	Normally open, from power control relay output
4	PWMNC	PWM	Normally closed, from power control relay output, to internal resistor
5	Key		
6	PWMRET	PWM	Return for PWM power
7	LAIN+	LINPWR	Positive rail, linear power supply input
8	Gnd	LINPWR	0 V linear power supply reference
9	LAIN-	LINPWR	Negative rail, linear power supply input
10	Line	ACLine	For power supply monitoring/brown out/cycle drop out
11	Neutral	ACNeutral	For power supply monitoring/brown out/cycle drop out

Table 3-33 High Voltage Power Supply In Connector

AB-J16



Connector Name Power Supply Connector
Connector Type 8 Pin Molex
Destination CB-J13
Via SCC-23-005 or SCC-23-105

Pin #	Function	Signature	Description
1	+5 V	Power	+5 V supply to the Auxiliary Board
2	Key		
3	+5 V	Power	+5 V supply to the Auxiliary Board
4	Gnd	Power	Return for +5 V, +12 V, -12 V and +24 V
5	Gnd	Power	Return for +5 V, +12 V, -12 V and +24 V
6	+12 V	Power	+12 V supply to the Auxiliary Board
7	-12 V	Power	-12 V supply to the Auxiliary Board
8	+24 V	Power	+24 V supply for isolated I/O (before fuse)

Table 3-34 Power Supply Connector

3-3-4 Controller AC Power System

AC electrical power feeds into the controller at a module at the back of the chassis. This module contains a switch for various international voltages (100, 115, 230 V). For details, refer to the documentation supplied in the fuse kit with each system.

Two contacts in the switch on the front panel switch both phases of the AC power when you press the ON/OFF button. Power is routed to the primary winding of the main transformer. The transformer feeds AC voltage to all the controller power supplies via a number of secondary windings.

- Computer power feeds through a zero-cross switching relay. This relay inhibits electricity from reaching the computer power supply until the AC cycle reaches zero Volts.
- To remove a current spike on a start-up, the path of current is routed through a series resistance for a length of time sufficient to suppress the AC inrush current to 10 Amps. This resistance is then shunted out. The circuit contains a thermal cutoff that opens when the 5 VDC logic level is not present or a high AC overload voltage is detected.
- Linear amplifier power enters through a 50 V center tap. It is rectified and filtered to provide a ±35 VDC supply. This powers all the motor amplifiers, the brakes, and the servo gripper amplifier.
- PWM amplifier power enters via a 45 VAC secondary tap. It is rectified and filtered to provide a 64 VDC supply to the amplifier modules. (This applies only to the A255 Track axes).

3-3-5 Soft Start Board

The pin-outs for the Soft Start board connectors are:

J1

Pin	Function
1	Line In
2	N/C
3	N/C
4	N/C
5	Neutral
6	N/C
7	Line Out

Table 3-36 Soft Start Board J1

J2

Pin	Function
1	Line
2	N/C
3	Neutral

Table 3-35 Soft Start Board J2

J3

Pin	Function
1	Ground
2	+5 V

Table 3-38 Soft Start Board J3

J4

Pin	Function
1	Chassis Ground

Table 3-37 Soft Start Board J4

Note: J3 is included on boards with Rev. 4.0 or earlier.

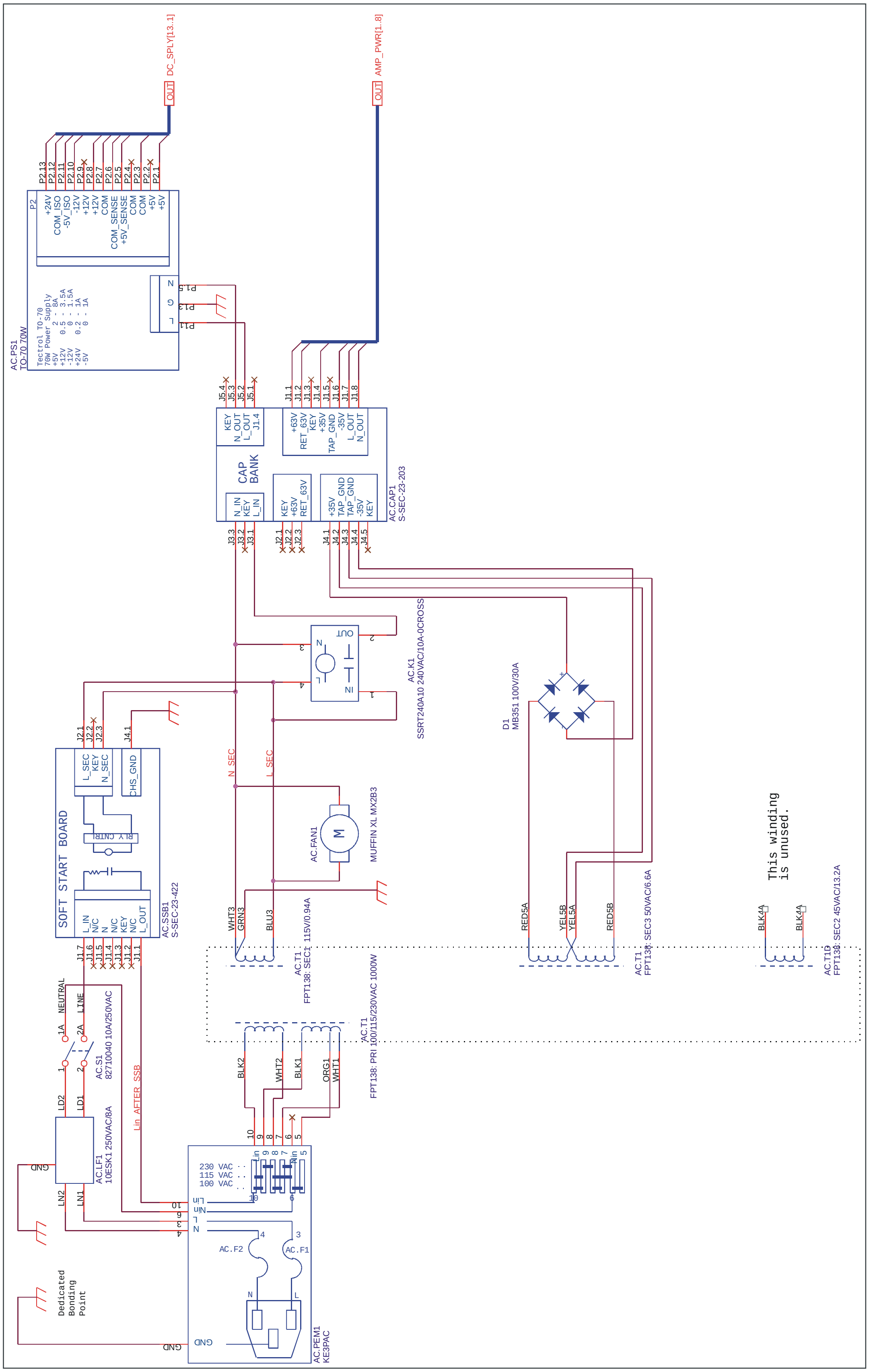


Figure 3-5 Primary Power Circuit A255

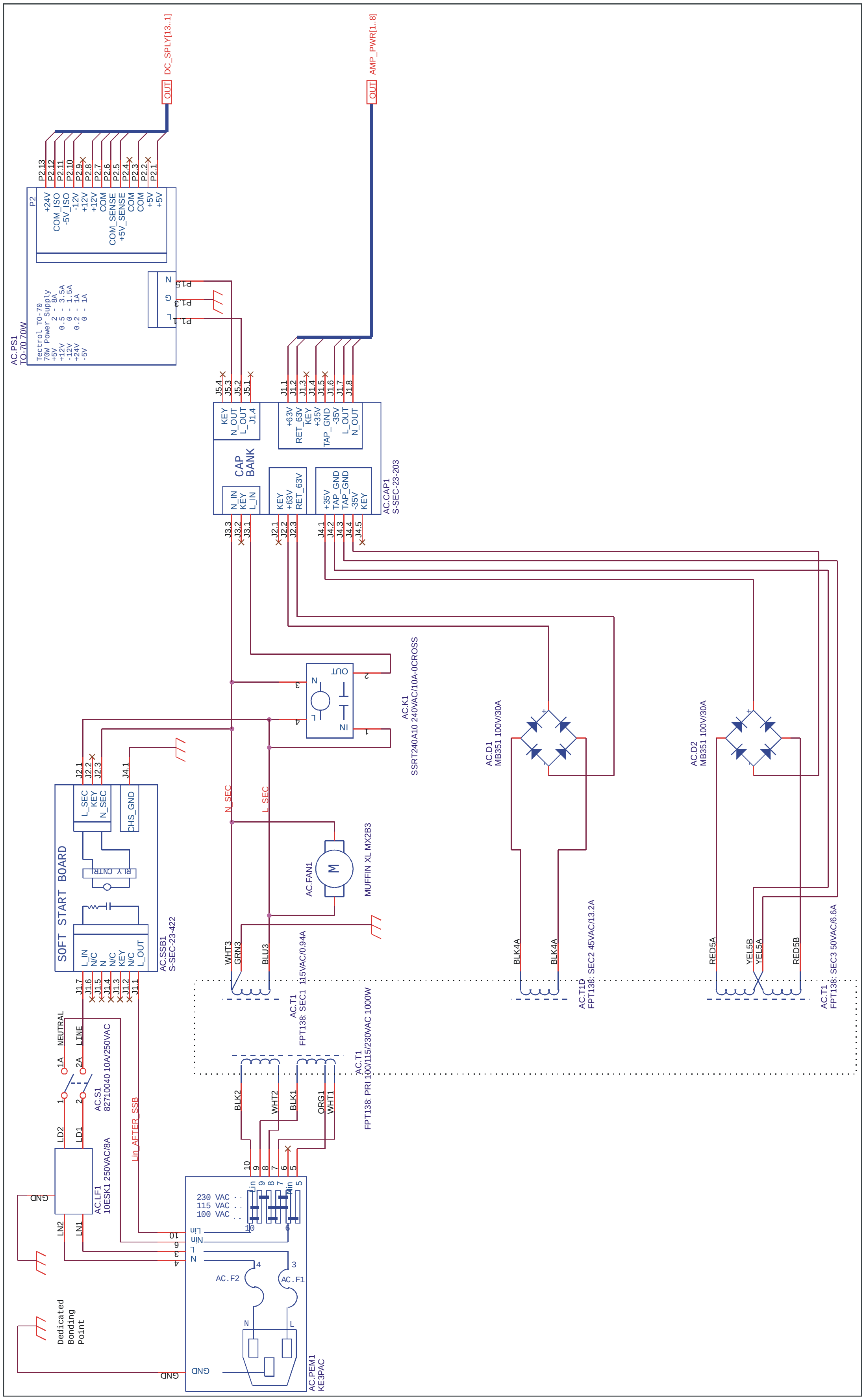


Figure 3-6 Primary Power Circuit T265/A465/T475

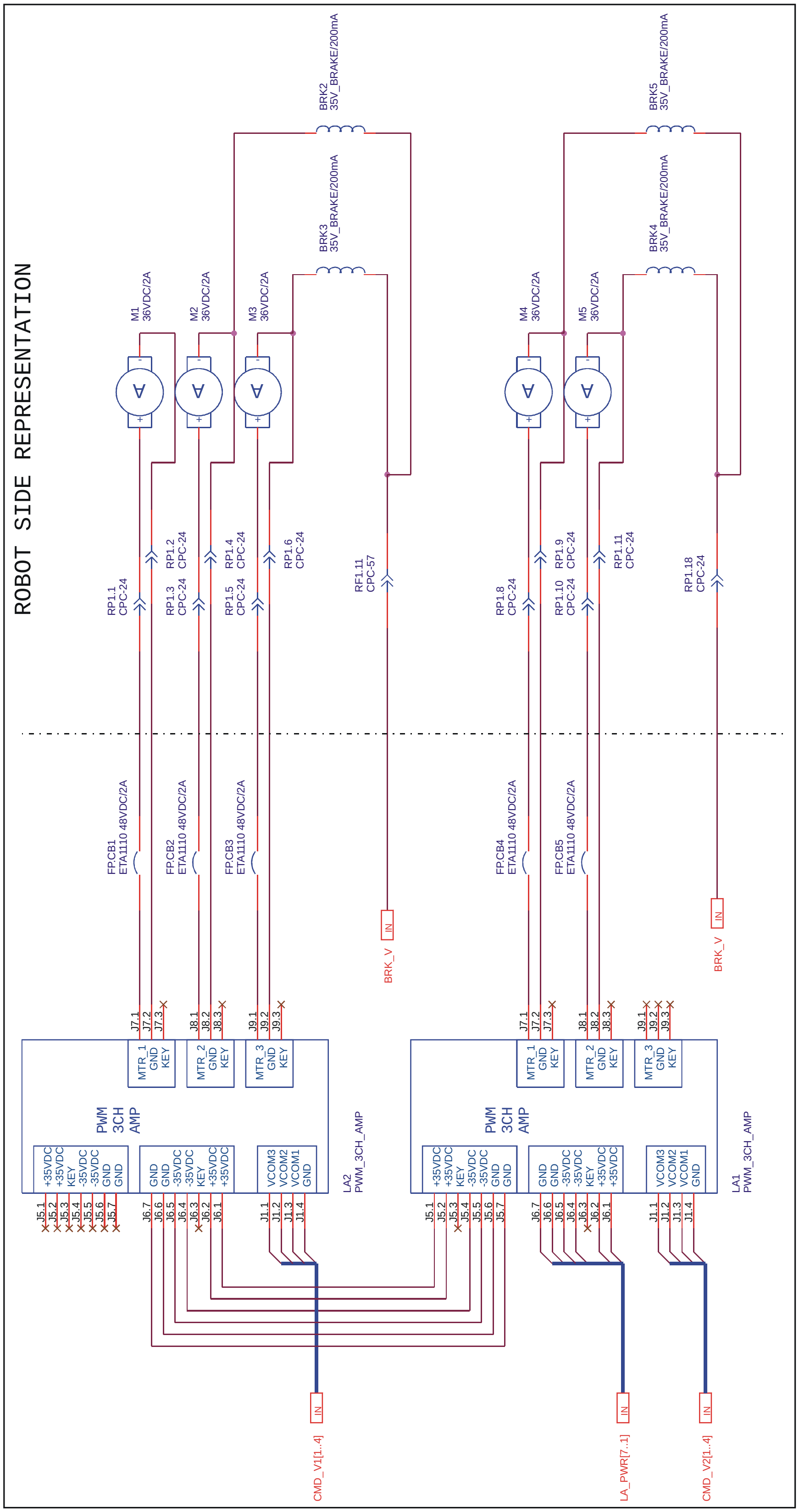


Figure 3-7 A255 Motor Power

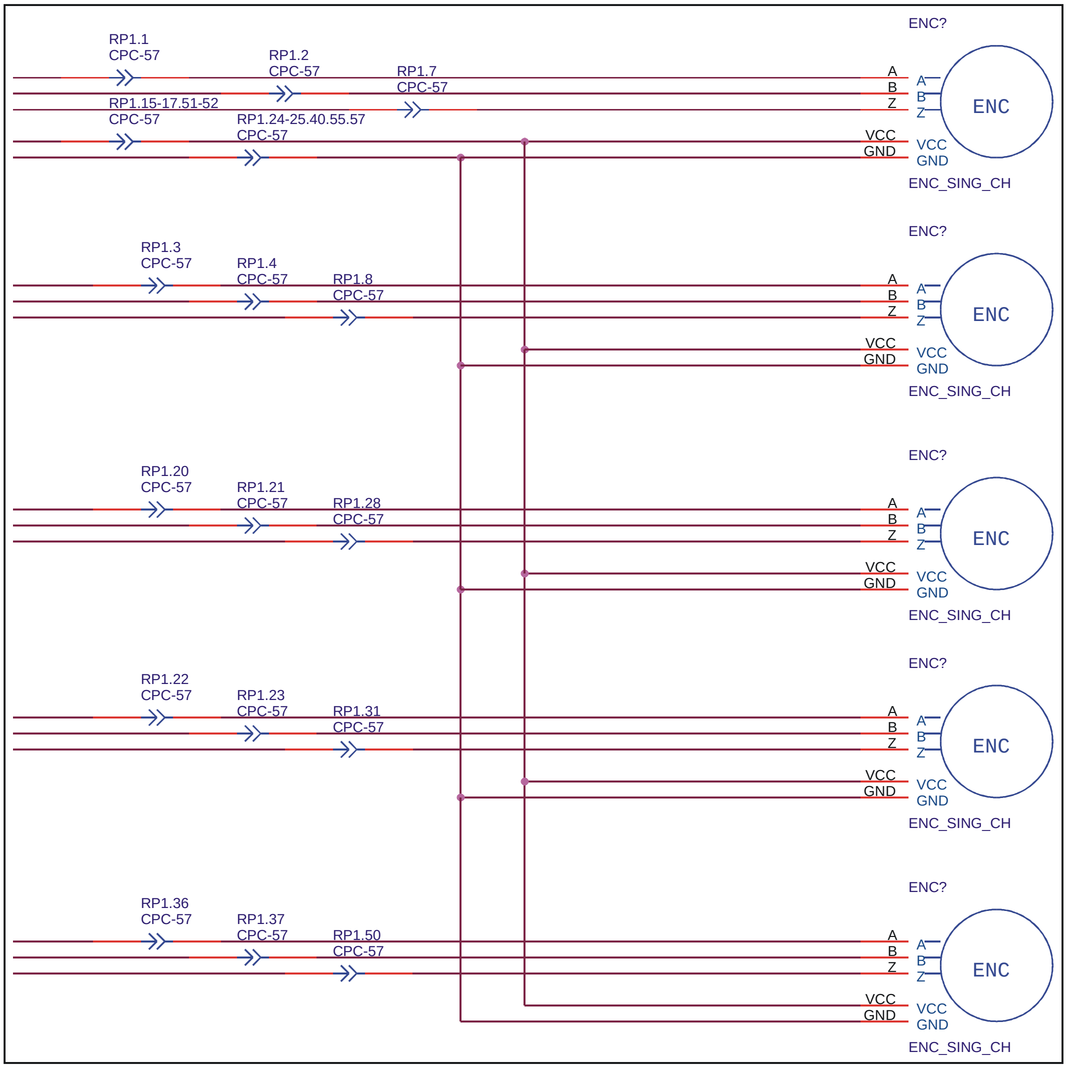


Figure 3-8 A255 Position Feedback From Encoders

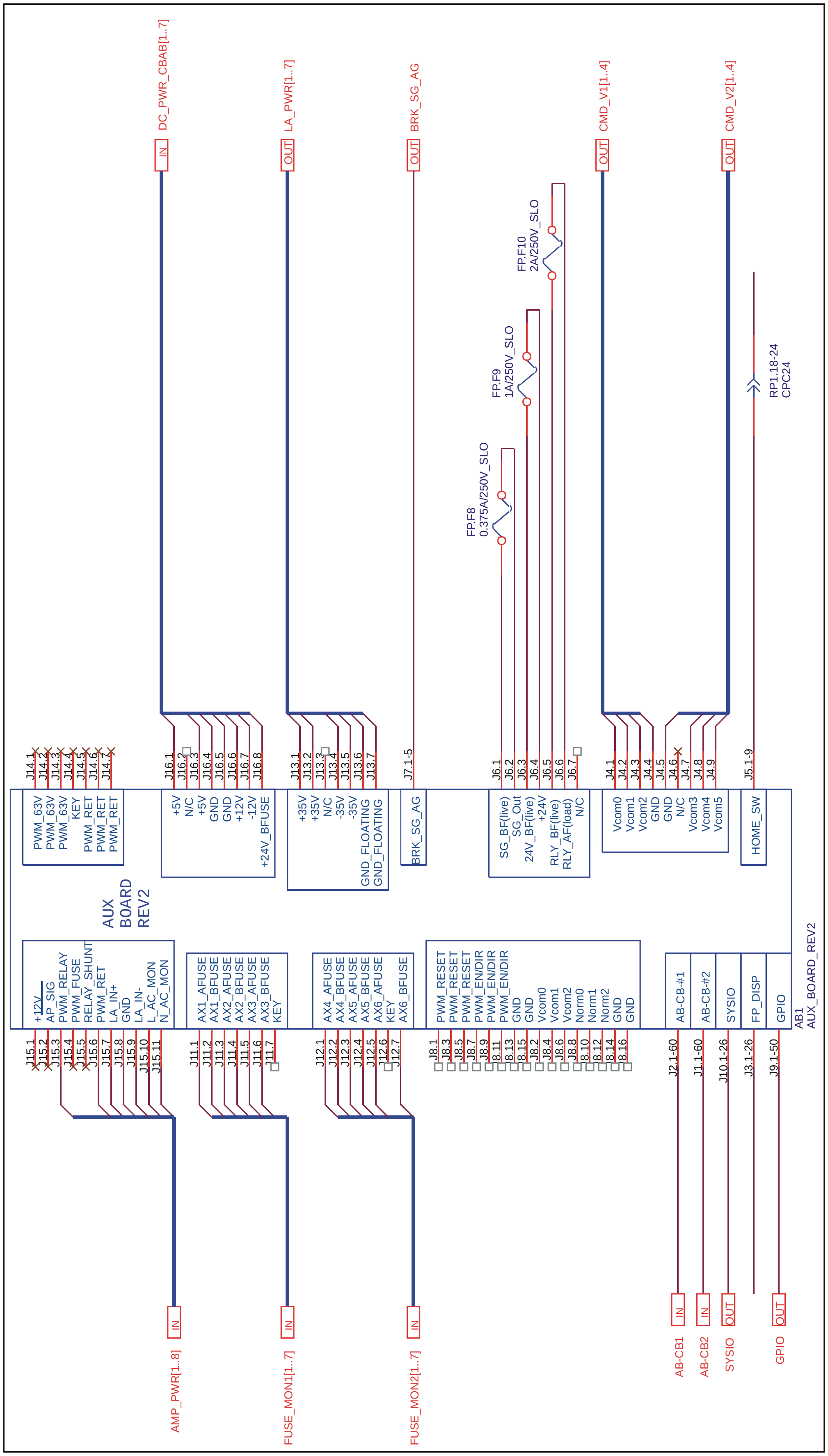


Figure 3-9 A255 Connections to the Auxiliary Board (AB)

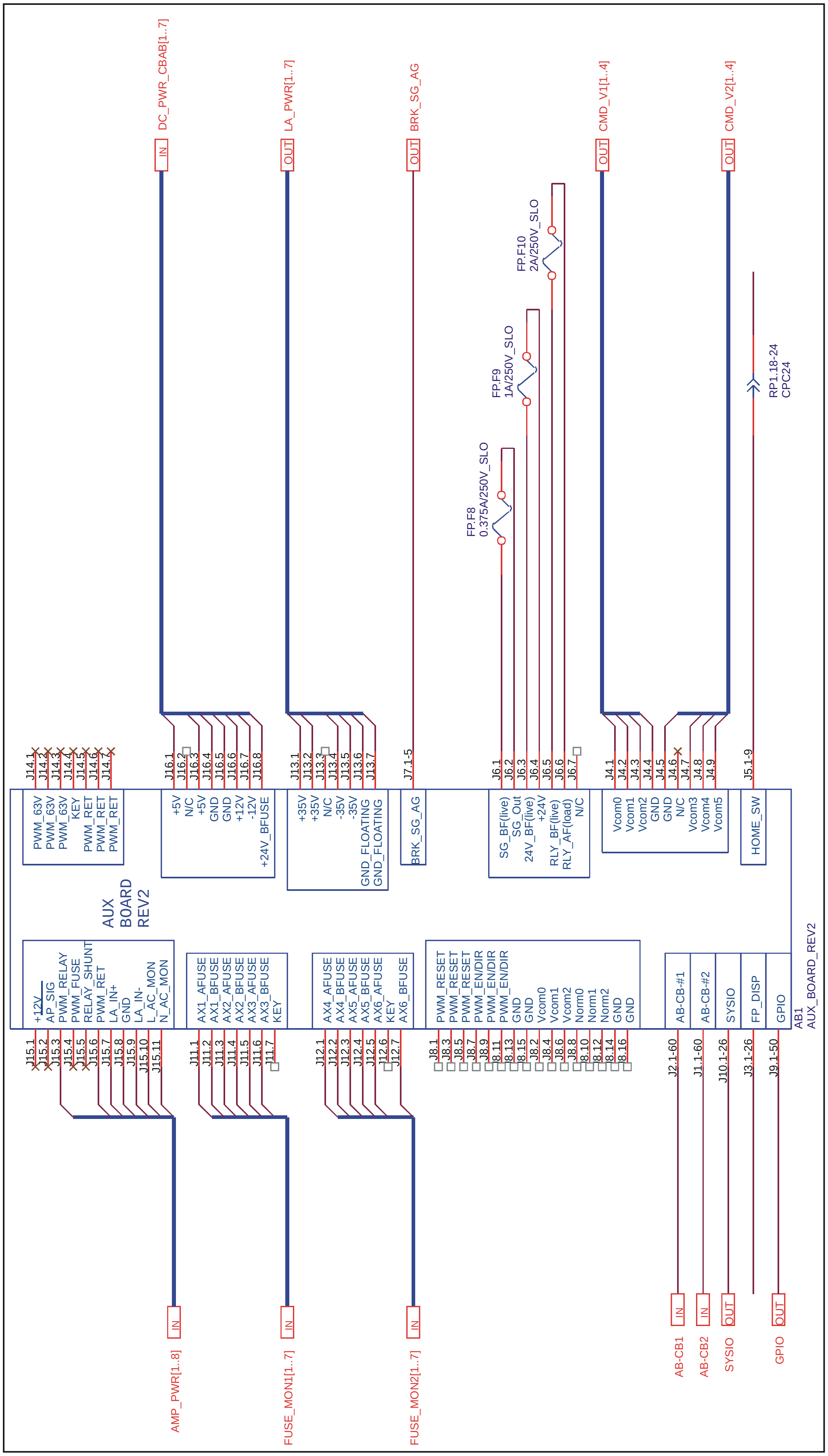


Figure 3-10 A255 Connections to the Controller Board (CB)

3-4 Computer Power Supply and Amplifier Power

The computer power supply is a switching mode supply with four output voltages.

1. +5 VDC at 6.0 A
2. +12 VDC at 1.0 A
3. -12 VDC at 0.5 A
4. +24 VDC at 1.0 A

The supply is safeguarded by over-voltage clamping and short-circuit protection.

3-4-1 Power Supply

The pin-out for the power supply connectors are as follows:

Note: See AC.PS1 in figures 3.7 and 3.8.

J1

Pin	Function
1	Line
2	N/C
3	Ground
4	N/C
5	Neutral

Table 3-39 Power Supply J1

J2

Pin	Function
1	+5 V
2	N/C
3	Ground
4	Ground
5	5 V Sense
6	N/C
7	Ground
8	+12 V
9	N/C
10	-12 V
11	Ground
12	+5 isolated
13	+24 V

Table 3-40 Power Supply J2

3-4-2 Power Filter Board

This board, located in the amplifier section, takes power coming from the transformer via rectifiers and filters it for the required amplifiers.

Note: See AC.CAP1 in figures 3.7 and 3.8.

J1

Pin	Function
1	+65 V
2	Ground
3	N/C
4	+35 V
5	Ground
6	-35 V
7	Neutral
8	Line

Table 3-41 Power Filter Board J1

J2

Pin	Function
1	Line 115 VAC
2	N/C
3	Neutral 115VAC

Table 3-42 Power Filter Board J2

J3

Pin	Function
1	Ground
2	+5 V

Table 3-43 Power Filter Board J3

J4

Pin	Function
1	+35 V
2	Ground
3	Ground
4	-35 V
5	N/C

Table 3-44 Power Filter Board J4

J5

Pin	Function
1	N/C
2	Line
3	Neutral
4	N/C

Table 3-45 Power Filter Board J5

3-4-3 Linear Amp/Brake/Gripper Power

This power supply consists of a step-down transformer (50 VAC at 7 A), a bridge rectifier, and two filter capacitors on the power filter board. The output is ±35 VDC at 10 A and is unregulated.

As soon as arm power is turned on, power feeds to the servo gripper circuit, and to the linear amplifiers. The brakes release and the positional servo takes over to maintain the position of the robot joints.

3-4-4 Power Supply Function of Auxiliary Board

Power passes from the power filter board to the auxiliary board via an intermediate wiring harness. The auxiliary board, located in the controller's upper compartment, performs the following power supply functions:

1. Protects the ±35 VDC linear Amp/brake/gripper power supply with a 10 Amp/250 Volt fast blow fuse for each rail.
2. Protects the brake circuit with a 2 Amp/250 Volt slow blow fuse.
3. Monitors the input AC voltage for a low voltage condition. If a low voltage condition occurs, then the arm power is turned off and the controller is shut down. The battery manager then senses shut-down and transfers battery power to protect memory.
4. Switches the brake/gripper power (to the DC amplifiers) according to a signal from the controller board.

Danger! There is a potential of a shock hazard if you are removing or replacing the fuses. Bleed the capacitor bank with a 2 k Ω resistor (5 Watt or larger).

3-5 Amplifier Electronics

The amplifiers are located in the right hand side of the controller compartment.

Quantity	Module Number	Location
2	SEC-13-903 -or- SEC-920-001* * For PWM amp serial numbers greater than PWMXXX	Right Side of Compartment

The DC Amplifiers drive each axis of the robot arm. The supply rail voltage to these modules is ±35 VDC (refer to section 3-4 Computer Power Supply and Amplifier Power).

3-5-1 Linear Amplifier Module

The DC Amplifier Module contains three separate amplifiers, each supplied with ±35 VDC. The command signal to each amplifier is 0 V to ±10 VDC. The output is the motor voltage of ±25 VDC at a rated 2 Amps each.

Each module has an adjustable gain in the range of x1 to x 2.8. It has no phase reversal and a low crossover distortion.

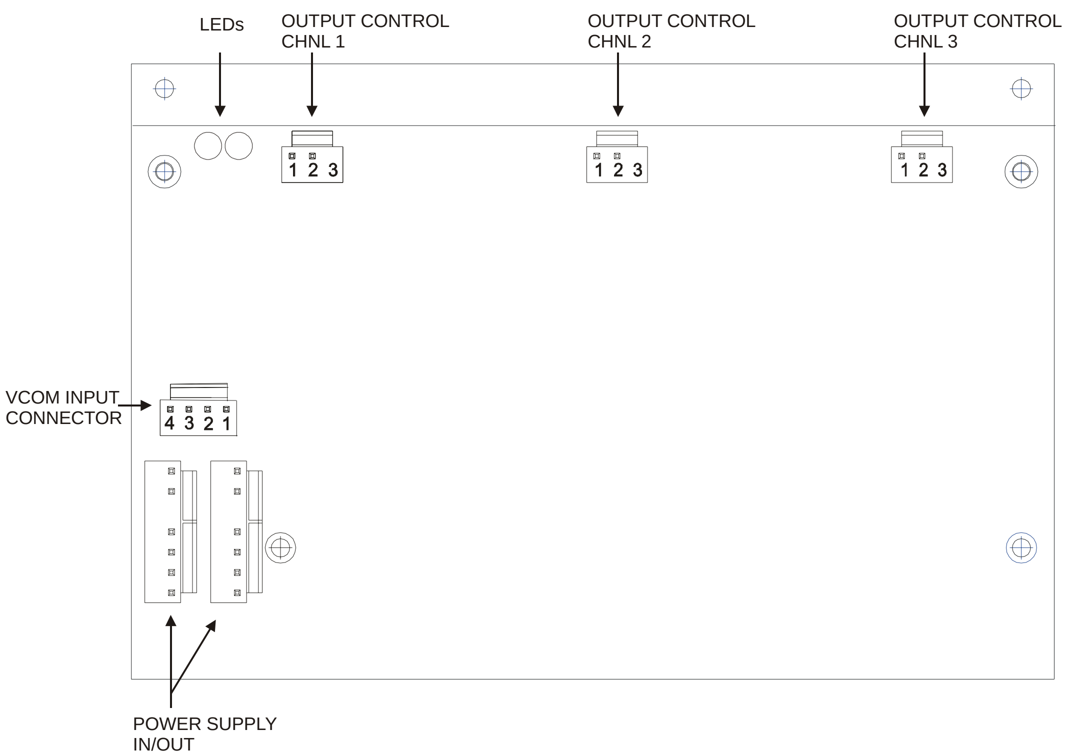


Figure 3-11 Linear Amplifier Module

3-5-2 Linear Amplifier Connectors

The following tables refer to the Amplifier Module connectors, see Figure 3-11 Linear Amplifier Module, and Figure 3-7 A255 Motor Power.

Note: See LA1 and LA2 in Figure 3-7 A255 Motor Power.

1. The 4-pin Molex VCOM Input connector labeled Vin, connects the command signals from the servo axis output to the amplifier module. The signal level is ±10 VDC at 20 mA. The pin-out configuration of this connector is shown below:
J1

Pin	Function (Amp #1)	Function (Amp #2)
1	Reference GND	Reference GND
2	Vcom I/P 1	Vcom I/P4
3	Vcom I/P 2	Vcom I/P5
4	Vcom I/P 3	Vcom I/P6 (extra)

Table 3-46 Amplifier Input Connector Pin-out

2. Two 7-pin Molex connectors for Power Supply In/Out connect the amplifier module to the Arm Power Supply carrying ±35 VDC at 10 Amps. The pin-out is shown below:
J5 and J6

Pin	Function
1	GROUND
2	GROUND
3	-35 VDC RAIL
4	-35 VDC RAIL
5	KEY
6	+35 VDC RAIL
7	+35 VDC RAIL

Table 3-47 Amplifier Power Supply Connector Pin-out

3. Three 3-pin Output Control connectors for motor power output connect the amplifier module to the DC servo motors. The pin-out is as shown below:
J7, J8, and J9

Pin	Function
1	KEY
2	RETURN
3	Motor Output Voltage

Table 3-48 Motor Output Connector Pin-out

4. Three 20K, 20-turn trim pots. The amplifier gain is increased by turning the adjusting screw counter-clockwise.
5. Three test points, TP1, TP2, and TP3. The voltage at the each test point corresponds to the motor armature voltage for the respective axis.

J1 Connector

For a pin-out of the J1 connector refer to Table 3-21 Display/Control Connector.

3-5-3 PWM Amplifiers

The T265 track system contains one Copley Model 900-12 PWM amplifier in axis 6. The amplifier is fed with a 64 VDC rail voltage from the capacitor board, and provided with ±10 V command signals from the controller board. In addition, the amplifier is fed with two complimentary, redundant enable signals from the controller board.

The proper configuration for the T265 track system is shown in the following table:

	Robot Type													
	A460			A465			T475			T265		G300		
Enabling Jumper (Location 3)	Installed			Removed			Removed			Removed		Removed		
Joint #	J1	J2	J3	J1	J2	J3	J1	J2	J3	J7	J6	J1	J2	J3
Peak Current Resistor Value (Location 4)*	1.8	10	1.8	1.8	10	1.8	1.8	10	1.8	10	10	1.8	1.8	10

* Resistors given in Kohms.

