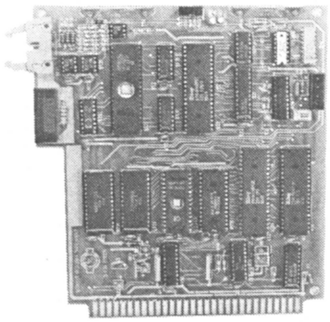
IB-11B003

MOTION CONTROL SYSTEM, MSC-850

AUGUST 1989



ACE-850 ENCODER AXIS CONTROLLER

INSTRUCTION BOOK

INDUSTRIAL INDEXING SYSTEMS, INC.

ER-6012

ERRATA SHEET, IB-11B003 JULY 1993

Date	Rev.	ECN No.	DR	CHK	CHK
8/31/92	A	ECN-92-191 (See Note 1)	MFE		
12/3/92	B	ECN-92-318 (See Note 2)	MFE	EB	JC
7/12/93	C	ECN-93-112 (See Note 3)	EB		

Notes:

1) Section 5, Page 4, dated September 1992, supercedes Section 5, Page 4, dated August 1989.

2) Section 2, page 2-2; Section 5, page 5-8; Section 6, pages 6-3 thru 6-4, dated December 1992, supersedes Section 2, page 2-2; Section 5, page 5-8; Section 6, pages 6-3 thru 6-4, dated August 1989.

3) Section 2, page 2-4 dated July 1993 supercedes page 2-4 dated August 1992.

INDUSTRIAL INDEXING SYSTEMS, Inc.
626 Fishers Run
Victor, New York 14564
Tel: (585) 924-9181 Fax: (585) 924-2169

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

LIST OF TABLES

1.0 INTRODUCTION

1.1 About This Instruction Book

This document is part of a series of books that support Industrial Indexing Systems' MSC-850 based Motion Control System. It provides product information about the ACE-850 Encoder Axis Controller including; a product overview, product description, product specifications, description of controls and indicators, and connection diagrams.

1.2 Product Overview

The ACE-850 Encoder Axis Controller is an edge connector printed circuit board (Figure 1-1) that can be plugged into one of the controller slots of the MSC-850 System Unit. It provides precision position loop control utilizing feedback data from the encoder on the motion control device (Figure 1-2).

