7-1 INTRODUCTION

This section describes the RSC-M1A controller hardware. Table 7-1 describes the various modules.

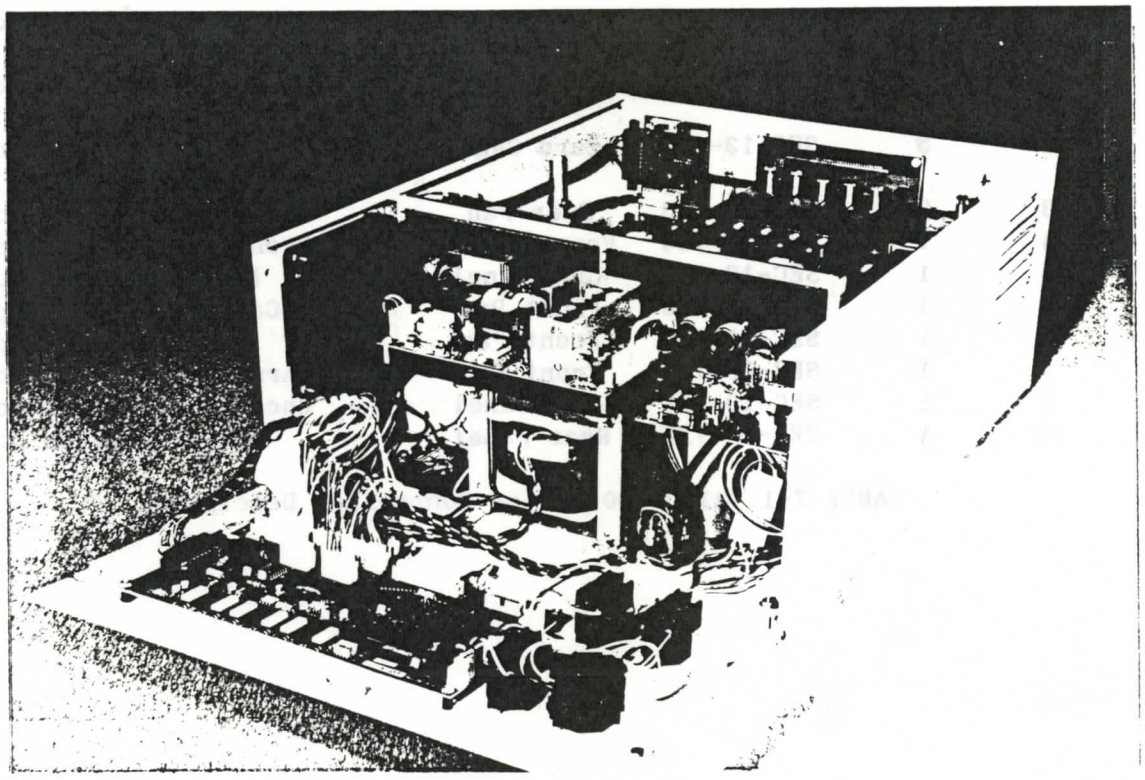

FIGURE 7-1 A100/200 Controller (Lid removed and front panel dropped)

The controller is designed to be servicable. The controller box is designed in two compartments: the front contains all the power supply and AC circuits, while all control electonics are in the rear compartment. A bulkhead which supports the arm amplifiers forms the break between the two.

Notice in Figure 7-1 that the front panel drops to allow access to the front compartment of the controller box. This is accomplished by removing the three #10 button head screws on each side of the front of the main box. The smaller #8 button-head screws at the bottom of each side forms the "hinge" for the panel. Do not remove these screws. Once the front panel has been dropped, the front pan which holds the isolation transformer, AC conditioning circuitry, computer power supply, and the arm power switching/filter board can be removed. To do this, undo the main AC connector and all harnesses between the pan and the front panel, and remove the nuts on the studs at the corners of the pan.

7-1 INTRODUCTION (Continued)

The rear pan can also be removed by undoing harnesses and removing the four nuts which secure it.

Item	Quantity	Module Number	Location	Description
1	1	SEC-13-700	Card Cage	Mother Board
2	5	SEC-13-701	Card Cage	P-type Axis card
			or	
2	5	SEC-13-702	Card Cage	PID-type Axis card
3	2	SEC-13-703	Rear Pan	D.C. Amplifier Module
4	1	SEC-13-704	Front Panel	Front Panel Logic Board
5	1	SEC-13-705	Rear Panel	Digital I/O Connection Board
6	1	SEC-13-708	Front Pan	Computer Power Supply
7	1	SEC-13-716	Front Pan	Arm Power Supply
8	1	SEC-13-709	Front Pan	Arm Power Filter Board
9	1	SEC-13-7XX	Rear Panel	Encoder Connector Board
10	1	SEC-13-7XX	Rear Panel	Amp Expansion Board

TABLE 7-1 A100/200 Series Controller Desciption

7-2 MOTHERBOARD

The Motherboard as shown in figure 7-2, is the largest printed circuit board (P.C.B.) in the CRS RSC-M1A controller. Table 7-2 describes the Motherboard connectors and major features.