Table 3-49 T265 Track System Configuration

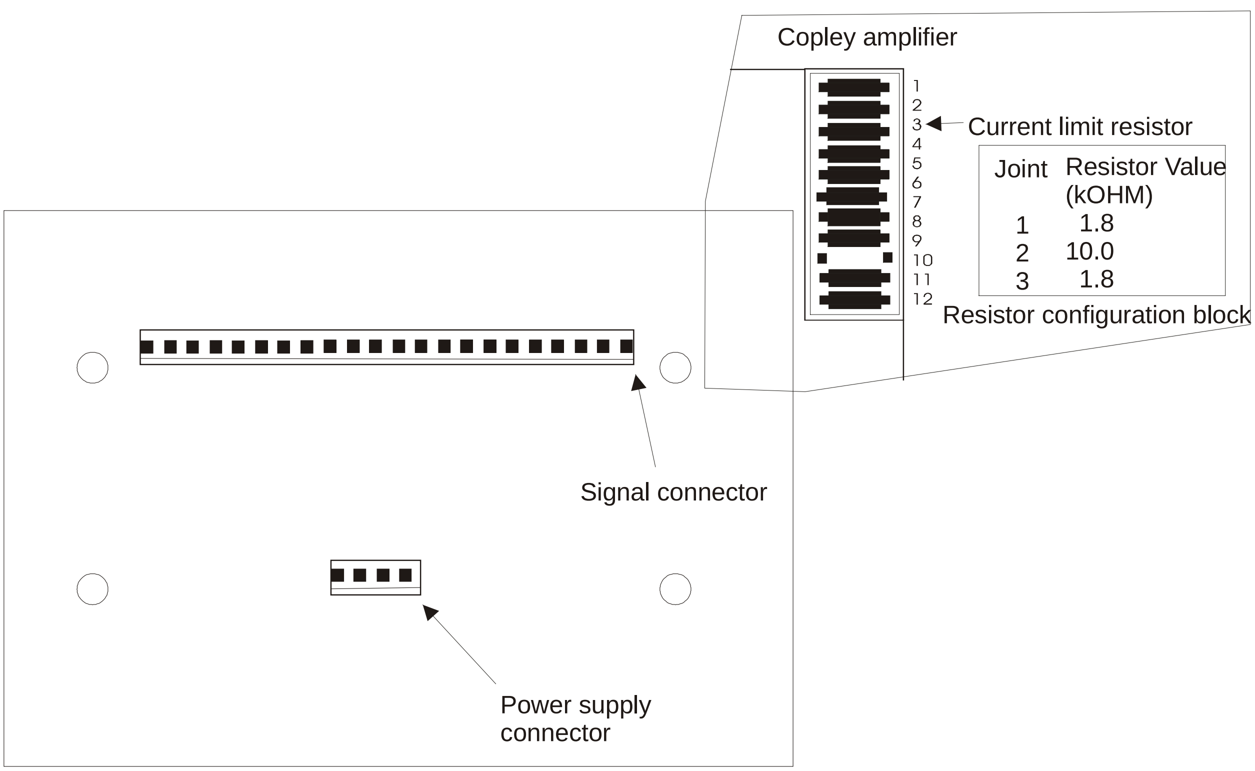


Figure 3-12 PWM Amplifier for the T265 Track

3-5-4 PWM Amplifier Connectors

Refer to the following tables for the pin-outs of the PWM amplifier connectors:

4 Pin Power Connector

	Type	Remarks
AA	Passive	+HV, the high-voltage DC power input
BB	Output	Out- , or negative output
CC	Output	Out+ , or positive output
DD	Passive	Ground and +HV power return

Table 3-50 PWM - 4 Pin Molex Connector

22 Pin Signal Connector

Pin	Type	Signal	Remarks
1 (A)	Input	+Ref	Differential (+) reference signal input
2 (B)	Input	-Ref	Differential (-) reference signal input
3 (C)	Passive	Signal Gnd	Gnd for tachometer, signal gnd
4 (D)	Output	Ref Amp out	Output of differential input amplifier
5 (E)	Input	Aux input	Auxiliaary input
6 (F)	Output	+11 V	20 K Ohms in series with +11 V
7 (G)	Passive	Logic gnd	Gnd for Enable inputs
8 (H)	Output	-11 V	20 K Ohms in series with -11 V
9 (I)		N/C	No connection to this pin
10 (J)	Input	/Reset	LO or Gnd to reset fault condition
11 (K)	Output	PreAmp out	See schematic
12 (L)		Opt. Ext. comp	See schematic
13 (M)	Input	Tach input	Tachometer input
14 (N)		Opt. Ext. comp	See schematic
15 (O)	Input	/Enable	LO or Gnd to enable amplifier
16 (P)	Input	/Pos Enable	LO or Gnd to enable positive output
17 (Q)	Input	/Neg Enable	LO or GND to enable negative output
18 (R)	Output	+14 V	1K Ohms in series with +14 V
19 (S)	Output	Normal	HI (+5 V) when amplifiers operating Normally
20 (T)	Output	+5 V	2.49 K in series with internal +5 V
21 (U)		N/C	
22 (V)	Output	Current monitor	Outputs ±6 V at amplifier peak current

Table 3-51 PWM - 22 Pin Signal Connector

3-5-5 T265 Track Connectors

The following table shows the track amplifier wiring as the signals are passed from the Copley Amp Phoenix connector through to the 14 pin Amp Motor Power connector.

Signal	Passage of the Signal Through the Connectors			
	Copley Amp Phoenix Connector	**Track Filter Molex Connector**	**Track Filter Phoenix Connector**	**14 Pin Amp Motor Power Connector**
AA	65 V Power In	AA (NC)	1 (NC)	
BB	Out (–)	BB (–)	2 (–)	12
CC	Out (+)	CC (+)	3 (+)	13
DD	Chassis Gnd	DD Chassis Gnd	4 Chassis Gnd	

Table 3-52 T265 Track Connectors

3-6 Front Panel Display Board

Part Number SEC-23-300T

The display board contains the main user controls and status display. It has five user accessible momentary contact switches and a 2-digit LED display.

J2 E-Stop Connector

Pin	Function
1	E-Stop+
2	E-Stop-

Table 3-53 E-Stop Connector

The function of each of these switches is described below:

CYCLE START This button is used to start a pre-programmed procedure or to resume after a programmed pause. The small LED in the upper right corner flashes to attract attention if the procedure is halted and the robot operator is expected to perform a task. The procedure resumes when the operator presses the button (see the ONSTART command in the RAPL-II Programming Manual).

PROG (program) RESET This button is used to return control of the current program cycle to the beginning. It is generally used if other equipment in the robot work cell is malfunctioning. This situation would generally require that the robot work cell be cleared, the robot program reset, and then restarted.

PROG (program) RUN/PAUSE This is used to halt the current program if the operator detects a problem. The LED flashes to indicate the program has been halted at an unscheduled spot. When the cause of the problem is rectified, press the button which allows the robot to proceed in the current program without having to return to the beginning.

HOME This initiates either the home program or the HOME command, depending on the resident programs. After successful execution of the home program/command, the button LED comes on and stays on, indicating that the arm is homed. The ARM POWER must be on in order to home the robot.

ARM POWER This button enables the arm power circuit by disengaging the brakes and latching the Linear Amp relays and the PWM enable circuit. The button LED stays lit as long as arm power remains on. The Serial Teach Pendant (STP) or the override plug must be connected and the e-stop(s) engaged in order to turn on arm power.

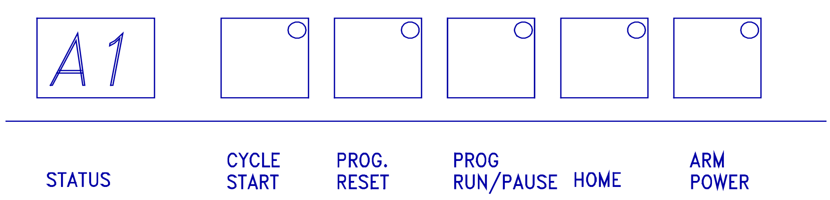


Figure 3-13 Front Panel Function Buttons

3-6-1 Front Panel Display Board Connectors

The following tables list the pin-outs for the front panel display board connectors.

J1

Pin #	Function	Description
1	Vcc	Logic power
2	+12 V	
3	Digit0	Hex Display
4	FPESTOP-	ESTOP
5	Digit1	Hex Display
6	FPMOMSW+	Arm Power momentary switch
7	Digit2	Hex Display
8	FPMOMSW-	Arm Power momentary switch
9	Digit3	Hex Display
10	FPRPSW	Run/Pause switch
11	Digit4	Hex Display
12	FPHOMESW	Home request switch
13	Digit5	Hex Display
14	FPPRSTSW	Program reset switch
15	Digit6	Hex Display
16	FPCYCSW	Cycle start switch
17	Digit7	Hex Display
18	HMA	Home Acknowledge signal
19	BLANK	Blanking control
20	PRA	Program reset acknowledge
21	R0A	Run/Pause state 0
22	CSA	Cycle start acknowledge
23	R1A	Run/Pause state 1
24	APA	Arm power acknowledge
25	Gnd	
26	Gnd	

Table 3-54 Front Panel Display Board Connector J1

J2

Pin #	Function	Description
1	+12 V	Logic power
2	FPESTOP-	E-stop

Table 3-55 Front Panel Display Board Connector J2

3-7 Encoder Connector Board

Part Number S-SEC-23-204T

The following tables list the pin-outs for the encoder board connectors.

J1

Pin #	Function	Description
1	A1+	Axis 1 Channel A input
2	A1-	Axis 1 Channel A input (complementary)
3	B1+	Axis 1 Channel B input
4	B1-	Axis 1 Channel B input (complementary)
5	Z1+	Axis 1 Channel Z input
6	Z1-	Axis 1 Channel Z input (complementary)
7	A2+	Axis 2 Channel A input
8	A2-	Axis 2 Channel A input (complementary)
9	B2+	Axis 2 Channel B input
10	B2-	Axis 2 Channel B input (complementary)
11	Z2+	Axis 2 Channel Z input
12	Z2-	Axis 2 Channel Z input (complementary)
13	A3+	Axis 3 Channel A input
14	A3-	Axis 3 Channel A input (complementary)
15	B3+	Axis 3 Channel B input
16	B3-	Axis 3 Channel B input (complementary)
17	Z3+	Axis 3 Channel Z input
18	Z3-	Axis 3 Channel Z input (complementary)
19	A4+	Axis 4 Channel A input
20	A4-	Axis 4 Channel A input (complementary)
21	B4+	Axis 4 Channel B input
22	B4-	Axis 4 Channel B input (complementary)
23	Z4+	Axis 4 Channel Z input
24	Z4-	Axis 4 Channel Z input (complementary)
25	A5+	Axis 5 Channel A input
26	A5-	Axis 5 Channel A input (complementary)
27	B5+	Axis 5 Channel B input
28	B5-	Axis 5 Channel B input (complementary)
29	Z5+	Axis 5 Channel Z input
30	Z5-	Axis 5 Channel Z input (complementary)
31	A6+	Axis 6 Channel A input
32	A6-	Axis 6 Channel A input (complementary)
33	B6+	Axis 6 Channel B input
34	B6-	Axis 6 Channel B input (complementary)
35	Z6+	Axis 6 Channel Z input
36	Z6-	Axis 6 Channel Z input (complementary)
37	N/C	No Connect
38	Shield	No Connect
39		
40		
41	SGPos	Servo gripper position
42	SGTor	Servo gripper torque (not used)
43	AirGrip-	Solenoid return
44	Gnd	
45		
46	Gnd	
47	+12 V	+12 Volt supply to the servo gripper/Air Gripper Solenoid
48	Gnd	
49	+12 V	+12 Volt supply to the servo gripper/Air Gripper Solenoid
50	Gnd	

Table 3-56 Encoder Connector Board J1

J2

Pin #	Function	Description
1	+5Enc	Isolated encoder supply
2	Gnd	Ground: Encoder power supply return
3	+5Enc	Isolated encoder supply
4	Gnd	Ground: Encoder power supply return
5	+5Enc	Isolated encoder supply
6	Gnd	Ground: Encoder power supply return
7	+5Enc	Isolated encoder supply
8	Gnd	Ground: Encoder power supply return
9	+5Enc	Isolated encoder supply
10	Gnd	Ground: Encoder power supply return

Table 3-57 Encoder Connector Board J2

J3

Pin #	Function	Description
1	Servogripper	Motor 380 mA max @15 V
2	AirGripOut	Solenoid 300 mA max @ 12 V
3	Brake Power	Motor voltage used for brakes fuse @ 2 A +35V
4	NC	
5	Gnd	

Table 3-58 Encoder Connector Board J3

C H A P T E R 4

4 Wiring and Connectors

4-1 Introduction

This chapter describes the locations and functions of all the controller's panel connectors and the robot arm wiring harnesses. Included are:

- Front Panel Connectors
- Rear Panel Connectors
- Arm Wiring Harnesses
- Front Panel Connectors

4-2 Front Panel Connectors

The A255 controller front-panel connections are shown in Figure 4-1.

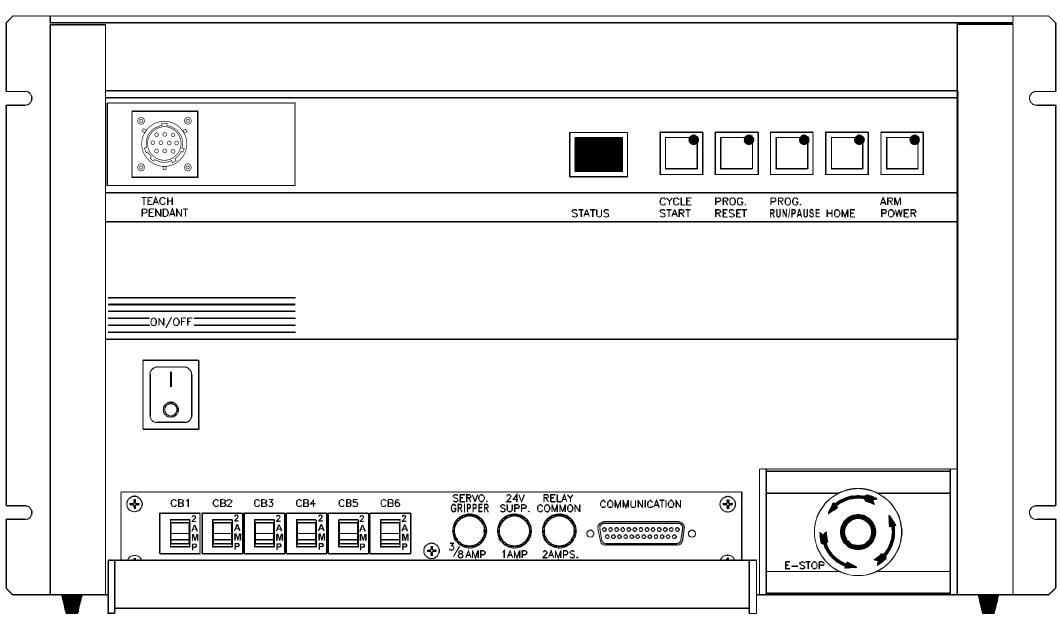
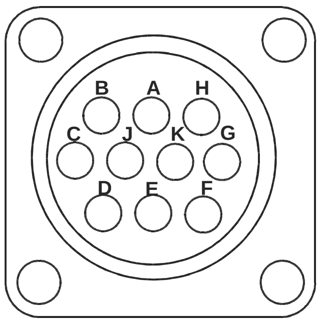


Figure 4-1 A255 Controller front panel connectors with access door flipped down.

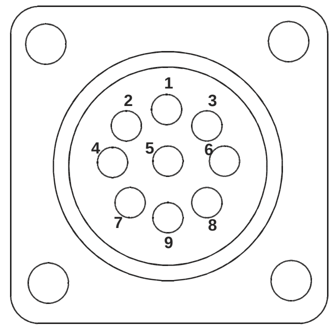
4-2-1 Teach Pendant Connector

The teach pendant connector is located at the upper left of the controller front panel. It is either a Cannon KPT style 10 pin connector, or an AMP style 9 pin connector. The teach pendant controls the robot arm when the robot is in Manual Mode. It can also start and stop the system.

In cases where the teach pendant is not required, use the override plug in the connector to enable start-up.



Cannon KPT style 10 pin connector



AMP style 9 pin connector

Cannon KPT Style 10 Pin Connector		**AMP Style 9 Pin Connector**	
Pin	**Function**	**Pin**	**Function**
A	Pendant Installed	1	Pendant Installed
B	TX	2	TX
C	Ground	3	RX
D	T.P. e-stop+	4	Ground
E	T.P e-stop-	5	Liveman-
F	Vcc	6	Liveman+
G	Liveman+	7	T.P. e-stop+
H	RX	8	T.P e-stop-
J	Shield	9	Vcc
K	Liveman-		

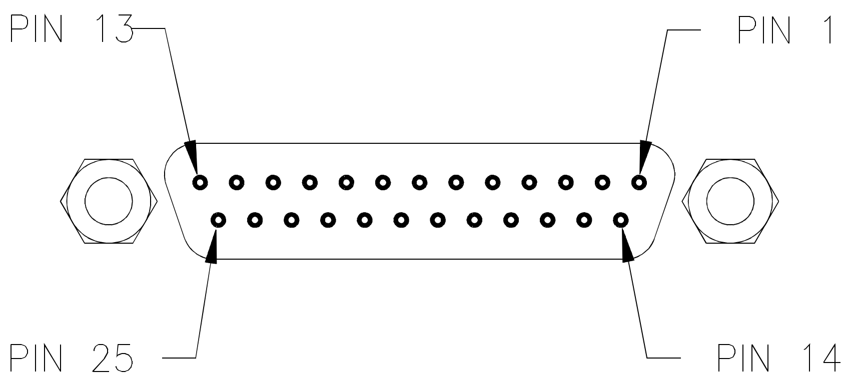
Table 4-1 Teach Pendant Connector Pin-out

4-2-2 Communication Serial Connector

This is a standard 25-pin D type female receptacle. Signal level compatibility is maintained with RS232 standard. In addition, it provides power connections on unused pins and supplies power for the CRS Robotics RS422 conversion option. Baud rates from 50 to 38400 are supported. Table 4-2 lists the pin out for this connector.

The RS422 enable connection permits multi-drop function for use with the ACI protocol. With this pin LO, the outputs are disabled and the connector is in “listen” mode. The ACI protocol software controls this pins logic.

Pin 1 (Chassis GND) is left floating.



Pin #	Function	Pin #	Function
1	CHASSIS	14	N/C
2	RXD	15	N/C
3	TXD	16	N/C
4	CTS	17	N/C
5	RTS	18	-12 VDC
6	DTR	19	N/C
7	GND	20	DSR
8	N/C	21	N/C
9	RS422 Enable	22	N/C
10	N/C	23	N/C
11	+12 VDC	24	N/C
12	N/C	25	+5 VDC
13	N/C		

Table 4-2 Communication Serial Connector Pin Functions

4-3 Controller Rear Panel Connectors

The controller rear panel, shown in Figure 4-2, contains the connectors for interfacing to the robot arm, as well as general I/O interfacing connectors include:

- System I/O (SYSIO)
- General Purpose I/O (GPIO)
- CPC-57 Robot Feedback Connector
- CPC-28 Expansion Amp (Optional)
- CPC-24 Motor Power Connector

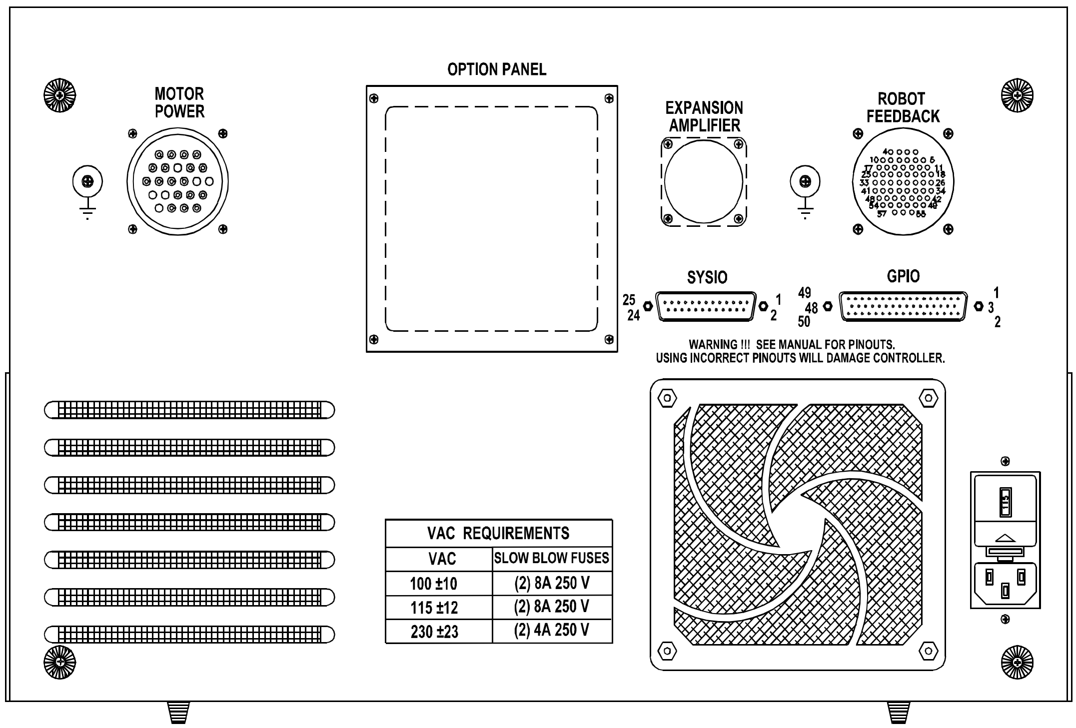
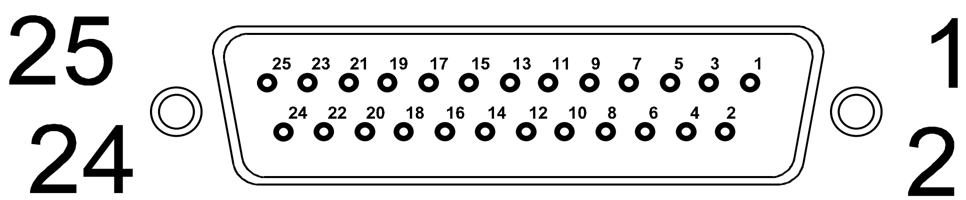


Figure 4-2 C500 Controller Rear Panel Connectors.

4-3-1 System I/O (SYSIO)

The SYSIO connector provides access to the front panel switch signals, permitting these functions to be controlled from a remote location. The pin-out is shown in Table 4-3. **Refer to the pin-out diagram on this page and not the actual numbers on the connector. Each connector manufacturer may use a different standard.**



Pin #	Function	Signature	Description
1	+24 V	Power	Optional Source for external I/O, internal supply
2	+24 V	Power	Optional Source for external I/O, internal supply
3	IPW	24-40 VDC	Isolated external power
4	IPW	24-40 VDC	Isolated external power
5	RPS	Opto	Run/Pause Request
6	ERA	Opto	Error signal
7	HMS	Opto	Home Request
8	R0A	Opto	Run/Pause State 0
9	PRS	Opto	Program Reset Request
10	R1A	Opto	Run/Pause State 1
11	CSS	Opto	Cycle Start Request
12	HMA	Opto	Home Ack
13	JigIns	Opto	Jig Installed
14	PRA	Opto	Program Reset Ack
15	APA	Opto	Arm Power Ack
16	CSA	Opto	Cycle Start Ack
17	REMONSW+	Contact	Remote arm ON contact
18	REMONSW-	Contact	Remote arm ON contact
19	REMESTOP+	Contact	Remote e-stop
20	REMESTOP-	Contact	Remote e-stop
21	N/C		
22	Shield		
23	IRT	IsoRet	Isolated return for IPW, externally supplied
24	IRT	IsoRet	Isolated return for IPW, externally supplied
25	Gnd	Digital	Internal return for 24 V

Table 4-3 System I/O (SYSIO) Pin Descriptions

SYSIO Connector

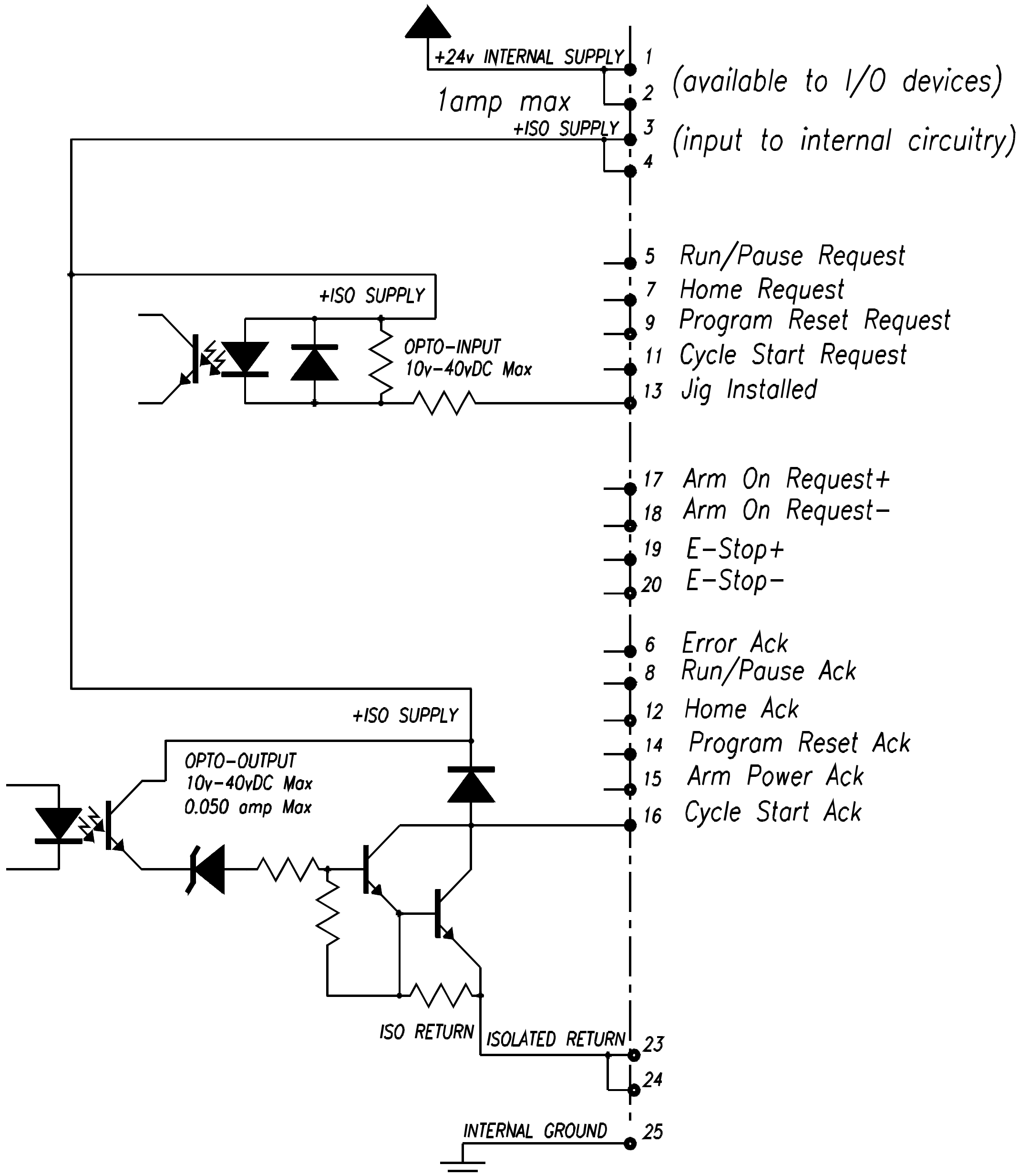
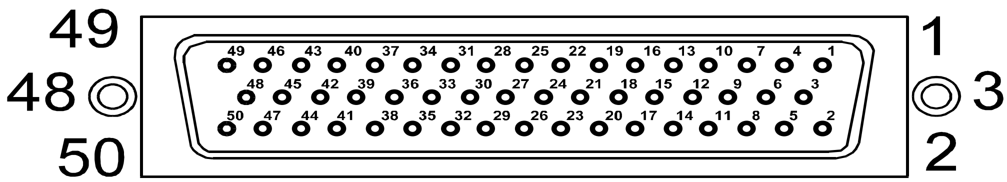


Figure 4-3 C500 SYSIO connector description.

4-3-2 General Purpose I/O (GPIO)

The GPIO connector allows the controller to control or monitor other machines. **Refer to the pin-out diagram on this page and not to the actual numbers on the connector. Each connector manufacturer may use a different standard.** The pin-outs are shown in Table 4-4.



Pin #	Function	Signature	Description
1	+24 V	24 VDC internal	Optional Source for 24 V, internal
2	+24 V	24 VDC internal	Optional Source for 24 V, internal
3	IPW	24-40 VDC	Iso Power, externally supplied
4	IPW	24-40 VDC	Iso Power, externally supplied
5	GPI1	Opto	General Purpose input #1
6	GPI2	Opto	General Purpose input #2
7	GPI3	Opto	General Purpose input #3
8	GPI4	Opto	General Purpose input #4
9	GPI5	Opto	General Purpose input #5
10	GPI6	Opto	General Purpose input #6
11	GPI7	Opto	General Purpose input #7
12	GPI8	Opto	General Purpose input #8
13	GPI9	Opto	General Purpose input #9
14	GPI10	Opto	General Purpose input #10
15	GPI11	Opto	General Purpose input #11
16	GPI12	Opto	General Purpose input #12
17	GPI13	Opto	General Purpose input #13
18	GPI14	Opto	General Purpose input #14
19	GPI15	Opto	General Purpose input #15
20	GPI16	Opto	General Purpose input #16
21	GPO1	Opto	General Purpose output #1
22	GPO2	Opto	General Purpose output #2
23	GPO3	Opto	General Purpose output #3
24	GPO4	Opto	General Purpose output #4
25	GPO5	Opto	General Purpose output #5
26	GPO6	Opto	General Purpose output #6
27	GPO7	Opto	General Purpose output #7
28	GPO8	Opto	General Purpose output #8
29	GPO9	Opto	General Purpose output #9
30	GPO10	Opto	General Purpose output #10

Table 4-4 General Purpose I/O (DD5OS Connector)

GPIO DD 50 Connector (Continued)

Pin #	Function	Signature	Description
31	GPO11	Opto	General Purpose output #11
32	GPO12	Opto	General Purpose output #12
33	Shield		
34	N/C		
35	GPO13NC	Relay	General Purpose output #13, Normally closed contact
36	GPO13NO	Relay	General Purpose output #13, Normally open contact
37	GPO14NC	Relay	General Purpose output #14, Normally closed contact
38	GPO14NO	Relay	General Purpose output #14, Normally open contact
39	GPO15NC	Relay	General Purpose output #15, Normally closed contact
40	GPO15NO	Relay	General Purpose output #15, Normally open contact
41	GPO16NC	Relay	General Purpose output #16, Normally closed contact
42	GPO16NO	Relay	General Purpose output #16, Normally open contact
43	RLY common	Relay common line	All relays attached here, and to front panel fuse
44	RLY common	Relay common line	All relays attached here, and to front panel fuse
45	AnalogIn1	Analog	Analog input channel (0-4.7 V, diode clamped), ch #3 of A/D
46	AnalogIn2	Analog	Analog input channel (0-4.7 V, diode clamped), chl #4 of A/D
47	IRT	IsoReturn	Return for IPW, externally supplied
48	IRT	IsoReturn	Return for IPW, externally supplied
49	Gnd	Digital	Internal ground return for 24 V
50	Gnd	Digital	Internal ground return for 24 V

General Purpose I/O (DD5OS Connector) Continued

GPIO Connector

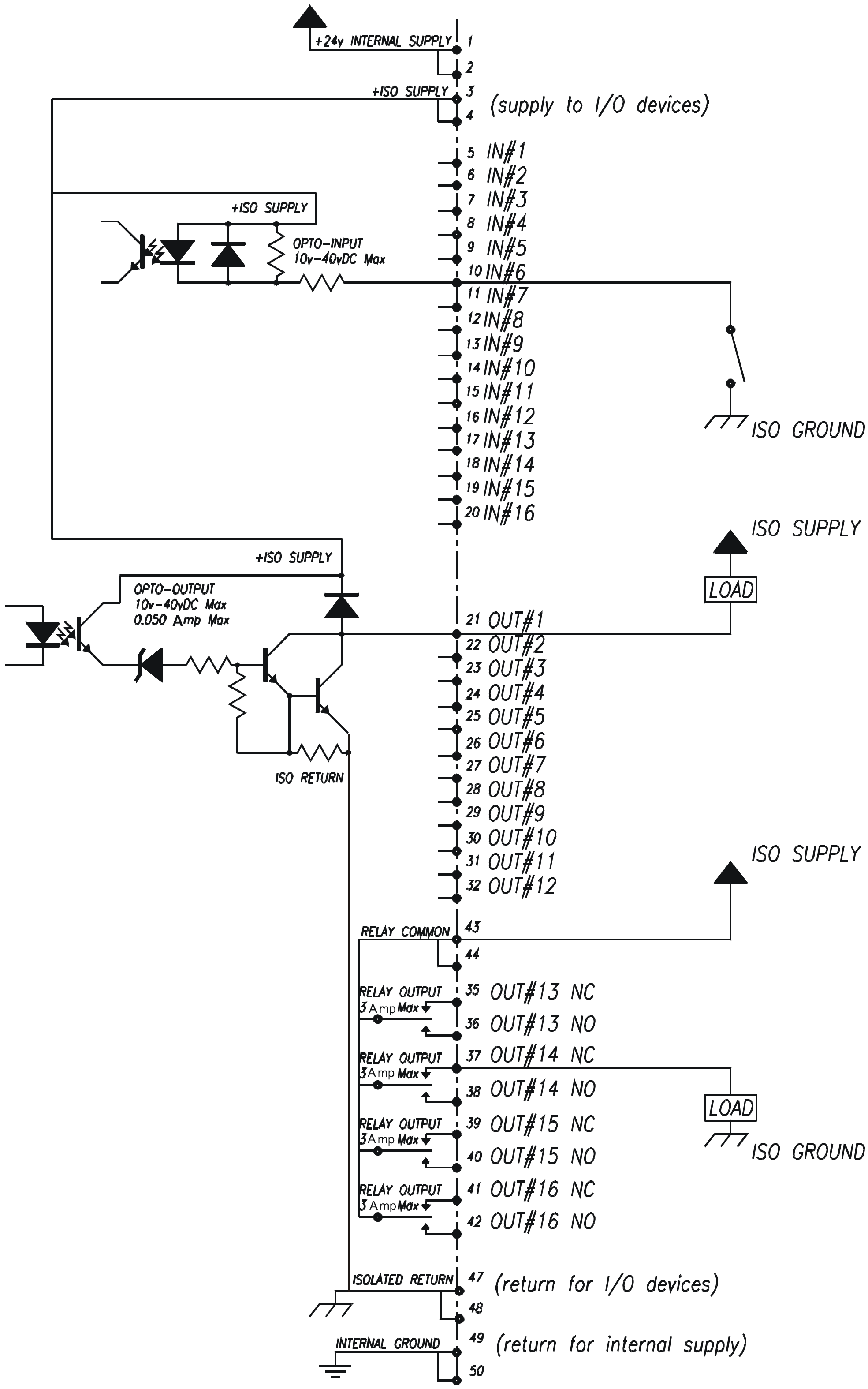
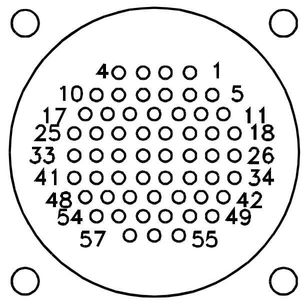


Figure 4-4 C500 GPIO connector description.

4-3-3 Robot Feedback Connector

The robot feedback connector provides channels for six axes of single-ended encoder feedback and encoder supply voltage, in addition to the servo gripper feedback and control, brake power, air gripper solenoid supply and control. The pin-outs are shown in Table 4-5.