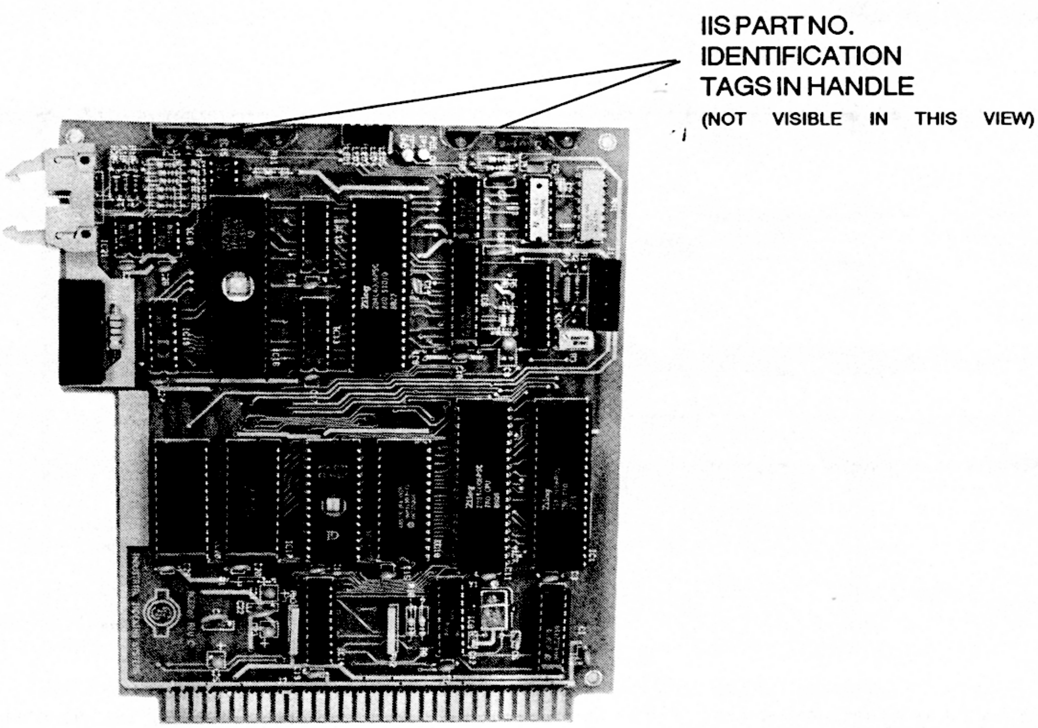


Figure 1-1 ACE-850 Encoder Axis Controller

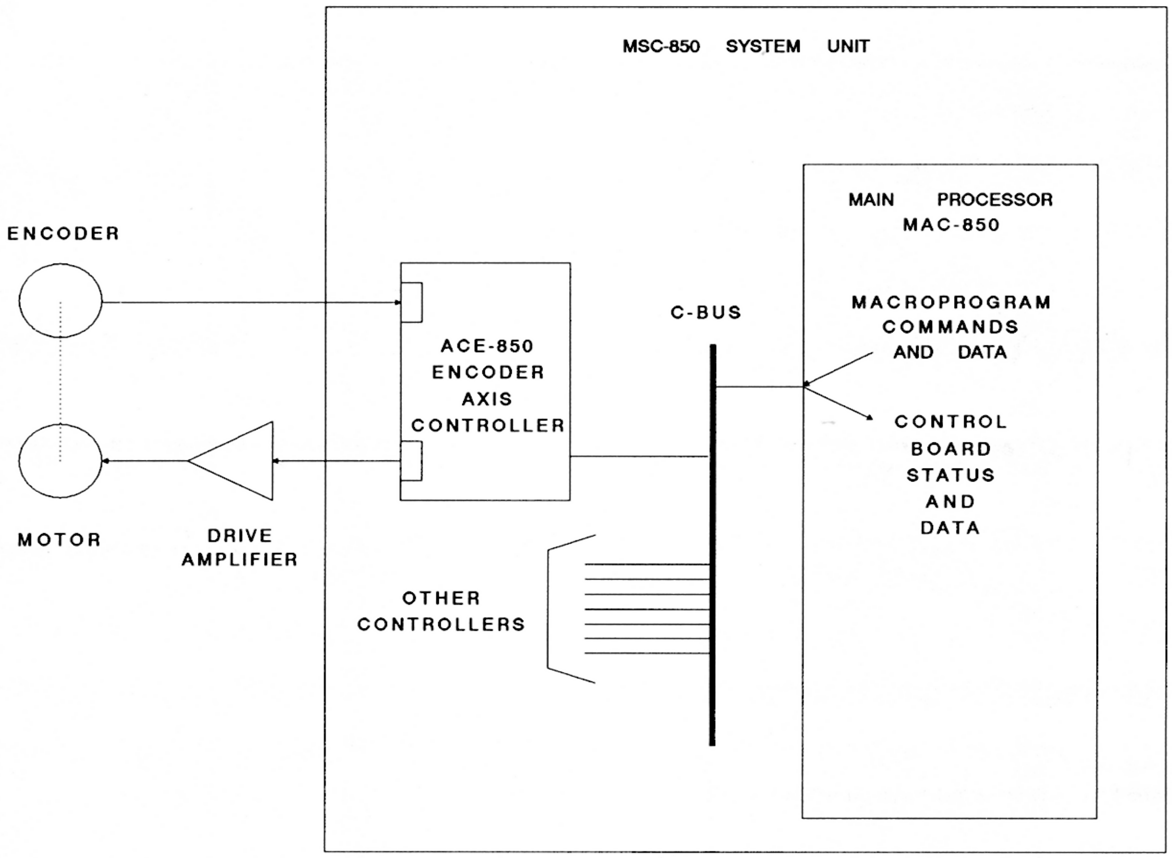


Figure 1-2 ACE-850 Position Loop Overview Diagram

2.0 DESCRIPTION

2.1 General

The ACE-850 Encoder Axis Controller is an intelligent circuit board that works in conjunction with an encoder connected to the motion device. In combination, the two devices produce an offset output signal that causes the motion device to move in relation to the commands as instructed by the Macroprogram running in the System Unit. The controller is capable of performing indexing, positioning, cam following, piecewise profiling, and can also be used as a passive position sensing device.

2.2 Encoder Functional Description

The encoder produces current loop pulses of approximately 10 mA per channel. There are three channels. Two of the channels are quadrature encoded and the third channel produces a marker. Each of the quadrature channels (Figure 2-1) produce a squarewave signal that is offset by 90 degrees from each other. Each edge of the squarewave is counted by an interface circuit. This technique provides direction sensing capability as well as an increase in resolution that is 4 times the encoder line count. The marker produced by the third channel is used to mark the 0.0 degree absolute reference point. It also is used for loss of count detection.

2.2.1 Encoder Count Channels

The feedback, with a resolution of 1024 counts from the encoder, is multiplied by a factor of 4 to produce 4096 counts per revolution. All further descriptions in this instruction book are based on this line count. Encoders having line counts of other than 1024 lines per revolution can be used but must be compensated for by scaling the rpm and acceleration values accordingly (ie, a 512 line encoder commanded to 200 rpm will actually provide 400 at the encoder shaft).

The line count of the encoder determines the performance of the system. High line count encoders offer high resolution and accuracy but affect speed and acceleration rates. Low line count encoders provide higher speed and acceleration but resolution is sacrificed.

2.2.2 Home Reference Channel

Unlike a resolver, an encoder is not an absolute position sensing device. At power up, the true encoder position is not known. For this reason, the power up location is defined to be 0.00 and is known as the local mode home. The encoder contains a once per revolution pulse channel called the marker (Figure 2-1) to provide an absolute 0.00 degree reference.