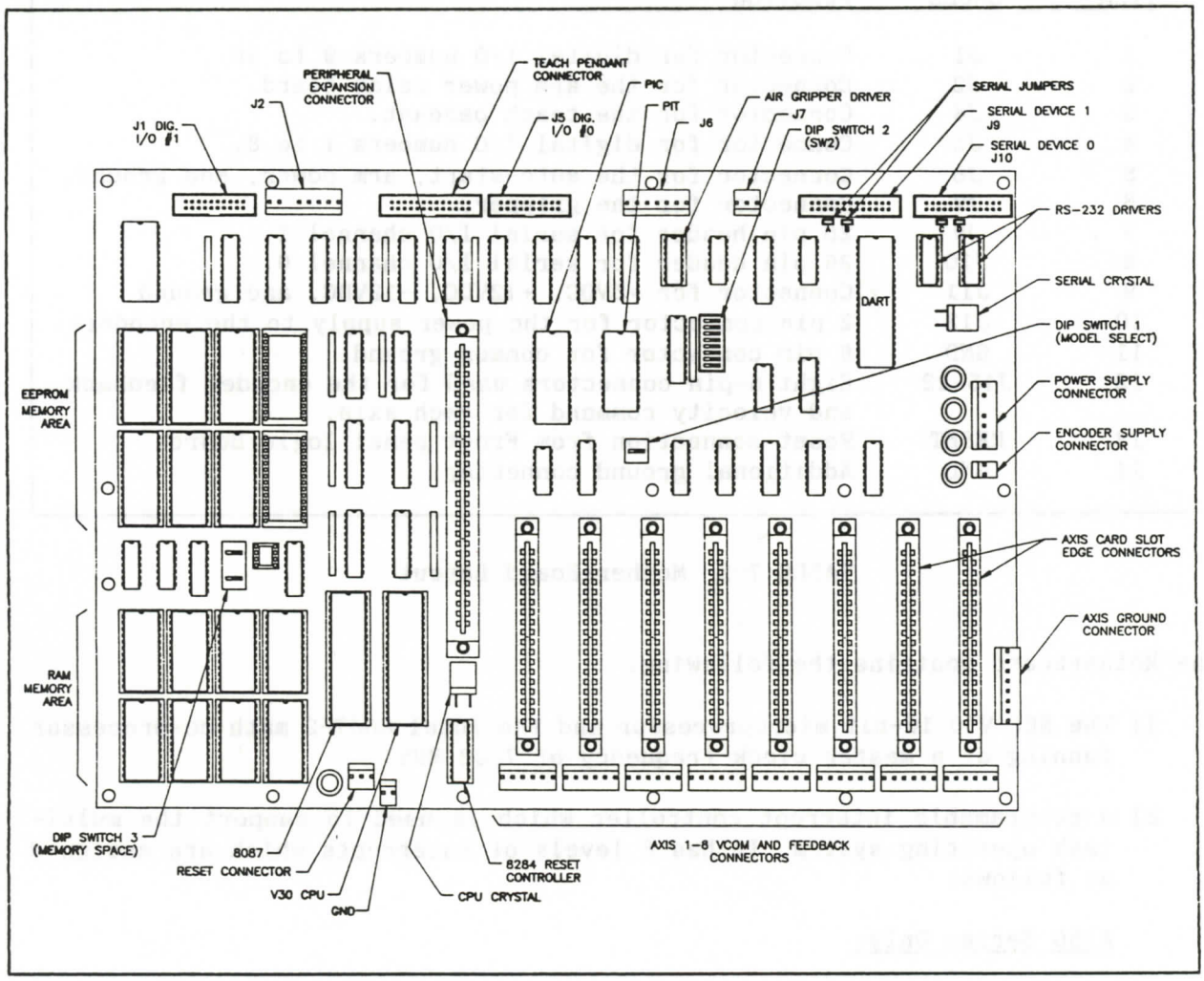

FIGURE 7-2 Motherboard P.C.B.

7-2 MOTHERBOARD (Continued)

Table 7-2 is listed in order from upper left moving clockwise around the board as shown in Figure 7-2.

ITEM	LABEL	FUNCTION
1	J1	Connector for digital I/O numbers 9 to 16.
2	J2	Connector for the arm power relay board.
3	J4	Connector for the teach pendant.
4	J5	Connector for digital I/O numbers 1 to 8.
5	J6	Connector for the auto-start, arm power, and ground.
6	J7	Connector for the gripper.
7	J9	26 pin header for serial I/O channel 1.
8	J10	26 pin header for serial I/O channel 0.
9	J11	Connector for +5VDC, +12VDC, -12VDC, and ground.
10	J12	2 pin connector for the power supply to the encoders.
11	GND	8 pin connector for common ground.
12	J15-22	Eight 6-pin connectors used for the encoder feedback, and velocity command for each axis.
13	RESET	Reset connection from Front panel logic Board.
14	GND	Additional ground connector.

TABLE 7-2 Mother-Board Layout

The Motherboard contains the following:

1) The NEC V30 16-bit microprocessor and the Intel 8087-2 math co-processor running at a master clock frequency of 7.33 MHz.

2) A programable interrupt controller which is used to support the multi-task operating system. It has 8 levels of interrupts which are assigned as follows:

   A150 Series Only:

   - Level 0 is used for the encoders zero crossing signal, used only during homing the robot.
   - Level 1 is used for closing the position loop every 3.8 mSec.
   - Level 2 is used for generating the positional command every 3.8 mSec in the run mode, and 15 mSec. in the manual mode.

   A250 Series Only:

   - Level 0 is used in a poll-mode for communication with the PID axis cards.
   - Level 1 is used for the arm and I/O Watch-dog signals every 3.8 mSec
   - Level 2 is used for generating the positional command to the axis cards. Timing varies depending on mode of operation from 16-40 mSec.

Common to Both A150 and A250 series:

- Level 3 is used for scanning the digital I/O every 40 mSec.
- Level 4 is to support the TEACH button on the teach pendant.
- Level 5 is to support the ABORT button on the teach pendant.
- Level 6 is to support the serial channel 0.
- Level 7 is to support the serial channel 1.

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

A150 Series:

- Timer 0 generates the time base for the position loop of (~3.8 mSec).
- Timer 1 generates the time base for the command generation (variable)
- Timer 2 generates the time base for the I/O scanning (~40 mSec).

A250 Series:

- Timer 0 generates the time base for the watch dogs (~3.8 mSec).
- Timer 1 generates the time base for the command generation (variable).
- Timer 2 generates the time base for the I/O scanning (~40 mSec).

4) A Dual Asynchronous Receiver/Transmitter (DART) which controls two serial channels with the RS-232 format having a programmable baud rate of between 50 and 19,200 bps.

5) DIP Switches:

Three DIP switches are used to set the configuration of the mother board for various operational modes:

LABEL/POS'N	ON	OFF
DIP Switch 1 - SPDT Controller Model Select		
POLE 1	CLK1 - A150 Conf	CLK2 - A250 Conf
DIP Switch 2 (SW2) - 8 Pole Single-throw		
POLE 1	METRIC Units	INCH Units
POLES 2-8	Future Use	
DIP Switch 3 - DPDT EPROM Select		
POLE 1	C1 - 27256	C2 - 27512
POLE 2	C1 - 27256	C2 - 27512

7-2 MOTHERBOARD (Continued)

6) Socketed Components

1) U12 - The driver (SN7417) is used to drive the gripper air valve or provide a voltage source for the servo gripper positional feedback. It also supports the ABORT and TEACH push-buttons on the Teach Pendant. If the air valve is shorted, this component is vulnerable to damage.