Pin	Signal Name	Signal Description
1	1A	RS422+, 200 Khz max pulse rate
2	1B	RS422+, 200 Khz max pulse rate
3	2A	RS422+, 200 Khz max pulse rate
4	2B	RS422+, 200 Khz max pulse rate
5	N/C	
6	N/C	
7	1Z	RS422+, 200 Khz max pulse rate
8	2Z	RS422+, 200 Khz max pulse rate
9	N/C	
10	N/C	
11	BRAKE	35 V @ 100 mAmp (Motor 2,4)
12	SGM+	±15 V @ 300 mAmp (Servo Gripper)
13	SGM+ (N/C)	±15 V @ 300 mAmp (N/C)
14	N/C	N/C
15	Vcc (N/C)	Encoder Supply +5 VDC @ 80 mAmp (N/C)
16	Vcc (N/C)	Encoder Supply +5 VDC @ 80 mAmp (N/C)
17	Vcc	Encoder Supply +5 VDC @ 80 mAmp (Joint 1, Encoder 1) Supply
18	Brake	35 V @ 100 mAmp (Motor 3,5)
19	N/C	RS422+, 200 Khz max pulse rate
20	3A	RS422+, 200Khz max pulse rate
21	3B	RS422+, 200Khz max pulse rate
22	4A	RS422+, 200Khz max pulse rate
23	4B	RS422+, 200Khz max pulse rate
24	GND	Encoder digital return (Encoder 1)
25	GND	Servo Gripper Motor Return

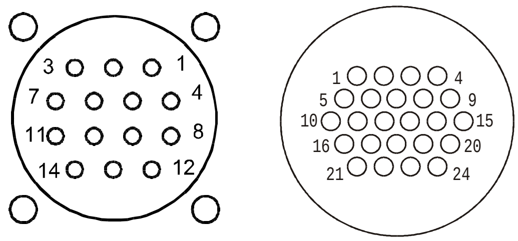
Table 4-5 Robot Feedback (CPC57 Connector)

Robot Feedback Connector Continued

Pin	Signal Name	Signal Description
26	N/C	RS422+, 200 Khz max pulse rate
27	N/C	RS422+, 200 Khz max pulse rate
28	3Z	RS422+, 200 Khz max pulse rate
29	N/C	
30	N/C	
31	4Z	RS422+, 200 Khz max pulse rate
32	N/C	N/C
33	N/C	N/C
34	N/C	
35	N/C	
36	N/C	
37	N/C	
38	N/C	
39	N/C	
40	N/C	N/C
41	N/C	
42	N/C	
43	5A	RS422+, 200 Khz max pulse rate
44	N/C	
45	N/C	
46	N/C	
47	SGRIPTRQ	±1 V
48	SGRIPPOS	0-4.7 V
49	5B	RS422+, 200 Khz max pulse rate
50	5Z	RS422+, 200 Khz max pulse rate
51	Vcc	Encoder Supply +5 VDC @ 80 mAmp (Joints 2 and 4)
52	Vcc	Encoder Supply +5 VDC @ 80 mAmp (Joints 3 and 5)
53	S/A G+	Air solenoid 12 V @ 200 mAmp (Potentiometer Vcc)
54	S/A G-	Air solenoid return. This is switched by software control, Potentiometer GND
55	GND	Encoder Digital return (Joints 2 and 4)
56	N/C	
57	GND	Encoder Digital return (Joints 3 and 5)

Robot Feedback (CPC57 Connector) Continued

4-3-4 Motor Power Connector



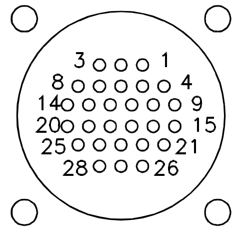
A255 Arm Connector Controller End

Pin # On A255 Arm	Pin # On Controller	Signal Name	Signal Description
1	1	Motor1+	Motor power ± 25 V @ 2 A max
4	2	Motor1-	Motor power return
3	3	Motor2+	Motor power ± 25 V @ 2 A max
7	4	Motor2-	Motor power return/Brake return
5	5	Motor3+	Motor power ± 25 V @ 2 A max
9	6	Motor3-	Motor power return/Brake return
2	7	Not connected	
6	8	Motor4+	Motor power ± 25 V @ 2 A max
10	9	Motor4-	Motor power return/Brake return
8	10	Motor5+	Motor power ± 25 V @ 2 A max
12	11	Motor5-	Motor power return/Brake return
11	12	Motor6+	Motor power ± 25 V @ 2 A max (extra)
14	13	Motor6-	Motor power return/Brake return (extra)
13	14	Not connected	
	15	Not connected	
	16	Not connected	
	17	Not connected	
	18	Not connected	
	19	Not connected	
	20	Not connected	
	21	Not connected	
	22	Not connected	
	23	Not connected	
	24	Not connected	

Table 4-6 Motor Power Connectors

4-3-4-1Expansion Amplifier Connector (Optional)

The expansion amplifier connector connects the servo expansion axis signals to an external amplifier. It accepts feedback from incremental optical encoders on the extra axis motors to the same servo axis. Custom ordered controllers may have a slight variation of this connector. The pin-outs are shown in Table 4-7.



Pin #	Signal Name	Signal Description
1	6A	RS422+, 200 Khz max pulse rate
2	6B	RS422+, 200 Khz max pulse rate
3	6Z	RS422+, 200 Khz max pulse rate
4	Vcom-6	±10 V (output)
5	Not Connected	
6	Not Connected	
7	Not Connected	
8	ArmOn-	Switch contact
9	7A	RS422+, 200 Khz max pulse rate
10	7B	RS422+, 200 Khz max pulse rate
11	7Z	RS422+, 200 Khz max pulse rate
12	Vcom-7	±10 V (output)
13	Vcc	Encoder Supply +5 V @ 300 mA
14	+12 VDC	
15	Not Connected	
16	Not Connected	
17	Not Connected	
18	GND	Encoder digital return
19	ArmOn+	Switch contact
20	Brake+	Switch contact
21	Vcom-8	±10 V (output)
22	8A	RS422+, 200 Khz max pulse rate
23	8B	RS422+, 200 Khz max pulse rate
24	8Z	RS422+, 200 Khz max pulse rate
25	Brake-	Switch contact
26	Not Connected	
27	Not Connected	
28	Not Connected	

Table 4-7 Expansion Amplifier Connector Pin Signal Descriptions

4-4 Arm Wiring Harnesses

Main Wiring Harness

The main wiring harness begins at the connector panel on the rear of the robot's base. It carries signals and power for all robot functions. It includes the pneumatic line for powering an air gripper.

Signals for motor 1 exit from the main harness while still inside the base. The rest of the wiring travels up into the cavity formed by the skirt of the waist casting. Here, the harness forms a coil which tightens and loosens as joint 1 rotates. The harness is protected by a nylon sheath. The top end of the coil is strain relieved on the bottom of the waist casting cavity.

The wiring for motors 2, 3, 4, and 5 terminates at a bracket located below the wrist motors. Each motor (2, 3, 4, or 5) disconnects independently from the base harness at this point.

The wiring to operate the servo gripper, solenoid, and the pneumatic line, pass up through the waist. A single loop around the joint 2 shaft reduces wire fatigue as the wiring continues up through the arm. A similar loop is present as the wiring passes joint 3 (elbow). The servo gripper wiring terminates in a Hirose connector on the left side of the upper link (about 2 inches from the wrist). The air solenoid wiring and pneumatic line terminate on an air solenoid located in the upper arm.

Note: For a pin-out description of the A255 main harness connector refer to section 4-3-3 Robot Feedback Connector.

4-4-1 Encoder Connectors

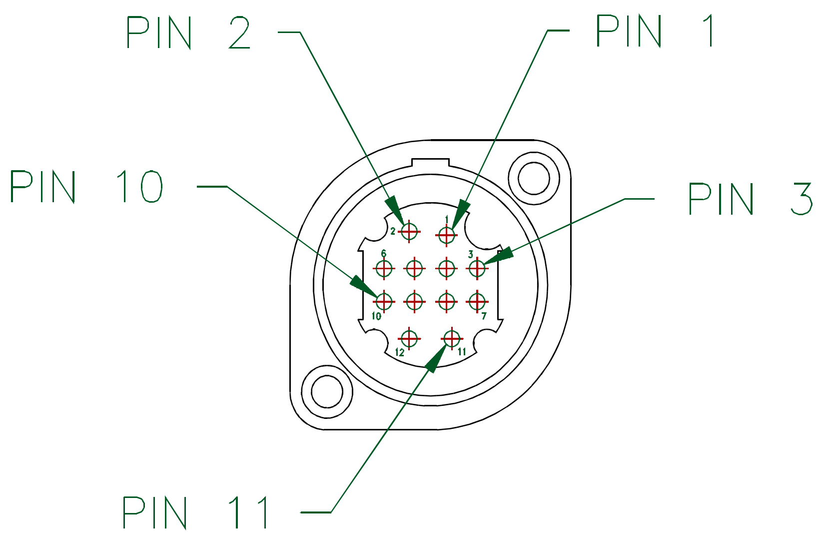


Figure 4-5 Encoder Connector (RP-17)

Joint 1

Pin #	Function	Pin #	Function
1	GND	7	N/C
2	+5 V	8	CH Z
3	CH A	9	N/C
4	N/C	10	N/C
5	CH-B	11	MOT-
6	N/C	12	MOT +

Table 4-8 Joint 1 Encoder Connector (RP-17)

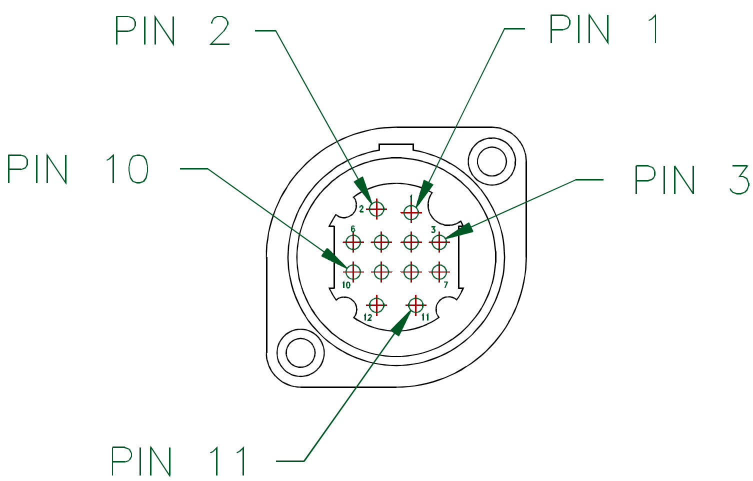
Joints 2, 3, 4, 5

Pin #	Function	Pin #	Function
1	GND	7	N/C
2	+5 V	8	CH Z
3	CH A	9	N/C
4	N/C	10	Brake
5	CH-B	11	MOT-
6	N/C	12	MOT +

Table 4-9 Joints 2, 3, 4, 5 Encoder Connector (RP-17)

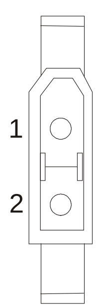
4-4-2 External Connectors

The external connectors consist of the Robot Feedback Connector, (see section 4-12 the Motor Power Umbilical Connector and the Servo Gripper Connector (below).



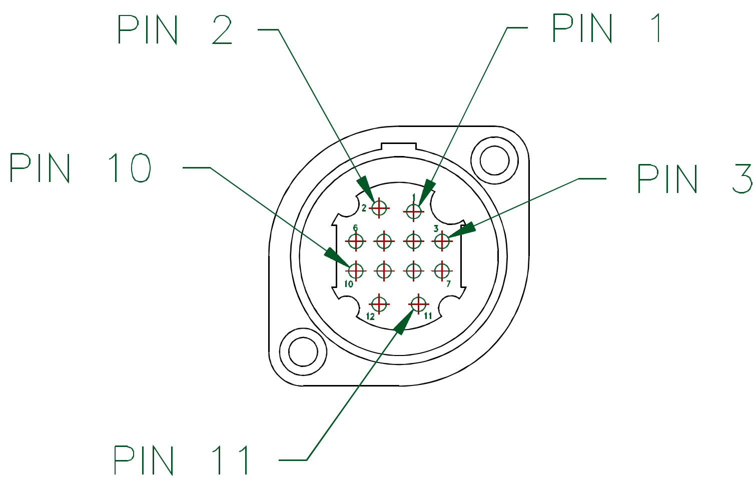
Pin #	Function	Pin #	Function
1	S/A G+	7	SGRIP torque
2	GND	8	N/C
3	N/C	9	SGRIP Position
4	SGM+	10	N/C
5	N/C	11	N/C
6	SGM- (GND)	12	Esd GND

Table 4-10 Servo Gripper Connector (RP-17)



Pin #	Function
1	SA+
2	SA-

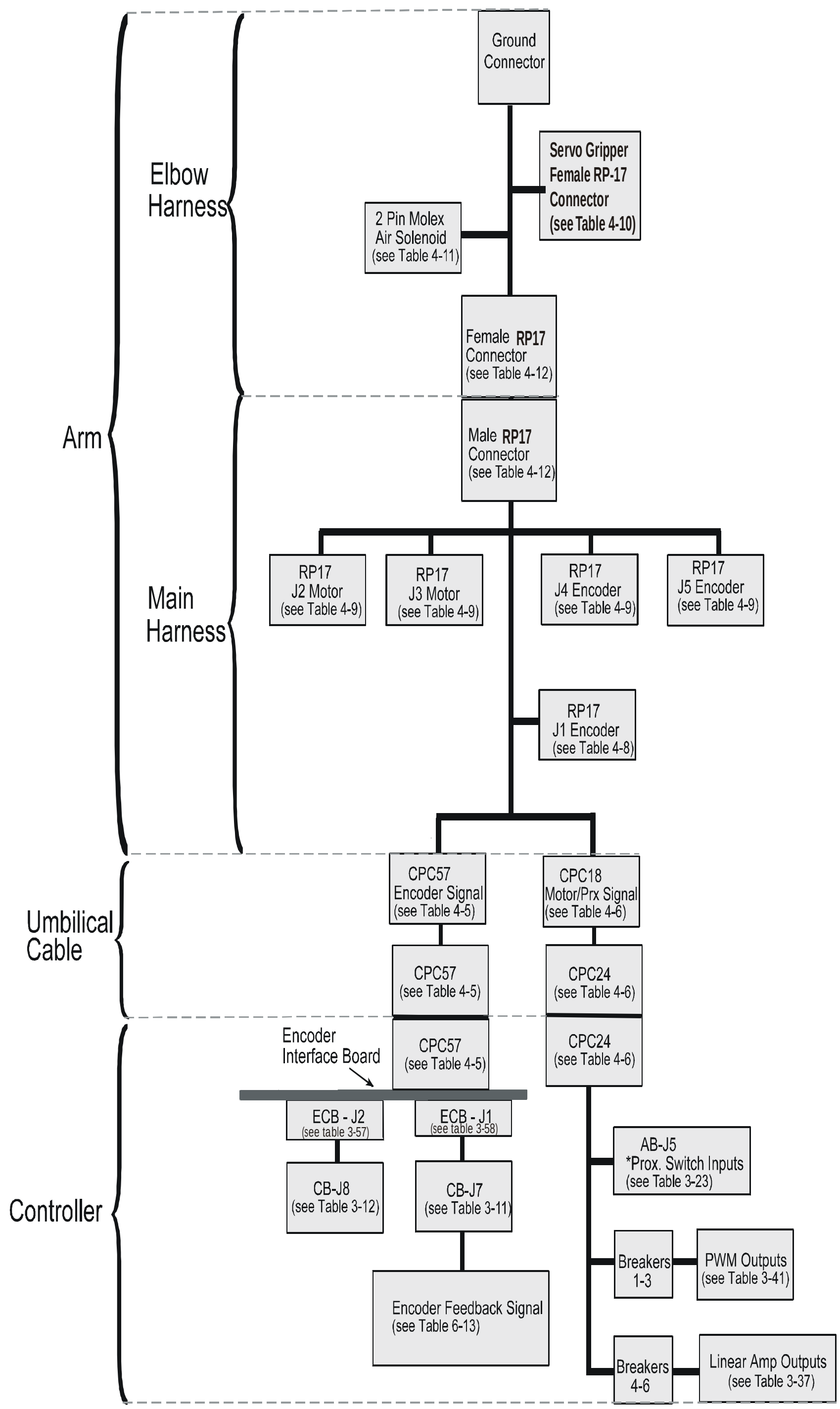
Table 4-11 Air Solenoid Connector (2 pin Molex)



Pin #	Function	Pin #	Function
1	+12 VDC	7	Torque Feedback
2	S/A GND (Servo Gripper)	8	N/C
3	G- (Air Solenoid)	9	Position Feedback
4	VMG+	10	N/C
5	N/C	11	N/C
6	VMG-	12	GND

Table 4-12 Link 2 Cable Connector (RP-17)

4-5 Arm Signal Connector Schematic



* Proximity switch inputs apply to the A255 Track Axes, G365, and the A465 Robot Arm

Figure 4-6 Arm Signal Connector Schematic

CHAPTER 5

5 Diagnostics and Troubleshooting

5-1 How To Use This Chapter

This chapter provides directions for troubleshooting problems and describes field serviceable procedures for the A255 and A465 robot arms. Procedures and tests specific to the A255 or A465 arm are marked as such. To service a problem, use the following table to find a description of the problem, reference the page number and then follow the diagnostic checks described for servicing in Chapter 6.

Electrical problems that require further diagnosis are numbered and prefixed with RE (for Repair Electrical). These refer to the detailed repair procedures (RE1 to RE9) found in Chapter 6.

The performance of any of these procedures requires care, and in some cases, technical skill and even specialized training. As a guideline, if you cannot understand the description of the procedure, do not attempt the procedure without requesting assistance from CRS, or your distributor.

5-2 Arm Power Problems

For additional information on the requirements for arm power operation (refer to section 2-9 Requirements for Arm Power).

5-2-1 Arm Power Cannot Be Turned On

Controller Operation Checks

RE1.1 Is main power applied?
Check if the front panel Status Display is illuminated.

RE1.4 Is the Controller operating normally?
Check the teach pendant, and/or the terminal communication (see section 2-10 Requirements for Interactive Communication).

RE1.5 Is the ARM ENABLED?
The arm may have been disabled from within an AUTOEXEC program that was executed immediately with the power up.

Emergency Stop Signal Checks

RE1.6 Check the e-stop switches of the SYSIO, Amp expansion, and teach pendant.

RE4.4 Check the function of the e-stop push button on the front panel.

RE2.7 Check the LEDs on the auxiliary board for e-stop circuitry and supply voltage.

RE3.2 Use a scope to look for the watchdog signal on the controller board.

RE3.1 Check the arm power enabling circuits.

5-2-2 Arm Power Turns Off with Error “40” Display

This may happen immediately or when the arm is moved.

Circuit Breaker Checks

RE4.7 Check the continuity of the circuit breakers.

Check for popped breakers on the front panel of the controller. The breaker sensing shuts off arm power when a breaker opens.

PWM Amplifier Checks

RE2.6 Check the PWM amplifiers enable LED’s for the A465, Gantry, and Track model.

RE8.1 Check the voltage supply from the auxiliary board to the PWM amplifier module.

Linear Amplifier Checks

RE8.2 Check the voltage supply from the auxiliary board to the Linear amplifier module.

RE8.3 Check the continuity of the DC Amps to the arm power connector.

RE8.5 Check and adjust the DC amplifier output level.

5-2-3 Arm Power Indicator on Front Panel Comes On But All Joints of the Arm Stay Limp

Is the arm LIMP? - Use the STATUS command to check.

Feedback Checks

RE5.2 Check for encoder feedback signals on the controller board.

RE7.3 Use the W1 command to check the feedback from all the encoders.

Amplifier Checks

RE2.3 Check the linear Amp supply fuses.

RE2.6 Check the PWM amplifier's enable LEDs for the A465, Gantry, and Track model.

RE2.7 Check the diagnostic LED's on auxiliary board for presence of linear amplifier rail voltages.

RE8.1 Check the continuity of power supply to the PWM amplifier modules.

RE8.2 Check the continuity of the power supply to the linear amplifier modules.

RE8.5 Check and adjust the DC amplifier output level.

Controller Signal Check

RE3.2 Check for the arm power on signal.

Wiring Checks

RE4.2 Check the continuity of the encoder feedback wiring.

RE4.8 Check for the connection of the motor power umbilical from the rear of the controller to the arm base.

5-2-4 "ARM POWER" Error Message Seen but Arm Power Indicator Still On

Controller Signal Checks

RE3.2 Indicates a failure of the ARM ON signal from the auxiliary board to the controller board.

5-2-5 Arm Power Indicator Comes On, One Axis Stays Limp, No "AXIS OUT" Error

This is a feedback problem (see 5-3-2 One Axis Limp Until Command Given, Then Runs Away).

Software Check

RE7.3 Use the W1 command to check the feedback from all the encoders.

Wiring Check

RE4.2 Check the continuity of the encoder feedback wiring.

Signal Checks

RE5.2 Check for the presence of the A and B encoder feedback signals.

5-2-6 Arm Power Indicator Comes On, One Axis Stays Limp, "AXIS OUT" Error When the Axis in Question is Moved

This is a feed forward problem. Use the @LOFB RESET command to remove the check for the loss of feedback. The @LOFB RESET command prevents the "AXIS OUT" errors from displaying. Once the problem has been remedied type @LOFB SET to re-enable the check for loss of feedback. For RAPL versions of 2.50 or greater the @LOFB command has been replaced with the "@SERVERR" command. See the RAPL-II Programming Guide for information on how to use this command.

Controller Check

RE5.1 Check the Vcom input to the amplifiers.

Amplifier Signal Checks

RE8.1 Check the voltage supply from the auxiliary board to the PWM amplifier module.

RE8.2 Check the voltage supply from the auxiliary board to the Linear amplifier module.

RE8.3 Check the continuity from the DC amplifier to the rear panel motor power connector.

RE8.5 Check the linear amplifier module TP1 (test point) for ±26 VDC.

Check if the motor connectors in the arm are in place. Refer to section 4-4-2 External Connectors and Table 6-16 Amplifiers Settings for the A255.

Wiring Checks

RE4.8 Check the umbilical connections on both ends.

Circuit Breaker Checks

RE4.7 Check the continuity of the circuit breakers.

5-3 Servo Problems

For an understanding of the servo system operation (see section 2.13 Servo Operation).

5-3-1 One Axis Runs Away as Soon as Power is Applied

Controller Signals

RE7.3 With arm power removed, check for an encoder feedback problem with the W1 command.

Correct Feedback Function

a) Does it count up and down smoothly?

Incorrect Feedback Functions

a) Does it count just up or just down?

b) Does it seem to skip as it counts?

c) Does it count at all?

If the feedback is not functioning then:

The problem is in the feedback path from the encoder to the processor.

Wiring Checks

RE4.8 Check the encoder umbilical connectors for displaced feedback contacts.

RE4.2 Check the encoder to controller board continuity.

RE4.10 Check the arm main harness wiring.

Controller Signal Checks

RE5.2 Check the encoder input on the encoder test strip JP25 on the controller board. Use a scope.

If the feedback is functioning then:

The problem is in the forward part of the servo control loop.

Amplifier Servo Signal Level Checks

RE8.4 Check for a good ground connection to the controller board.

Check the motor brush polarity (see section 7-7 Check Motor Brush Wear).

RE8.5 Check the amplifier output.

Check the connection between the controller board and the amplifiers.

Controller Signal Checks

RE5.1 Check the Vcom output from the controller board to the amplifier if the amplifier output is not working.

5-3-2 One Axis Limp Until Command Given, Then Runs Away

This suggests a complete loss of feedback.

Software Check

RE7.3 Check the encoder feedback with the W1 command. This will likely show no change for the axis in question.

Wiring Checks

RE4.2 Check the encoder to controller board continuity.

RE4.8 Check the umbilical connectors for displaced feedback contacts.

Controller Signal Check

RE5.2 Check the encoder input on the encoder test strip JP25 on the controller board. Use a scope.

Am Electronic Check

RE9.1 Check for the voltage supply and ground at the encoder electronics.

5-3-3 All Axes Run Away Simultaneously

Amplifier Signal Check

RE8.4 This could be due to loss of signal ground to the amplifier modules.

Check the AXIS ground connector at the controller board and the Vcom input connector to the Amp modules.

Wiring Check

RE4.8 Check the umbilical cable connectors.

Controller Signal Check

RE5.3 This could be due to a loss of feedback from all the encoders. Check the encoder supply output from the controller board.

5-3-4 Robot Position Changes in "Jumps" of One Axis

The robot position may change in “jumps” of one axis due to one of two problems: an intermittent contact in the feedback loop, or a badly adjusted encoder.

If the jumps are repetitive and constant (i.e., at a rate which is consistent with a turn of the motor), then replace the encoder.

Wiring Check

RE4.10 Does the robot position jump in only one position of the joint? Determine if the break is in the main or wrist harness. Replacement of the these harnesses should be done at an authorized CRS repair depot.

5-3-5 Robot Position Changes Slowly in One Axis (Drift)

This problem is further identified in that it is cleared up after homing the arm.

The servo is injected with noise which is misinterpreted as legitimate position change pulses by the controller board. See section 7-7 Check Motor Brush Wear.

Motor Brushes

- Check that the brushes for the motor in question are not severely worn. See section section 7-7 Check Motor Brush Wear.

Umbilical Cable Checks

- Check that the cable shield grounds are connected.

RE4.8 Poor wiring is usually the cause of noise. For instance, a bad crimp connector or an intermittent short in a wire can cause problems.

Check all connections of the axis in question. The pins could be loose, pushed in, bent, or crimped, or the termination’s could have fatigued over time.

Wiring Check

RE4.2 Check the continuity of the encoder feedback wiring.

Inspect the encoder termination resistors. The resistors vary according to the type of arm driven. If the controller board was replaced before this problem appeared, an incorrect termination may be the problem.

Controller Signal Check

RE5.2 Check channels A and B at the encoder input to the controller board.

Inspect the encoder signal before and after the termination chips on the controller board. If noise is generated inside the chip, then replace the controller board.

- If an oscilloscope shows noise on the encoder test points, replace the controller board, and note that an encoder termination circuit failure is evident.
- Remove additional external wiring from the system. If the problem goes away check the external wiring for ground loops and shield problems.

5-4 Homing Problems

5-4-1 056 Checksum Errors

The homing routine in the 255 Track axes and the 465 use a compensation value for each joint to place the motor half a revolution away from the zero cross of the encoder. A checksum error indicates that either the home compensation value or the calibration value is corrupt.

Software Check

RE7.1 Reload the arm calibration using Robcomm. Each robot is shipped with a calibration disk which contains the factory calibration for the arm, refer to section 7-8 Calibrating the Arm for detailed instructions on calibrating the robot arm.

5-4-2 101 Sequence Error

This error will only appear in the A465 and A255 Track axes. It indicates that the homing routine was unable to successfully complete its cycle.

To check for the presence of arm power perform the following checks.

Controller Internal Visual Check

RE2.5 Check the Proximity switch connection for the rear panel CPC-24 connector to the auxiliary board.

Wiring Check

RE4.9 Check the proximity sensor controller signal.

5-4-3 034-39 Home Fail Error

The controller did not receive a zero cross marker pulse within one revolution of the motor. This indicates that either the encoder is not functioning correctly or there is a break in the wiring to the encoder.

Wiring Check

RE4.2 Check the continuity of the encoder wiring.

Controller Signal Check

RE5.2 Check channel Z at the encoder input to the controller board.

RE5.3 Check the encoder supply from the controller board.

5-5 Digital I/O Problems

For an understanding of the requirements for correct digital I/O operation (refer to section 2-11 Host Interface Communication (ACI Operation).

For any I/O problem, check the wiring from the controller to the I/O device carefully to make sure there are no cuts in the wire, the wire installation is correct, the device is plugged into the correct connector (GPIO) on the rear panel, and that the cable is plugged in all the way at both ends.

Check the function of any or all external devices before assuming the problem is in the robot controller.

5-5-1 Input from External Device Errors

If there is a state change on the input (measured by a meter at the rear panel):

- Check using the WAIT command in the terminal emulator or teach pendant to determine if it is functioning correctly.
- Check all inputs to determine if the device is triggering the correct input; use the WAIT command for each input. If the wrong input is being triggered, check the external wiring.

If the external wiring is correct:

- Send either the CB/AB assembly or whole controller to CRS for service.

If there is no state change on the input (measured by a meter at the rear panel):

- Check for voltage across the terminals for the isolated supply.
- Internal Supply - Check across pins 3, and 50 for a 24 Volts
- Isolated Supply - Check across pins 3 and 47 for 10-40 Volt supply
- Check the external wiring if no voltage is present.
- Check the 24 V fuse at the front panel. If you are using the internal 24 V supply to power the GPIO, the lack of this voltage may cause the inputs to not change state.
- Disconnect the input device. There should be 24 Volts on this signal with no load. If the signal is not 24 Volts send either the CB/AB board assembly or the whole controller to CRS for service.

5-5-2 Output to an External Device

If an output to an external device is not switching properly:

- Check the signal at the rear panel GPIO.

DS2002 Chips

The DS2002 are socketed chips located at U7 (SYSIO), and U8/9 (GPIO) on the Auxiliary Board assembly, which only control the outputs.

To check the outputs when using the internal supply:

1. Check that either of the supply voltage pins 1/2 is connected to either of the isolated supply pins 3/4.
2. Check that either of the isolated ground pins 47/48 is connected to either of the controller ground pins 49/50.
3. Check for 24 Volts between the supply and the ground pins. If the voltage is not present, check the 24 Volt fuse on the controller's front panel.
4. Enter the following command sequence:

   >>output <+output #> should see 0 Volts at appropriate pins

   >>output <-output #> should see +24 Volts at appropriate pins
5. If all the voltages appear to be correct then change the DS2002 chip for the GPIO and SYSIO.

To check the outputs when using the external supply:

1. Verify that either one of the external supply pins 3/4 is connected to the external supply.
2. Verify that either one of the external supply pins 47/48 is connected to the external ground.
3. Check for 10-40 VDC between the supply and ground pins. If the voltage is not present, check the operation of the external power supply.
4. Enter the following command sequence:

   >>output <+output #> should see 0 Volts at appropriate pins.

   >>output <-output #> should see +24 Volts at appropriate pins.
5. If all the voltages appear to be correct then change the DS2002 chip for the GPIO and SYSIO.

Note: The voltage of an un-terminated signal (output) does not change significantly.

5-6 Serial Communication Problems

For a complete description of the requirements for terminal or serial communication (refer to sections 2-9 Requirments for Arm Power and section 2-10 Requirements for Interactive Communication.

- Ensure correct baud rate etc. on the terminal or host computer. After a restart you can view the default serial communication values.

Controller Visual Checks

RE1.4 Check for normal boot-up.

RE2.1 Physically check the controller board to ensure that all memory and processor components are fully inserted into sockets.

RE2.2 Check the ribbon harness from the controller board to the front panel serial connector.

RE2.7 Check for supply voltages using Diagnostic LED's.

Serial Communication Signal Level Checks

RE3.8 Check the terminal device transmit function.

RE3.5 Check the UART (Universal Asynchronous Receiver/ Transmitter) function.

RE3.7 Check the terminal device receive function.

RE3.11 Check the controller board function alone. If it passes, determine the faulty connection or component and replace or repair it.

RE3.17 Replace the serial drivers if necessary.

RE3.15 Check for serial ground current loops.

Check Boot-up Sequence

RE1.4 Check for normal controller boot-up.

RE3.3 Check the power fail indicator (PFI).

RE7.1 Perform a Diagnostic start.

5-7 Recurring Memory "Failures"

Perform a system restart with factory parameters. See the @@SETUP command in the RAPL-II Programming Manual.

Controller Internal Visual Checks

RE2.1 Check for correct insertion of all the socketed components on the controller board.

Check the earth ground for cleanliness and continuity. This is very important to the function and reliability of the controller.

Check the AC power to the line spikes which pass through the internal power supply line filter.

Check for isolation. Install a line isolator if AC conditions are poor.

Signal Level Check

RE3.12 Check the connection from the power supply to the controller board. The contacts should be clean.

Firmware Check

RE7.2 Reload firmware.

5-8 Servo Gripper Problems

To diagnose and repair a gripper problem, follow the procedure described in this section. For more detailed information refer to the Servo Gripper User's Guide.

Signal Level Checks

RE4.3 Check the continuity of servo gripper wiring

5-8-1 Diagnostic for Gripper Recently Installed

1. Check the gripper fuse on the front panel, refer to section 5-8-4 Servo Gripper Fuse Test.
2. Check that the Arm Power light is ON.
3. Check that the arm is rigid while Arm Power is on. No joints should be limp. This verifies that drive power is reaching the arm and that the controller is working properly.
4. Verify that the gripper is correctly installed. Refer to Servo Gripper User's Guide for more information.

   If the problem persists, perform the Standard Diagnostic Procedure (next section).

5-8-2 Standard Diagnostic

Use this procedure to methodically check motor driver output and finger position feedback.

1. Check the motor driver output, refer to section 5-8-5 Motor Driver Output Test. If the test fails, do perfrom the following procedures:
   a) Check the servo gripper fuse, refer to section 5-8-4 Servo Gripper Fuse Test.
   b) Check the gripper motor continuity, refer to section 5-8-8 Servo Gripper Motor Test.
   c) Check the servo gripper motor, refer to section 5-8-10 Set Servo Potentiometer Position.
2. Check the finger position feedback, refer to section 5-8-6 Finger Position Feedback Test.

- If the displayed position does not change:
  a) Check the finger position feedback continuity, refer to section 5-8-7 Finger Position Feedback Continuity Test.
  b) Check the servo potentiometer, refer to section 5-8-9 Servo Potentiometer Check.

- If the displayed position does not smoothly count up or down:
  a) Check the servo potentiometer, refer to section 5-8-9 Servo Potentiometer Check.
  b) If the servo potentiometer is not correctly positioned, set servo potentiometer position, refer to section 5-8-10 Set Servo Potentiometer Position.

- If steps 1 and 2 pass, then the gripper appears to be working normally. Read the Detailed Examples in Chapter 3 of the Servo Gripper User's Guide to check if the problem is caused by your RAPL-II programs.
- If you have further problems please contact your distributor for assistance.

5-8-3 Connector Visual Inspection

Visually check that all cable connectors for the servo gripper option are properly connected.

1. At the rear of the controller, inspect the CPC-57 connector, and check the connector at the base of the robot. Within the robot, the gripper signal wires are hidden.
2. At the wrist of the robot, check the RP-17 connector where the servo gripper signal emerges.

5-8-4 Servo Gripper Fuse Test

Check that the 0.375 Amp slow-blow fuse protecting the gripper motor is intact.

1. Flip down the front panel cover on the C500 controller.
2. Locate the servo gripper fuse; it is labeled Servo Gripper. A good fuse consists of a light-colored bar with a thin wire spiral-wrapped around its length.
3. If a visual check does not give conclusive evidence, use an Ohm meter to measure the resistance of the fuse (it should be less than 2 Ohms). Measure fuse impedance with the fuse removed from its clip.

5-8-5 Motor Driver Output Test

Check that the controller is providing motor drive voltage to the servo gripper. The procedure requires a PC with Robcomm for Windows software and a voltmeter (DVM).

Warning! Wear a grounded wrist strap for the following procedure. *Electronic components inside the controller can be damaged by electrostatic discharge.*

1. With the controller main power switched OFF, connect the PC to the controller, and remove the controller top cover.
2. Connect a DVM (10 VDC scale) between pin #1 and #5 on connector J7 of the auxiliary board. The auxiliary board is the bottom board, and J7 is located on the front right edge of the board.
3. Switch the PC and the controller ON. Switch Arm Power ON. The robot does not have to be homed.
4. At the PC, run Robcomm for Windows, enter into Terminal mode, and press Ctrl-C. You will see the >> prompt.
5. Type OPEN GRIPPER OPENING FORCE(%): 100 and press Enter.

- The fingers should quickly open to maximum open position and the DVM should read -15 ±0.5 VDC.
- Approximately 5 seconds after the fingers stop moving the voltage should drop to -12 ±0.5 VDC.

6. Type CLOSE GRIPPER CLOSING FORCE(%): 100 and press Enter. The fingers should quickly close until they touch.

- The DVM should read +15 ±0.5 VDC.
- Approximately 5 seconds after the fingers stop moving the voltage should change to +12 ±0.5 VDC.
    - If the fingers do not move, then power may not be reaching the gripper motor.
    - If you do not see the expected voltages, then the servo gripper circuit needs to be adjusted. Refer to the Servo Gripper User's Guide for details.

5-8-6 Finger Position Feedback Test

This procedure tests the gripper feedback circuitry (needed for position mode) with a program that slowly moves the fingers while continuously monitoring the feedback signal. The procedure requires a PC with Robcomm for Windows software.

1. Connect the PC to the controller, and switch the PC and the controller ON.
2. Run Robcomm, enter into Terminal mode, and press Ctrl-C. The sign on message should appear on the screen followed by the >> prompt.
3. Type EDIT GRIPTEST and press Enter. The prompt changes to **>***.
4. Type I and then 1. The screen will display the following line.