The Encoder Axis Controller provides 'find_mark_cw' and 'find_mark_ccw' commands which are used to initialize the system. This is referred as the absolute mode. These instructions cause the motor to move in the desired direction until the marker is crossed and the motor stops (not necessarily at 0.00 degrees). At this time, automatic bit loss detection begins.

Some drive manufactures provide an electronic encoder interface with a marker whose pulse width is 180 degrees (Figure 2-2) of shaft movement instead of the normal 1/4 cycle pulse width. The 'find_tm_cw' and 'find_tm_ccw' instructions should be used for these drives.

The ability to find a marker or initialize the system is only valid when the controller is being used as an active (versus passive) position sensing device and does not affect the master angle data.

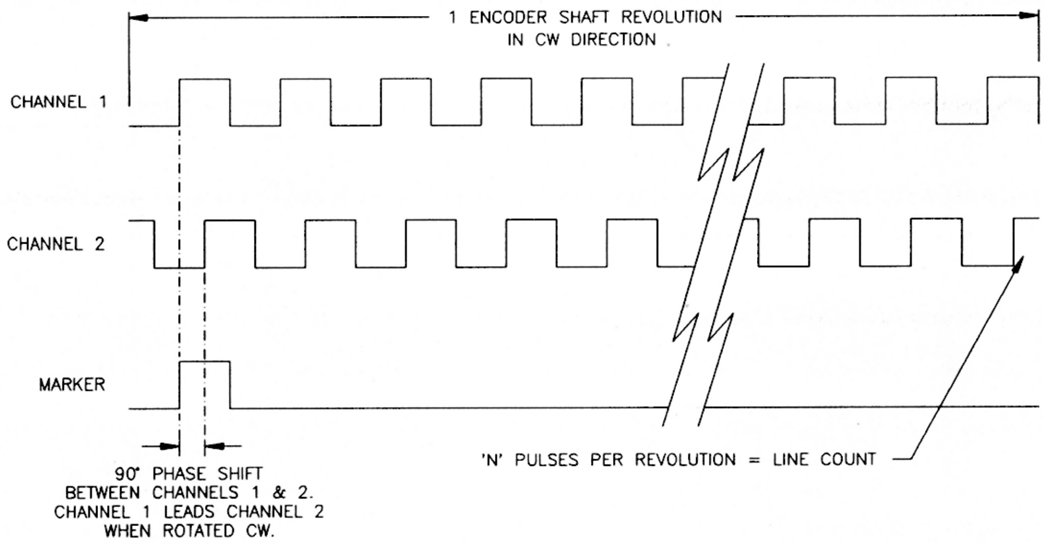


Figure 2-1 - Standard Encoder Output Channels Relationship

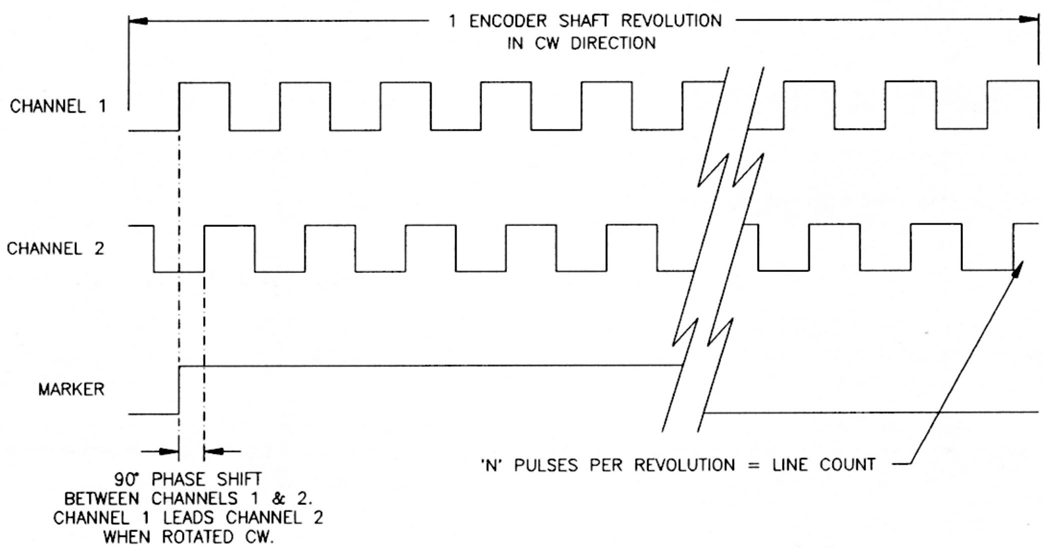


Figure 2-2 - 180° Marker Output Channels Relationship

2.3 Position Loop Control Functions

2.3.1 Overall Position Loop Description

The ACE-850 Encoder Axis Controller is the heart of the position loop (Figure 2-3). Instructions from the Macroprogram tell the controller what the parameters of the motions are for indexing or positioning. The information is processed by the command generator and the resulting position commands are sent to the comparator along with feedback from the encoder. The command generator produces a command position which represents speed, acceleration rate, direction, and distance that the motion device must move. This difference between the commanded position and the actual position is the POS OUT signal which is sent to the drive amplifier to power the motion device. The shaft of the motion device and the shaft of the encoder are mechanically connected. As the encoder turns to this new position, the actual position command feedback signal once again matches the position command signal thus satisfying the comparator and thereby causing the POS OUT signal to go to 0.00 Volts. The difference between the actual position of the encoder shaft and the commanded position is known as the following error.