2) U17 - Serial device receiver (MC1489) converts incoming RS-232 signal levels (+/- 12 Vdc) from both devices 0 and 1 to TTL (0 - 4 Vdc).

3) U18 - Serial device transmitter (MC1488) converts outgoing TTL (0 -4 Vdc) from both devices 0 and 1 to RS-232 signal levels (+/- 12 Vdc).

4) U60 - Power-up Reset and clock generator chip (P8284A) for the V30 CPU.

5) U54 - V30 CPU chip (NEC 70116C).

6) U52 & 58 - RAM Memory Chips. Locations are also used to locate the "piggy-back" RAM expansion board.

7) U19-22 & U30-33 - Locations of the EPROM memory chips (27256 or 27512) which contain the RAPL-II firmware.

The memory section has up to 128 Kbyte of Read Only Memory which contains the RAPL-II executive program. 16 Kbyte of Random Access Memory (Expandable to 64 Kbyte) is provided for the user programing and computer "scratch-pad" space. The RAM chips have an integral lithium energy source which will retain the memory contents for up to 35 years.

It also has eight (8) axis slots, five of which are used for the A100/200 Series robot axes. The other 3 may be used for extra servo axes including a servo gripper. It also has one peripheral slot which contains the local microprocessor bus and is used for the COMBO/32 or EEROM/32 expansion cards.

7-3 DC AMPLIFIER MODULE

The D.C. Amplifier Module as shown in Figure 7-3 contains three (3) separate amplifiers, each supplied with +/- 26 VDC. The signal to each amplifier is +/- 10 VDC. The output is the motor voltage of +/- 20 VDC. at 2 amperes each.

Each module has an adjustable gain in the range of x1 to x2. It has no phase reversal and a low crossover distortion.

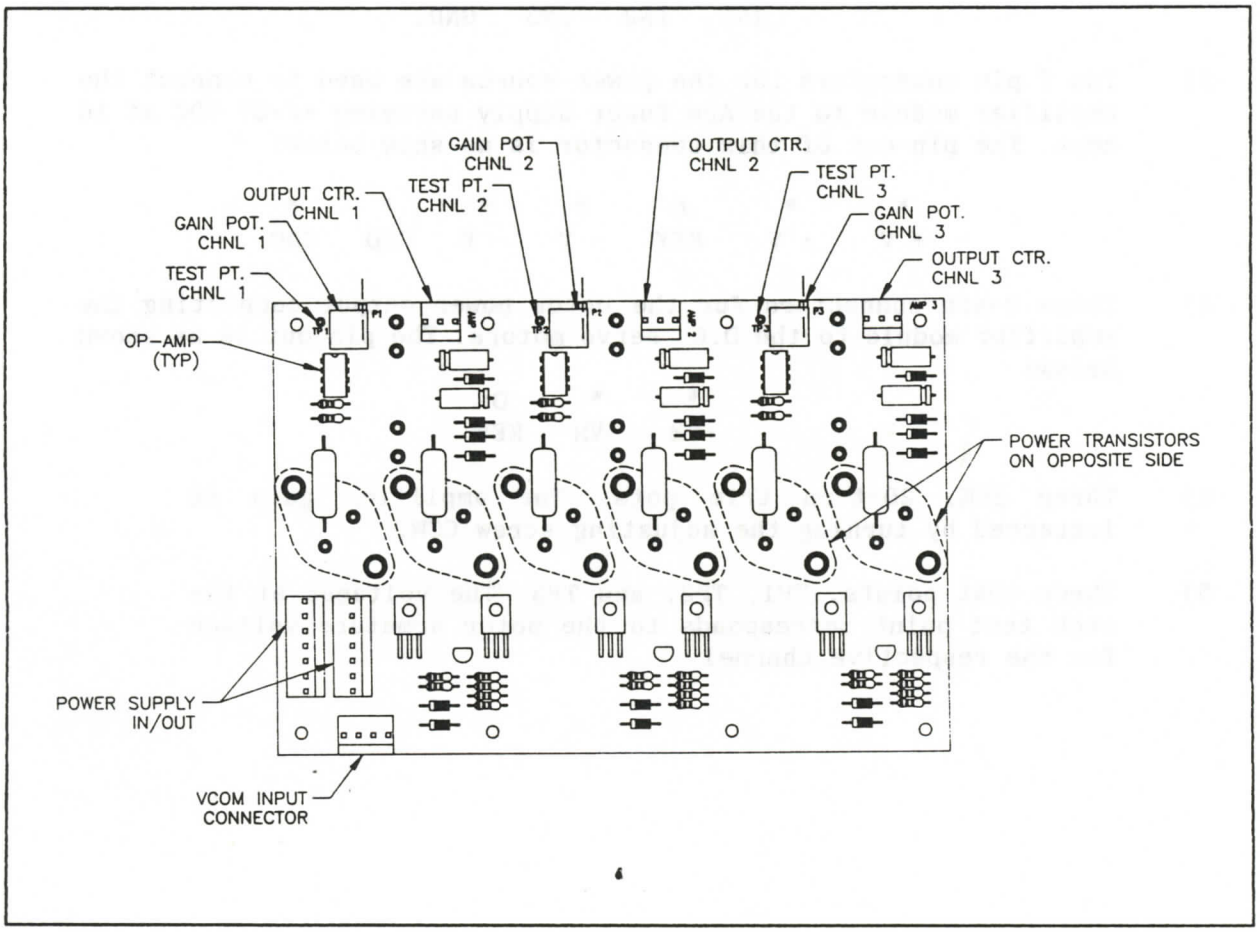

FIGURE 7-3 D.C. Amplifier Module

7-3 DC AMPLIFIER MODULE (Continued)

ITEM	FUNCTION

1) 4 pin connector for the command signals connecting the servo axis output to the amplifier module. The signal level is +/- 10 VDC at 70 ma. The pin-out configuration of this connector is:

*	*	*	*
IN1	IN2	IN3	GND.