   INSERT<Line#> 1

5. Press Enter and then type the following program.

```
;       Program Name: GRIPTEST
100     OPEN 35
110     IF (WGRIP()) > 1.75 THEN 150
130     PRINTF 1,'\N\R%F',WGRIP()
        GOTO 110
150     CLOSE 35
160     PRINTF 1,'\N\R%F',WGRIP()
        IF (WGRIP()) < .2 THEN 100
        GOTO 160
$
```

6. When finished, at the next blank line press Enter. The **>*** prompt returns. Then type Q (for QUIT). The program remains in the controller memory and the >> prompt returns.
7. Switch Arm Power to ON, type RUN GRIPTEST and press Enter to run the program.
8. As the program slowly opens and closes the gripper, observe the finger positions displayed on the screen. The numbers should smoothly reflect the actual position of the fingers.

- If the numbers jump suddenly then the servo potentiometer is not positioned correctly.
- If the feedback signal does not change, then there may be a broken wire in the feedback circuit.

9. Press Ctrl-C to quit the GRIPTEST program.

5-8-7 Finger Position Feedback Continuity Test

This checks the availability of feedback voltage to the servo gripper feedback circuit. The procedure requires a voltmeter (DVM).

Warning! Wear a grounded wrist strap for the following procedure. *Electronic components inside the controller can be damaged by electrostatic discharge.*

1. With the controller main power switched OFF remove the controller top cover.
2. Connect the DVM between signal ground at connector J13, pin #4 on the controller board and the servo gripper feedback test point at the analog/digital converter chip U33, pin #4. Use a small test probe to test this point.
3. With the controller switched ON, and the Arm Power *OFF*, measure the voltage of this test point while pulling the fingers open and pushing them closed by hand.

   The voltage should read between 0.4 and 4.5 Volts. This reading does not have to be exact, but, the voltage must never read exactly 0, nor should it read exactly 4.6 Volts. The voltage should change linearly while moving the gripper fingers.

   If the voltage does not change, test the voltage between U32 pin #3 and ground.

- If this voltage does not change, the fault is in the external wiring.
- If this voltage does change, then the fault is in the controller board, and the board must be serviced.

5-8-8 Servo Gripper Motor Test

This checks for a damaged gripper motor by measuring armature resistance at the motor terminals. This procedure requires an Ohm-meter.

1. Disconnect the servo-gripper cable from the robot upper arm and remove the gripper from the tool flange.
2. Connect the Ohm-meter between the red and black contacts on the rear of the gripper motor.
3. Pull or push on the fingers to re-position the brushes so the meter changes. You should see a reading between 15 and 50 Ohms. If the motor brushes are not making complete contact with the rotor you will get an abnormally high reading.

- If you measure less than the expected resistance then the motor armature may be shorted.
- If you measure more than the expected resistance, then the motor armature may be broken.

  In either case, the servo gripper and controller board/auxiliary board assembly should be returned to your distributor for factory repair.

5-8-9 Servo Potentiometer Check

Perfrom this test is to verify that the servo potentiometer and wires inside the servo gripper body are not broken. This requires an Ohm-meter.

1. Disconnect the servo gripper cable from the robot upper arm.
2. Connect the Ohm-meter to pins 1 and 2 of the RP-17 connector coming from the servo gripper. Move the fingers together and apart by hand. You should measure 11 ±2 kOhm, regardless of the finger position.
3. Connect probe A to pin 1 of the RP-17 connector and connect probe B to pin 9 of the RP-17 connector. Move the fingers together and apart by hand. You should see a change of roughly 10 kOhms (closed) to 4.5 kOhms (max. open), depending on finger position.

- If you see no change in resistance at step 3, then the wiring is likely damaged.
- If you do see change, but it is non-linear or missing readings in the middle, the pot may need adjustment (refer to section 5-8-10 Set Servo Potentiometer Position. If adjustment fails to correct the problem, replace the pot.

5-8-10 Set Servo Potentiometer Position

This procedure correctly positions servo potentiometer travel, relative to the pinion. This should be done only after Procedure 5 has failed, indicating faulty feedback, or after the installation of a new servo pot. The test requires a PC with Robcomm software.

1. Disconnect the servo-gripper cable from the robot upper arm and remove the gripper from the tool flange.
2. Remove the body upper cover from the servo gripper. This is the cover through which the cable does not enter.
3. Locate the position feedback potentiometer. This is the small black round cylinder next to the motor.
4. The pot is mounted with “servo-clamps” to the main body of the gripper. Loosen these clamps by turning the central screw by approximately ½ turn. The far clamp screw can be accessed through a hole in the rear mounting plate.
5. With the controller main power OFF, connect the gripper cable to the robot upper arm. Follow the procedure in section 5-8-7 Finger Position Feedback Continuity Test to test for valid feedback.
6. With the WGRIP program running, move the fingers in and out by hand. If the Finger Position Feedback Continuity Test (section 5-8-7) failed there will be an area of finger position where feedback will not be valid. To set it correctly, pull open the fingers until they are approximately 1 inch (or 25 mm, if metric) apart. Gently rotate the servo pot in its seat until the program displays approximately the correct value. Tighten the servo clamps.
7. Again, move the fingers in and out by hand through the complete range. If the feedback changes linearly and is without jumps, the potentiometer is positioned correctly. If not, repeat steps 5 and 6. If two attempts have been made without success, the pot is probably damaged and needs to be replaced.
8. Ensure the potentiometer clamps are fastened firmly up before replacing the body cover.
9. Perform the position calibration procedures. Refer to section 7-8 Calibrating the Arm.

5-9 Air Gripper Problems

Check the voltage to the air gripper at both the controller and the arm.

Controller Signal Level Check

RE3.18 Check air gripper driver output.

Arm Signal Level Checks

1. Remove the wrist covers.
2. Remove the 2 pin Molex connector (refer to section4.4 Arm Wiring Harnesses.
3. Check for a change in voltage when the OPEN and CLOSE commands are issued from the terminal. The voltage should read 12V when the OPEN command is issued and 0V when the CLOSE command is issued.
4. If the voltage is seen at the Molex from the terminal pins, but the air gripper does not work, indicates that the air solenoid is defective.
5. An audible “click” can be heard when changing the gripper state with the OPEN/CLOSE command. Perform this test in a quiet environment if possible, with no air supplied.
6. Contamination of the air supply can clog the air valve.
7. Ensure that the air pressure is at least 80 psi for any test.

5-10 Controller Boot-up Problems

The controller should boot-up and display “A1” on the front panel. When this does not occur refer to section 2-4 Initialization Logic Sequence and determine where the controller has failed. With the exception of “A1” or “A7”, reload your firmware as if it has become corrupt.

Firmware Corruption

RE7.1 Perform a Diagnostic Start

Enable the installed jig signal on the SYSIO connector.

Turn the controller on. The controller should display “D1”on the front panel display.

RE7.2 Reload the firmware.

User Software Corruption

- The front panel will display “A7” if there is a problem with the user software.
- The teach pendant will display a message prompting the user to re-allocate memory. Re-allocate the memory and then reload the user software.

Hardware Checks

RE3.12 Check the connection from the computer power supply to the controller board.

Provide power to the CB/AB.

RE3.3 Check the power fail indicator (PFI).

If the PFI is defective the controller will not boot-up.

RE2.1 Check the controller board components

Check the controller board socket chips.

5-11 Serial Teach Pendant Problems

No Screen

1. Remove the serial teach pendant connector. Refer to section 4-2-1 Teach Pendant Connector.
2. Measure the supply voltage with reference to the ground.
   A = pendant installed (5.1 Vdc)
   C = ground
   F = Vcc (5.1 Vdc)
3. Place a probe on the Tx pin. Set the scope to 20 milliseconds 10 Volt/division. Turn the controller on. You should see a burst of signals.
4. If no signal are seen, check the signals on the drive chip. Refer to section RE3.8 Check Terminal Device 0 Transmit Function.
5. Replace the drive chip if required. See section RE3.17 Replace Serial Device Drivers.

No Signal Received By Controller

1. If the controller does not respond to any serial teach pendant input, check the device 0 receive function. Refer to section RE3.7 Check Serial Terminal Device 0 Receive Function.
2. Replace the driver chip if necessary.

Irregular Pendant Operation

1. Plug the pendant in.
2. Press Crtl + Shift + F1
3. Turn the controller on.
4. The following prompt appears: “Load Defaults, Yes=F1 No=F5”.

Teach Pendant does not boot-up or the set up menus cannot be accessed

1. With the controller off, connect the Serial teach pedant to the front panel connector.
2. Press and hold down Crtl + Shift + F1 and turn ON main power.
3. The teach pendant should display "Reload defaults (Y/N)". Answer Y (yes) to the prompt. This reconfigures the teach pendant to near factory standards and should allow normal pendant boot-up.

5-11-1 Serial Teach Pendant Parameters

Parameters for the teach pendant's operation are set to factory standards at CRS. Should your teach pendant exhibit unusual operation, it may be necessary to reconfigure its parameters.

Note: Custom configurations many be required for special applications.

To access the teach pendant's configuration settings:

1. Press Crtl, Shift, and F1, at the same time.
2. Follow the instructions on the teach pendant display.
3. Refer to the table below for parameter settings.

Parameter	Setting
BAUD	19200
DATA BITS	8
PARITY	NONE
STOP BITS	1
REPEAT	MEDIUM
KEY CLICK	ENABLE
KNP FUNCTION	DISABLE
CURSOR	DISABLE
XON/XOFF	DISABLE
HANDSHAKE	DISABLE
ECHO	DISABLE
ESCAPE MODE	ANSI
CRLF	NORMAL
TEST	DISABLE
SHIFTLOCK	DISABLE
SCROLL	81
VIEW ANGLE	*NOTE1
BREAK CMND	DISABLE
BACKLIGHT	OFF

Table 5- 1 Serial Teach Pendant Parameter Settings

Note: The VIEW ANGLE parameter may vary depending on the version of the teach pendant and on the environment in which it is used (light condition, and how it is held by the operator). For best results experiment with different view angle parameter settings.

5-11-2 Function Key Settings

To access the function key settings:

1. Press Ctrl + Shift + F2 at the same time. The following prompt appears: `Select function key`
2. Select the function key whose setting you want to change, for example press F1, F2, F3, or F4.
3. Refer to the following table to verify that the function key parameter settings are correct.

Parameter	Setting
F1	H81
F2	H82
F3	H83
F4	H84
F5 (ESC)	H85
F6 (Shift + F1)	H91
F7 (Shift + F2)	H92
F8 (Shift + F3)	H93
F9 (Shift + F4)	H94
F10 (Shift + ESC)	H95

Table 5- 2 Serial Teach Pendant Function Key Settings

4. If the function key setting is incorrect:
   a) Press F1 (Change) to change the setting.
   b) Press F5 (Hex) or F4 (Num) to enter hex mode.
   c) At the H prompt, type the two digit hex number, for example H81.
5. Press F2 (save) to save the setting, and then press F1 (yes) to verify that your changes are correct.
6. Repeat the above procedure for each incorrect function key setting.

5-12 AC Power Problems

AC Power Checks

Check the major components that bring the in-coming AC to the computer power supply or to the transformer.

RE1.3 Check or replace the AC line fuse(s) to determine if the power line is intact.

RE3.22 Check the AC Soft Start board if the AC main fuses blow upon start-up.

RE3.23 Check the function of the Zero Cross relay if the controller will not boot-up

CHAPTER 6

6 Service Repair Checks

This chapter details field serviceable procedures for the CRS A255 and A465 robot arms. Electrical problems that require further diagnosis are numbered and prefixed with RE (for Repair Electrical). Procedures and tests specific to the A255 or A465 arm are marked as such.

The procedures described under any of these topics are not in any particular order. Each troubleshooting procedure is performed in steps and no procedure relies on the completion of any other, unless specifically stated. In most cases, follow the procedure as closely as possible. Each describes a purpose, method, and result. The result is determined as a pass or fail condition, and indicates the next action needed to repair the problem.

The performance of any of these procedures requires care, and in some cases technical skill and even specialized training. As a guideline, if you cannot understand the description of the procedure, do not attempt the procedure without requesting assistance from your distributor or CRS.

Service Repair Checks (expanded)

RE1 Control External Visual Checks
Visual and functional checks that can be made from the outside of the controller.

6-1 Controller External Checks

RE1.1 Check For Main Power

Purpose

To determine if AC power is applied to the controller.

Method

1. Switch the main power switch to the ON position.
2. Check the status display; look for any activity on the display.
3. Check the status lights on the panel buttons; look for any activity as you apply main power.
4. Listen or feel for airflow to indicate that the fan is operating.

Results

- If any of the above checks indicate activity, then main power is present.
- If none of the above checks indicate the presence of main power, then refer to RE 1.2 AC Power Cord Checks.

RE1.2 AC Power Cord Checks

Purpose

To determine if AC power is supplied to the controller.

Method

1. Remove the AC power cord from the controller rear panel.
2. With a voltmeter, measure the voltage at the two outer terminals of the AC cord. Measure from terminal 1-2.
3. With a voltmeter, measure the voltage from the line to Ground from terminal 1-3.
4. Re-connect the AC cord to the controller.

Result

If both measurements were performed, the voltage should measure ±10% of the controller's operating voltage. Set the operating voltage to 100 VAC, 115 VAC, or 230 VAC. Observe the setting by looking into the window of the fuse drawer, located in the AC inlet module.

RE1.3 Check or Replace the AC Line Fuse(s)

Purpose

To determine if the power line fuse is intact.

Method

1. Remove the AC power cord from the controller rear panel.
2. Use a small slot screwdriver to pry upward on the fuse drawer clip to release the fuse drawer.
3. Remove the fuses from the holder. Visually check for signs of broken filaments or burn marks on the glass.
4. Check the fuses with an ohm-meter. The resistance of each fuse should read zero ohms.
5. Check fuses for correct value.

Result

If the fuses show signs of damage in steps 3 and 4, replace the fuses with the same type and rating (refer to the table located on the rear panel of the controller).

RE1.4 Check For Normal Controller Boot-Up

Purpose

To determine if the controller is indicating a problem at boot-up.

Method

1. Switch the main power switch to the ON position.
2. Observe the status display. The display should indicate “A1”, see section 2-2 Power-Up Sequence.
3. Test terminal mode and teach pendant operation.

Results

- If the display indicates something other than “A1”, a problem may exist. For example, a display of “A7” may indicate a problem related to user memory. Communication may only be available at the teach pendant at this point. Erase or correct the portion of memory that has been corrupted. Refer to Figure 2-1 Initialization Sequence for more information on the initialization sequence.
- If a “D1” diagnostics continually displays, it may indicate the absence or corruption of the RAPL firmware. It may be necessary to reload the RAPL firmware, refer to RE7.2 Reload Firmware.
- If the status code appears to be different after each boot-up, it may be necessary to reload RAPL firmware or contact CRS for assistance.

RE1.5 Check "ARM ENABLED" Switch

Purpose

To determine if the arm power signal is enabled.

Method

1. Turn main power on.
2. In Robcomm, go to the terminal emulator and obtain the prompt.
3. Type the RAPL command ENABLE <CR>. A list of parameters appears.

Results

- Look for the "Arm" parameter in the left hand column. The "ENABLE" state is located on the right hand side.
- If "DISABLED" displays on the screen, use the ENABLE ARM, or ARM ON command to enable the arm.
- Check the contents of the programs in memory to determine if one of these commands was used to turn off arm power.
- Check the AUTOEXEC and any other program which is used to terminate the arm's operation.

RE1.6 Check External E-Stop Wiring

Purpose

To determine if the e-stop wiring is closed.

Method

Before checking the e-stop wiring, you must first turn off arm power in the C500 controller.

A. Check the Front Panel E-Stop Wiring

1. Turn off the C500 Controller Arm Power
2. Press the front panel e-stop button. The switch mechanically latches, twist the e-stop button to release it.
3. Perform a continuity test between pins 1 and 2 of the cable connected to J2 on the front panel display board.

B. Check the Teach Pendant E-Stop

1. Press the teach pendant e-stop button and then twist the e-stop to release it. If the teach pendant is not available plug in the over-ride switch.
2. Insert the teach pendant over-ride connector and test arm power.

C. Check the Teach Pendant E-Stop

1. Locate the SYSIO and the Expansion Amp connectors on the rear panel. The SYSIO signals are enabled by the dip switch on the auxiliary board, refer to section 3-3 Auxiliary Board.

2. Unplug the connectors from the rear panel.
3. Test the continuity of the e-stop contacts at pins 19 and 20 of the SYSIO.
4. The amplifier expansion arm on signals may be enabled by the dip switch on the auxiliary board. If they are enabled, check pins 8 and 19 for continuity of the amplifier expansion connector. Signals are also available on CB-J9 pins 23 and 24.

Result

If an interruption is found in any contact pair, then the test has failed.

RE1.7 Check Arm Feedback Signal Connector Locking

Purpose

To determine if the feedback signal connector is locked properly.

Method

1. Locate the arm feedback signal connector on the rear panel of the controller (see section 4-3-3 Robot Feedback Connector).
2. Loosen the locking ring until it begins to disengage the connector.
3. Orient the large tab on the tip of the connector to the top position.
4. Tighten the ring clockwise until you feel it click. This indicates full engagement of the connector.

Result

Failure to tighten the locking ring may cause an intermittent connection in one of the feedback lines and robot runaway.

RE1.8 Check Front Panel Fuses

Purpose

To check the integrity of the three front panel fuses.

Method

1. Turn off main power.
2. Flip down the front panel lid.
3. Unscrew the fuse caps to remove the screws.
4. Check the continuity of the fuses with a fuse meter.
5. Replace the fuses if they are damaged.

Name	Rating (Amps)	Object(s) In Series With Fuse
Gripper fuse	0.38 (3/8)	Servo Gripper
Relay Fuse	2.0	GPIO Relays
24 Volt Fuse	2.0	GPIO, SYSIO, and Proximity Sensors

Table 6-1 Front Panel Fuses

Result

If the fuses are open, the fuse must be replaced.

6-2 Controller Internal Visual Checks

RE2.1 Check Controller Board Components

Purpose

To determine if any of the socketed chips in the controller board have been removed partially or completely.

Method

1. With main power off, remove the controller lid.
2. Ensure that you are properly grounded before touching any circuit boards inside the controller. Static can damage the boards.
3. Visually check all socketed components on the controller board. Each component must be in the socket with all legs in place.
4. Look carefully for any chip legs protruding outside the socket or tucked under the chip.
5. If all chips appear to be in place, press each one down firmly into its socket.

Check the following components to ensure that each chip is securely connected to its socket conductor. For more information on controller board socket components refer to section 3-2-2 Socketed Components.

Controller Board Components	Position
Processor 80286 PLCC package	U1
EPROM Memory (2 chips), 28/32 pin JEDEC	U15, U16
FPGA 1, PLCC package	U14
FPGA 2, PLCC package (encoder feedback)	U69, U70
LM324 quad op Amp for torque and servo position feedback	U36, U32
Serial Drivers	U37, U38

Table 6-2 Socketed Components on the Controller Board

Auxiliary Board Components	Position
Darlington drivers DS2002	U7, U8, U9

Table 6-3 Socketed Components on the Auxiliary Board

Result

- If all chips are present, no legs out, and pressed firmly in place, this test passed.
- If any problems were found, the test fails.

RE2.2 Check Internal RS-232 Connector

Purpose

To check the internal RS-232 connector.

Method

The RS-232 connections to the controller board is located in the right front of the controller. It consists of a ribbon cable (on most controllers) which goes from the front panel receptacle to the header designated as J2 on the controller board.

1. Ensure that you are properly grounded before touching any circuit boards inside the controller. Static can damage the boards.
2. Ensure that the connector is firmly seated into the controller board header.
3. Check that the triangular mark on the connector is in the same corner as the corresponding mark on the header.

Result

If both connectors are in place, the test passed.

RE2.3 Check Servo Gripper, Brake, Linear, and PWM Amplifier Fuses on Auxiliary Board

Purpose

To check the Servo Gripper, Brake, Linear, and PWM amplifier power supply fuses on the auxiliary board.

Method

1. With main power off, remove the lid of the controller.
2. Ensure that you are properly grounded before touching any circuit boards inside the controller. Static can damage the boards.
3. Locate the fuses at the rear of the controller on the auxiliary board designated as F1 and F2. Inspect the fuses for damage. Perform a continuity check with a meter, the fuses may appear to be intact visually but still damaged.
4. Replace the fuse(s) if damaged, with fuses of the same type and rating (10 A, 250 V, fastblow).

Fuse Designation		
Fuses	**Location**	**Fuse Supplies Voltage To:**
Linear Amp Fuse	F1	Linear Amp positive rail Servo gripper Amp positive rail Brake fuse (F4)
Linear Amp Fuse	F2	Linear Amp negative rail Servo gripper Amp negative rail
PWM Fuse	F3	PWM rail voltage
Brake Fuse	F4	Brakes

Table 6-4 Internal Fuse Location

Result

If the fuse(s) are blown, the test failed.

RE2.4 Check Connection From Auxiliary Board to the GPIO and SYSIO Connectors

I/O signals are carried to and from the auxiliary board via two ribbon cables. These must be installed correctly or the controller may not be able to control digital I/O correctly.

Purpose

To check the connection from the auxiliary board to the GPIO and the SYSIO connectors.

Method

1. With power off, remove the controller lid.
2. Ensure that you are properly grounded before touching any circuit boards inside the controller. Static can damage the boards.
3. Check the box headers at the auxiliary board positions J9 and J10.

Result

If the connectors are installed correctly, the test passes.

RE2.5 Check Proximity Switch Connections From the Rear Panel CPC-24 Connector to the Auxiliary Board

The signals from the homing proximity switches of the A465 and Track axes of the A255 are carried through the harness from the rear panel CPC-24 connector to the auxiliary board. After opto-isolation on the Auxiliary board, the signals (TTL level) are then fed to the controller board via the 60 pin ribbon cable.

Purpose

To check the proximity switch connections from the rear panel CPC-24 connector to the auxiliary board.

Method

- Locate the CPC-24 connector and check for the presence of the harness. It should be plugged into J5 on the auxiliary board.

Result

If the connectors are installed correctly, the test passes.

RE2.6 Check PWM Amplifiers Enable LEDs for the 465, Gantry, and Track Model

Each PWM amplifier contains a LED that indicates that it is enabled. If the amplifier is not enabled the arm remains limp when the arm power is turned on. The amplifiers enable when they receive two independent signals from the auxiliary board. These enable signals have an opposite sense, so if the harness from the auxiliary board to the amplifier is missing, then the amplifiers do not enable.

Note: If only one enable signal is present, the Copley Amps indicate a green LED, but they still do not enable.

Warning! Keep the e-stop close at hand when enabling arm power, and keep out of the workspace of the robot. *If a sudden motion occurs when the arm power is turned on, press the e-stop immediately to prevent damage.*

Purpose

To check the enable/disable states of PWM amplifiers.

Method

1. Ensure that the controller is placed a safe distance from the robot arm.
2. Remove the lid from off the controller box. Turn the arm power on.
3. Ensure that each of the PWM amplifier LEDs are on. With an A465 robot, there are three of these amplifiers. Refer to section 3-5-3 PWM Amplifiers.
4. Ensure that power is being applied to all motors by moving the robot with the teach pendant.

Result

The test passes if the motors are energized when arm power is on.

RE2.7 Check Diagnostic LED’s (Auxiliary Boards REV 1.3 and Above)

Purpose

To check the diagnostic LED’s.

Method

Use the diagnostic LED’s to diagnose problems in the power supply, e-stop lines, arm power watchdog, and in the linear rail voltage.

1. Remove the lid from the controller.
2. Turn on the main power.
3. Observe the LEDs on the auxiliary board from location D59 to D70, refer to Table 3-17 Auxiliary Board Diagnostic LED’s.
4. Check these LEDs, one by one starting at D59. Refer to the instructions below.

D59 + 5 Volt Signal (Vcc)

This signal provides power to operate the logic level electronics of the controller. Without this signal there will be essentially no operation of the controller. This LED should be bright. An unlit or dim LED generally indicates a problem with the voltage. Measure at the controller board J10 connector between pins 1/2 and 3/4 (GND).

D60 + 24 Volt Signal

This is the supply voltage used to power the GPIO optical relays on the auxiliary board and the proximity switches on Tracks and A465’s which are used in the homing sequence.

It may also be used to power external circuits through the GPI0 and/or the SYSIO. Without this voltage, no inputs or outputs would work from the GPIO and/or SYSIO and external circuits would not operate if connected to these two connectors.

An unlit or dimly lit LED may indicate a problem with the power supply, external circuits, or a blown fuse in the front panel of the controller.

To check the DC voltage level:

1. With a voltmeter measure at the controller board J10 connector between pin 10 and 3/4 (GND)
2. Check the 24 Volt fuse in the front panel, inside the front panel flip down lid.
3. If this fuse is blown, check the external circuits before replacing this fuse.

D61 + 12 Volt Signal

This is the supply voltage used in the controller electronics as well as in the arm electronics. Without the proper voltage the controller would not have a reference voltage established and various symptoms of failure would be exhibited such as improper voltage offset on the amplifiers, and erratic arm and gripper operation.

An unlit or dimly lit LED generally indicates a problem with the power supply.

To check the voltage level:

1. With a voltmeter measure at the controller board's J10 connector between pins 6 and 3/4 (GND).

D62 -12 Volt Signal

This is the supply voltage which is complementary to the +12 Volt signal in some of the controller circuits. Without the proper voltage, the controller would exhibit failure indicating improper voltage offset to the amplifiers, and erratic arm and gripper operation.

An unlit or dimly lit LED generally indicates a problem with the power supply.

To check the voltage level:

1. With a voltmeter measure at the controller board's J10 connector between pins 7 and 3/4 (GND).

D63 Front Panel E-Stop

This e-stop is located at the lower right side of the front panel. It is the first e-stop in the daisy chain.

1. If the LED is not on, then check to see that the large switch is not depressed; it can be unlocked by rotating it counter-clockwise.
2. If the LED is still not on, then it is necessary to check the switch and wiring internally. The switch is secured by two clips and the 2 wires that run from it to the J2 connector on the display board.
3. Check the integrity of the switch and wiring.

D64 Teach Pendant E-Stop

This stage of the e-stop can be bypassed by the:

1. Teach Pendant E-Stop Button
2. Override Plug
3. Auxiliary DIP switch setting S1 #1

If the teach pendant is connected to the front panel connectors, make sure that it is connected securely. The e-stop button on the pendant is located at the upper right hand side of the teach pendant.

- If the teach pendant is depressed, it can be unlocked by rotating it clockwise.
- If the override plug is connected to the front panel, make sure that it is connected securely. There are connections made inside of the connector that short-out this stage of the daisy chain.
- If nothing is connected to the front panel teach pendant connector then it is necessary to manually override by flipping the DIP switch on the auxiliary board. This DIP switch is located between connector J4 and J16 (refer to Figure 3-4 Auxiliary Board Connector Locations). Flip switch S1 #1 to the ON position (refer to section 3-3-1 Auxiliary Board DIP Switch).

D65 LIVEMAN E-Stop

This stage of the e-stop daisy chain can be bypassed by:

Warning! Do not bypass the e-stop switch on the Teach Pendant.
Eliminating this e-stop will create a harazardous working condition when operating the arm and teaching locations.

1. Auxiliary DIP switch setting S1 #4 (auxiliary board revisions 1.3 and above).
2. Manually depressing the liveman bar on the teach pendant when in manual mode.
3. Software configuration in the @@SETUP command. (RAPL-2.5 and earlier only).

The liveman only plays an active part when the system is in manual mode. Otherwise, the controller’s own software generates a signal to override the liveman switch.

You can use the DIP switch on the auxiliary board to override the liveman switch. Set S1 #4 to the ON position (auxiliary board revisions 1.3 and above). This manual switch overrides all liveman e-stop switches.

If the @@SETUP is configured to enable the liveman switch in manual mode, and the DIP switch S1 #4 is OFF, then it is required to manually depress the liveman bar on the teach pendant whenever moving a joint in manual mode. Since software controls this signal the LED should appear to be lit if D63 and D64 are lit. Only a flicker will be noticed if the e-stop daisy chain is broken while in manual mode.

D66 REMOTE (SYSIO) E-Stop

The illumination of this LED indicates that the SYSIO e-stop is closed-circuited. The LED turns off when the e-stop contacts are open. The SYSIO e-stop contacts are available on pins 19 and 20 of the SYSIO connectors on the rear panel. These contacts can be overridden by the auxiliary board DIP switch S1. Sliding position #2 to the ON position (towards the edge of the board) overrides the SYSIO e-stop (closes the contacts). This is the factory setting.

D67 Remote (Amp Expansion) E-Stop

The illumination of the LED indicates that the Expansion Amp e-stop is closed-circuited. The LED turns off when the e-stop contacts are open. The Expansion Amp e-stop contacts are available at J9 on the controller boards pins 23 and 24. These contacts can be overridden by the auxiliary board DIP switch S1. Sliding position #3 to the ON position (towards the edge of the board) overrides the Expansion Amp e-stop (closes the contacts). This is the factory setting.

Note: In D63 through D67, the LED's do not light independently, but in a descending order of their connections in the e-stop daisy chain. For example, when an e-stop contact is opened, its LED and LED's pertaining to e-stops further down the chain turn off.

D68 Watchdog

The illumination to the LED indicates the presence of the watchdog signal. If the signal is not present, arm power can not be turned on. The watchdog is not present if an "ARM OFF" command has been issued or if a servo or other error has occurred on the controller board. Refer to section RE3.20 Check for Watchdog Signal.

69 Linear Amplifier +ve Rail Supply Voltage

The illumination of this LED indicates the presence of the positive rail voltage supply for the linear amplifiers. This LED turns on if the Rail voltage is present and arm power is turned on. A dimly lit LED may indicate a problem with the supply voltage. To check arm power supply voltages refer to the following sections: RE8.1 Check Voltage Supply From Auxiliary Board to PWM Amplifier Module and RE 8.2 Check Voltage Supply From the Auxiliary Board to the Linear Amplifier Module.

D70 Linear Amplifier -ve Rail Supply Voltage

The illumination of this LED indicates the presence of the negative rail voltage supply for the linear amplifiers. This LED turns on if the Rail voltage is present and arm power is turned on. A dimly lit LED may indicate a problem with the supply voltage. To check arm power supply voltages refer to the following sections: RE8.1 Check Voltage Supply From Auxiliary Board to PWM Amplifier Module and RE 8.2 Check Voltage Supply From the Auxiliary Board to the Linear Amplifier Module.

Result

If an LED is not on, the signal pertaining to it is not present.

6-3 Controller Internal Function Checks

RE3.1 Check Arm Power Enabling Circuits

The arm power enabling circuit consists of two subsections: a controller board main processor generated watchdog signal and a series of e-stop contacts in a daisy chain configuration. If the watchdog is not present, or if one of the e-stop contacts is open, arm power can not be turned on.

Note: Check that the robot arm is plugged in, that the circuit breaker sensing connectors are removed (J11 and J12 on the Aux. Board) or the sensing circuitry turns off arm power soon after its enabled.

Purpose

To check arm power enabling circuitry.

Method

1. Remove the controller lid with the main power off.
2. Ensure that you are properly grounded before touching any circuit boards inside the controller. Static can damage the boards.
3. Turn on the main power and check the status of the e-stop daisy chain using the diagnostic LED's, located near the back of the controller on the auxiliary board. If the board is not equipped with these LED's then skip this step.

Relevant LED

LED	Name	Location
D63	Front Panel E-Stop	Front Panel - Controller
D64	Teach Pendant E-Stop	Override S1 #1 (Auxiliary Board)
D65	Liveman E-Stop	S1 #4
D66	Remote (SYSIO) E-Stop	S1 #2
D67	Expansion Amp E-Stop	S1 #3
D68	Watchdog	Auxiliary Board

Table 6-5 LED Locations

4. If the LED is on, then that set of contacts is closed and is not disabling arm power. The LED's do not light individually, but in a descending order in the e-stop daisy-chain. For example, when a e-stop contact is opened, it's LED and LED's pertaining to e-stops further down the chain turn off. Refer to section RE2.7 for details on these e-stops and the diagnostic LED's.

5. Check for the presence of the watchdog signal. On the auxiliary boards equipped with diagnostic LED's the presence of the watchdog signal is indicated by the illumination of LED D68. On boards not equipped with LED's, a good indicator of the presence of the watchdog signal is to listen for the arm power enabling relay to turn on a few seconds after boot-up. Refer to section RE3.2 for details on the watchdog signal.

   Note: The watchdog is not present if the "ARM OFF" command has been issued or a server error has occurred.

6. If the e-stop LEDs can not be made to turn on or the auxiliary board is not equipped with these LEDs then some other e-stop checks can be made. Make sure that the teach pendant is connected or the override plug is installed and that all e-stop contacts are closed (buttons are not depressed).

   a) Remove connectors from the rear panel at the expansion amplifier and the SYSI0 locations. Locate the e-stop overrides switches on the right hand side of the auxiliary board between J16 and J4.

      Ensure that contacts #2 and #3 are in an “ON” or “OVERRIDE” condition (slide towards the edge of the board). Try to turn on arm power. If arm power turns on, the problem may be external to the controller.

   b) Disconnect the teach pendant or the override plug from the front panel. Override the e-stop by moving contact #1 of the e-stop override switches to the “ON” position. Try to turn arm power on.

      If arm power turns on, the problem could be external to the controller or related to damage to the internal pendant cable, the 60 pin ribbon cable, or damage to traces on the controller or the auxiliary boards.

   c) Unplug the front panel e-stop connector from the front panel display boards J2. Measure the resistance between these two wires with an ohmmeter. The resistance should be (0 Ω with the contacts closed and an open circuit (∞ Ω) when the contacts are open (front panel e-stop button depressed).

      If the test passes, reconnect the e-stop cable to J2 on the display board. With the e-stop contacts closed, measure the voltage at each of the 2 wires connected to J2. The voltage should be +12 V ±.1 V at each location. If this voltage is not present, there may be a problem on the display board, auxiliary board, or the ribbon cable that connects them.

   d) Disable the liveman e-stop. This e-stop is only active in manual mode. In normal operation this contact is overridden by a relay under software control. Contact #4 of the e-stop override switches on the auxiliary board is in parallel with this relay. Move contact #4 to the “ON” position.

      Try to turn arm power on. If arm power turns on then a failure has occurred on the controller auxiliary boards.

Result

If all e-stop contacts are closed, and the watchdog signal is present, then arm power can be enabled, and the test passes.

RE3.2 Check Arm Power On Signal

When arm power is off, the joint servos are in LIMP mode. When the arm is at a location, and power is applied, the servo command register resides at that location.

When power is applied, the system sends a signal from the auxiliary board to the front panel display board to inform the user that power is on. A signal is also sent to the controller board to indicate to the system that arm power is on, the servos are unlimped, and the motors control the arm. If that signal does not arrive at the controller board, the servos stay limp after power is applied. Axes under a gravity load may fall.

Purpose

To check the arm power feedback to the controller.

Method

1. Remove the lid of the controller.
2. First ensure that the arm power check is turned on from software. Issue the "ENABLE APC" or the “ARM ON” command.
3. Ensure that you are properly grounded before touching any circuit boards inside the controller. Static can damage the boards.
4. Check all point to point wiring for obvious bad connections and check that all connectors on the display board are seated properly.
5. Check the 60 pin ribbon cable connecting J1 on the controller board to J2 on the auxiliary board. Make sure the connections are set properly.
6. Turn on the main power. With a voltmeter, measure the voltage at U24 pin 15 on the controller board. It should be 5 V. Turn on arm power. Measure the voltage again, it should be 0 V.

Result

If the signal levels are seen as described above, then the test passes.

RE3.3 Check Power Fail Indicator (PFI)

The PFI informs the computer when a fatal power drop is imminent. This prevents the computer from being caught in the middle of a read/write cycle when the power supply voltage drops. Circuitry on the Aux. Board reads the AC line status and sends a signal on the reset line to the controller board when the AC condition indicates a brown out or cycle drop out condition. The computer power supply delivers 5 Volts for about 90 msec, giving the processor time for an orderly shutdown.

Purpose

To check the power fail indicator.