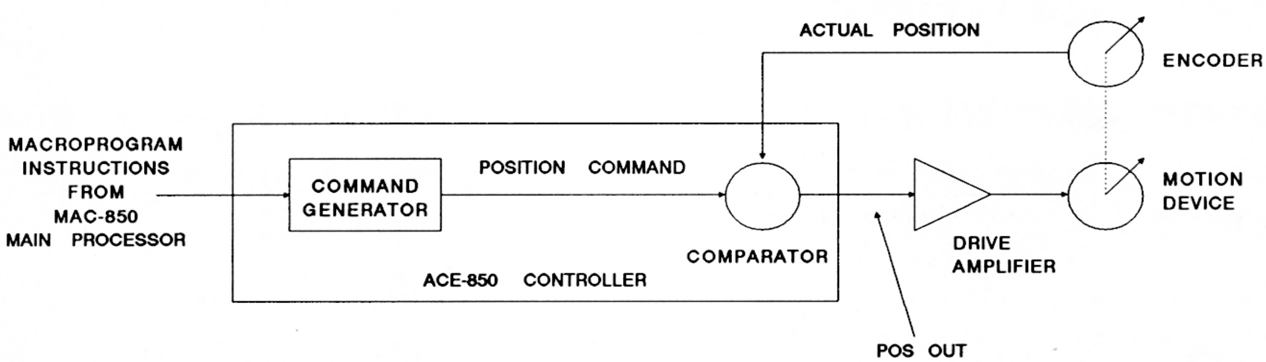


Figure 2-3 Position Loop Block Diagram

2.3.2 ACE-850 Encoder Axis Controller Description

The controller (Figure 2-4) is a microprocessor based board running under the control of a unique IIS Operating System. The digital signals from the encoder are detected by the controller. The output of the feedback device connected to channel 1 of the controller must lead the output connected to channel 2 when the feedback device is rotating in a clockwise direction (Table 2-1).

Table 2-1 Encoder Output to Controller Interface

ENCODER OUTPUT	ACE-850 CONNECTIONS CH1	CH2	CH3
Channel A leads B when CW	A	B	I,M, or Z
Channel B leads A when CCW	B	A	I,M, or Z

Commands from the Macroprogram running in the MAC-850 Main Processor (Figure 1-2) are sent over a Command Bus (C-Bus) to the controller's microprocessor. The 24-bit wide digitized signals from the encoder and command generator are parallel processed. The microprocessor and its associated circuits perform the multiple functions of position command generation, comparator, and PID digital compensation to produce the POS OUT signal. With the standard default in the digital compensation gain algorithm (P), the POS OUT voltage is +/-5 Volts (ccw versus cw respectively) at the 90 degree position of the encoder shaft and +/-10 Volts at the 180 degree position.