2) Two 7 pin connectors for the power source are used to connect the amplifier module to the Arm Power Supply carrying +/-27 VDC at 10 amps. The pin-out of this connector is as show below:

*	*	O	*	*	*	*
+ V	+ V	KEY	- V	- V	GND	GND

3) Three 3-pin connectors for the motor power output connecting the amplifier module to the D.C. servo motors. The pin-out is as shown below:

*	*	O
+VM	-VM	KEY

4) Three 20K, 20-turn trim pots. The amplifier gain is increased by turning the adjusting screw CCW.

5) Three test points, TP1, TP2, and TP3. The voltages at the each test point corresponds to the motor armature voltage for the respective channel.

7-4 P-TYPE SERVO AXIS CARDS (A150/151 Only)

The P-Type Servo Axis cards as shown in figure 7-4 contain the necessary functions to close the position loop. It takes an incremental digital command from the mother board, converts it to an analog voltage, and send it to the DC Amplifier. It also takes the feedback signal from the incremental optical encoder in a square wave form (channel A, channel B, and a zero crossing index signal). The signal is then shaped and converted to a pulse train, with pulse width of 1 uSec (+/-30%).

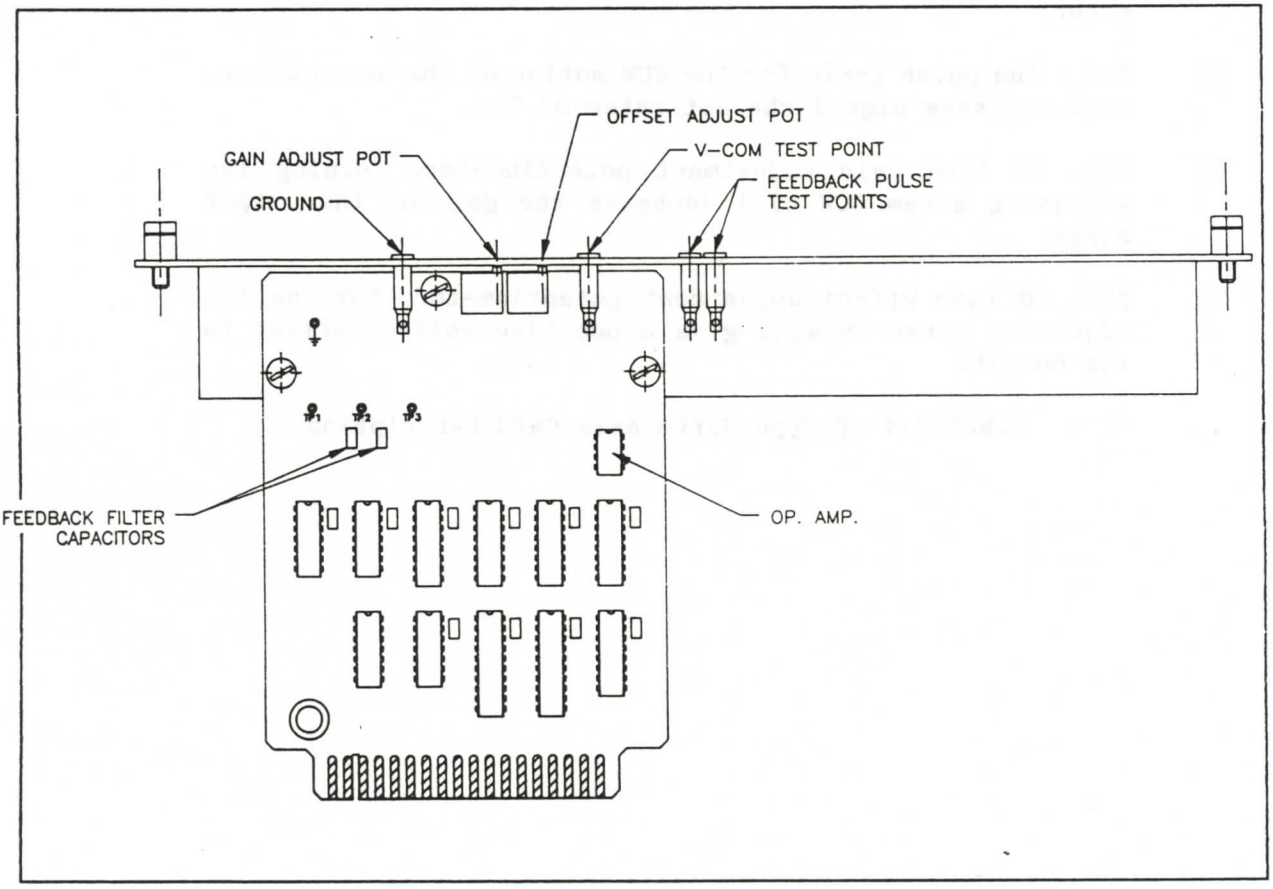

FIGURE 7-4 P-Type Servo Axis Card

ITEM	FUNCTION
1)	TP1 - the analog command voltage. Should be in the range of +/- 10VDC.
2)	TP2 - the pulse train for the CW motion of the servo motor. The signal at this test point has a pulse width of 1 uSec (+/-30%) and a period depending on the speed of the servo motor.
3)	TP3 - the pulse train for the CCW motion of the servo motor, with the same signal characterstec as TP2.
4)	20K, 20 turn gain adjustment potentiometer. Turning the adjusting screw CCW will increase the gain of the output stage.
5)	20k, 20 turn Offset adjustment potentiometer. Turning the adjusting screw CW will give a positive voltage offset to the output.

TABLE 7-4 P-Type Servo Axis Card Description

7-5 PID-TYPE SERVO AXIS CARDS (A250/251 Only)

DESCRIPTION

The PID type axis cards are self-contained micro-controller based servo controllers. A single Intel 8095BH micro-controller chip is used to provide a high performance PID servo loop with a 1 millisecond closure time. The position feedback is updated at the same 1 millisecond intervals. The PID axis card also has the ability to command a trapezoidal or a parabolic velocity profile. The path parameters are generated by the motherboard CPU and are fed to the axis card. A start signal is provided which is then sent to all axis cards in order to provide a synchronized motion.