Method

1. Remove the lid of the controller and ensure that you are properly grounded before touching any circuit boards inside the controller.
2. If the controller is not booting up, then the PFI may be holding it in a reset condition. Check the following signal:
   - Turn on the main power. Using a voltmeter, measure the voltage at U2 pin 11 on the controller board. It should be 5 Volts under normal operation.
   - O V indicates a reset condition
3. There are two reasons why a reset condition may be present: the condition of the AC line is not acceptable to the to the PFI, or the PFI has failed in some way.
4. To disable the PFI, turn off main power.
   - Remove the 60 pin ribbon cable that connects J1 on the controller board to J2 on the auxiliary board.
   - Turn on main power. Watch for controller boot-up on the pendant or the terminal emulation device connected to the comm port.
5. Check the operation of the PFI during a power down cycle, use an oscilloscope with capturing capabilities.
6. With main power off and all cabling in place, use channel #2 of the scope to monitor the 5 V supply (J10 pin 1 of the controller board) with channel #1, probe U2 pin 11.
7. To turn on main power:

- Set the scope for 2 V/divisions vertical and 25 msec/div horizontal scales.
- Trigger on the negative going transition of channel #1.

8. To turn off main power:

- The scope should show a transition on channel #1 from high to low with the signal on channel #2 starting to delay 90 msec later.

Result

If the controller is not held in a reset state and the waveforms appear as described during a power down cycle then the test passes.

RE3.4 Check Voltage Supply to Brake Circuits

The brakes receive power from the linear power supply through the two auxiliary board fuses F1 and F2. The brake voltage is then fed to the encoder connector board.

Purpose

To check the voltage supply to the brake circuits.

Method

1. With main power off, remove the lid from the controller.
2. Ensure that you are properly grounded before touching any circuit boards inside the controller. Static can damage the boards.
3. Observe the condition of the brake fuse, designated as F4 on the auxiliary board. Verify its condition with an ohmmeter. The resistance across the fuse should be 0 Ohms.
4. Turn on main power.
5. Inspect the connectors at J7 on the auxiliary board and J3 of the encoder connector board on the rear panel.
6. Check the Molex connector at J7, pin 3, and check for the presence of brake voltage.

- Turn the arm power off and on to observe a change in the brake supply voltage.
- The voltage should be 0 Volts with the brakes applied (fail safe condition), and 35 V with the brakes disengaged (arm power on).

7. Gently tug on all contacts in each connector to ensure that the wires are crimped correctly. Also inspect for loose wire filaments protruding from the crimped terminal.

Result

If no voltage is seen, the test failed.

RE3.5 Check UART Initialization

Purpose

To verify that the UART chips have been correctly initialized by the CPU during a power up.

Method

1. Turn the controller on.
2. Ensure that you are properly grounded before touching any circuit boards inside the controller. Static can damage the boards.
3. Check the input clock frequency to the two UART chips (U39, pin 16, U40 pin 16) on the controller board. It should be 2.4576 MHz.
4. Check the output baud rate frequency:

- With the default controller settings (see @@SETUP command), the baud rate frequencies should be 307 kHz for U39 at pin 15, and 614 kHz for U40 pin 15.

  U_{39} - Baud 19, 200 (S.T.P)
  pin 9 at 307 kHz

  U_{40} - Baud 38, 400 (TERM)
  pin 9 at 614 kHz

Result

If these frequencies do not exist, then the UART is not initialized correctly. Repeat the power-up sequence after resetting the "Reload Parameters" setting in the @@SETUP command, and try again. If a failure remains, the test fails.

RE3.6 Check Programmable Interval Timer (PIT)

Purpose

To determine if the programmable interval timer on the controller board is functioning correctly.

Method

1. Remove the lid of the controller.
2. Ensure that you are properly grounded before touching any circuit inside the controller. Static can damage the boards.
3. The device is an Intel 82C54 and is located at U12 on the controller board. The PIT is used to control the repeated timing functions of the controller.
4. Use a scope to check the following signals:

- Input clock signals to the 82C54 should be 205Khz on pin 9 and 800Hz on pin 18. These are TTL level square wave signals.
- Timing pulse signal on pin 10 - active low with a 1 msec period.
- Timing pulse signal on pin 13 - active high with a 8-32 msec period.
- Timing pulse signal on pin 17 - active low with a 20-150 msec period.

5. Observe the timing pulse outputs. Each timing pulse output is activated when its timed interval expires. The output is reset low by the processor when the corresponding interrupt is acknowledged.

- Use a single shot low-high transition on the scope trigger to observe the timing pulses. These signals may be difficult to locate with a digital scope, since the pulse width is normally 5-10 µsec.
- If the signal appears as pulse trains, this may indicate that the processor is reading the signals correctly.
- If the signal outputs appears at a steady state this may indicate a processor failure, where the controller it is unable to read the signals correctly.

6. Verify the count frequencies with the @@DIAG command, and PIT Timer tests. These tests will indicate a pass/fail state.

Result

If any of the signals are not seen at correct TTL levels and timed as indicated above, there is a failure on the controller board and the test fails.

RE3.7 Check Serial Terminal Device 0 Receive Function

Note: Refer to section 2-10 Requirements for Interactive Communication and section 2-11 Host Interface Communication (ACI Operation) for a clear understanding of the requirements for serial communication.

Device 0 is the default serial channel which supports the teach pendant.

Device 1 identifies the front panel communication port.

Purpose

To verify that characters transmitted by an external device are successfully received and recognized by the controller CPU.

Method

1. Issue characters to the controller in a continuous fashion by repeatedly pressing the ESC key on the teach pendant.

2. Ensure that you are properly grounded before touching any circuit boards inside the controller. Static can damage the boards.

3. Using a scope, note the activity of the serial data line arriving at the serial receiver, U38 pin 1 on the controller board. Signal levels should be RS232 compatible at this point, at approximately ±12 Volts.

4. Using a scope, note the activity of the serial data line leaving the receiver chip, U38 pin 3 on the controller board. Activity should mimic the input pin 1, but with TTL signal levels.

5. Verify that the serial data arrives at the UART, U39 pin 10.

6. Verify that the UART recognizes the incoming data by observing U39 pin 30 (INTR). This signal changes if the UART is operating. A proper signal at this point would be a predominantly low signal with positive pulses that are approximately 20 msec wide. Pulses should be no closer than 10 msec apart. If this signal is low, the UART has not recognized any data, indicating a UART failure. If the signal is high, then the CPU has not read the UART, indicating a CPU or general controller board failure.

Result

Failure of the line receiver or the UART constitutes a failed result. Proper activity on U39 pin 30 (INTR) indicates a pass condition.

RE3.8 Check Serial Terminal Device 0 Transmit Function

Note: Refer to section 2-10 Requirements for Interactive Communication and section 2-11 Host Interface Communication (ACI Operation) for a clear understanding of the requirements for serial communication.

Device 0 is the default serial channel which supports the teach pendant.

Device 1 identifies the front panel communication port.

Purpose

To verify that characters are issued from the controller.

Method

1. Connect a teach pendant to the controller and turn main power on. Issue characters to the controllers in a continuous fashion by repeatedly pressing the ESC key on the teach pendant.
2. Ensure that you are properly grounded before touching any circuit boards inside the controller. Static can damage the boards.
3. Test pendant U39 pin 11 on the controller board to verify that characters are leaving the UARTs. This signal should change constantly at TTL levels.
4. Verify that the data leaving the UART arrives at the line driver, pendant U37 pin 2 on the controller board.
5. Verify that the data leaves pendant U37 pin 3 at RS232 signal levels.

Result

Signal continuity from the UART to the output of the line driver indicates a passed result. Any other result is a failure.

RE3.9 Check Serial Device 1 Receive Function

Note: Refer to sections 2-10 and 2-11 for a clear understanding of the requirements for serial communication.

Device 0 is the default serial channel which supports the teach pendant.

Device 1 identifies the front panel communication port.

Purpose

To verify that characters transmitted by an external device are received and recognized by the controller CPU.

Method

1. Issue characters to the controller continuously. Use a terminal device and repeatedly press a key on the keyboard. Use Robcomm for Windows or DOS in the terminal emulation mode to perform this test.
2. Ensure that you are properly grounded before touching any circuit boards inside the controller. Static can damage the boards.
3. Using a scope, note the activity of the serial data line arriving at the serial receiver, U38 pin 13. Signal levels should be RS232 compatible at this point at approximately ±12 Volts.
4. Using a scope, note the activity of the serial data line leaving the receiver chip, U38 pin 11. Activity should mimic the input pin 13, but with TTL signal levels.
5. Verify that the serial data arrives at the UART, U40 pin 10.
6. Observe U40 pin 30 (INTR) to verify that the UART recognizes the incoming data. This signal changes if the UART is operating. A proper signal is defined as a low signal with positive pulses that are approximately 20 msec wide. Pulses should not be closer than 10 msec apart.

- If this signal is low, the UART has not recognized any data. This indicates a UART failure.
- If the signal is high, the CPU has not read the UART. This indicates a CPU or general controller board failure.

Result

Failure of the line receiver or the UART constitutes a failed result. Proper activity on U40 pin 30 indicates a pass condition.

RE3.10 Check Serial Device 1 Transmit Function

Note: Refer to sections 2-10 and 2-11 for a clear understanding of the requirements for serial communication.

Device 0 is the default serial channel which supports the teach pendant.

Device 1 identifies the front panel communication port.

Purpose

To verify that characters are issued from the controller.

Method

1. Issue characters to the controller in a continuous fashion to perform the sequence. Use a terminal device and repeatedly press a key on the keyboard. Use Robcomm for Windows or DOS in the terminal connection mode to perform this test.
2. Ensure that you are properly grounded before touching any circuit boards inside the controller. Static can damage the boards.
3. Test U40 pin 11 on the controller board to verify that characters are leaving the UARTs. This signal should change constantly at TTL levels.
4. Verify that the data leaving the UART arrives at the line driver, U37 pin 12 on the controller board.
5. Verify that the data leaves U37 pin 11 at RS232 signal levels.

Result

Signal continuity from the UART to the output of the line driver indicates a passed result. Any other result is a failure.

RE3.11 Check Function of Controller Board (Alone)

Purpose

To determine if the controller board is functioning properly while excluding all peripheral equipment which could be detrimental to its performance.

Method

1. Disconnect main power and remove the lid of the controller.
2. Ensure that you are properly grounded before touching any circuit boards inside the controller. Static can damage the boards.
3. Remove all connectors from the controller board except for the power supply connector J10 and the serial connector J2.
4. Connect a terminal device to the front panel communication port.
5. With the main power off, connect the teach pendant connector J3 to the controller board. Verify that the controller board still operates.
6. Turn on the main power and watch for a sign-on message at the terminal screen and the teach pendant.
7. With the main power off, connect each of the following connectors verifying controller board operation after each connection.
   - J3 supplies power to the auxiliary board
   - J6 connection to the auxiliary board
   - J1 connection to the auxiliary board including PFI/Reset signal
   - J7 encoder feedback
   - J8 encoder power

Result

If the board fails to issue a sign-on message with only J10 and J2 connected, then the test fails.

RE3.12 Check the Computer Power Supply Signal to the Controller Board

The connection from the computer power supply to the controller board is critical to the operation of the controller. If the contacts get dirty or lose their effectiveness, the operating voltage at the controller board could drop, causing a failure.

Purpose

To check the connection from the computer power supply to the controller board.

Method

1. With main power off, remove the controller lid.
2. Ensure that you are properly grounded before touching any circuit boards inside the controller. Static can damage the boards.
3. With main power on, measure the voltage on the controller board between a ground point (located at the 4 corners of the board) and U71 pin 16. This is the 5 V supply voltage. Measure the 12 V supply voltage at U93 pin 4.
4. Compare these voltage levels with those found at the power supply connection J10.

Pin	Voltage Level
1,2	5.10 (±0.05)
3,4	ground
6	12.00 (±0.1 V)

5. The power supply adjustments potentiometers can be accessed through the hole in controller/auxiliary board plate assembly in the front left of the controller. The adjustment for the 5 V supply is identified by a 5 V marking on the power supply circuit board. It is the potentiometer closer to the front of the controller. The potentiometer closer to the rear of the controller adjusts the 12 V supply.
6. Make supply adjustments carefully as an over voltage situation may damage the electronics of the controller. After making any adjustments check both 12 Volt and 5 Volt lines.

Note: If the power supply is not connected to the controller board, these signal levels do not apply.

Result

If the supply voltage levels at the test points described above are identical and at the correct level, then the test passes.

RE3.13 Check Computer Power Supply Voltage Levels

The following measurements must be referenced to the signal ground. This can be accessed at connector J10, pins 3 and 4, or one of the 4 GND PTS. on the controller board.

Purpose

To check the computer power supply voltage levels.

Method

1. Ensure that you are properly grounded before touching any circuit boards inside the controller. Static can damage the boards.
2. Make the following checks with arm power turned on.

+5 Volt Check:

1. Place a scope or digital voltmeter probe on pin 1 or 2.
2. The +5 Volt signal must be in the range of +5.05 to +5.15 Volts DC. If it is not, adjust the power supply to bring it into this range.
3. The adjustment is made on the front board-mount potentiometer on the computer power supply. This is accessible through the access hole in the PCB tray, just in front of the electronics boards.
4. Use a long, small flat head screw driver to access the trim pot. Turn the pot in small amounts, observing the voltage change on the scope or DVM.
5. If using a scope, check that the noise level is below ±100 mV peak to peak. If it is higher, contact CRS.

In future revisions, these following adjustments will not be possible.

+12 Volt check:

6. Place a scope or a digital voltmeter probe into the controller board power supply connector, J10 position 6.
7. Observe the voltage. The +12 Volt signals should be within ±0.1 Volts DC of the nominal level. If not, adjust the potentiometer directly behind the 5 V adjustment pot.

-12 Volt check:

8. Place a scope or a digital voltmeter probe into the controller board power supply connector, J10 position 7.
9. Observe the voltage. The -12 Volt signals should be within ±1.5 Volts DC of the nominal level. This voltage cannot be adjusted on the power supply. If it is outside the specified range, contact CRS.

+24 Volt check:

10. Place a scope or a digital voltmeter probe into the controller board power supply connector, J10 position 10.
11. Observe the voltage. The +24 Volt signal should be within ±2 Volts DC of the nominal level. This cannot be adjusted.

RE3.14 Check Programmable Interrupt Controller (PIC) Initialization and Function

Purpose

To determine if the programmable interrupt controller on the controller board is functioning correctly.

Method

1. Ensure that you are properly grounded before touching any circuit boards inside the controller. Static can damage the boards.
2. The Programmable Interrupt Controller (PIC) receives signals from the various sources around the controller including the programmable interrupt timer (PIT). It coordinates these signals and feeds them to the appropriate interrupt vectors of the CPU.
3. The PIC is an Intel 82C59 and is located at U11 on the controller board.
4. Use a scope to locate and check the following signals:

Input	Signal
Input from PIT at pin 18	active low pulse 5 µsec wide with a 1 msec period
Input from PIT at pin 19	active high pulse 12 µsec wide with a 8-32 msec period
Input from PIT at pin 20	active high pulse 12 - 800 µsec wide with a 20-150 msec period

Table 6-6 Input Signals

5. Check for response to serial inputs from the communication port at U40 pin 30 and the teach pendant. These signals should be active high pulses with a width of 20 µsec at U39 pin 30.

Result

If any of the signals described above are missing or different from the description, the test has failed.

RE3.15 RS232 Serial Ground Current Loop Check

The official standard for RS232 defines pin 1 as an earth (shield) ground and pin 7 as an electrical ground (0 VDC). If the two are joined together at either, or both ends of a serial cable a current loop may form. Although current loops do not damage the hardware, they may disrupt communications.

Purpose

To perform a serial ground current loop check.

Method

Use an Ohm or Continuity meter to perform a serial ground current loop check.

1. Disconnect all serial cables from the controller. Disconnect the controller's AC power cord from the wall socket.
2. Test for shorts between pins 1 and 7 of the serial communication connector on the front panel. If a short is found, remove the controller lid.
3. Ensure that you are properly grounded before touching any circuit boards inside the controller. Static can damage the boards.
4. Remove the communications connector from the controller board at location J2. Test for a short between J2 pin 1 and GND PT. on the controller board. If a short is found, then the fault is on the controller board.
5. Test for a short between pins 1 and 7 of the serial cable. If a short is found, then the cable has failed.

Result

If there is no short between pin 1 and 7 of the serial cable then the test passes.

RE3.16 Check RESET Chip Function

The reset chip is an 82C284 device located at U2 of the controller board. It resets the CPU when the power supply output is unstable. The chip receives power line status information from the auxiliary board via the reset line which comes in at the 60 pin ribbon cable at J1 on the controller board. When this line is low, the CPU holds in a reset state, U10 pin 1.

Purpose

To check the RESET chip function correctly.

Method

1. Ensure that you are properly grounded before touching any circuit boards inside the controller. Static can damage the boards.
2. With the main power on, check the output of the power fail indicator circuitry from the auxiliary board to make sure it is not holding the controller in a reset state. It can be measured at U10 pin 1 on the Auxiliary board and should be a logic high.
3. Measure the input to the reset chip at U2 pin 11 on the Controller board, it should be a logic high. If U10 pin 1 is a logic high and U2 pin 11 is not, then U10 has failed.
4. Check the boot cycle of the reset chip. With main power off, connect a scope to U2 pin 12. Set the scope for 2 V/division vertical scale and 100 msec/division horizontal scale. Establish a low to high transition on main power.
5. Turn on main power. Observe the reset line going high for about 600 msec then low. If you cannot see this waveform and the input to the reset chip is correct (a logic high) it indicates a RESET chip failure.

Result

If the voltage levels and waveform are not as described above, then the test fails.

RE3.17 Replace Serial Device Drivers

The controller board includes two driver chips which convert TTL signals to RS232 levels. These chips are more likely to be damaged than the UART itself in cases of over voltage, static discharge, short circuiting, or other line problems. They are socketed for simple replacement in the field.

Purpose

To replace the serial device drivers.

Method

1. With main power off, remove the lid of the controller.
2. Ensure that you are properly grounded before touching any circuit boards inside the controller. Static can damage the boards.
3. Locate the driver chips on the controller board located on the right front of the controller board. The chips are labeled U37 and U38. The chips are socketed for easy removal using a small screwdriver or a chip puller.
4. Replace with chips of the same type. The transmitter is an MC1488C U37 and the receiver is an MC1489C U38. Ensure they are pressed firmly in the socket with all legs in place.

RE3.18 Check Air Gripper Driver Output

Purpose

To verify the operation of the air gripper circuitry.

Method

1. Ensure that the controller is set up for an air gripper (see @@SETUP command in the RAPL-II Programming Manual).
2. With main power off, remove the lid of the controller.
3. Ensure that you are properly grounded before touching any circuit boards inside the controller. Static can damage the boards.
4. Since the gripper driver is a current sinking device, with the arm disconnected from the controller, a pull-up resistor is required. For the test, a quarter Watt resistor between 1KΩ and 10KΩ is sufficient.
5. Place the pull-up resistor between the gripper output, J7 pin 2 on the auxiliary board, and the +12 V supply, J16 pin 6 on the auxiliary board. Turn on main power.
6. Command the gripper open. The voltage at J7 pin 2 should be +12 V.
7. Command the gripper closed. The voltage at J7 pin 2 should drop to 0 V.

Result

If the voltage at the air gripper output is seen as described above, the test passes.

RE3.19 Check Function of AC Components

Purpose

To check that AC power is present in the lower assemblies.

Method

1. Listen for the fan. The operation of the fan is a good indicator the AC power is reaching the lower assemblies.
2. Remove the AC cord from the back of the controller. Check the main fuses. Remove the voltage selector and inspect its connection points. Re-install the voltage selector and ensure that it is set to the right setting, then install the main fuses.
3. With main power off, remove the controller lid.
4. Ensure that you are properly grounded before touching any circuit boards inside the controller. Static can damage the boards.
5. Locate J15 on the auxiliary board, turn main power on and measure the AC voltage at J15 between positions 10 and 11. It should be 120 VAC. If this voltage is present and the fan is not operating then it is likely that the fan has failed in some way.
6. To check the lower assemblies with the main power off:

- Disconnect all the wiring from the controller and auxiliary boards.
- Remove the 4 screws which hold the controller/auxiliary board mounting plate to the controller chassis.
- Carefully remove the electronics from the controller chassis.

7. With an ohmmeter, measure the resistance of the 10Ω resistor and the thermal fuse mounted to it on the suppression board. The resistance of the thermal fuse should be 0Ω.

   Note: Some controllers were not equipped with a surge suppression board.

8. To ensure AC power is reaching the computer power supply:

- Turn on the main power.
- Measure the AC voltage between the white and black wires on the 5 position Molex connector on the power supply. It should be approximately 120 VAC.

Result

If AC power is measured at the power supply, then the test passes.

RE3.20 Check for Watchdog Signal

The controller board main processor generates a watchdog as a result of the execution of a priority software loop. This signal feeds through each major gate array chip on the controller board. The watchdog (a 500 Hz square wave) feeds to the auxiliary board, where it activates a monostable device. This becomes an enabling signal to the e-stop daisy chain.

Purpose

To check for the presence of the watchdog signal.

Method

1. With the main power off, remove the controller lid.
2. Ensure that you are properly grounded before touching any circuit board inside the controller. Static can damage the boards.
3. Locate the watchdog indicator LED D68 on the auxiliary board near the back of the controllers. The auxiliary boards below REV1.3 are not equipped with LED's.
4. Turn main power on.
5. The watchdog LED should turn on after a few seconds. On boards not equipped with this LED, listen for the arm power enabling relay to turn on a few seconds after main power is applied.
6. If the LED does not light, check for the presence of the watchdog signal on the controller board with an oscilloscope.
7. Place the ground lead on one of the ground points (labeled GND PT.) located at each of the four corners of the controller board.
8. Set the scope for 2 V/division vertical and 1 msec/division horizontal sides.
9. Probe all four test points at JP23 and JP24. The signal should be TTL level 500 Hz square wave.

Result

The test passes if LED 68 turns on. The controller board passes if the correct signal is seen at the points.

RE3.21 Check Power to Front Panel Display Board

The front display board requires Vcc and ground to operate properly. It obtains these voltages along with all of the necessary signals (TTL level) through one ribbon cable. An additional Molex style connector permits the front panel e-stop switch to connect to the auxiliary board. This e-stop signal does not interact with any other logic on the display board.

If the front panel display is blank, and/or if the controller does not respond to the front panel push-buttons then it is possible that voltage is not being supplied to the front panel display board.

Purpose

To check the power to the front panel display board.

Method

1. With Main Power off, remove the lid from the controller.
2. Ensure that you are properly grounded before touching any circuit boards inside the controller. Static can damage the boards.
3. Turn on the main power to the controller.
4. Check that 5 V is available across the capacitor C2 beside U3 on the display board.
5. If there is no voltage present on the board:

- Check the harness connections
- Check for the presence of 5 V on the controller board.
- Check the power supply cable from the auxiliary board to the controller board.

Results

- If the correct operating voltage is seen on the board, then the test has passed.
- If the voltage is present, but the board is not indicating any activity, then replace the front panel display board.
- If there is no voltage, the problem lies elsewhere.

RE3.22 Check the Function of the AC Soft Start Board

Check the functionality of the AC Soft Start board if the AC main fuses blow upon start-up.

Purpose

To check the function of the AC Soft Start board.

Method

1. Place a current meter on the AC main power cord.
2. Turn the controller on.
3. Turn on the controller arm power.
4. Observe the current reading.

Results

- If the value of the current reading is above 1 Amp, then the Soft Start board should be replaced.

RE3.23 Check the Function of the Zero Cross Relay

Check the functionality of the Zero Cross Relay board if the controller will not boot-up.

Purpose

To check the function of the Zero Cross relay.

Method

1. With power off, remove the lid of the controller.
2. Ensure that you are properly grounded before touching any circuit boards inside the controller.
3. Remove the controller and auxiliary board set.
4. Turn ON main power.
5. Locate P1 on the power supply.
6. Measure the AC voltage between pins 1 and 5. You should see 110 V.

Results

- If the fan and the voltage are on, and the connector does not show 110 V, then replace the Zero Cross relay.

6-4 Wiring Diagnostic Checks for the Controller, Arm, and Umbilical Cables

RE4.1 Check Continuity of AC Line Cord

Purpose

To determine if AC power from the socket is reaching the controller.

Method

1. Disconnect the AC cord from the rear panel of the controller. Leave it plugged into the wall socket.
2. Place an AC voltmeter across the hot and return contacts of the controller end of the cord. It should read the standard line voltage found locally.
3. If it does not read the standard line voltage, remove the plug from the wall.
4. Check the socket for power. If power is found, replace the cord.

Result

If power is found at the controller end of the cable, the test passes.

RE4.2 Check Continuity of Encoder Feedback Wiring

Correct servo operation depends on three signals from each encoder: channels A, B, and Z. Channels A and B are the shaft angle position signals. From them, the position and direction of motion can be determined. Channel Z is the zero-crossing signal (index pulse, marker pulse). It is used only during the homing and calibration sequences of the arm. In A465 and G365 robots, encoder feedback is differential, so each of the A, B, and Z signals have their compliment, i.e. A*, B*, and Z*.

The C500 controller board uses a different resistor termination network for each encoder type. The receiver chips are identical. There are no socketed chips in the feedback buffering path. The resistor networks are socketed, ensure that you check for the right configuration before replacing a controller board.

The C500 controller card has a test strip which tests the encoder feedback after the termination network and line receivers. The most likely encoder feedback failure may occur between this point and the encoder itself.

Purpose

To perform a test to determine the cause of the fault is within the:

1. Controller (chip, or harness)
2. Umbilical
3. Arm wiring
4. Encoder

Method

Each signal from the encoder travels through several wiring harnesses and connectors. Refer to Chapter 4 for pin-outs for all these signals.

1. Trace a wiring fault in this signal path by disconnecting the motor from the motor connector.
2. Ensure that you are properly grounded before touching any circuit boards inside the controller. Static can damage the boards.
3. Start by checking the continuity from the controller board to the next connection point and continue through all connections to the motor connector

Result

If the continuity checks out all the way from the encoder to the controller board, then the test has passed. If a break was found, the test failed.

Signal	Chip	Pin
1A	U76	2
1A*	U76	1
2A	U76	14
2A*	U76	15
3A	U76	6
3A*	U76	7
4A	U76	10
4A*	U76	9
5A	U77	2
5A*	U77	1
6A	U77	14
6A*	U77	15
7A	U77	6
7A*	U77	7
8A	U77	10
8A*	U77	9

Signal	Chip	Pin
1B	U78	2
1B*	U78	1
2B	U78	14
2B*	U78	15
3B	U78	6
3B*	U78	7
4B	U78	10
4B*	U78	9
5B	U79	2
5B*	U79	1
6B	U79	14
6B*	U79	15
7B	U79	6
7B*	U79	7
8B	U79	10
8B*	U79	9

Signal	Chip	Pin
1Z	U80	2
1Z*	U80	1
2Z	U80	14
2Z*	U80	15
3Z	U80	6
3Z*	U80	7
4Z	U80	10
4Z*	U80	9
5Z	U81	2
5Z*	U81	1
6Z	U81	14
6Z*	U81	15
7Z	U81	6
7Z*	U81	7
8Z	U81	10
8Z*	U81	9

Table 6-7 Signal Feedback Signals Directly From Encoders

RE4.3 Check Continuity of Servo Gripper Wiring

Correct servo gripper operation is dependent upon the transmission of the following signals: motor plus and minus, position reference and signal, and ground.

Purpose

To check the continuity of servo gripper wiring.

Method

Each signal from the gripper travels through several wiring harnesses and connectors. Refer to Chapter 4: External Connectors and Figure 4-5 Encoder Connectors to identify the connectors through which the servo gripper signals travel.

1. Trace a wiring fault in this signal path by disconnecting the gripper from its receptacle.
2. Ensure that you are properly grounded before touching any circuit boards inside the controller. Static can damage the boards.
3. Trace the Servo Gripper's RP-17 connector to the base of the arm robot feedback connector at the base of the arm.
4. Check continuity from the robot umbilical feedback connector to the controller.
5. If the continuity problem is intermittent, this procedure may have to be performed several times.

Result

If the continuity checks out all the way from the encoder to the controller board, then the test has passed. If a break was found, the test failed.

RE4.4 Check the Continuity of the E-Stop Switch

Purpose

To determine if there is a break in the signal path of the arm power shut off circuitry switch.

Method

1. With the power off, remove the lid of the controller.
2. Ensure that you are properly grounded before touching any circuit boards inside the controller. Static can damage the boards.
3. Locate the front panel display board behind the front panel, along the edge of the board there is a two pin Molex connector terminating in two short wires which go to terminals of the e-stop switch on the front panel.
4. Disconnect the connector and test for continuity across the two contacts of the connector. With the switch released, there should be a dead short across these contacts.
5. If this is the case, press the switch. The circuit should be open when the switch is pressed.

Result

If the function is not as described above, the test failed.

RE4.5 Check the Continuity of the External E-Stop Wiring

Purpose

To determine if there is a break in the signal path for the arm power shut off circuitry in the external wiring to any external e-stop connections on the controller rear panel.

Method

1. Disconnect the external SYSIO, Expansion Amp connectors and test for continuity across the two contacts in each of the connectors. On the SYSIO the two contacts are pins 19 and 20. The Expansion Amp connector has no e-stop contact but pins 8 and 9 may be part of the e-stop circuit if they have enabled through the dip switch on the auxiliary board, J9 on the controller board between pins 23 and 24, refer to Table 3-4 Controller Board Connectors Legend for more information.
2. With any switches wired into the circuit in a released state, there should be a dead short across these contacts.
3. If this is the case, press each switch in turn. The circuit should be open when any switch is depressed.

Result

If the function is not as described above, the test failed.

RE4.6 Check Continuity of Motor Wiring

Correct servo operation depends on correct connection of the output of the DC amplifiers to the motor commutation circuitry.

Purpose

To check the continuity of the motor wiring.

Method

1. This test assumes that the circuit breaker for the suspected motor signal has been checked and is not tripped. The circuit breakers are under the front panel.
2. Each signal from the gripper travels through several wiring harnesses and connectors. Refer to Chapter 4: External Connectors and Figure 4-5 Encoder Connectors to identify the connectors through which the servo gripper signals travel.
3. Ensure that you are properly grounded before touching any circuit boards inside the controller. Static can damage the boards.
4. Test to trace a wiring fault in signal path:
   a) Locate the motor connector in question and disconnect the motor connector from the motor.
   b) Work from the motor connector back to the controller rear panel motor connector.
   c) Work from the controller rear panel motor connector to the amplifier connect.
5. If the continuity problem is intermittent, this procedure may have to be performed several times to isolate the failure.

Result

If the continuity checks out all the way from the motor to the DC Amp module, then the test has passed. If a break was found, the test failed.

RE4.7 Check Continuity of Circuit Breaker

The power to each motor of the robot travels through a circuit breaker. Sometimes, when a breaker is tripped it loses its ability to reset.

Purpose

To test the integrity and continuity of the circuit breaker.

Method

1. With main power off, remove the lid of the controller.
2. Disconnect the motor power cable.
3. Ensure that you are properly grounded before touching any circuit boards inside the controller. Static can damage the boards.
4. Ensure all the breakers on the front panel are in the reset position (not tripped).
5. Locate J11 and J12 on the auxiliary board. Make the following measurements with an ohmmeter. Measure between the following pins:

Breaker Circuit	Pins
CB1	J11 pin 1 and J11 pin 2
CB2	J11 pin 3 and J11 pin 4
CB3	J11 pin 5 and J11 pin 6
CB4	J12 pin 1 and J12 pin 2
CB5	J12 pin 3 and J12 pin 4
CB6	J12 pin 5 and J12 pin 7

Table 6-8 Breaker Circuit Pin Measurements

5. The resistance across any circuit breaker should be 0 Ohms.

Result

If any of the circuit breakers have a high resistance or are an open circuit, the test fails.

RE4.8 Check Umbilical Connections

Purpose

To determine if a signal interruption is due to a bad connection at the umbilical connectors or a broken wire in the cable.

Method

1. Turn main power off. Disconnect both ends of both cables connecting the robot arm from the controller.
2. Inspect all four plugs for damaged pins or pins which do not appear to be protruding the same distance as the others.
3. Push gently on all contacts to ensure that each is firmly seated in the plug shell.
4. Test the continuity of the umbilical with an ohmmeter. The cables are wired straight through so that contact 1 at one end is contact 1 at the other. For a pin-out of the contacts and their functions, see Table 4-5 Robot Feedback (CPC57 Connector), Table 4-6 Motor Power (CPC24 Connectors), and Table 4-7 Expansion Amplifier Connector Pin Signal Descriptions.
5. Replace broken pins in the cable or send them to CRS for repair or replacement.
6. Ensure that the cable shield grounds are connected to the controller.
7. The cable connectors have locking rings. If these are broken the cable will not provide a solid connection. When installing the cables take care not the cross thread the locking ring as this will also not provide a good connection.

Result

If a pushed in contact or break in the continuity is detected, the test has failed.

RE4.9 Check Continuity of Proximity Sensor Wiring

Proximity sensor signals pass from the motor power umbilical directly to the auxiliary board. The signals are optically isolated on that board.

Note: The A255 arm does not use proximity sensors. The A465 Arm/Track and the A255 Track axis use proximity sensors.

Purpose

To check the continuity of proximity sensor wiring.

Method

1. Check the front panel 24 V fuse. If the fuse is blown, replace it and try the sensors again.
2. Check the input signal for the sensor at the input connector (J5) of the auxiliary board. The correct signal levels are 25 V untriggered and 0 V triggered.
   - If the signal does not change, check the external wiring.
   - If the signal changes, test J5 at the following location positions:

Position	Proximity Sensor Location	Position	Proximity Sensor Location
1	1	5	5
2	2	6	6
3	3	7	7
4	4	8	8

Table 6-9 Proximity Sensor Wiring on Auxiliary Board

3. If the signal changes check for the signal on the controller board. The correct levels are 5 V untriggered and 0 V triggered.

Proximity Switch	Location
1	U72 pin 2
2	U72 pin 11
3	U73 pin 2
4	U73 pin 11
5	U74 pin 2
6	U74 pin 11
7	U75 pin 2
8	U75 pin 11

Table 6-10 Proximity Sensor Location on Controller Board

4. If these signals change from 0 to 5 V and the controller does not recognize the proximity sensors, then there is a fault on the controller board.
5. If the correct signals are seen at J5 of the auxiliary board but not at the chip locations on the controller board, then there is a fault on the controller board.

Result

If the correct signal levels are seen at the controller board chip locations and the controller recognizes the proximity sensors; the test passes.

RE4.10 Check the Arm Harness Wiring

The A465 arm contains three main harnesses. To detect a break in the harness move only those joints that flex a particular harness and monitor the feedback.

The A255 contains only one main harness.

Purpose

To check the main harness.

Warning! This check must be perfromed with the help of at least two people. *Be prepared to press one of the e-stops. When there is a loss of feedback, there is a chance of a "Runaway" condition.*

Method

- To check the main harness in the A255, follow procedure A. A255 Main Harness Check
- To check the A465s three harnesses, follow procedure B. A465 Harness Check.

A. A255 Main Harness Check

The A255 contains only one main harness. To detect a break in the harness move only those axes that flex a particular portion of the harness and monitor the feedback.

To check the main harness

1. Limp axis one.
2. Type "PASSWORD 255" and type the "@ZERO" command.
3. Execute the "W1" command to monitor the feedback.
4. Move the limped axis.
5. Watch the feedback. The numbers should count up and down evenly as the arm is moved. The numbers should return to zero when the axis is returned to the position where the "@ZERO" command was executed.
6. Perform the above function for each axis.

Result

If the check for the main harness did not encounter any jerky motions or loss of feedback, then the test passed.

B. A465 Harness Checks

There are three harness checks for the A465:

- the main harness check
- the elbow harness check
- the wrist harness check

To check the main harness

1. Execute the "W1" command.
2. In manual joint mode move only joints 1 and 2. If the arm encounters an area where motion becomes very jerky and the feedback does not count, there is a break in a wire within the harness.

To check the elbow harness

1. Execute the "W1" command.
2. In manual joint mode move only joint 3. If the arm encounters an area where motion becomes very jerky and the feedback does not count, there is a break in a wire within the harness.