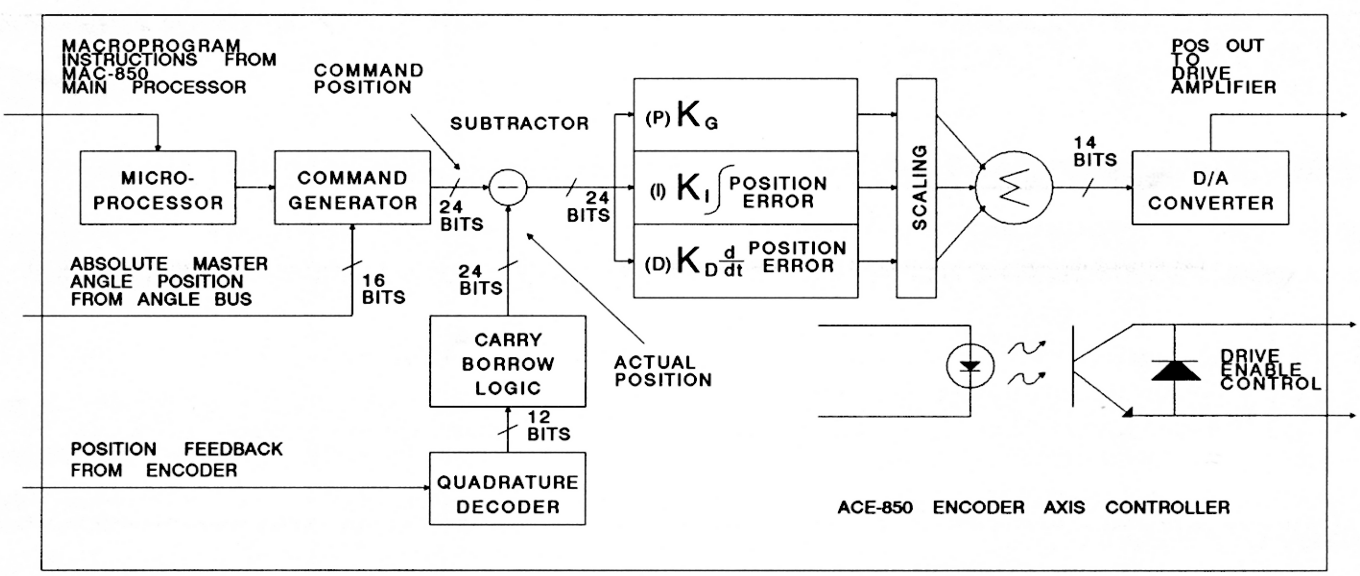


Figure 2-4 ACE-850 Controller, Functional Block Diagram

The Macroprogram can override the standard gain value of 16, integral value of 0, and damp value of 0 which represents the Proportional, Integral, and Derivative terms of the algorithm. The gain value can be set to produce a per revolution POS OUT signal of 20 Volts per 1/16th turn of the encoder shaft to 20 Volts per 16 turns of the encoder shaft. Refer to the Macroprogram Development System Instruction Book for further information about the setting of the digital compensation values.

The controller can communicate over the 2 Angle Buses which are located on the motherboard of the System Unit for a master/slave applications. The controller can be designated as the master controller (talker) by the Macroprogram or the controller can be designated a slave controller (listener). This master/slave relationship is communicated over either of the 2 Angle Buses.

Depending upon the specific mechanical motion being simulated, the command generator of the slave controller (Figures 2-5 and 2-6) computes a command position based on the absolute master angle information from the Angle Bus.