The motherboard CPU communicates to the PID controller at a variable time base, depending upon the type of operation the robot is performing. When the robot is moving with a joint interpolated motion, the axis card generates all commands, and issues updates of commanded and actual position to the motherboard. When the robot is executing a coordinated path, the motherboard provides command set-points to the axis cards, and then the axis cards perform additional compensation to the commanded signal to provide a smooth output motion.

ANALOG FEEDBACK

Connector 'J2' provides access to the two 10 bit analog to digital converters provided by the 8095BH CPU. These analog inputs can range from 0 to 5 volts.

CONNECTOR J2

PIN	FUNCTION
1	GND
2	ANALOG INPUT CHNL 1
3	ANALOG INPUT CHNL 0

7-5 PID-TYPE SERVO AXIS CARDS (Continued)

INPUT/OUTPUT

Header block 'J3' provides access for the TTL level input and output signals that are used by the axis card to detect travel and thermal limits. Outputs are used as status indicators.

CONNECTOR J3

PIN	NAME	FUNCTION
1	VCC	+5 VOLTS
2	IN0	HOME LIMIT
3	IN2	POSITIVE LIMIT
4	IN4	NU
5	IN6	NU
6	OUT0	INTERNAL
7	OUT2	INTERNAL
8	OUT4	READY
9	N/C	
10	N/C	
11	OUT5	HOME
12	OUT3	ERROR
13	OUT1	NU
14	IN7	NU
15	IN5	NU
16	IN3	THERMO LIMIT
17	IN1	NEGATIVE LIMIT
18	GND	SIGNAL GROUND

MOTOR COMMAND/FEEDBACK

Connector 'J50' provides access for all motor command and feedback signals.

CONNECTOR J50

PIN	FUNCTION
1	A
2	A*
3	B
4	B*
5	Z
6	Z*
7	VCOM
8	GND

7-5 PID-TYPE SERVO AXIS CARDS (Continued)

FEEDBACK CONFIGURATION

The 'JP2' jumper block is used to determine feedback type, being either single ended (SE) or differential (DI) encoder feedback.

JUMPER BLOCK JP2

PIN	SIGNAL
1	A(SE)
2	A(DI)
3	B(DI)
4	B(SE)
5	Z(SE)
6	Z(DI)

Jumper block 'JP3' is used to determine whether or not the encoder feedback will be used in a multiply x1, x2 or x4 fashion. This facility permits higher effective encoder resolution. For x1 multiplication, no jumpers should be closed. For x4, all should be jumpered.

JUMPER BLOCK JP3

PIN	MULTIPLIER
1	x2, x4
2	x4
3	x4
4	x2, x4
5	x4
6	x4

MOTOR COMMAND SELECTION

Jumper block 'JP4' selects the command voltage output. The axis card generates two types of output. One selection will provide 10 volts of analog output with 12 bit precision. This gives a voltage resolution of 0.0048 volts. The other output selection will provide 0 to 5 volts of pulse-width modulated output. The PWM stage has effective 8 bit resolution, or 0.0195 volts of resolution.

JUMPER BLOCK JP4

PIN	FUNCTION
1	PWM (8 bits)
2	ANALOG (12 bits)