To check the wrist harness.

1. Execute the "W1" command.
2. In manual joint mode move only joint 4. If the arm encounters an area where motion becomes very jerky and the feedback does not count, there is a break in a wire within the harness.

Result

If each check for the main, elbow, and wrist harness encountered no jerky motion or loss of feedback, then the test passed.

6-5 Controller Board Servo Loop Signal Checks

RE5.1 Check and Adjust Vcom Output From the Controller Board

The amplifiers drive the robot motor relays on an analog command voltage from the controller board. An incorrect voltage command affects robot performance.

Purpose

To check and adjust the Vcom out from the controller.

Method

1. With main power off, remove the controller lid.
2. Ensure that you are properly grounded before touching any circuit boards inside the controller. Static can damage the boards.
3. Disconnect amplifier outputs by unplugging the motor power umbilical from the robot arm.
4. Disconnect the circuit breaker detection connectors J11 and J12 on the auxiliary board.
5. Disconnect the linear amplifier inputs from the auxiliary board J4 to prevent the amplifiers from loading the Vcom signal.
6. Turn on main power. Using a terminal device such as Robcomm Terminal Emulator obtain the terminal prompt.
7. Turn on arm power.
8. Set all velocity commands to zero (0) using the LIMP command.
9. Place a voltmeter with a fine probe tip on the following chip pins:

Axis	IC#	Pin	Offset Adjustment Potentiometer	Gain Adjustment Potentiometer
1	U92	7	R31	R29
2	U92	14	R33	R32
3	U93	7	R35	R34
4	U93	14	R37	R36
5	U94	7	R39	R38
6	U94	14	R41	R40
7	U95	7	R43*	R42*
8	U95	14	R45*	R44*

Table 6-11 Chip Pins

* only if used in the system

Adjust the offset adjustment to 0 V ±.01

10. Set the motor velocity command to 114 for all motors. Issue the following commands:

```
>>LIMP
>>NOLIMP
>>MOTOR 1,114
>>MOTOR 2,114
>>MOTOR 3,114
>>MOTOR 4,114
>>MOTOR 5,114
>>MOTOR 6,114
```

11. Adjust the gain potentiometer to +10 V ±0.05 V.

12. Set the velocity command to -114. Use the following commands:

```
>>LIMP
>>NOLIMP
>>MOTOR 1,-114
>>MOTOR 2,-114
>>MOTOR 3,-114
>>MOTOR 4,-114
>>MOTOR 5,-114
>>MOTOR 6,-114
```

13. Adjust the gain potentiometer to -10.0 V ±.1 V. If it is not in this range, change the controller board.

Result

If the VCOM signals are within the described voltage ranges then the test passes.

Note: Before making adjustments make sure power supply is set to 5.10 V ±.1 V with arm power on.

With RAPL 2.50 the “@SERVERR” parameters may have to be altered to perform this test.

RE5.2 Check Channels A, B, and Z at Encoder Input to Controller Board

Check channels A and B at the encoder input to the controller board to determine if the encoder position feedback signals are reaching the controller board. Two channels are required in order to determine motion and direction of rotation. A “Z” channel is required when homing the robot. It is a pulse which occurs once every encoder revolution.

Note: The A465 uses the compliment signal A*, B*, and Z*, while the A255 does not.

Purpose

To check channels A and B at encoder input to controller board.

Method

1. With power off, remove the lid of the controller.
2. Ensure that you are properly grounded before touching any circuit boards inside the controller. Static can damage the boards.
3. Turn on main power but not arm power.
4. Connect the ground of an oscilloscope to the GND PT. connection on the controller board.
5. Locate the feedback test strip on the left side of the controller board JP25, near the rear. Refer to Table 6-12 JP25 Test Strip (Condition Signals) for pin-outs of the signal.
6. If there is no signal present, check the unconditioned signals as described in Table 6-13 Feedback Signals Directly From Encoders (Unconditioned Signals).
7. Observe the rate, frequency, and signal quality of the signals in question.

- A typical encoder pulse rate would be about 60 kHz at maximum motor speed.
- The duty cycle of each of the A and B waves should be about 50%. No apparent noise should exist on the test points, the digital filtering of the controller board will eliminate any signals under 200 nanosecond duration.

Result

The test passes if both signals appear as described.

JP25 Test Strip

Pin	Signal
1	1A
2	2A
3	3A
4	4A
5	5A
6	6A
7	7A
8	8A
9	1B
10	2B
11	3B
12	4B

Pin	Signal
13	5B
14	6B
15	7B
16	8B
17	1Z
18	2Z
19	3Z
20	4Z
21	5Z
22	6Z
23	7Z
24	8Z

Table 6-12 JP25 Test Strip (Condition Signals)

Feedback Signals From Encoder

Signal	Chip	Pin
1A	U76	2
1A*	U76	1
2A	U76	14
2A*	U76	15
3A	U76	6
3A*	U76	7
4A	U76	10
4A*	U76	9
5A	U77	2
5A*	U77	1
6A	U77	14
6A*	U77	15
7A	U77	6
7A*	U77	7
8A	U77	10
8A*	U77	9

Signal	Chip	Pin
1B	U78	2
1B*	U78	1
2B	U78	14
2B*	U78	15
3B	U78	6
3B*	U78	7
4B	U78	10
4B*	U78	9
5B	U79	2
5B*	U79	1
6B	U79	14
6B*	U79	15
7B	U79	6
7B*	U79	7
8B	U79	10
8B*	U79	9

Signal	Chip	Pin
1Z	U80	2
1Z*	U80	1
2Z	U80	14
2Z*	U80	15
3Z	U80	6
3Z*	U80	7
4Z	U80	10
4Z*	U80	9
5Z	U81	2
5Z*	U81	1
6Z	U81	14
6Z*	U81	15
7Z	U81	6
7Z*	U81	7
8Z	U81	10
8Z*	U81	9

Table 6-13 Feedback Signals Directly From Encoders (Unconditioned Signals)

RE5.3 Check Encoder Supply Output From Controller Board

The power for the encoder optics and electronics is sourced from the controller board. This is a 5 V and ground that is fed through the encoder connector. There are multiple 5 V supplies that feed through the harness.

Purpose

To check the encoder supply output from the controller board.

Method

1. With main power off, remove the lid of the controller.
2. Ensure that you are properly grounded before touching any circuit boards inside the controller. Static can damage the boards.
3. Locate the connector for the encoder supply. It is a 10 pin ribbon harness on the left rear of the controller board, marked J8.
4. Turn on the main power.
5. Measure across the pins of the connector and ground with a DC voltmeter. It should read 5.0 ±0.2 VDC.
6. Odd number pins are 5 V. Even number pins are GND.

Result

The test passes if the 5 VDC is present.

6-6 Controller Module Replacement Procedures

RE6.1 Replace Controller Electronics

Purpose

To replace controller electronics.

Method

1. Turn off the controller main power and disconnect its power cord and then remove the lid of the controller.
2. Ensure that you are properly grounded before touching any circuit boards inside the controller. Static can damage the boards.
3. Remove all peripheral boards installed in the controller: SIO TRAM card, analog TRAM card, etc. Store them properly in their shipping packages, or on conductive foam, or in an anti-static bag.
4. Remove all connections around the perimeter of the controller and Auxiliary boards.

   Note: The Power Jumper cable between J13 on the Controller Board and J16 on the Aux. Board on an A255 set is supplied with the assembly and it does not require to be disconnected.
5. Remove the four screws that hold the mounting plate to the controller chassis. The ring terminal from the Teach Pendant is held by one of these screws.
6. Remove the defective assembly from the controller. Ensure that the cables or connectors are not damaged in any way.
7. Use the packing material from the new set to store the defective assembly and return it to CRS.
8. Install the new assembly into the controller and re-attach all the cabling. Ensure that the cabling is not pinched or scratched and that connector polarity is maintained.
9. Replace the four screws that fasten the mounting plate to the controller chassis. Do not forget the ring terminal from the Teach Pendant. Ensure that no cables have been disconnected.
10. Re-install and reconnect any removed peripheral boards. Replace and fasten the controller. Reconnect the power cord.

IMPORTANT

There are currently two revisions of the Aux. board in use. These boards function similarly but differ in the positioning of a key at connector J15. The Aux. boards having serial numbers AB6xxx or higher can be identified by a row of LEDs located along one side of the board. The other style of Aux. board use the serial numbers in the AB5xxx range.

Due to the re-keying of J15 there may be a compatibility problem between a replacement board set and controller. To overcome this situation, a modification connector is provided which should be used to adapt the wire connector in the controller to the one newly supplied Aux. board. Use this supplied connector to attach J15 if required.

Be very careful, use the proper polarity when installing this connector since the key may be located directly in the center. The connector locking mechanism locks with the appropriate key when inserted correctly.

If replacing an AB6xxx series auxiliary board, with an AB6xxx series board, the additional supplied connector is not needed. Similarly, when replacing an AB5xxx series board with another AB5xxx series board, the connector is not required.

Note that connectors J2 on the Controller Board and J3 on the Aux. Board are similar and can be misconnected. Ensure that J3 on the Aux. Board is connected to J1 on the Display Board. Connecting J1 from the Display Board into J2 (communication port) in the Controller Board (upper one) will result in damage to the Display Board.

RE6.2 Replace Front Panel Display Board

Purpose

To replace the front panel display board.

Method

1. Ensure that the power to the controller is off.
2. Ensure that you are properly grounded before touching any circuit boards inside the controller. Static can damage the boards.
3. Remove the M3 nuts holding the board onto the studs on the panel. Ensure that the nuts and washers do not fall into the bottom of the controller.
4. Lift the board out carefully. Install the board by reversing the above procedure. Do not over-tighten the nuts holding the board onto the front panel. Sit the insulation material between the board and the front panel.

RE6.3 Replace Encoder Connector Board

Purpose

To replace the encoder connector.

Method

1. Remove connectors from the board.
2. Remove the four Philips screws from the rear panel.
3. Reverse the above procedure to re-install the encoder connector.

RE6.4 Replace Power Filter Board

Purpose

To replace the power filter board.

Method

1. With main power off and AC unplugged, remove the controller lid.
2. Ensure that you are properly grounded before touching any circuit boards inside the controller. Static can damage the boards.
3. Remove the CB/AB board. Refer to RE6.1 Replace Controller Electronics for detailed instructions.
4. Remove the J1, J2, J3, and J4 Molex connectors to the power filter board.
5. Remove the four Philips screws holding the board to the chassis.
6. To re-install the power filter board, reverse the above procedure.

RE6.5 Replace Bridge Power Rectifier

Purpose

To replace the bridge power rectifier.

Method

1. Ensure that the power to the controller is off.
2. Remove the controller lid.
3. Remove the electronics assembly as per RE6.1.
4. Ensure that you are properly grounded before touching any circuit boards inside the controller. Static can damage the boards.
5. Locate the rectifier in the bottom compartment of the controller.
6. Remove all the wires attached to the rectifier. Note the colors of the wires and to which terminals they are installed.
7. Remove the nut holding down the rectifier.
8. Remove the rectifier itself.
9. Install the new rectifier.
10. Re-install the wiring. Ensure it corresponds to the factory installation.

RE6.6 Replace Cooling Fan

Purpose

To replace the cooling fan.

Method

1. Ensure that the power to the controller is off.
2. Remove the controller lid.
3. Remove the electronics assembly, refer to RE6.1 Replace Controller Electronics.
4. Locate the fan at the back of the controller.
5. Remove the fan plug.
6. Remove the filter cover from the rear panel and remove the 4 Philips screws beneath it.
7. Remove the fan.
8. Install the new fan making sure the air flow is into the controller and that the plug receptacle is next to the zero cross relay.

RE6.7 Replace Computer Power Supply

Purpose

To replace the computer power supply.

Method

1. With main power off and AC unplugged, remove the controller lid.
2. Ensure that you are properly grounded before touching any circuit boards inside the controller. Static can damage the boards.
3. Remove the electronics assembly, refer to RE6.1.
4. Locate the computer power supply inside the lower compartment of the controller.
5. Disconnect the 5-pin Molex on the right of the board and the 14 pin Molex on the left.
6. Remove the four screws holding the power supply in place and remove the supply.
7. Re-install the new supply.
8. Replace the wiring to the power supply board.
9. Replace the CB/AB boards and check the voltage from the new power supply.
10. With main power on, measure the voltage on the controller board between a ground point (located at the 4 corners of the board) and U71 pin 16. Measure the 12 V supply voltage at U93 pin 4.
11. Compare the voltage levels with those found at the power supply connection J10. Positions 1, and 2 are the 5 V supply, positions 3, and 4 are ground and position 6 is the 12 V supply.
    - If the power supply connection is good then the voltage levels measured from these two areas should be almost identical.
    - The correct voltage levels are +5.10 VDC (±.05 V) and 12.00 VDC (±.1 V).
12. Access the power supply adjustments potentiometer through the hole in the controller/auxiliary board plate assembly in the front left controller. The adjustments for the 5 V supply is identified by a 5 V marking on the power supply circuit board. It is a potentiometer closer to the front of the controller. The potentiometer closer to the rear of the controller adjusts the 12 V supply.
13. Make supply adjustments carefully as a over-voltage situation may damage the controller electronics. After making any adjustments check both 12 Volt an 5 Volt lines.

Result

If the supply voltage levels at the test points described above are identical and at the correct level, then the test passes.

RE6.8 Replace PWM Amplifier Module

Purpose

To replace the PWM amplifier module.

Method

1. Ensure that the power to the controller is off.
2. Remove the controller lid.
3. Ensure that you are properly grounded before touching any circuit boards inside the controller. Static can damage the boards.
4. Remove the following connections to the defective PWM amplifier module:
   a) Motor output connectors
      3 three-pin Molex connectors along the top edge of the module.
   b) Power input connectors
      1 seven-pin Molex connector along the edge of the PCB. There may be one or two of these connected to the module.
   c) Signal input connector
      1 four-pin Molex connector at the bottom of the module PCB.
5. Remove the screw holding the upper edge of the module heat sink into the amplifier bulkhead. Be careful not to drop the plastic standoffs into the bottom of the controller.
6. Remove the module from the controller.
7. Replace the module and reinstall it by reversing the above procedure.
8. Ensure that all connections are made in the same way as removed.

Note: Ensure the bottom edge of the heat sink is sitting in the rack at the bottom of the controller. The circuit board can be shorted out if installed incorrectly.

RE6.9 Replace PWM Amplifier Module

Purpose

To replace the PWM amplifier module.

Method

1. Ensure that the power to the controller is off.
2. Remove the controller lid.
3. Ensure that you are properly grounded before touching any circuit boards inside the controller. Static can damage the boards.
4. Remove the following connections to the amplifier.
   - 22 pin Amp connector
   - 4 pin Phoenix connector
5. Remove the four hex screws holding the amplifier to the chassis.
6. Remove the module from the controller.
7. Replace the module and reinstall it by reversing the above procedure.
8. Ensure that all connections are made in the same way as removed.

6-7 Software Checks

RE7.1 Diagnostic Start

The purpose of the diagnostic start is to boot the controller directly into the diagnostic mode. This may be necessary if the firmware has been corrupted.

Purpose

To perform a diagnostic start.

Method

1. Take the “jig installed” signal (accessible at the SYSIO connector) to ground potential when main power is turned on.
2. With main power off, remove any connectors from the SYSIO on the rear panel. The SYSIO connector is wired for internal power supply use.
3. Jumper pins 13 (Jig INS) to pin 23 (ISO Return), pin 24 (ISO Return) to pin 25 (GND), and pin 3 (ISO power) to pin 2 (+24 V).
4. Turn on main power, the controller boots into diagnostic mode.
5. The baud rate for device 1 is 38400. The diagnostic sign-on message appears on the terminal screen and the status display on the front panel reads “D1”. See the “@@DIAG” command for information on how to use diagnostics, refer to the RAPL-II Programming Guide.

Result

If the diagnostic sign-on message appears at the terminal screen and “D1” appears on the status display then the test passes.

RE7.2 Reload Firmware

Load firmware if installing a new electronics assembly, upgrading to a newer RAPL version, or if the controller firmware is corrupt.

Purpose

To reload the firmware.

Method

1. Use the “@@DIAG” command or perform a diagnostic start (RE7.1) to access the diagnostic mode.
2. Press “Y” if the initial statements on the terminal screen are true. The system displays the diagnostic menu.
3. Select ‘L” from the menu for Flash tests. The Flash diagnostic menu appears.
4. Press 2 and Enter. This action deletes the current RAPL version from the controllers flash memory and takes about one minute to complete. The Flash menu re-appears when it is finished erasing.
5. Type 4 and press Enter. This enables ACI mode for downloading the new flash memory.
6. On your computer, exit Terminal mode and quit Robcomm to return to the DOS prompt.
7. If the RAPL firmware is on diskette, decompress the file and copy it to your hard drive.
   a) Create a directory for the RAPL firmware on the hard drive.
   b) Copy the contents of the diskette into this directory.
   c) Uncompress the file by typing:
      - (filename).exe and pressing Enter.
8. Load the new firmware as follows:

- If you are using a version 2.0 teach pendant, run the LOAD.bat file. Follow the comport instructions below.
- If your PC is using COM1, type LOAD and press Enter.
- If your PC is using COM2, type LOAD-C2 and press Enter
- If you are using a version 1.0 teach pendant, edit the LOAD.BAT file. Find the line containing the instance of STPV2.HEX and replace this with STPV1.HEX. After editing the file, load the firmware as described above.

9. The downloading takes about 15 minutes. The DOS prompt appears when it is finished.
10. Re-enter the terminal mode in Robcomm and turn the controller main power off, then on again. Observe the sign-on message.

Note: Reloading firmware sets all parameters to a default setting (i.e. device/start-up baud rate is 38 400).

Result

If the sign-on message is observed and it displays the correct RAPL version, then the test passes.

RE7.3 Check for Feedback From Encoder With the W1 Command

Purpose

To determine if the encoder is issuing correct signals and that they are read correctly by the computer.

Method

1. Turn on the arm power, issue the LIMP command, and place the robot arm in a stable pose.
2. Issue the PASSWORD, the @ZERO command, and the W1 command from the terminal.

   Note: You will have to re-home the arm after this procedure is complete. Executing the @ZERO command will put the arm out of its home position.

3. The numbers should display dynamically across the screen. Each number refers to the actual position register value for one axis, starting with axis one. Initially all numbers should read zero.
4. Manually, move each axis slowly first in one direction and then the other. If any number is not cleared when first displayed, there could be a problem with the controller board. As an axis of the robot is moved, the number should change; one direction should cause the numbers to increase (or decrease negatively), and the other to decrease (or increase positively).

Result

If the numbers do not change as described, the test failed.

RE7.4 Check for Digital Velocity Command

The purpose of checking for the digital velocity command is to determine if the controller is issuing correct signals and that they pass to the amplifier.

Purpose

To check for the velocity command.

Method

1. Turn the arm power ON.
2. Issue the LIMP command.
3. Unlimp the axis being checked. Issue the "NOLIMP n" command where "n" is the axis in question. Issue the W5 command from the terminal.
4. Observe the data as it updates and scrolls across the screen. Each number refers to the velocity command register value for one axis, starting with axis one. All LIMPED axes should have a value of 0. The axis that was unlimped should have a number which changes as the axis moves.

Result

If the numbers are not changing, there could be a feedback problem. If the numbers change slowly, check that the GAIN for that axis (see the “@GAIN” command). Also check the Vcom output of the controller refer to RE5.1 Check and Adjut Vcom Output From the Controller Board and RE8.5 Check and Adjust DC Amplifier Output Level.

RE7.5 Check SERIAL Status

Information about the serial communication parameters can be displayed with the SERIAL command.

Purpose

To check the serial status.

Method

1. Enter the SERIAL command in the terminal mode.
2. The following display appears:

Serial Command	Display	Display
Attribute	0	1
Baud rate	19200	38400
Parity	None	None
Data Bits	8	8
Stop Bits	2	2
Xon/Xoff	On	On
RTS/CTS	Off	Off
Echo	On	On

Table 6-14 Serial Command Display

3. The displayed values mean:

Values	Definitions
BAUD RATE	Rate of transmission in BITS/SEC.
PARITY	Is parity of each data segment checked? If so what will it be?
DATA BITS	Number of bits in the data field.
STOP BITS	Number of bits in the stop field.
HANDSHAKE	RTS/CTS, XON/XOFF Both, or None.
ECHO	Will controller echo characters sent to it?

Table 6-15 Displayed Value Definitions

RE7.6 Check @@RS for Remote (ACI) Status

Information about the status of ACI communication can be displayed with the "@@RS" command.

Purpose

To check the @@RS for remote (ACI) status.

Method

1. Enter the PASSWORD command in the terminal mode.
2. Enter the @@RS command.
3. A dynamic display as seen below appears:

- >>@@RS
- SLAVE DEVICE #001 -- ACI now enabled
- R7.7E INTERFACE STATUS - press "E" to end.
- NRCS NRCF NRCA NHT NBT ERR DBP ENC HDC DBC RCC
- 000 000 000 000 000 000 000 000 000 000 000

4. The static items in the display are:

- Slave Device number - can be between 1 and 127.
- ACI Enabled or Disabled.

5. The dynamically displayed items are:

- NRCS - Number of Requested Communications Successful.
- NRCF - Number of Requested Communications Failed.
- NRCA - Number of Requested Communications Aborted.
- NHT - Number of Header Tries
- NBT - Number of Block Tries
- ERR - Error number
- DBP - Data Block Pointer
- ENC - Enquiry Complete flag
- HDC - Header Complete flag
- DBC - Data Block Complete flag
- RCC - Requested Communication Complete flag

6. To end the display, press "E" or <Ctrl-C>. The <Ctrl-C> will also interfere with the communication in progress so "E" is the preferred method.

6-8 Amplifier Servo Signal Level Checks

RE8.1 Check Voltage Supply From Auxiliary Board to PWM Amplifier Module

The PWM amplifier module receives power from the auxiliary board.

Note: This procedure applies to the A465 arm and Tracks, and the A255 Track axes only.

Purpose

To check the voltage supply from the Auxiliary Board to the PWM amplifier module.

Method

1. With power off, remove the lid of the controller.
2. Ensure that you are properly grounded before touching any circuit boards inside the controller. Static can damage the boards.
3. Turn on main power.
4. Check the signals at the auxiliary board.
   a) Inspect the J14 connector on the auxiliary for damage. Ensure that all wires are crimped correctly and inspect for loose wire filaments protruding for the crimped terminal.
   b) Use a DVM to check the following signals at AB-J14:
   - pins 1, 2, and 3 = 63 Volts
   - pins 5, 6, and 7 = Gnd
5. Check the signals at the PWM module
   a) Remove the four pin Molex connector to the PWM Amp module.
   b) Use a DVM to check the following signals:
   - pins 1, 2, and 3 = 63 Volts
   - pin 4 = Gnd
6. Turn off the power.

Result

If no voltage is detected, the test failed.

RE8.2 Check Voltage Supply From the Auxiliary Board to the Linear Amplifier Module

The Linear DC Amp module receives power from the auxiliary board.

Purpose

To check the voltage supply from the Auxiliary Board to the Linear amplifier module.

Method

1. With power off, remove the lid of the controller.
2. Ensure that you are properly grounded before touching any circuit boards inside the controller. Static can damage the boards.
3. Turn on main power.
4. Check the signals at the auxiliary board.
   a) Inspect the J13 connector on the auxiliary for damage. Ensure that all wires are crimped correctly and inspect for loose wire filaments protruding for the crimped terminal.
   b) Use a DVM to check the following signals at AB-J14:
   - pins 1, and 2 = 35 Volts
   - pins 4 and 5 = -35 Volts
   - pins 6 and 7 = Gnd
5. Check the signals at the Linear Amp module
   a) Remove the seven pin Molex connector to the Linear Amp module.
   b) Use a DVM to check the following signals:
   - pins 1 and 2 = GND
   - pins 3 and 4 = -35 Volts
   - pins 6 and 7 = +35 Volts
6. Turn off the power.

Result

If no voltage is detected, the test failed.

RE8.3 Check Continuity of the DC Amp to the Rear Panel Motor Power Connector

Check the continuity from the DC Amp to the rear panel motor connector to determine if there is a broken wire in the harness carrying the output from the DC amplifiers to the rear panel.

Purpose

To check the continuity from the DC Amp to the motor power connector.

Method

1. With power off, remove the lid of the controller.
2. Ensure that you are properly grounded before touching any circuit boards inside the controller. Static can damage the boards.
3. Determine and locate the amplifier which is giving the problem. The amplifiers are numbered in the controller.
4. Check the continuity between the Amp out connector to the rear panel motor power connector. Refer to section 3-5 Amplifier Electronics for a listing and description of the Linear and PWM Amp connectors.
5. If there is a break in the continuity:
   a) Check the continuity from the breaker detection point on the auxiliary board at J11 or J12, refer to RE4.7 Check Continuity of Circuit Breaker.

Result

If continuity is seen the test passed.

RE8.4 Check Axis Ground to DC Amps

A good signal ground to the DC amplifier is necessary to establish a reference for the command voltage signal (Vcom). There is one such ground for each amplifier module.

Purpose

To check the ground axis to the DC Amps.

Method

1. With power off, remove the lid of the controller.
2. Ensure that you are properly grounded before touching any circuit boards inside the controller. Static can damage the boards.
3. The input connectors to the Amp modules are located at the bottom edge of each amplifier board. Refer to section 3-5 Amplifier Electronics.

- The ground is pin 4 in the 4-pin Molex designated VIN.

4. Disconnect the Vcom connector. Check the continuity of pin 4 of the plug that connects to the GND PT on the of the controller board.

Result

If continuity is found, the test passed.

RE8.5 Check and Adjust DC Amplifier Output Level

Purpose

To check and adjust DC Amplifier output level.

Method

1. With main power off, remove the controller lid.
2. Ensure that you are properly grounded before touching any circuit boards inside the controller. Static can damage the boards.
3. Disconnect amplifier outputs by unplugging all amplifier output connectors.
4. Using a terminal device such as Robcomm-II for Windows Terminal Emulation mode, turn on both main and arm power.
5. Locate the test point for amplifiers 1-5 (refer to Figure 3-11 Linear Amplifier Module).
6. Set each axis velocity command to 114. Issue the following commands:

>>NOLIMP

>>MOTOR 1,114

>>MOTOR 2,114

>>MOTOR 3,114

>>MOTOR 4,114

>>MOTOR 5,114

>>MOTOR 6,114

7. Use the potentiometer beside each test point to adjust the amplifier output. Refer to the following table for proper amplifier settings:

A255

Axis Number	Motor Type	Test Point	Adjustment Pot	Voltage
1	CMC/Tamagawa	TP3 (DC Amp)	P3	25 Volts
2	CMC/Tamagawa	TP2 (DC Amp)	P2	25 Volts
3	CMC/Tamagawa	TP1 (DC Amp)	P1	25 Volts
4	CMC/Tamagawa	TP3 (DC Amp)	P3	25 Volts
5	CMC/Tamagawa	TP2 (DC Amp)	P2	25 Volts

Table 6-16 Amplifiers Settings for the A255

8. Set the axis velocity command to -114. Use the following commands:

>>LIMP

>>NOLIMP

>>MOTOR 1,-114

>>MOTOR 2,-114

>>MOTOR 3,-114

>>MOTOR 4,-114

>>MOTOR 5,-114

>>MOTOR 6,-114

9. Check the amplifier outputs for each channel to see if the voltage changes from +25V to –25V.

10. If the output of any amplifier channel is not present, changing, or not within this range; check for the presence and level of the Vcom signal as per RE5.1 Check and Adjust Vcom Output From the Controller Board.

Result

If the amplifier module still fails this test, the amplifier requires repair or replacement.

RE8.6 Check PWM Enable Signals

Purpose

To check the output levels of the PWM enable signals.

Method

1. Check the following pins on the 22 pin connector to the PWM amplifier, refer to Table 3-51 PWM – 22 Pin Signal Conector for pin locations.

- Pin 15 - positive enable signal +3.5 Volts
- Pins 16, 17 - negative enable 0 Volts

Result

If the signals are present the PWM amplifier is enabled.

6-9 Arm Electronic Checks

RE9.1 Check for Voltage Supply at Encoder

Purpose

To determine if power and a good signal ground are present at the encoder.

Method

1. Expose the motor/encoder.
2. Remove the cover from the encoder.
3. Locate the rear of the LED light source.
4. Using a DC voltmeter, measure across the leads entering the rear of the LED.
5. The voltage should read between 1.2 to 1.5 VDC.

Result

If voltage is present, the test passes.

CHAPTER 7

7 Mechanical Checks and Adjustments

7-1 A255 Robot Arm General Schematic

Before proceeding to service the robot, study the graphic to familiarize yourself with the robot components.

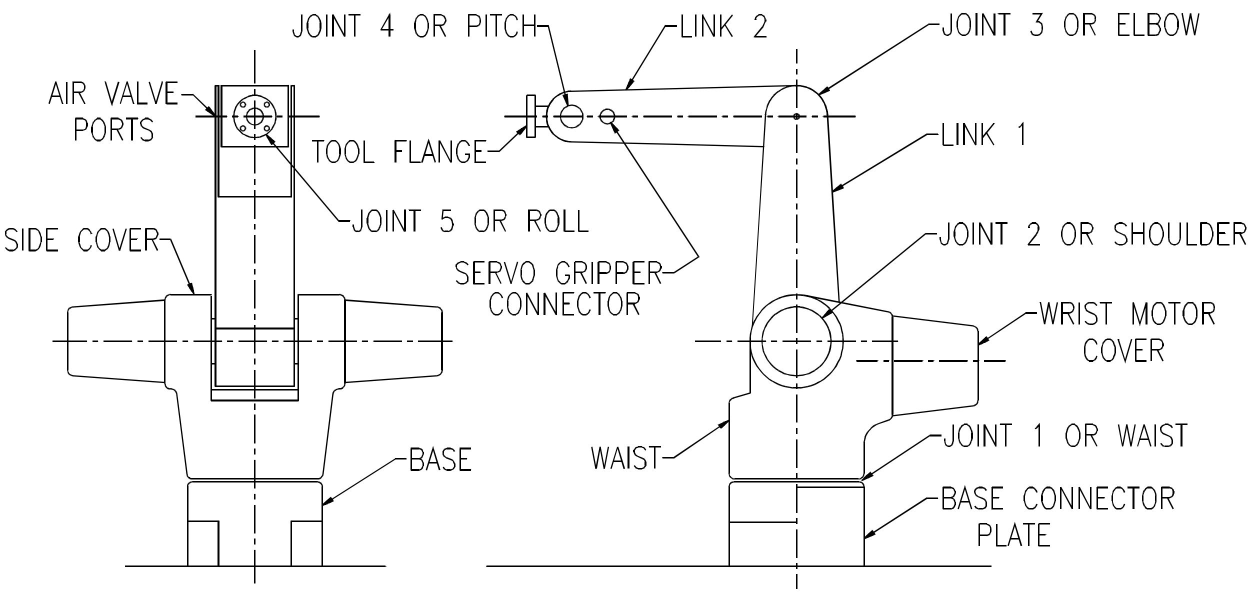


Figure 7-1 A255 Robot Arm General Schematic

7-2 Mechanical Maintenance Schedule

7-2-1 A255 Robot Arm and Controller

This section describes the recommended maintenance schedule for the mechanical system of the A255 Robot Arm. Maintenance procedures include: cleaning, lubricating, and adjusting the robot during its service life.

The recommended maintenance schedule is listed below.

Maintenance Item	Inspection Period 100% Duty Cycle	Inspection Period 75% Duty Cycle
Controller Filter Cleaning • Filters	2,000 hours/ 3 months	4 months
Service Transmission Chains • Adjust the chain tension	1,000 hours (initial inspection period)	2 months (initial inspection period)
Check Inner Wiring Harness	1,000 hours (initial inspection period)	2 months (initial inspection period)
Adjust Wrist Gear Mesh	2,000 hours	4 months
Check Arm Covers for Wear and Cracking	2,000 hours	4 months
Check Motor Brush Wear	5,000 hours	9 months
Perform a Hysteresis Check • Inspect for grease distribution	5,000 hours	9 months

Table 7-1 Scheduled Mechanical Maintenance

Notes:

- At 100% of the duty cycle, the robot operates 24 hours a day, seven days a week.
- As the duty cycle is decreased, the inspection interval increases proportionally. For example a 50% duty cycle operates 12 hours/day and would require a 4,000 hour inspection period.

1. The rate at which the filters clog is related to the contaminants in the environment. It is recommended that the controller be protected from harsh chemicals and oils which may clog the filter and damage the electronics in the controller.
2. Perform a Service Transmission Chains and A Wrist Gear Mesh inspection within the first 1,000 hours of operation. After this, a 2,000 hour inspection is adequate at 100% duty cycle.
3. Perform routine checks at inspection period intervals.
4. The arm wiring harness and drive inspection should only be performed by a CRS factory trained technician.

7-2-2 A265 Track Maintenance

The following items are subject to wear:

Maintenance Item	Inspection Period 100% Duty Cycle	Inspection Period 75% Duty Cycle
Brushes	2,000 hours/3 months (initial inspection period)	4 months (initial inspection period)
Track Rail Lubrication	100 km or 1 year	N/A
Track Belt Tension	same as Track Rail Lubrication period	N/A

Table 7-2 T265 Track Scheduled Mechanical Maintenance

Note: At 100% of the duty cycle, the robot operates 24 hours a day, seven days a week.

1. The brush wear inspection period in the above chart represents the first inspection period only. From the first inspection, the brush wear rate can be determined and a brush replacement maintenance program can be implemented. Typical brush replacement intervals for the arm are between 6,000 - 12, 000 hours.
2. The Track rails require re-lubrication every 100 km of use for a minimum of one lubrication year.

   Note: According to our estimates, your Track will travel 43 km in one year which means the Track maintenance schedule for the Track Rail Lubrication and Track Belt Tension checks is every 12 months.
3. When lubricating the Track Rail, perform a Track Hysteresis to determine if the belt tension needs to be adjusted.

7-3 Chain Tension Adjustment

Tools Required

- Long allen key driver - 3/32" AF
- #0 Robertson screwdriver
- Loctite #601 retaining compound
- Heavy molybdenum-based oil

To perform a chain tension adjustment:

1. With robot arm power on, check the chain tension on the slack side of the loop when the robot is carrying its expected load. Play in the chain occurs when there is a "dead". Swing the chain from side to side, feel the slack (unloaded) side of the chain to detect a dead. If a dead feel can be detected, proceed to adjust the tension as described below.
2. Remove the rear lower arm cover, take out all screws on top section of upper arm cover and bend it back to expose the insides of the upper arm. You will be able to access all five of the chain tensioners.
3. Using a long handled allen key tighten the screws in the tensioner until moderate finger pressure fails to deflect the chain as described above. This should be a simple task.

   Note: Do not over-tighten as damage to the chain, sprocket, and joint bearings can result.
4. After the chain has been tightened, apply a small drop of screw retaining compound (blue Loctite) to each screw in the tensioner. Use sparingly and ensure that none gets on the chain.
5. Apply a molybdenum compound heavy weight oil to the chain. Use sparingly, because of the slow speeds the chain must endure. However, under severe operating conditions, a moly grease may be more suitable.

Important Note

Adjustments made to the chain tension will change the calibration of the robot, therefore some of your taught locations will be slightly off.

In order to minimize the number of taught locations you will have to re-teach after a chain adjustment, recalibrate axes 3, 4, and 5, refer to section 7-8 Calibrating the Arm.

7-4 Wrist Gears

7-4-1 Wrist Gear Mesh Adjustment

Tools Required

- Allen keys
- Small gear puller

To perform a wrist gear adjustment:

1. Remove the gripper and any other components mounted to the wrist flange.
   a) With power on, command the robot to move to the ready position.
   b) Observe the orientation of the joint 5 homing marks relative to one another.

   Note: In the next few steps, you will be removing the wrist flange, adjusting the wrist gears, and re-installing the flange. It is important when re-installing the flange to ensure that the position of the homing marks is the same as when the flange was removed.