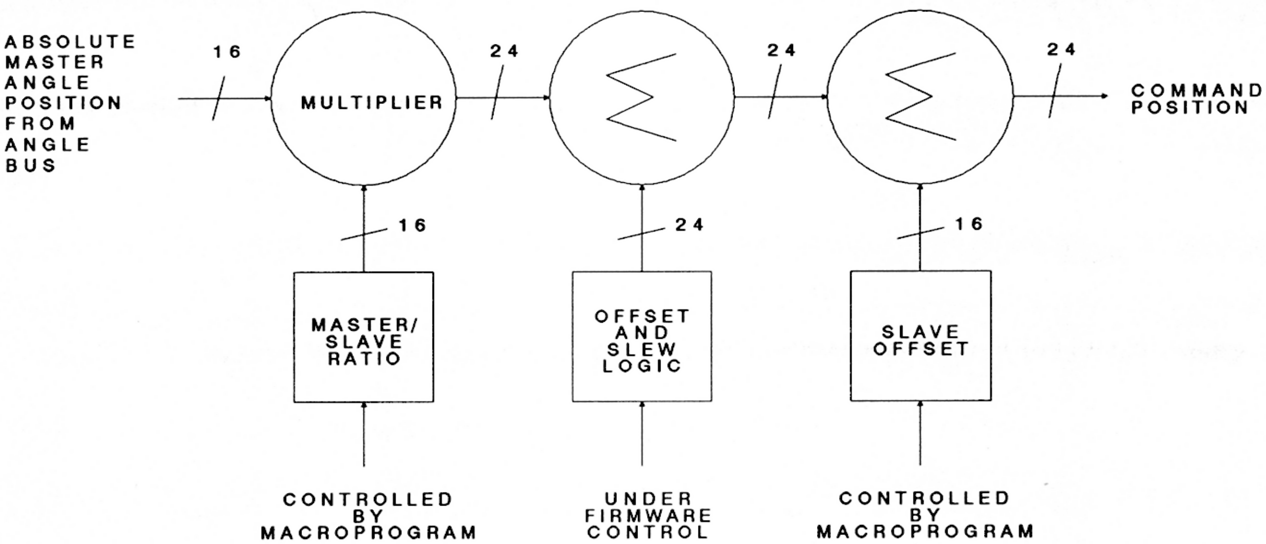


Figure 2-5 Electronic Gearbox Command Generator

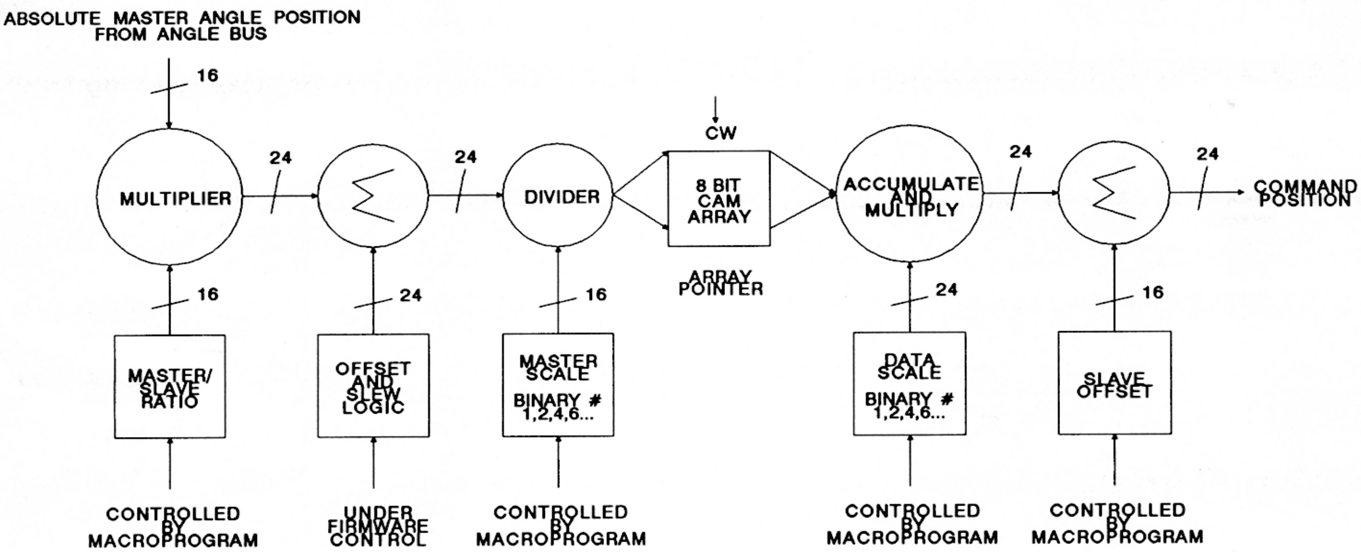


Figure 2-6 Electronic CAM and Gearbox Command Generator

As a passive position sensing device, the controller can be used to monitor the motion of other machine components. This information can be communicated over the angle buses or reported to the Main Processor for integration into functions of the Macroprogram

When the Macroprogram commands the controller with the 'drive_off' instruction, the drive enable control is turned off and the controller is now in a passive mode. The POS OUT signal represents the count of the encoder referenced to X.0 degrees home (ie; zero volts is zero degrees). This home reference is the encoder position at power up unless the 'find_mark_xx' or 'find_tm_xx' instructions were executed which changes the zero degrees of the encoder marker position. The transition from +10 Volts to -10 Volts represents 180 degrees angle of the encoder. Any time the System Unit is powered up, the Macroprogram can command the controller to look for the marker produced by the encoder to determine the 0 degree position of the encoder's shaft.

When 'drive_off' is executed in the Macroprogram, the POS OUT signal is first driven to 0V dc by making the command position equal to the actual position then the Drive Enable Control is turned on.

2.4 Hardware Interrupts

Hardware interrupts are selected and enabled by the Macroprogram using the 'enable_hwi' instruction. These hardware interrupt routines are initiated by MEC type input modules. The high level input being monitored is connected to the input module which isolates the low level logic circuitry of the controller from the high level input. Both AC and DC inputs can be handled. In addition, a special input module manufactured by IIS, Inc. can handle DC inputs at a much faster rate than the conventional module (MEC type). The input module servicing the controller is position dependent relative to the slot in which the controller is located (Figure 2-7). The controller located in slot 1 of the System Unit is serviced by the input module located in position 1 of the on-board I/O module connectors.

2.5 Status and Fault Indicators

2.5.1 Power-up Fault Detection

On power-up, the controller's microprocessor, memory, and multiply/divider circuits are put through a series of tests. If the controller passes these tests, then the board is considered to be operational and a green indicator, labeled SELF TEST OK, is lighted. On Start-up, the SELF TEST OK indicator may also be lighted along with the yellow INTERRUPT, red BUS FAULT, and red ERROR indicators. If this combination of indicators are lighted on start-up, a controller start-up fault has occurred. This may or may not be a fault of the controller. A start-up retry should be attempted and if the same combination of indicators are lighted, the controller can be suspected as being faulty.