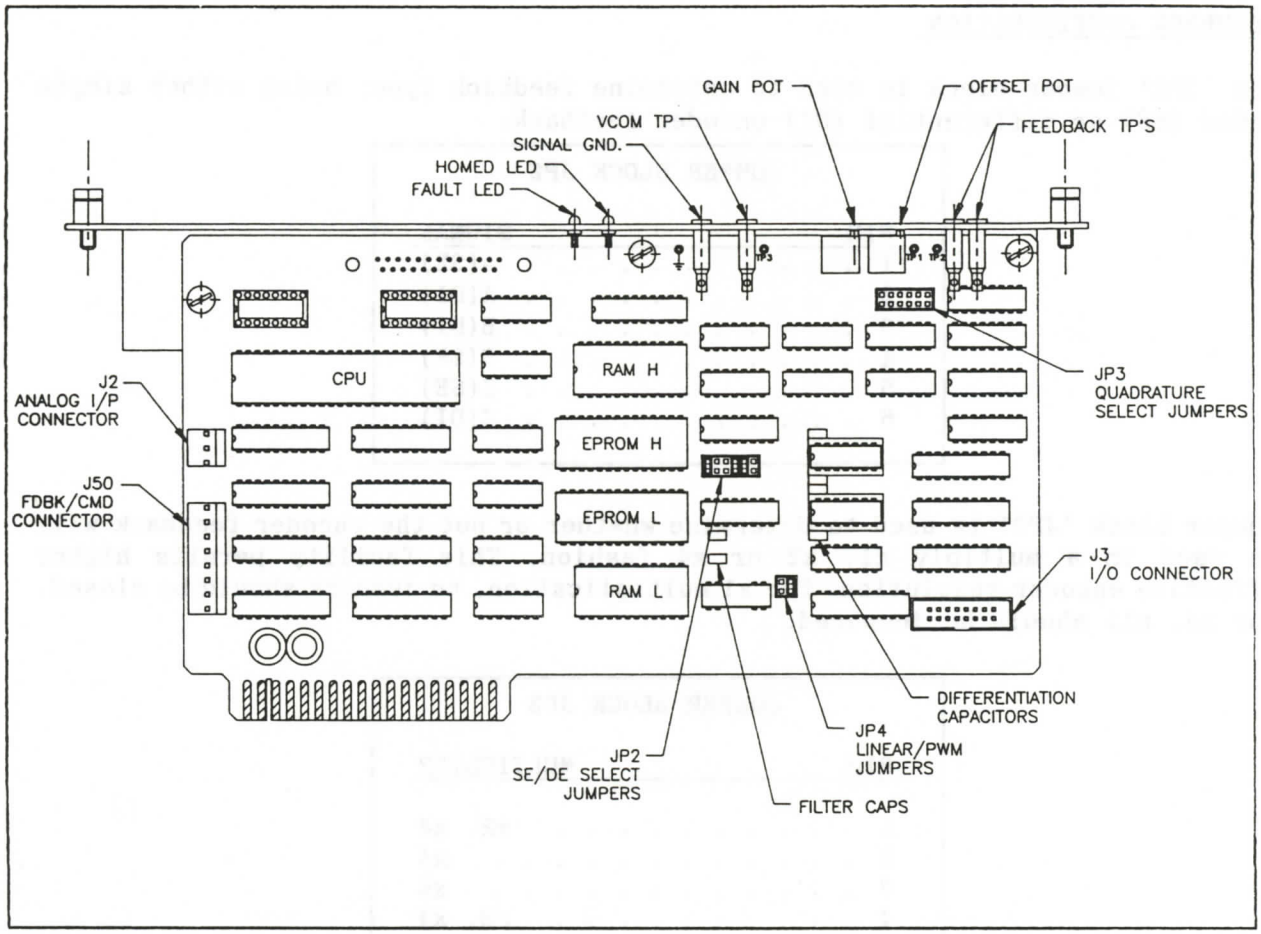

Figure 7-5 PID Type Servo Axis Card

ITEM	FUNCTION

1) TP1 - the analog command voltage. Should be in the range of +/- 10VDC.

2) TP2 - the pulse train for the CW motion of the servo motor. The signal at this test point has a low-true pulse width of 1.8 uSec (+/-30%) and a period depending on the speed of the servo motor.

3) TP3 - the pulse train for the CCW motion of the servo motor, with the same signal characteristic as TP2.

4) 20K, 20 turn gain adjustment potentiometer. Turning the adjusting screw CCW will increase the gain of the output stage.

7-5 PID-TYPE SERVO AXIS CARDS (Continued)

5) 20k, 20 turn Offset adjustment potentiometer. Turning the adjusting screw CW will give a positive voltage offset to the output.

6) Signal Ground - provides a reference point for measuring the other listed signals.

7) HOME LED - This LED comes on after the axis in question has been homed.

8) FAULT LED - This comes on when the axis is in an error condition. It is reset after recovery.

7-6 FRONT PANEL LOGIC BOARD

This board contains the arm power switch connections, AC power failure signal, arm power "watch-dog" circuitry, and the Auto Start switch connections. The function of the arm power will only be enabled by the computer if the controller is functioning normally. The continuing safe operation of the computer is checked by the "watch-dog" timer. The 'Arm-Power-On' is a signal to indicate to the mother board the status of the arm power (on/off). The AUTO-START is used in conjunction with the main power switch on the front panel to execute an AUTO_ST program on power-up.

The board connects to the mother board and the I/O termination board via a ribbon cable and a 20-pin edge connector. The latter contains the power supply to the board (+12, +5 VDC and Ground), the ARM-ON signal (to the external DC AMP board), the power fail signal, the AUTO-START signal, and the Arm Enable signal.

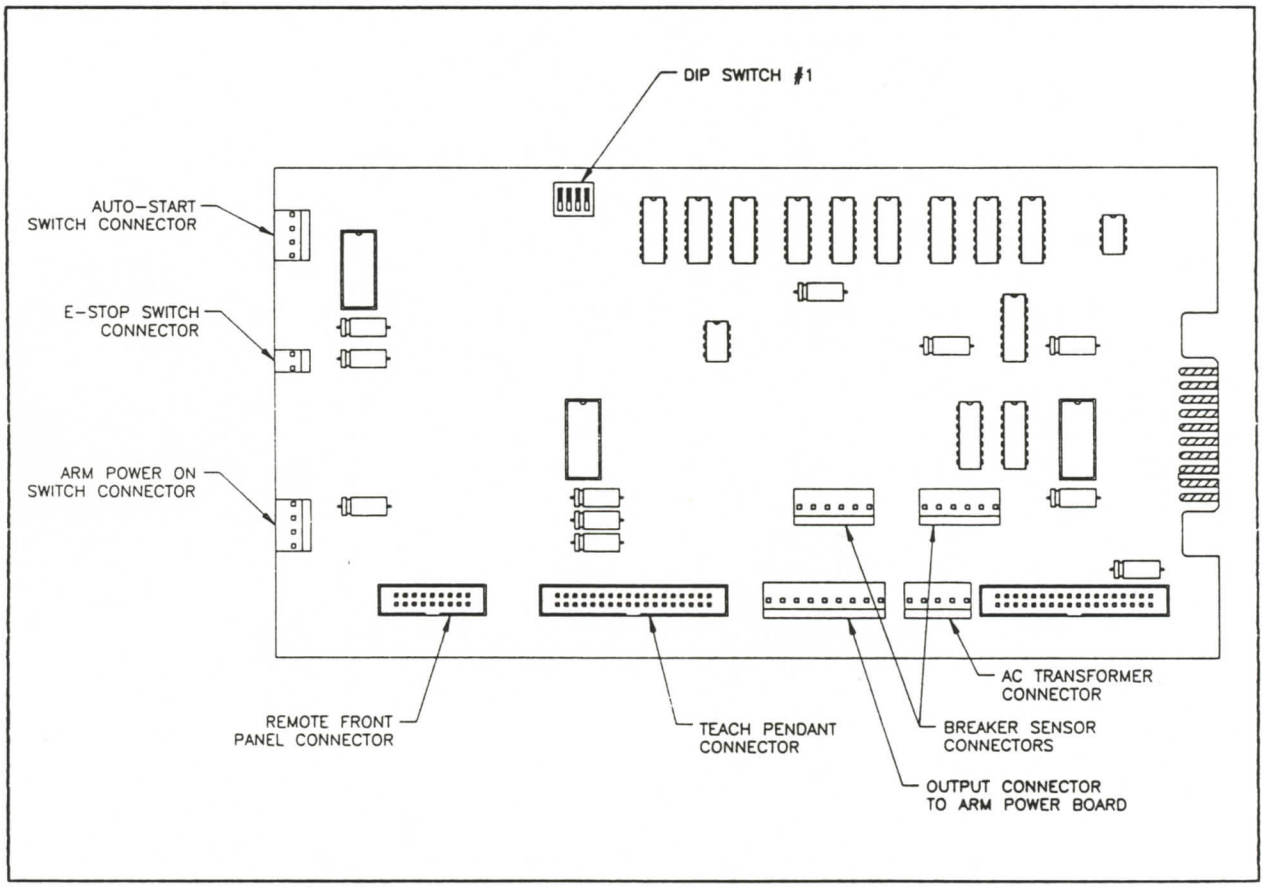

FIGURE 7-6 Front Panel Logic Board

7-6 FRONT PANEL LOGIC BOARD (Continued)

ITEM	FUNCTION

1) AUTO-START - Connection to the AUTO START switch containing the contact termination and lamp signal.