2. Enter the RAPL-II command ">>LIMP 4" <return> to "limp" the wrist.
3. Remove the wrist flange: Undo the #8-32 button-head cap screw at the center of the wrist flange.
   a) Pull the flange bearing clear of its seat on the shaft. The flange should slip off with just manual pressure.
   b) Ensure that dirt and metal filings do not get into the grease on the gear.
4. With the flange removed, two 4-40 SHCS screws will be visible above and below the wrist flange shaft (these may be obscured by grease). The shaft is held axially against a 10-32 set screw by these two screws.

   Note: Adjusting the axial position of this shaft changes the mesh of the wrist bevel gears.

5. To tighten the mesh, loosen the 4-40 screws by about a quarter of a turn.
   a) Flip the wrist by 180 degrees and locate the set-screw opposite to the wrist flange.
   b) Loosen the set-screw by about one-half turn. Return to the 4-40 screws and tighten them against the set screw to shift the shaft axially. At this point, the shaft has shifted inward, decreasing the clearance between the bevel gears.
   c) Loosen the 4-40 screws to their original position.

6. Install the wrist flange on the shaft.
    a) Install the BHSCS and tighten to ensure the bearing is fully seated on the shoulder of the shaft. Since the shaft had moved in axially, the gear mesh should be tighter than normal. Adjust the set screw slowly until the mesh is just right.
    b) Tighten past that by about $^1/_6$ turn.
7. Carefully remove the wrist flange.
    a) Tighten the 4-40 screws carefully and equally to prevent tipping of the shaft.
    b) Check the gear mesh to determine whether further adjustment is required.
8. Enter the RAPL-II command NOLIMP <ENTER> and command the arm to the ready position.
    a) Install the wrist flange, check the orientation of the homing marks mentioned in step 1 is correct.
    b) When the flange bearing is seated, re-check the quality of the gear mesh. If incorrect, repeat the adjustment procedure.

7-4-2 Wrist Gear Lubrication

Tools Required

- Allen keys
- Small gear puller
- High-pressure gear grease Metalon High Tech EP 1.5

Warning! ***Robots with serial number lower than RC2526 use Dow Corning BR2+ grease. Dow Corning BR2+ grease is black in color. Metalon High Tech EP 1.5 is blue in color. Do not mix different grease types.***

To lubricate the wrist gear:

1. Remove the gripper and any other components mounted to the wrist flange.
   a) With power on, command the robot to move to the ready position.
   b) Observe the orientation of the joint 5 homing marks relative to one another.

Note: In the next few steps, you will be removing the wrist flange, adjusting the wrist gears, and re-installing the flange. It is important when re-installing the flange, to align it in position with the original homing markers.

2. Enter the RAPL-II command ">>LIMP 4" <return> to "limp" the wrist.
3. Remove the wrist flange: Undo the #8-32 button-head cap screw at the center of the wrist flange.
   a) Pull the flange bearing clear of its seat on the shaft. The flange should slip off with just manual pressure.
   b) Ensure that dirt and metal filings do not get into the grease on the gear.
4. Apply high-pressure gear grease such as Metalon High Tech EP 1.5 (see *Warning!* above) to the pinion gear pressed into the flange.
   a) Pack the same grease into the small needle bearing in the pinion. Use a small clean screwdriver to ensure that the grease gets into the needles of the bearing. Remove excess.
5. Re-install the flange so that the gears mesh loosely.
   a) LIMP the wrist (RAPL-II command ">>LIMP 4") and rotate the flange by hand to distribute the grease on the bevel gear.
   b) UN-LIMP the arm and re-position the robot at the starting position.
   c) Remove the flange again and apply a bit more grease to the pinion.
6. Install the flange again. This time ensure that the gears mesh properly as noted by the position of the joint 5 homing marks. Tighten the button-head cap screw to approximately 18 Kg-cm.

7-5 Wrist Drive Gears Mesh Adjustment

Tools Required

- Allen keys
- Assorted shims
- High-pressure gear grease Metalon High Tech EP 1.5

Warning! Robots with serial number lower than RC2526 use Dow Corning BR2+ grease. Dow Corning BR2+ grease is black in color. Metalon High Tech EP 1.5 is blue in color. Do not mix different grease types.

To adjust the wrist drive gears mesh:

1. Remove the arm plastic covers.
    a) Unscrew the flat-head screws located at the front of the skirt, at the top of the shoulders, and at the rear above the rear motor cover; to remove the two main half covers.
    b) Disconnect the two wrist motors by un-plugging their connectors.
2. Remove wrist motor plate.
    a) Loosen the three 10-24 screws below the wrist motors.
    b) Pull the plate up and away. This removes the mesh between the spur gears in the drive train.
    c) Loosen but do not remove the three 10-24 screws which hold the plate in position.
3. Check the play in the bevel gears.
    a) Rotate the output bevel gear back and forth against the pinion to feel for the play.
    b) Adjust the play by moving the spur-gear/bevel gear cluster on its shaft. The axial position of the cluster is determined by the screw in the end of the shaft and a small wave-washer spring between the cluster and the wrist drive center block.
    c) Further adjust the play by turning the screw in the end of the shaft. Turning the screw clockwise loosens the gear mesh and turning it counter-clock wise tightens it. Do not let the spring force the gears together, the mesh will be rough.
    d) Attempt to just eliminate gear clearance.

Note: The screw is located with Loctite at the factory to prevent it from coming out of adjustment. This may result in difficulty when adjusting the screw.

If the end of the shaft is covered in Loctite, the outer bearing may be tight. Carefully remove and clean the parts before adjusting.

4. If the mesh of the gears is still rough after adjustment, check for burrs or debris in the gear teeth. If the roughness persists, it may be necessary to shim the motor.

5. Repeat above procedure for the other side of the wrist motor/gear assembly.

6. Liberally apply high pressure gear grease (DOW Corning DP2 or equivalent) onto the bevel gear and pinion. Before re-installing the motor plate to the robot, apply the grease to the spur gear pinion.

7. Install the wrist drive subassembly on the 10-24 SHCS's, meshing the spur gears loosely.

   a) Move the assembly around to find the best mesh of both sets of gears. When it feels as if the gears are properly meshed, gently tighten the center screw (of the three holding the assembly).

   b) Move the wrist up and down with your hand.

8. Check to establish proper installation of the wrist gears:

   a) Is there excessive play on the gear mesh?

   b) Is the mesh too tight?

   c) Are the gears aligned properly?

9. Make appropriate adjustments to the mesh.

   a) When the gear sets are adjusted satisfactorily, tighten the other 2 screws holding the assembly on the plate.

   b) Move the wrist again to determine if the gears are still adjusted properly. Repeat if necessary.

10. Re-install the plastic covers.

7-6 Check Motor Brush Wear

Tools Required

- $^{1}/_{4}$" slot screwdriver
- $^{1}/_{4}$" offset slot screwdriver

Warning! Installing the brushes in the wrong places reverses electrical polarity and results in the motor running away uncontrollably when power is applied.

To check the wear of the motor brushes:

1. The brushes for each motor are located on the outside of the rear bell-housing of each unit. The joint one motor is located inside the base casting. Its brushes are accessible with an offset screwdriver.
2. The brushes should be removed, inspected, and replaced one at a time to prevent them from being switched. Each brush has a different color of wire leads.
   a) Re-insert each brush so that its curved face fits correctly against the commutator.
3. The brushes should be routinely changed every 10,000 hours or if the brush length is less than 0.19 inches from the seat of the spring to the tip.

7-7 Encoder Alignment

7-7-1 Introduction

If a loss of feedback has been diagnosed and it has been determined that neither wiring nor connectors are the cause, the encoder may be at fault.

The positional encoder is a precision optical device which translates rotary motion into a string of directional pulses. The actual output from the encoders in the A100/200 Series Robot is a pair of square waves which are resolved into CW or CCW pulses by gating circuitry on the axis card. In addition, a zero-crossing pulse (also called the marker-pulse or index-pulse) is produced once for each rotation of the encoder and is only used during homing of the arm.

7-7-2 Square Wave

The square wave is generated as follows:

1. A metal or glass disk, with a grating on its periphery, is attached to the motor shaft. As the disk rotates, it passes by a static grating (the stator), engraved with the same size lines. A light source shines through the disk and stator gratings to a photo-cell below. As the grating lines alternately line up and oppose, the light level seen by the photo-cell alternates from strong to weak. The more "lines" on the disk, the finer the resolution of the encoder. Circuitry in the encoder amplifies and buffers the varying signal from the photo-cell into a square-wave.
2. Each encoder used in the A100/200 series arm is a Motion Control Device MCD-M21, referred to as a "modular" encoder. The concept of the modular encoder is that the disk is contained completely within the stator and the stator/rotor gap is set at assembly by installing the encoder as a whole and then removing a shim. The encoders in the motors of the robot have 1,000 lines per revolution.

7-7-3 Axial Adjustment of the Disk Relative to the Stator

This adjusts the optical gap which is critical for operation. If the gap is too large, the light from the source is not "focused" through the grating and the signal is lost, resulting in a loss of feedback. If the gap is too small, the loading on the shaft, while small, may be enough to cause the two to come into contact, leading to damage of the grating or disk failure.

To adjust the gap:

Note: This procedure should be followed before any other adjustment of the encoder is attempted.

1. Remove the encoder cover and loosen the disk on the shaft.
2. Insert a plastic shim of 0.004" thickness between the disk and stator.
3. Push the disk gently against the shim, trapping it between the disk and the stator. Once the disk is set at the correct position, tighten the screws in the disk hub.
4. Remove the shim and rotate the disk. Look in the area where the shim was in order to check if the axial has run-out of the disk.
5. The gap must not close to closer than 0.003" or there is danger that it may touch the stator under collision loads. If run-out is more than 0.002 TIR, replace the encoder.

7-8 Calibrating the Arm

Reload factory calibration parameters when:

- The calibration memory is corrupt.

Re-calibrate the system with new parameters when you:

- Remove or replace a servo motor, encoder or chains, etc.
- Add an extra axis(es).

7-8-1 Restoring Factory Calibration Values

The calibration values for your robot are unique. Reload factory calibration values if the calibration memory is corrupt (resulting in checksum errors) when you attempt to home the arm.

You need:

- A computer with Robcomm for Windows or DOS software
- Your A255 Robot Arm distribution software disk

The distribution disk contains calibration information stored in the following file.

cal\srs_(robot arm serial number).cal

The .cal file contains factory defined calibration values for the robot arm.

Note: If you have previously recalibrated the arm or are using an extra axis in your application, load the calibration values from your own backup disk instead.

If lost, a copy of the factory calibration data can be obtained from your nearest distributor or CRS Robotics.

Before you begin:

- Ensure that your computer is connected to the controller front panel communication port.

To restore the factory calibration values:

1. Switch both the computer and the controller ON.
2. Switch ON arm power.
3. Transfer control of the robot from the teach pendant to your computer.
   a) At the teach pendant, press **ESC** until the Terminate To screen appears.
   b) Select **F4** host, to terminate to the host point of control.

4. Run Robcomm and establish communication with the controller by selecting Terminal from the Utilities menu and pressing **Crtl+C**. Insert the distribution disk into drive a:.
5. Download the .cal file from the a:\cal directory into the controller memory.
   a) At the Robcomm Setup menu, choose Calibration Send.
   b) At the Calibrate window click Send.
   c) At the Send window, choose the correct .cal file to send and click OK. The calibration values download to the controller memory.
6. Home the arm (refer to the *A255 Robot System User Guide*) or use your own custom homing procedure.
7. Type **READY** and press **Enter** to place the robot at the Ready position. All markers on the robot should align properly.

7-8-2 Recalibrating the Robot Arm

Recalibrate the robot when there is a drive disturbance, such as the replacement of a servo motor, encoder, chain, etc.

Note: You must recalibrate even if the replacement part is of the same type as the one removed.

The following recalibration procedures restore adequate recalibration for the majority of robot applications. Precise calibration of the robot can only be obtained when performed with the aid of a calibration fixture. If you require precise calibration contact your nearest distributor or CRS Robotics.

Procedures:

Recalibration consists of a sequence of four procedures.

1. Establish communication with the robot
2. Adjust all the joints to the Zero (@CALRDY) position
3. Set and save the new calibration values
4. Check your locations

Note: These procedures do not calibrate extra axes. If you are adding an extra axis refer to page 7-19.

You need:

- Precision 24-inch square with scale
- Computer with Robcomm software
- Your A255 distribution disk, or your own backup, if your system was previously recalibrated. If the distribution disk is lost, you can obtain a copy from your nearest distributor or CRS Robotics.

Before you begin:

- Ensure that the arm is securely bolted down.
- Remove the gripper or other tooling attached to the arm. The tooling must be removed in order to calibrate joint 5.

  Tip: Mark the position of the tooling on the arm with a pencil. Use these marks as guidelines when re-installing the tooling.

  Note: The internal home command must be enabled in order to use the @@CAL command to recalibrate the arm (see @@SETUP in the RAPL-II Programming Manual for details).

1) Establish Communication With the Robot

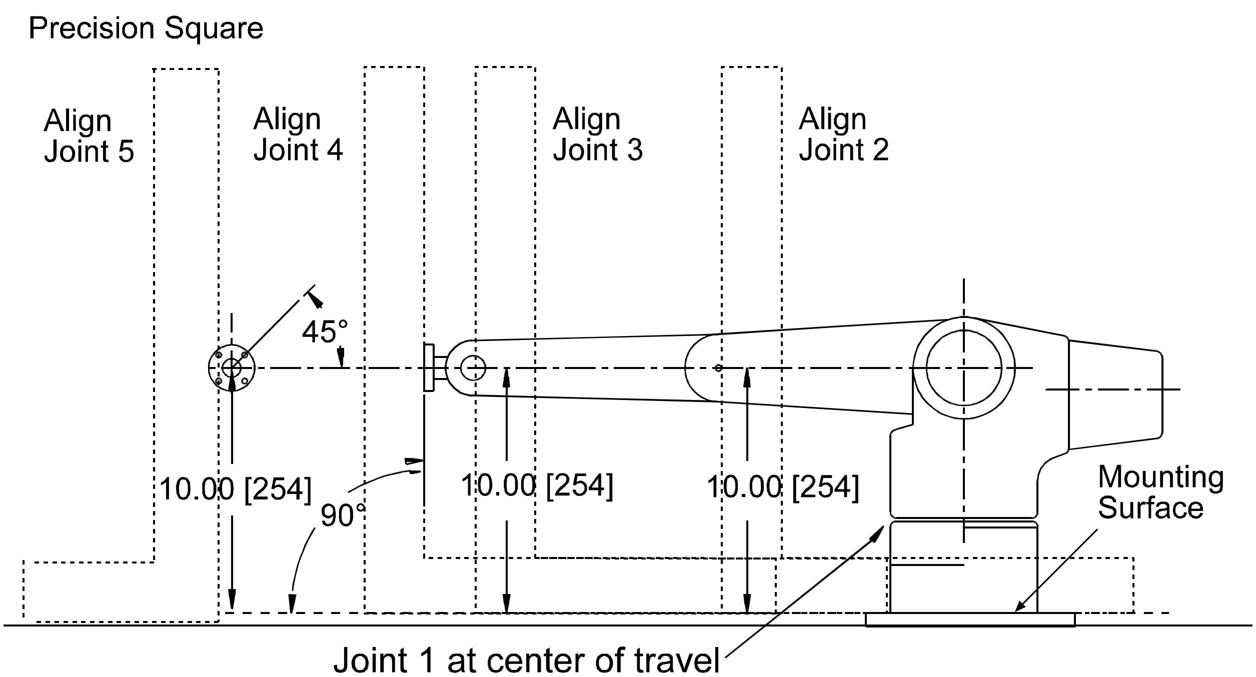
1. Turn ON the computer and controller.
2. Turn ON arm power.
3. Use the teach pendant to move the arm into an approximate Zero position, refer to the drawing in the next section.
4. Transfer control of the robot from the teach pendant to the terminal.
   a) At the teach pendant, press **ESC** until the Terminate To screen appears.
   b) Select **F4** host, to terminate to the host point of control.
5. Run the Robcomm Terminal Emulator, and press **Crtl+C**. The system prompt (>>) appears, indicating communication with the controller.
6. Type **PASSWORD 255** and press **Enter**.

2) Adjust All the Joints in Sequence to the Zero (@CALRDY) Position

Adjust joints 1, 2, 3, 4, and 5, to their Zero position using the following sequence. Use the following figure as a reference.

Caution! Review the safety precautions at the front of this guide before entering within the robot's work envelope, refer to the safety checks at the front of this manual.

Warning! Have someone else available to strike the e-stop when working inside the robot envelope*. Working within the robot envelope when arm power is on represents a risk. In the case of a controller or arm failure, there is a danger of impact or trapping.*



The Zero (@CALRDY) position for the arm. Use a 24-inch precision square with scale to pose joints 2, 3, 4, and 5.

Joint 1

1. Type **LIMP 1** and press **Enter**, the waist joint limps.
2. Type **W1** and press **Enter** to display the position of the robot joints in motor pulses. The first number lists the position of axis 1.
3. By hand, rotate axis 1 until it is positioned against one of its hardstops. Do not compress the hardstop.
4. Press **Enter** to terminate the W1 command.
5. Type **XZERO 1** and press **Enter** to zero the joint 1 position registers.
6. Type **W1** and press **Enter** and then rotate axis 1 until it is against its other hardstop.
7. Type **SPEED 10** and press **Enter**.
8. Type **NOLIMP** and press **Enter**. Joint 1 unlimps.
9. Note the displayed motor pulse position and divide the travel value by two. This determines the value of the half-way position.

   Note: The sign (±) must be opposite of the displayed value.
10. Type **MOTOR 1,** <**± half-way position value**> and press **Enter**. The arm moves to the half-way position.
11. Type **XZERO 1** to set the Zero position for joint 1. The motor pulse count for joint 1 (W1) should now read zero.

Joint 2

1. Place the 24-inch square to measure the perpendicular distance from the robot's mounting surface to the joint 3 axle hole on the side of the arm (refer to the drawing on the previous page).
2. Use the MOTOR command to adjust the joint so the measured distance is ten inches. For example:

   Type **MOTOR 2,** <**± motor pulse counts**> and press **Enter.**

   Note: Use small increments of motor pulses to move the arm (20 pulses).

Joint 3

1. Place the 24-inch square to measure the perpendicular distance from the robot's mounting surface to the joint 4 axle hole on the side of the arm (refer to the drawing on page 7-16).
2. Use the MOTOR command to adjust the joint so the measured distance is ten inches. For example:

   Type **MOTOR 3,** <**± motor pulse counts**> and press **Enter**.

Joint 4

1. Place the 24-inch square in position to check if the tool flange is perpendicular to the robot's mounting surface (refer to the drawing on page 7-16).
2. Use the MOTOR command to adjust the joint so the tool flange is perpendicular. For example:

   Type **MOTOR 4,** <± **motor pulse counts**> and press **Enter**.

Joint 5

1. With the joint 5 tool flange approximately at the center of its travel, use the square to align two of the tool flange screw holes so they are perpendicular to the robot's mounting surface (refer to the drawing on page 7-16).
2. Use the MOTOR command to adjust the joint. For example:

   Type **MOTOR 5,** <± **motor pulse counts**> and press **Enter**.

3) Set the New Values

1. Type **@ZERO** and press **Enter** to zero the position registers.
2. Type **JOINT 2,90** and press **Enter** to move the arm to the Ready position.
3. Type **@@CAL** and press **Enter**. At the prompt, type **Y** (yes). This resets the controller's calibration data and homes the arm.
4. If required, pull off and re-apply the homing markers, refer to *the A255 Robot System User Guide* for details.

   Note: New markers can be purchased from CRS Robotics.
5. Type **SPEED 10** and press **Enter**.
6. Type **READY** and press **Enter**.
7. Exit the Terminal Emulator.
8. Use Robcomm to save the new calibration values on a backup disk.
   - Choose Calibration Receive from the Setup menu.
   - Click Save and then save the values in your selected directory.

Warning! Do not save new calibration values using the original file name. *This overwrites the factory values causing them to be lost.*

4) Check Your Locations

1. Re-install the plastic arm covers.
2. Inspect the homing markers and reposition if necessary.

   Note: New markers can be purchased from CRS Robotics.
3. If you removed the arm tooling earlier, ensure that it is properly installed, aligned, and leveled before running your application.

   Note: Installing the tooling correctly can be as important as correctly recalibrating your robot arm.
4. If you are using a homing bracket, ensure that all steps required for recalibration with the homing bracket are performed before you run your application. See the Homing Bracket User's Guide.
5. Before running your application, perform the following check.
   a) Type **SPEED 10** and press **Enter**.
   b) Move the arm to predefined locations used in your application.
   c) Ensure that the arm moves to those locations as expected. If not, stop arm motion and recheck your calibration.
   d) If the problem persists after several tries, you may have to re-teach your locations.

7-8-3 Calibrating an Extra Axis

If you are adding an extra axis such as a carousel, use the following information to calibrate that axis. If you are adding a track axis, refer to the T265 Linear Track Option User's Guide.

Use the following RAPL commands to zero, calibrate, and home your extra axis, refer to the RAPL-II Programming Manual for details.

- XZERO
- @@CALZC
- HOMEZC

To customize the calibration of the extra axis you may need to use some of the following RAPL commands, refer to the RAPL-II Programming Manual for details.

- MOTOR
- FINISH
- @XPULSES
- @BYTE
- SPEED
- @@CALZC
- @SEEK
- GOSUB
- CALSEQ
- @XRATIO
- @GAIN
- @TRACK
- @XLIMITS
- @ACCEL
- @MAXVEL

7-9 Cleaning

All arm components can be cleaned using house-hold cleaning products.

Note: The use of some solvents or de-greasers may damage the printed surfaces.

7-9-1 Cleaning the Controller's Fan Filter

The controller air filters should be cleaned regularly. This procedure can be used to remove the filters for cleaning or to replace them. Clean with soap and water. Rinse and dry thoroughly before installing.

To clean the Foam Filter:

1. Snap the cover off the rear panel filter assembly of the controller.
2. Remove the foam element for cleaning.
3. Wash with soap and water.

To clean the Main (in going air) Filter:

The main filter is sandwiched between the fan and the rear panel.

1. Snap the cover off the rear panel filter assembly of the controller.
2. Remove the foam element.
3. Use a vacuum to clean the main filter, the filter is located behind the plastic grating of the filter assembly.

To clean the Secondary (outgoing) Filter:

This filter is found on the right rear side of the controller. Since it needs much less servicing than the main filter, it is held in place with nuts.

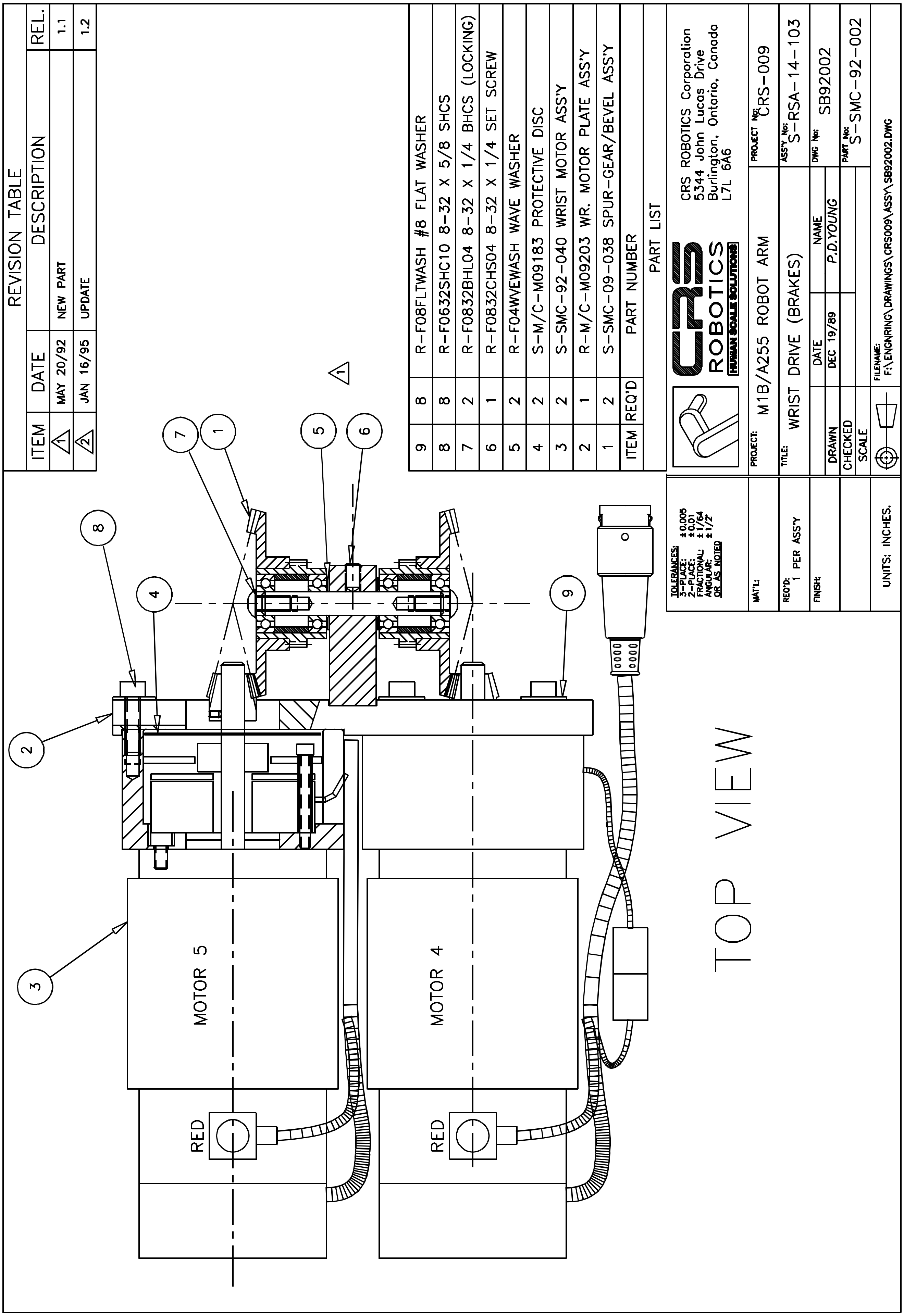
1. Remove the controller lid.
2. Remove the four #6 nuts holding it in place on the chassis studs.
3. Replace it by reversing the above procedure.

CHAPTER 8

8 Mechanical System Drawings

8-1 Mechanical Drawings

This chapter contains drawings of the major components for the A255 Robot arm.



REVISION TABLE

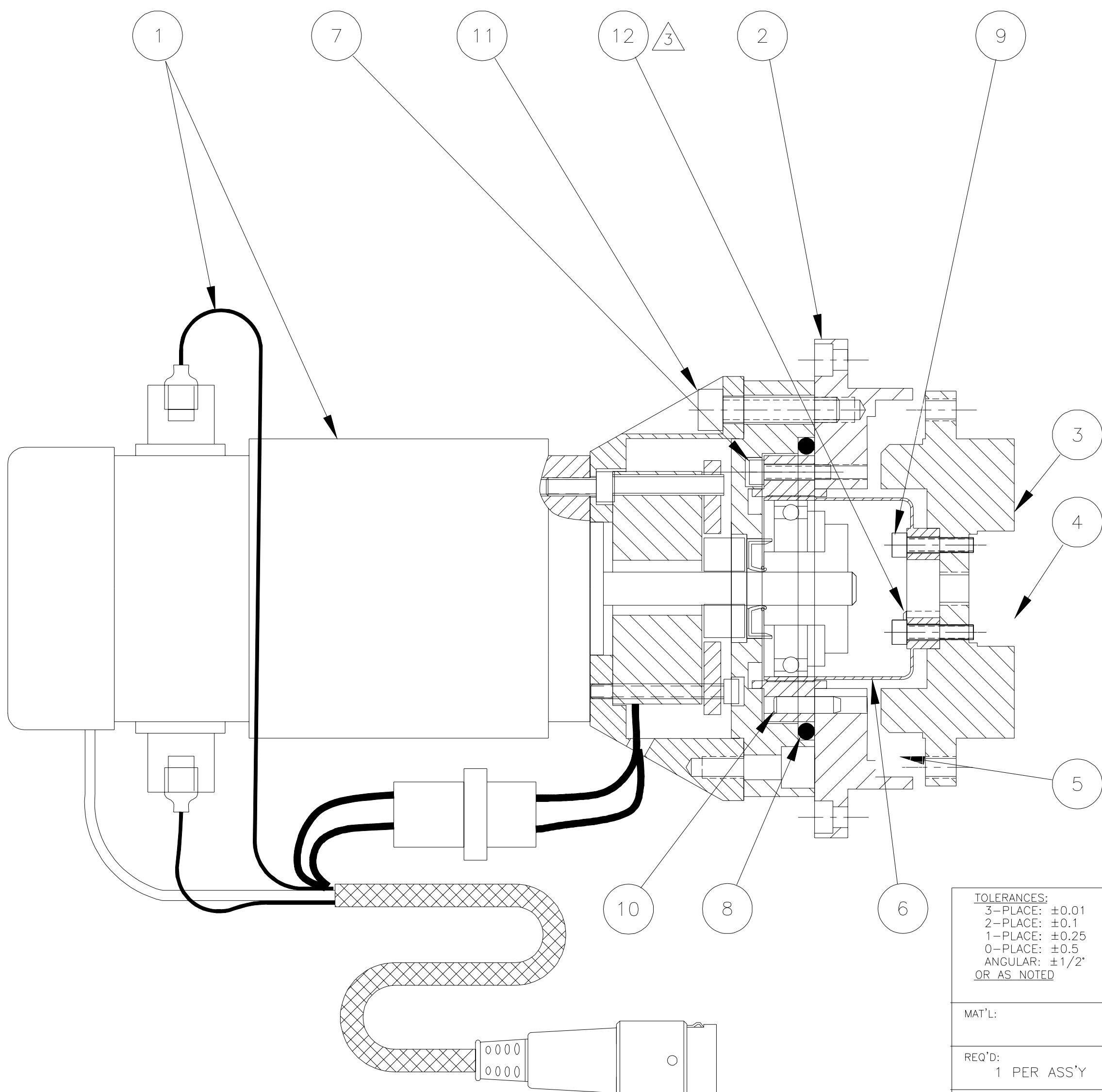
ITEM	DATE	DESCRIPTION	REL.
1	MAY 20/92	NEW PART	1.1
2	JAN 16/95	UPDATE	1.2

PART LIST

ITEM	REQ'D	PART NUMBER	
9	8	R-F08FLTWASH	#8 FLAT WASHER
8	8	R-F0632SHC10	8-32 X 5/8 SHCS
7	2	R-F0832BHL04	8-32 X 1/4 BHCS (LOCKING)
6	1	R-F0832CHS04	8-32 X 1/4 SET SCREW
5	2	R-F04WVEWASH	WAVE WASHER
4	2	S-M/C-M09183	PROTECTIVE DISC
3	2	S-SMC-92-040	WRIST MOTOR ASS'Y
2	1	R-M/C-M09203	WR. MOTOR PLATE ASS'Y
1	2	S-SMC-09-038	SPUR-GEAR/BEVEL ASS'Y

REVISION TABLE

ITEM	REV. DATE	DESCRIPTION	REV. BY	REL.
△	MAR 23/95	UPDATE ASSY		
△2	JUN. 20/96	UPDATE SEALS, RMOVD GREASE FIT	PG	1.2
△3	JUL 30/96	ADDED DOWEL PIN UPDATE PLIST	PG	1.2



PART LIST

	ITEM	REQ'D	PART NUMBER
△3	12	2	R-F020LPIN08 1/8" DIA x 1/2" DOWEL PIN
	11	4	R-F1024SHC14 10-24 X 7/8"CAP SCREW
△3	10	1	R-F02DLPIN10 1/8" DIA X 5/8"DOWEL PIN
△3	9	6	R-F0440SHC08 4-40 X 1/2"CAP SCREW
	8	1	R-GRO-RNG2ID O-RING SEAL
	7	6	R-F0440SHC10 4-40 X 5/8" CAP SCREW
	6	1	R-TRC/1C072A HARMONIC DRIVE
△2	5	1	R-BG0-61811S SEALED BEARING
△2	4	1	R-BG0608-2RS SEALED BEARING
	3	1	R-M/C-M91403 JOINT 2 FLANGE
	2	1	T-ABK-M91402 SHOULDER FLANGE
	1	1	S-SMC-14-103 JT 2/3 MOTOR ASS'Y -BRAKE

TOLERANCES:
3-PLACE: ±0.01
2-PLACE: ±0.1
1-PLACE: ±0.25
0-PLACE: ±0.5
ANGULAR: ±1/2°
OR AS NOTED

CRS ROBOTICS
HUMAN SCALE SOLUTIONS

CRS ROBOTICS Corporation
5344 John Lucas Drive
Burlington, Ontario, Canada
L7L 6A6

MAT'L:

PROJECT: A255 ROBOT ARM

PROJECT No: CRS-914

REQ'D: 1 PER ASS'Y

TITLE: J2 DRIVE ASSY - BRAKES

ASS'Y No: S-RSA-14-103

FINISH:

	DATE	NAME
DRAWN	DEC 19/89	PDY
CHECKED		
SCALE	FULL SIZE	

DWG No: SB14127

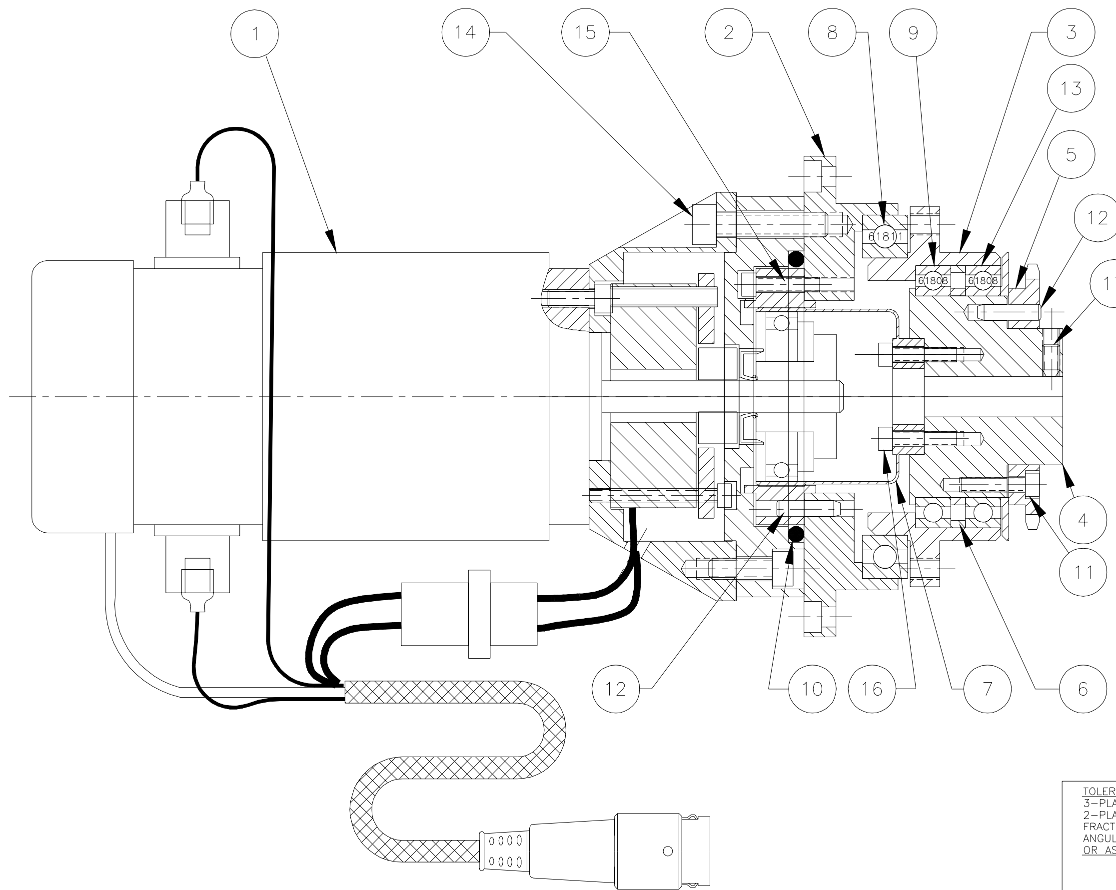
PART No: S-SMC-14-127

UNITS: MILLIMETERS

FILENAME: F:\ENGNRING\DRAWINGS\CRS914\ASSY\SB14127.DWG

REVISION TABLE

ITEM	REV. DATE	DESCRIPTION	REV. BY:	REL.
1	APR 3/95	UPDATED	IH	



ITEM	REQ'D	PART NUMBER
17	2	R-F0632CHS06 6-32 X 3/8 SET SCREW
16	6	R-F0440SHC08 4-40 X 1/2 CAP SCREW
15	6	R-F0440SHC10 4-40 X 5/8 CAP SCREW
14	4	R-F1024SHC14 10-24 X 7/8 CAP SCREW
13	1	R-BG-61608 S 61808 SEALED BEARING
12	4	R-F02DLPIN08 DOWEL PIN
11	4	R-F0440SHC06 4-40 X 3/8 CAP SCREW
10	1	R-GRO-RNG2ID O-RING SEAL
9	1	R-BG-061608 61808 BEARING
8	1	R-BG-61811S 61811 SEALED BEARING
7	1	R-TRC/1C072A HARMONIC DRIVE
6	1	R-M/C-M91407 J3 BEARING SPACERS
5	1	R-GER-M91410 JT 3 DRIVE SPROCKET
4	1	R-M/C-M91405 JOINT 3 PIVOT
3	1	R-M/C-M91404 J3 FLANGE
2	1	R-M/C-M91402 SHOULDER FLANGE
1	1	S-SMC-14-103 JOINT 2/3 MOTOR ASS'Y

PART LIST

TOLERANCES:
3-PLACE: ±0.005
2-PLACE: ±0.01
FRACTIONAL: ±1/64
ANGULAR: ±1/2°
OR AS NOTED

CRS ROBOTICS
HUMAN SCALE SOLUTIONS

CRS ROBOTICS Corporation
5344 John Lucas Drive
Burlington, Ontario, Canada
L7L 6A6

MAT'L:

REQ'D: 1 PER ASS'Y

FINISH:

PROJECT: A255 ROBOT ARM

TITLE: J3 DRIVE ASSY - BRAKES

PROJECT No: CRS914

ASS'Y No: S-RSA-14-103

DWG No: SB14129

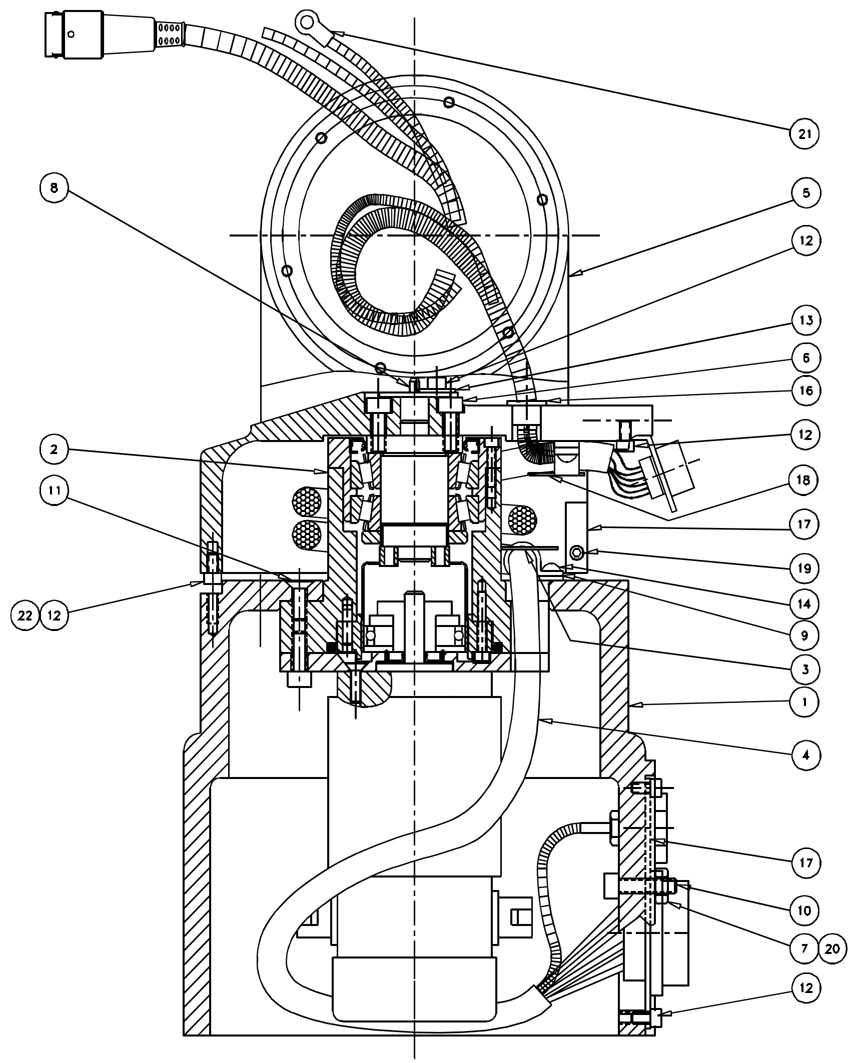
PART No: S-SMC-14-129

	DATE	NAME
DRAWN	DEC 89	PDY
CHECKED		
SCALE		

UNITS: INCHES.