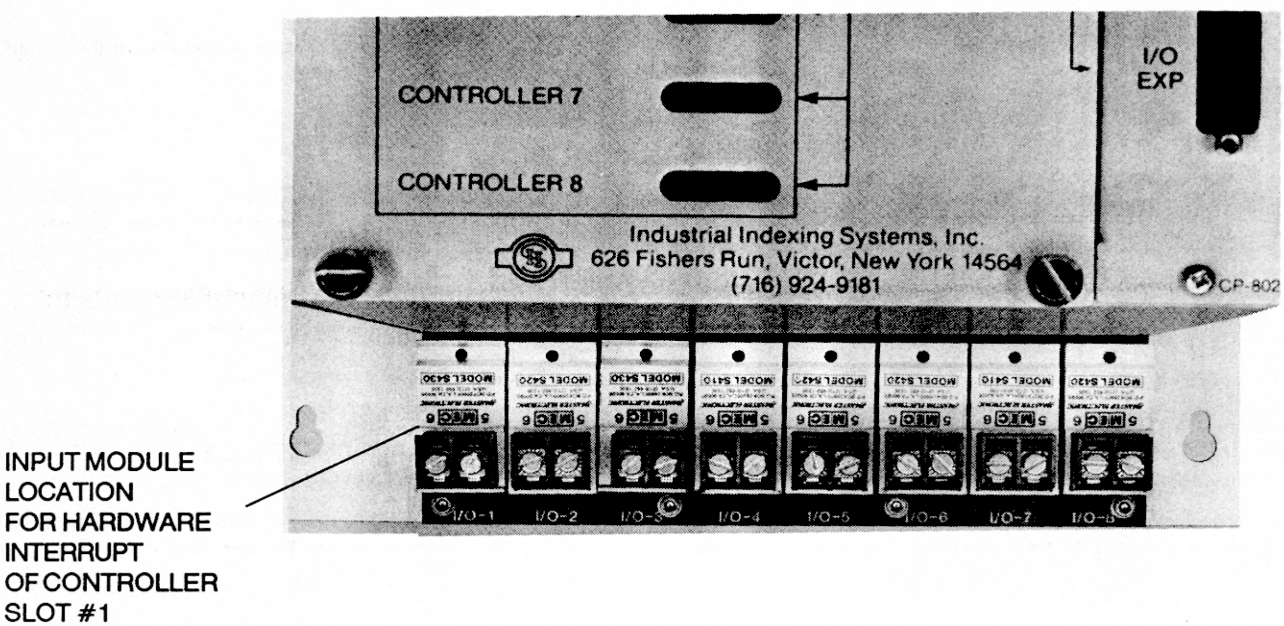


Figure 2-7 On-board I/O Module to Controller Slot Relationship

2.5.2 Operational Fault Detection

The ACE-850 Encoder Axis Controller has built-in fault detection. While the DRIVE ENABLE indicator is lighted, the controller monitors the following error and immediately sets the POS OUT signal to 0.00 Volts and then turns off the drive enable control under the following conditions;

- o If no motor motion is commanded, the controller will not allow the encoder to be more than 17 degrees off of its commanded position.
- o If motor motion is commanded, the controller will not allow the encoder to be more than 180 degrees from its commanded position.

The following error trip angles are modified when the digital compensation 'digi_comp' instruction is executed in the Macroprogram (Refer to the Macroprogram Development System Instruction Book).

2.5.3 Status Indicator Description

During normal operation, the SELF TEST OK indicator is lighted. As the Macroprogram executes the 'drive_on' instruction, the ENABLE OUTPUT indicator comes on to enable the position loop and to start monitoring the "following error". As the MAC-850 Main Processor communicates with the controller, the INTERRUPT indicator flickers (or appears to be on steady due to rapid flickering.

If, during normal operation, a problem with controller or main processor is detected, the BUS FAULT indicator will come on.

For a more detailed description of the physical and functional characteristics of these indicators, refer to Section 4.

3.0 SPECIFICATIONS

3.1 Functional Characteristics

Drive Enable Control	Optically Isolated
Off Voltage	30V dc
On Voltage	1.5V dc, 20mA
Drive Command Output	+/-10V dc @ 10mA
Digital Compensation	PID Loop with 1KHz Digital Signal Processing Sample Rate
Feedback Device	Digital Quadrature Encoder with marker.
Line Count	1024 Pulses per revolution
Quadrature Alignment	90 +/-22.5
Pulse Sysmmetry	180 +/-22.5
Marker Types	
1/2 revolution	MSB
1/4 cycle	A & B
Line Receiver	Dual Differential driving 10mA into Isolated Receivers.

3.2 Performance Characteristics

Positional Range	+/- 8,388,608 counts
Positional Absolute Accuracy	+/- 1 count
Acceleration/Deceleration Range	16 to 3,276,800 counts/sec/sec
Speed Range	0.266 to 245,760 counts/sec
Decoding	Fixed quadrature (X4) @400 KHz maximum
Environmental	
Operating Temperature	32° to 140° F (0° to 60° C)
Operating Humidity	30 to 90% (Non-condensing)

3.3 Physical Characteristics

Dimensions	
Width	5 5/16 in. (135 mm)
Depth	6 5/16 in. (160 mm)
Weight	1 lb. (0.45 Kg)
Mounting	Occupies any slot in the MSC-850 System Unit

4.0 CONTROLS AND INDICATORS

4.1 General

The ACE-850 Encoder Axis Controller is equipped with five status indicators. These indicators are visible through a cut-out in the faceplate of the System Unit. The indicators are illustrated in Figure 4-1 and listed in Table 4-1.