2) MAIN POWER - Connection to the MAIN POWER switch containing the contact termination and lamp signal.

3) REMOTE FRONT PANEL - Blank connection which carries signals to a remote duplicate front panel.

4) TEACH PENDANT - Connection to the Teach pendant signal cable.

5) ARM POWER BOARD OUTPUT CONNECTOR - Connection to the Arm power relay/filter board (APR/FB). It carries the AC Arm Power (36 VAC centre-tap), 12 Vdc, and Arm enable signal.

6) AC TRANSFORMER CONNECTOR - This connection carries the AC arm power from the secondary of the main transformer the FPLB. This signal is checked by the AC monitoring circuitry on this board and is passed on to the APR/FB.

7) BREAKER SENSOR CONNECTORS - Connection to the motor circuit breakers to detect an overload.

8) DIP SWITCH #1 - 4PST DIP Switch for the following functions:

JP1 - When ON, The remote front panel E-STROP switch must be closed to permit ARM POWER. When OFF, the remote panel E-STOP has no effect.

JP3 - When ON, the AUTO START switch is seen as on at all times. The controller will automatically enter the AUTO_ST program on start-up. When OFF, the AUTO-START switch functions normally.

JP2,4:

These work together as shown below to control the effect of the Emergency stop switch on the TEACH PENDANT. Depending on the application of the robot, it may be an advantage to have the pendant present and have its E-STOP switch active at all times. In other applications, the pendant may not have an E-STOP switch. In still others, the switch should be active only in MANUAL Mode:

7-6 FRONT PANEL LOGIC BOARD (Continued)

JP2	JP4	PENDANT EFFECT ON E-STOP
OFF	OFF	May be unplugged with no effect on Arm Power.
OFF	ON	May be unplugged with no effect on Arm Power.
ON	OFF	Pendant must be present for Arm Power when in Manual mode only.
ON	ON	Pendant must be present for arm power at any time.

7-7 I/O TERMINATION BOARD

The I/O termination board is shown in figure 7-6. This board has connectors for up to 40 digital inputs and 40 digital outputs at TTL levels un-buffered. It also contains the connectors for the remote E-Stop switch, the auxiliary input (used for example, by the at-home-sensor of the home bracket HOME/RAS) and the analog I/O.

In addition to connectors, it contains the I/O enable watch dog circuitry and the supply to the external buffered I/O racks. This latter supply is fused to protect the circuitry and the enable relay in case of an external short circuit. This fuse is on the board. Its rating is 1 Amp 250 Volt SLOW-BLOW.

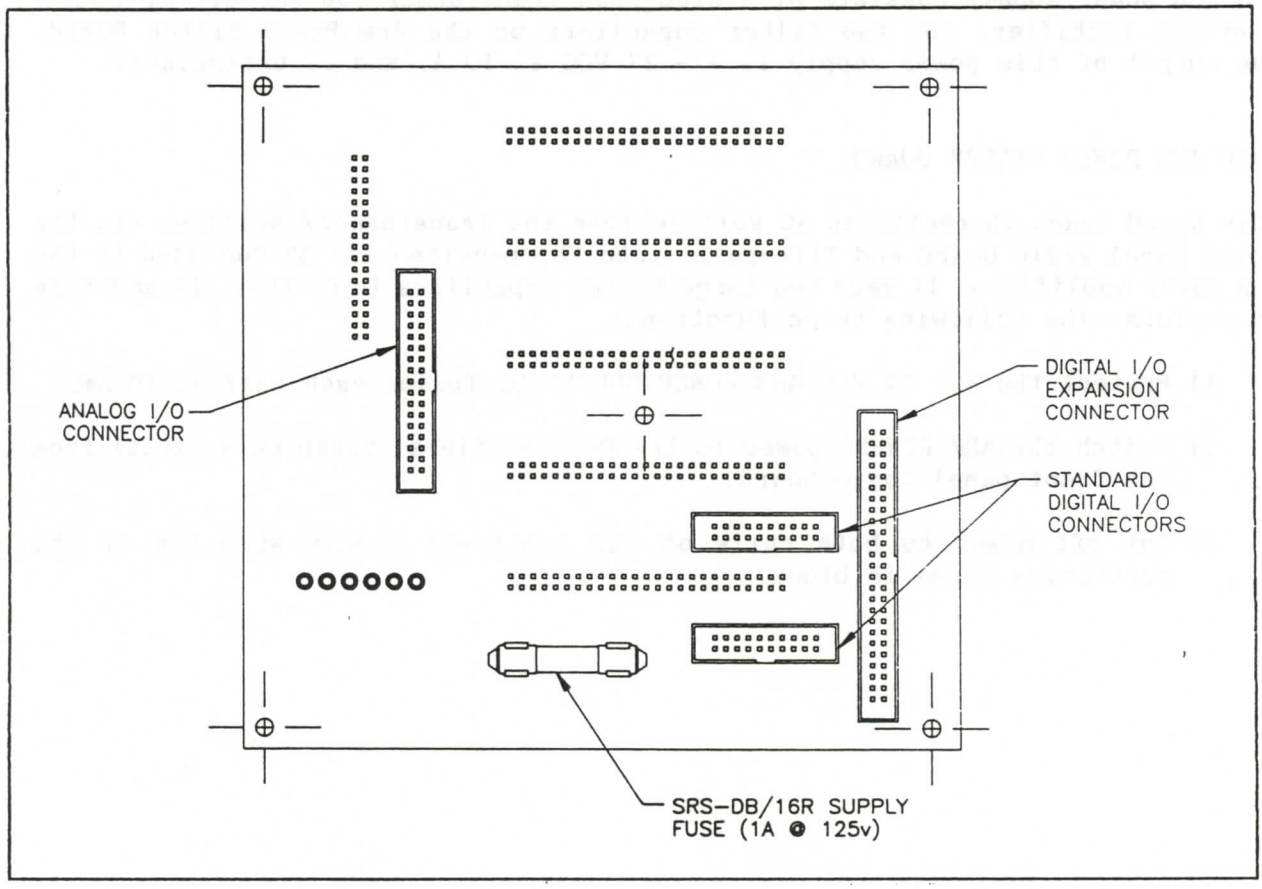

FIGURE 7-7 I/O Termination Board - Viewed from inside controller box.