FILENAME: F:\ENGNRING\DRAWINGS\CRS914\ASSY\SB14129.DWG

REVISION TABLE				
ITEM	DATE	DESCRIPTION		REL.
1	JUN. 16/95	DRAWING GENERALLY REVISED	RAH	1.1
2	AUG 21/95	UPDATED	TIH	1.2



ITEM	REQ'D	PART NUMBER
22	1	R-F06LCKWASH #6 LOCKWASHER
21	1	S-SCC-14-538 J2 GND STRAP
20	1	R-F10-LCKWASH #10 LOCKWASHER
19	2	R-F0440BHC04 4-40X1/4 BTN HD SCR
18	1	S-M/C-M91435WAIST HARNESS RAMP
17	1	T-ABK-M91429 COVER PLATE -A.BLK
16	1	R-WCC-10BU04 5/8" WIRE BUSHING
15	1	R-F02DLPIN10 1/8DIA X 5/8 DWL PIN
14	2	R-F0632BHC08 6-32X1/2 BTN HD C.S.
13	4	R-F06FLTWASHSS #6 FLAT WASHER-S.S.
12	9	R-F0632SHC04SS 6-32X1/4" CAP SCR-S.S.
11	4	R-F1024FHC08 10-24X1/2"FLT HD CAP SCR
10	1	R-F1024SHC12SS 10-24X3/4"CAP SCR - S.S.
9	2	R-WCC-05ID04 5/16DIA CABLE CLAMP
8	1	R-F02RLPIN16 1/8DIA X 1"ROLL PIN
7	1	R-F1024HEXNTSS 10-24 HEX NUT - S.S.
6	4	R-F1024SHC07ZN 10-24X7/16 CAP SCR-Z.P.
5	1	T-PBK-M91401 WAIST PAINTED BLACK
4	1	S-SMC-14-043 MAIN HARNESS ASSEMBLY
3	1	S-M/C-M91434 BASE HARNESS RAMP
2	1	S-SMC-14-106 NECK ASSEMBLY
1	1	T-PBK-M91411 BASE PAINTED BLACK

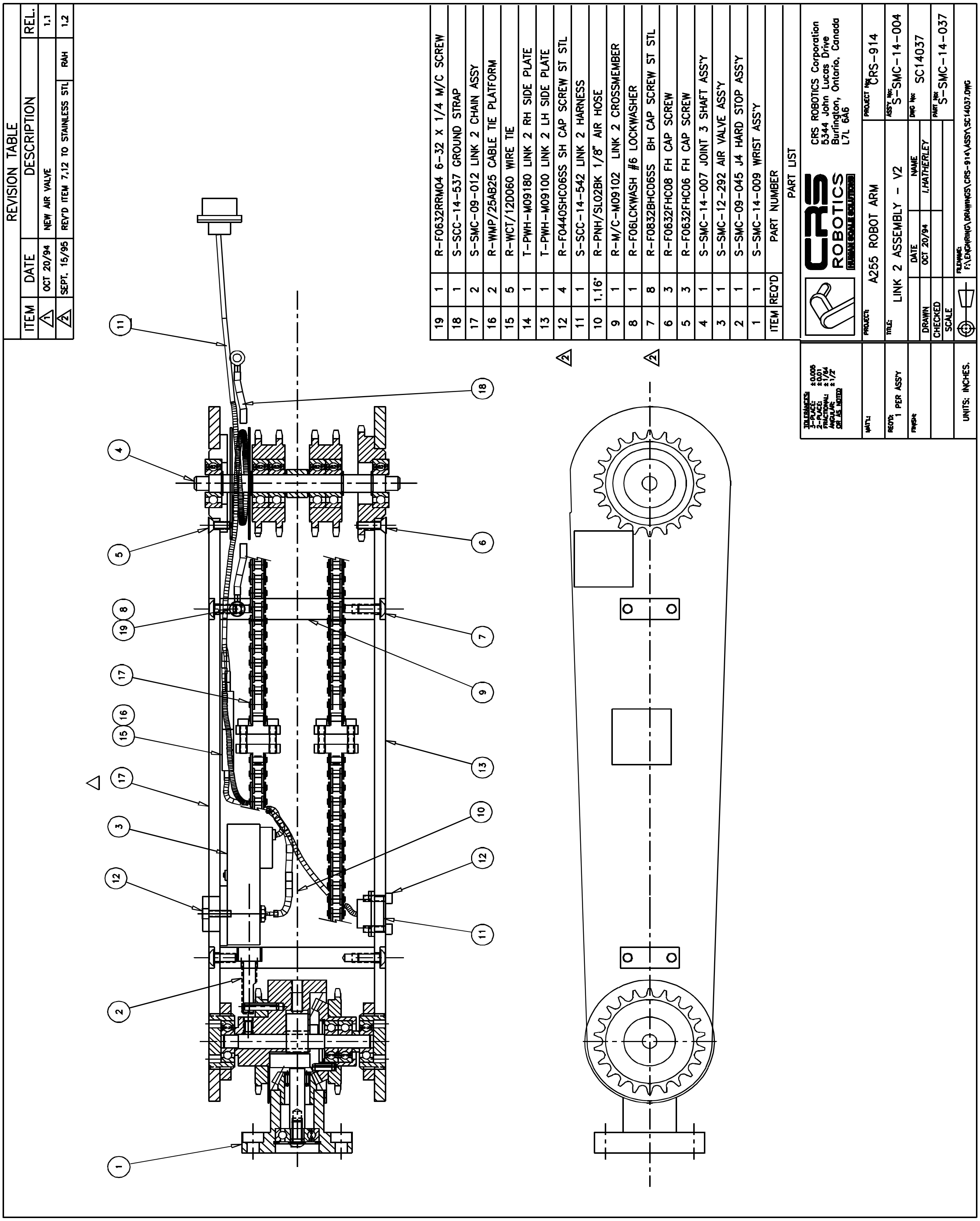
PART LIST

TOLERANCES:
3-PLACE: ±0.005
2-PLACE: ±0.01
FRACTIONAL: ±1/64
ANGULAR: ±1/2
OR AS NOTED

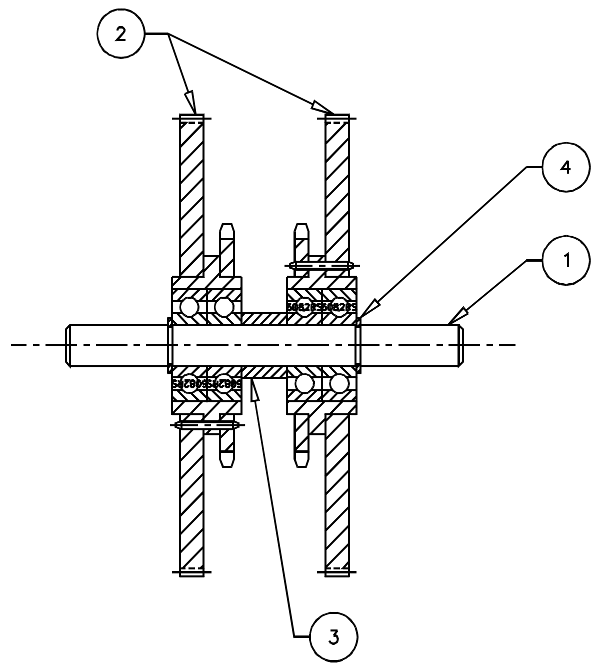
CRS ROBOTICS
HUMAN SCALE SOLUTIONS

CRS ROBOTICS Corporation
5344 John Lucas Drive
Burlington, Ontario, Canada
L7L 6A6

MAT'L:	PROJECT: A255 ROBOT ARM		PROJECT No: CRS-914
REQ'D: 1 PER ASS'Y	TITLE: BASE SUBASSEMBLY		ASS'Y No: S-RSA-14-003
FINISH:		DATE / NAME	DWG No: SC14104
	DRAWN	DEC. 18, 1989 / P.D.Y.	PART No: S-SMC-14-104
	CHECKED		
	SCALE	FULL SIZE	
UNITS: INCHES.		FILENAME: F:\ENGNRING\DRAWINGS\CRS914\ASSY\SC14104.DWG	


REVISION TABLE
ITEM DATE DESCRIPTION REL.
1 OCT 20/94 NEW AIR VALVE 1.1
2 SEPT. 15/95 REV'D ITEM 7,12 TO STAINLESS STL RAH 1.2
19 1 R-F0632RRM04 6-32 X 1/4 M/C SCREW
18 1 S-SCC-14-537 GROUND STRAP
17 2 S-SMC-09-012 LINK 2 CHAIN ASSY
16 2 R-WMP/25AB25 CABLE TIE PLATFORM
15 5 R-WCT/12D060 WIRE TIE
14 1 T-PWH-M09180 LINK 2 RH SIDE PLATE
13 1 T-PWH-M09100 LINK 2 LH SIDE PLATE
12 4 R-F0440SHC06SS SH CAP SCREW ST STL
11 1 S-SCC-14-542 LINK 2 HARNESS
10 1.16" R-PNH/SL02BK 1/8" AIR HOSE
9 1 R-M/C-M09102 LINK 2 CROSSMEMBER
8 1 R-F06LCKWASH #6 LOCKWASHER
7 8 R-F0832BHC06SS BH CAP SCREW ST STL
6 3 R-F0632FHC08 FH CAP SCREW
5 3 R-F0632FHC06 FH CAP SCREW
4 1 S-SMC-14-007 JOINT 3 SHAFT ASS'Y
3 1 S-SMC-12-292 AIR VALVE ASS'Y
2 1 S-SMC-09-045 J4 HARD STOP ASS'Y
1 1 S-SMC-14-009 WRIST ASS'Y
ITEM REQ'D PART NUMBER
PART LIST
CRS ROBOTICS
CRS ROBOTICS Corporation
5344 John Lucas Drive
Burlington, Ontario, Canada
L7L 6A6
PROJECT: A255 ROBOT ARM
PROJECT No: CRS-914
TITLE: LINK 2 ASSEMBLY - V2
ASS'Y No: S-SMC-14-004
DWG No: SC14037
DRAWN OCT 20/94 I.HATHERLEY
CHECKED
SCALE
PART No: S-SMC-14-037
FILENAME: F:\ENGNRING\DRAWINGS\CRS-914\ASSY\SC14037.DWG
MAT'L:
REQ'D: 1 PER ASS'Y
FINISH:
UNITS: INCHES.

REVISION TABLE			
ITEM	DATE	DESCRIPTION	REL.



ITEM	REQ'D	PART NUMBER
4	2	R-BGR-EX0312 SNAP RING
3	1	R-M/C-M09027 BUSHING
2	2	S-SMC-09-025 SPUR GEAR/SPRCT ASS'Y
1	1	R-M/C-M91406 JOINT 2 SHAFT

PART LIST

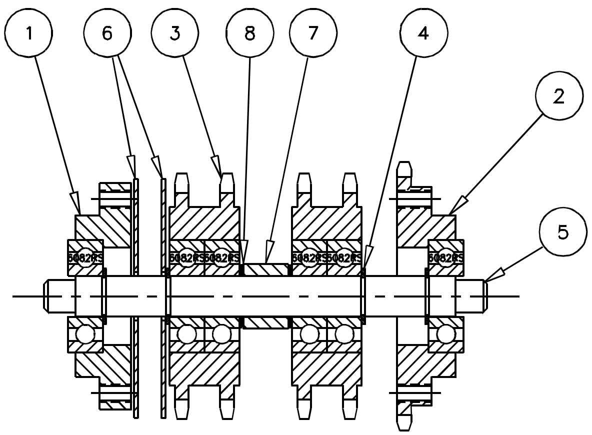
TOLERANCES:
3-PLACE: ± 0.005
2-PLACE: ± 0.01
FRACTIONAL: ± 1/64
ANGULAR: ± 1/2°
OR AS NOTED

CRS ROBOTICS
HUMAN SCALE SOLUTIONS

CRS ROBOTICS Corporation
5344 John Lucas Drive
Burlington, Ontario, Canada
L7L 6A6

MAT'L:	PROJECT: M1A ROBOT ARM			PROJECT No: CRS-914
REQ'D: 1 PER ASS'Y	TITLE: JOINT 2 SHAFT ASSEMBLY			ASS'Y No: S-RSA-14-003
FINISH:		DATE	NAME	DWG No: SB14006
	DRAWN	DEC. 04, 1989	P.D. YOUNG	
	CHECKED			PART No: S-SMC-14-006
	SCALE	FULL SIZE		
UNITS: INCHES.		FILENAME: F:\ENGNRING\DRAWINGS\CRS914\ASSY\SB14006.DWG		

REVISION TABLE			
ITEM	DATE	DESCRIPTION	REL.



ITEM	REQ'D	PART NUMBER
8	2	R-F05WVEWASH 5/16 WAVE WASHER
7	1	R-M/C-M09027 SHAFT SPACER
6	2	R-M/C-M09183 J3 PLASTIC DISK
5	1	R-M/C-M09231 JOINT 3 AXLE - VER. 2
4	4	R-BGR/EX0312 SNAP RING
3	2	S-SMC-14-032 WRIST SPROCKET ASS'Y
2	1	S-SMC-09-031 JOINT 3 SPRKT. ASS'Y
1	1	S-SMC-09-030 ELBOW BEARING ASS'Y

PART LIST

TOLERANCES:
3-PLACE: ±0.005
2-PLACE: ±0.01
FRACTIONAL: ±1/64
ANGULAR: ±1/2°
OR AS NOTED

CRS ROBOTICS
HUMAN SCALE SOLUTIONS

CRS ROBOTICS Corporation
5344 John Lucas Drive
Burlington, Ontario, Canada
L7L 6A6

MAT'L:

REQ'D: 1 PER ASS'Y

FINISH:

UNITS: INCHES.

PROJECT: A255 ROBOT ARM

PROJECT No: CRS914

TITLE: J3 SPROCKET ASSEMBLY

ASS'Y No: S-SMC-14-037

	DATE	NAME
DRAWN	DEC 89	PDY
CHECKED		
SCALE		

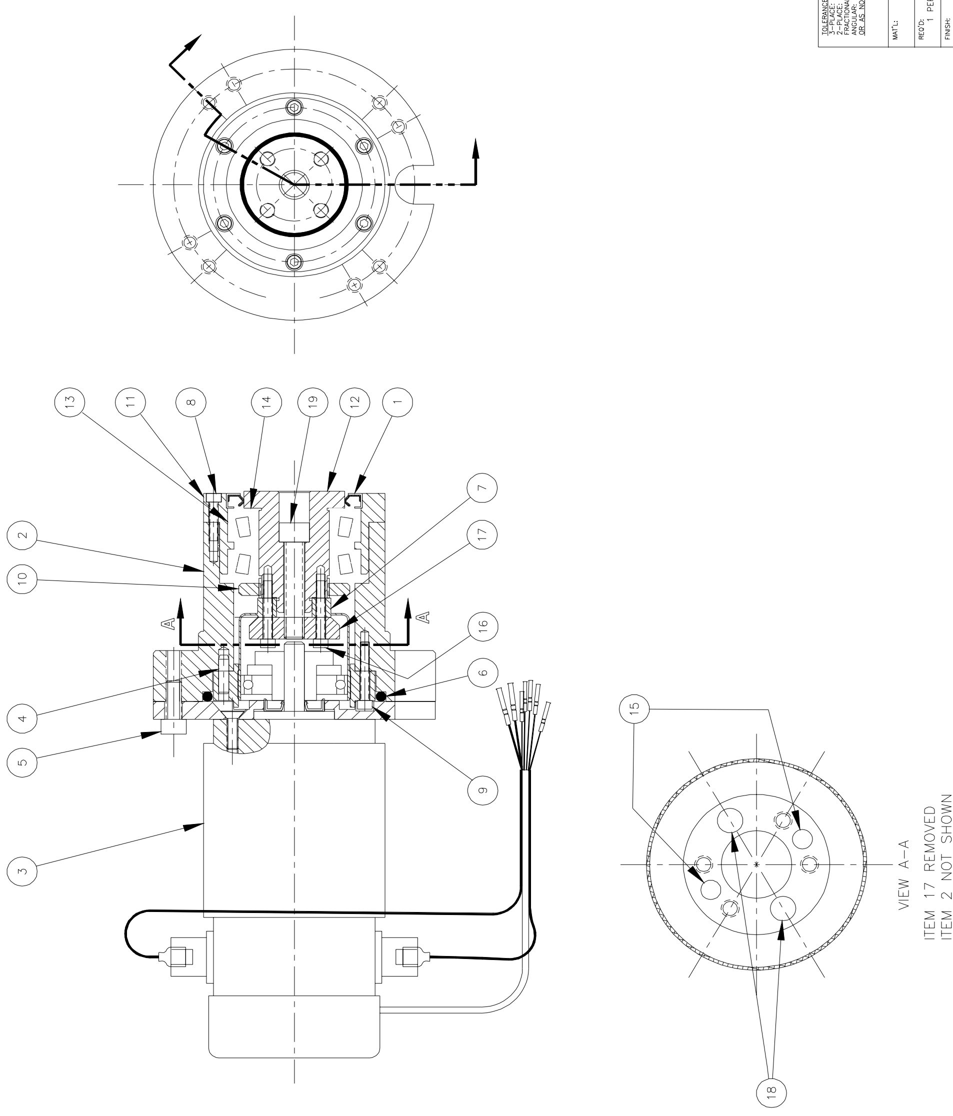
DWG No: SB14007

PART No: S-SMC-14-007

FILENAME: F:\ENGNRING\DRAWINGS\CRS914\ASSY\SB14007.DWG

ITEM	REV. DATE	DESCRIPTION	REV. BY	REL.

REVISION TABLE



ITEM	REQ'D	PART NUMBER
19	1	R-1420SHC20 CAP SCREW
18	2	R-FM4DLPIN16 4mmX16mm DOWEL PIN
17	1	R-M/C-M91436 NUT, J1 FLEXSPLINE CLAMPING
16	4	R-F0440SHC12 CAP SCREW
15	2	R-F02DLPIN10 DOWEL PIN
14	2	R-BG0LL52549 TIMKEN BEARING CONE
13	2	R-BG0LL52510 TIMKEN BEARING CUP
12	1	R-M/C-M09251 WAIST BEARING PIVOT
11	1	R-M/C-M09204 WAIST BEARING HOUSING
10	1	R-M/C-M09206 BEARING NUT
9	6	R-F0440SHC10 CAP SCREW
8	6	R-F0440SHC08 CAP SCREW
7	1	R-TRC/1C072A HARMONIC DRIVE
6	1	R-GRO-RNG2ID O-RING
5	4	R-F1024SHC10 CAP SCREW
4	1	R-F02DLPIN10 DOWEL PIN
3	1	S-SMC-14-107 JT 1 MOTOR ASS'Y
2	1	T-ABK-M09227 BASE NECK
1	1	R-GRO-SL12ID OIL SEAL

PART LIST

TOLERANCES:
3-PLACE: ±0.005
2-PLACE: ±0.01
FRACTIONAL: ±1/64
ANGULAR: ±1/2°
OR AS NOTED

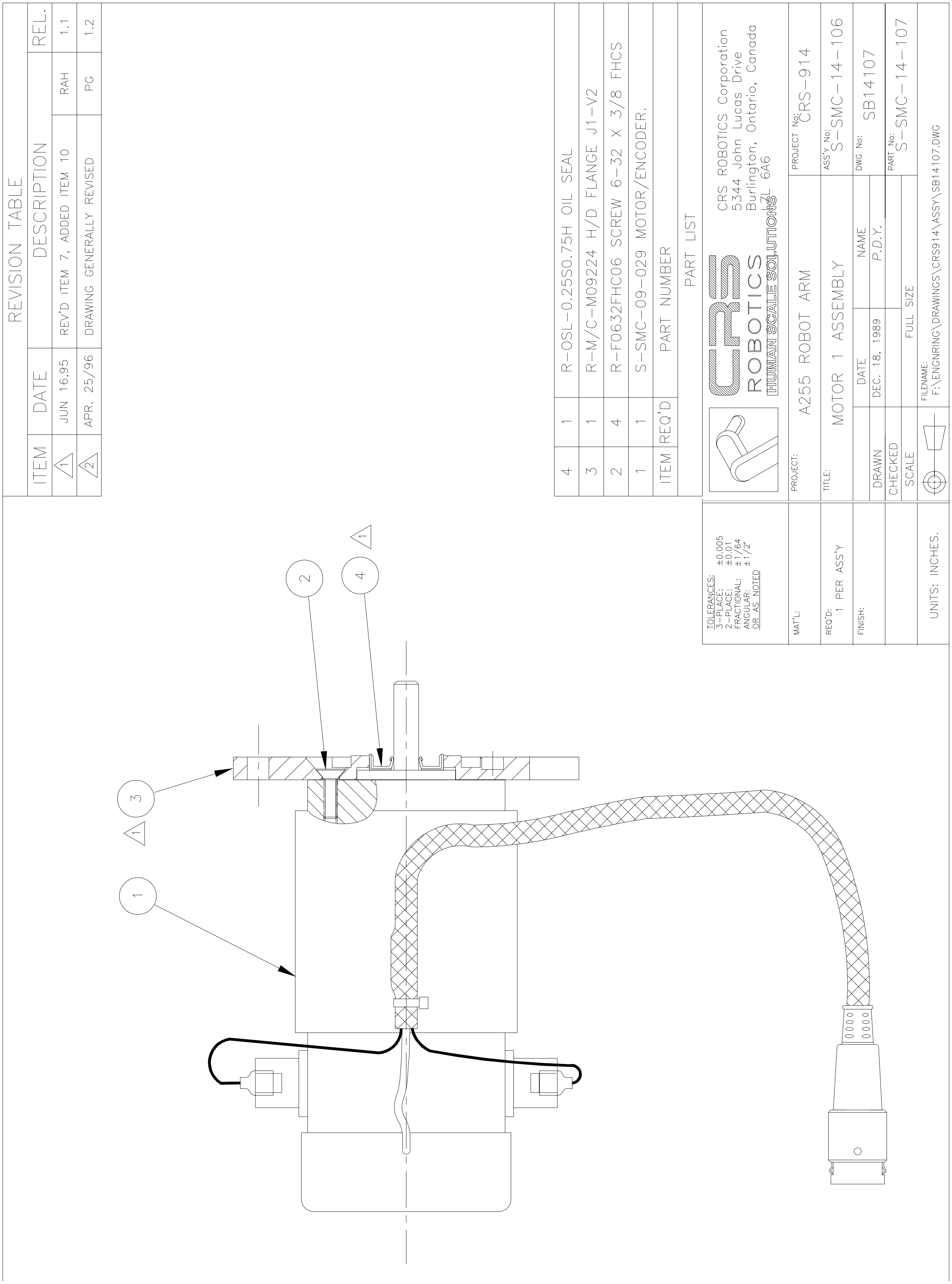
CRS ROBOTICS
HUMAN SCALE SOLUTIONS

CRS ROBOTICS Corporation
5344 John Lucas Drive
Burlington, Ontario, Canada
L7L 6A6

MAT'L:
PROJECT: A255 ROBOT ARM
PROJECT No: CRS-914
REQ'D: 1 PER ASS'Y
TITLE: NECK ASSEMBLY
ASS'Y No: S-SMC-14-104
FINISH:

	DATE	NAME
DRAWN	NOV. 29/96	P.GRIFFITHS
CHECKED		
SCALE	FULL SIZE	

DWG No: SC14206
PART No: S-SMC-14-206
UNITS: INCHES.
FILENAME: F:\ENGNRING\DRAWINGS\CRS-914\ASSY\SC14206.DWG



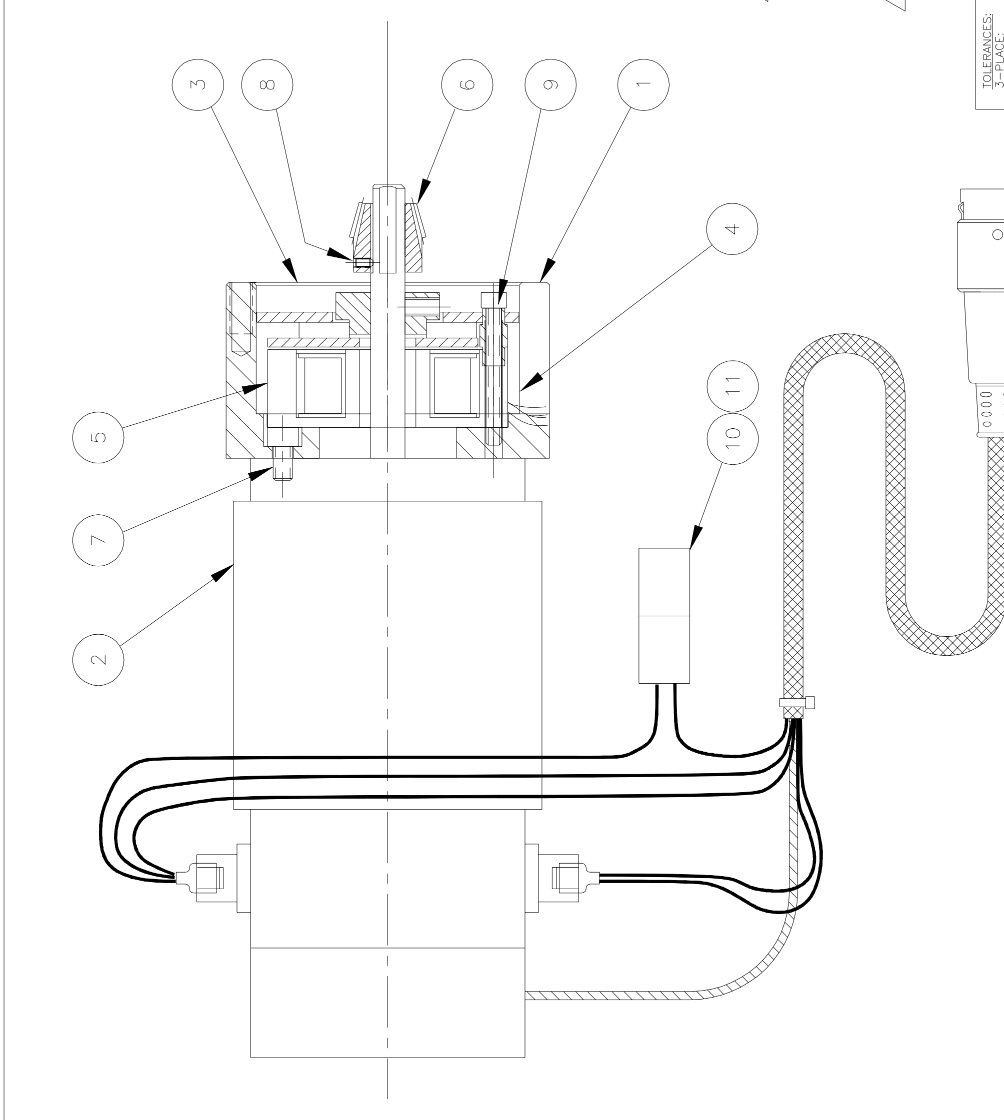
REVISION TABLE
ITEM | DATE | DESCRIPTION | | REL.
1 | JUN 16,95 | REV'D ITEM 7, ADDED ITEM 10 | RAH | 1.1
2 | APR. 25/96 | DRAWING GENERALLY REVISED | PG | 1.2
4 | 1 | R-OSL-0.25S0.75H OIL SEAL
3 | 1 | R-M/C-M09224 H/D FLANGE J1-V2
2 | 4 | R-F0632FHC06 SCREW 6-32 X 3/8 FHCS
1 | 1 | S-SMC-09-029 MOTOR/ENCODER.
ITEM | REQ'D | PART NUMBER
PART LIST
CRS ROBOTICS Corporation
5344 John Lucas Drive
Burlington, Ontario, Canada
L7L 6A6
ROBOTICS
HUMAN SCALE SOLUTIONS
PROJECT: A255 ROBOT ARM
PROJECT No: CRS-914
TITLE: MOTOR 1 ASSEMBLY
ASS'Y No: S-SMC-14-106
DATE
NAME
DRAWN DEC. 18, 1989 P.D.Y.
CHECKED
SCALE FULL SIZE
DWG No: SB14107
PART No: S-SMC-14-107
FILENAME: F:\ENGNRING\DRAWINGS\CRS914\ASSY\SB14107.DWG
TOLERANCES:
3-PLACE: ±0.005
2-PLACE: ±0.01
FRACTIONAL: ±1/64
ANGULAR: ±1/2°
OR AS NOTED
MAT'L:
REQ'D: 1 PER ASS'Y
FINISH:
UNITS: INCHES.
1
2
3
4

REVISION TABLE

ITEM	DATE	DESCRIPTION		REL.
1	OCT 11/95	ICD1109, SEE ICD FOR DETAILS	RAH	1.0
2	SEPT 22/99	FLATS MISSING FROM SHAFT-REC0185	TIH	1.1
3	AUG 10/98	ICD 1247 35V COILS FOR BRAKES	MFM	1.2
4	MAY 26/99	UPDATE PARTLIST ICD 1307	MFM	1.3

PART LIST

ITEM	REQ'D	PART NUMBER
11	1	R-CTB-PWR02S CONNECTOR 02 CIRCUITS RECEPT
10	2	R-CTB-PWRS22 TERMINAL SCKT CRIMP 22-24AWG
9	3	R-F0440SHC16 SCREW(CAP)4-40 X 1 HEX SCKT
8	2	R-F0632KHS03LK SCREW 6-32 X 3/16 KNUR
7	4	R-F0632SHC04 SCREW 6-32 X 1/4 SHCS
6	1	R-GER-M09172 PINION,WRIST MTR BEV 16 TEETH
5	1	R-TRC-FSB003-35V BRAKE FAILSAFE,3 IN.LB. 35V
4	0.10	R-WHS-02BKXX HEAT SHRINK 1/8" DIA BLK
3	1	S-M/C-M09184 JOINT 4/5 PLASTIC DISK
2	1	S-SMC-09-129 MOTOR/ENC,ML2110/RP17,BRAKE
1	1	R-M/C-M09208 J4/5 BRAKE HOUSING



CRS ROBOTICS Corporation
5344 John Lucas Drive
Burlington, Ontario, Canada
L7L 6A6

CRS ROBOTICS HUMAN SCALE SOLUTIONS

TOLERANCES:
3-PLACE: ±0.005
2-PLACE: ±0.01
FRACTIONAL: ±1/64
ANGULAR: ±1/2°
OR AS NOTED

MAT'L:
REQ'D: 2 PER ASS'Y
FINISH:
UNITS: INCHES.

PROJECT: A255 ROBOT ARM
TITLE: WRIST MOTOR ASSEMBLY

	DATE	NAME
DRAWN	OCT. 11,1995	RICK HUBER
CHECKED		
SCALE		

PROJECT No: CRS-009
ASS'Y No: SMC-92-002
DWG No: SB92040
PART No: S-SMC-92-040
FILENAME: F:\Engnring\DRAWINGS\CRS-009\ASSY\sb92040