7-8 COMPUTER POWER SUPPLY

The computer power supply is a switching mode supply with three output voltages:

+5 VDC at 8.0 A.
+12 VDC at 2.5 A.
-12 VDC at 1.0 A.

The power supply has output over-voltage clamping, and output short circuit protection.

7-9 ARM POWER SUPPLY

The arm power supply consists of a step_down transformer (36 VAC CT. at 13 A), a bridge rectifier, and two filter capacitors on the Arm Power Filter Board. The output of this power supply is +/- 27 VDC at 10 A, and is unregulated.

7-10 ARM POWER FILTER BOARD

This board takes in rectified AC voltage from the transformer/rectifier via the front panel logic board and filters it into the required +/- 27 Vdc used by the arm power amplifiers. It uses two large filter capacitors to do this. In addition it performs the following three functions:

1) Protect the +/- 27 Vdc ARM POWER SUPPLY by fusing each rail at 10 Amp.

2) Switch the ARM POWER (power to the DC amplifiers) based on a signal from the front panel logic board.

3) Cut off power to both rails of the arm power supply when one of the protection fuses is blown.

7-11 ENCODER CONNECTOR BOARD

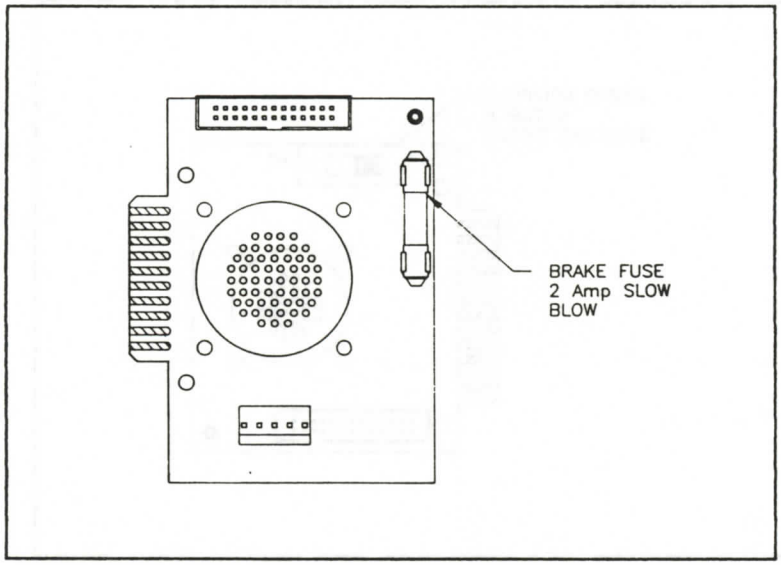

FIGURE 7-8 The Encoder Connector Board.

This board supports the Encoder and Servo Gripper connections to the Robot arm via a 57 pin round connector. It also supports the brake function in the A151/A251 models.

It connects to the Mother board via a 20 pin edge connector for the encoders and servo gripper functions, and a 5 pin connector for the encoder power supply (+5VDC) and ARM ON signal. A 26 pin ribbon cable is used to interconnect this board with the AMP EXPANSION BOARD. The brake fuse is removed on A150/A250 robot systems.

7-12 AMP EXPANSION BOARD

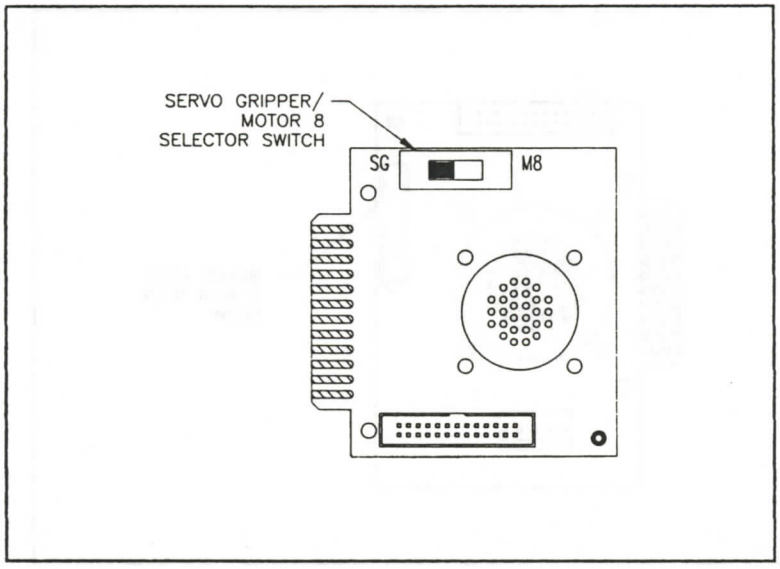

FIGURE 7-9 The Amp Expansion Board

This board supports the differential encoders and command voltages for joints 6, 7, and 8. It connects to the Expansion DC Amplifier via a 28 pin round connector. It uses a 24 pin edge connector to connect to the Mother board, and a 26 conductor ribbon cable to the ENCODER CONNECTOR BOARD.

The SERVO GRIPPER/MOTOR 8 selector switch sets up the function of the mother board axis card #8. When set to SERVO GRIPPER, it routes the gripper position, torque, and motor voltage to/from the arm from/to slot 8. When set to MOTOR 8, it correctly routes the joint 8 encoder and command voltage to/from the expansion DC AMP.