There are no setable devices on the ACE-850 Encoder Axis Controller. All parameters and functional control are established by the Macroprogram

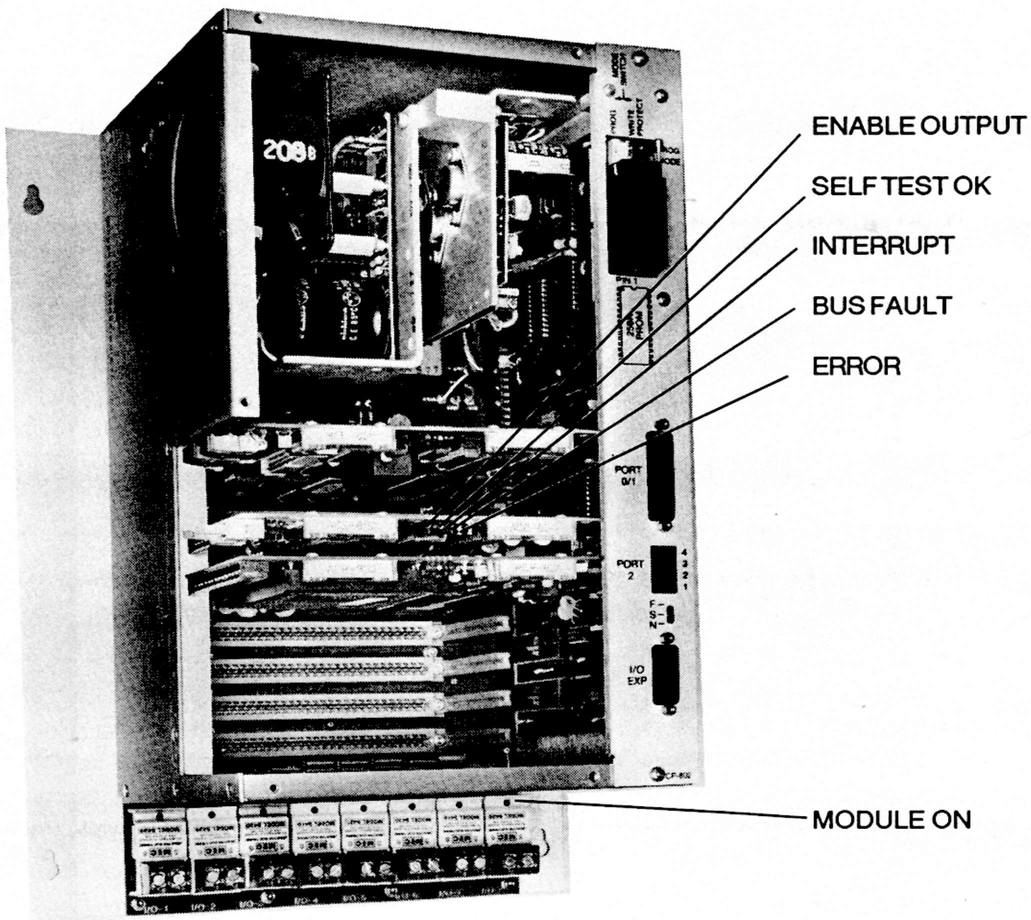


Figure 4-1 Identification of Status Indicators

Table 4-1 Description of Indicators

PANEL MARKING	DESCRIPTION	OBSERVED INDICATION	INDICATOR FUNCTION
ENABLE OUTPUT	Green LED	Steady On	The position loop is active and drive enable is closed
SELF TEST OK	Green LED	Steady On	The controller passed the self test during start up.
INTERRUPT	Yellow LED	Flashing	The controller is communicating with the Main Processor.
BUS FAULT	Red LED	Steady On	Communication, on the C-Bus between the controller and the Main Processor was faulty. A subsequent good communication sequence resets the BUS FAULT indicator
ERROR	Red LED	Steady On	A following error fault has been detected.
		Flashing	A controller fault has been detected.

NOTE

If, during start up, the SELF TEST OK, INTERRUPT, BUS FAULT, and ERROR indicators all come on, a controller start-up fault has occurred. A start-up retry should be attempted and if the same combination of indicators are lighted, then the controller can be suspected of being faulty.

5.0 FUNCTIONALITY TESTS

5.1 General

The ACE-850 Encoder Axis Controller provides motion control by controlling the position of a encoder type feedback device. The encoder is physically connected to the motion device and is aligned such that the encoder's shaft position is relative to the motion device's position.

The position loop, consisting of the ACE-850 Encoder Axis Controller and the encoder, controls a velocity loop consisting of the drive amplifier, motor, and power supply. The velocity loop has a voltage input which is proportional to motor speed. The velocity loop polarity must be configured such that a positive voltage drives the encoder counterclockwise.

The Overall Trouble Shooting Chart (Figure 5-1) provides a quick reference guide to fault isolation. the specific tests provided in paragraphs 5.2 and 5.3 are designed to quickly isolate the faulty component.

To determine if the ACE-850 Encoder Axis Controller is functioning properly, it is first necessary to check whether the problem is in the velocity loop or in the position loop. This is accomplished by using the test described in paragraph 5.2. If the problem is found to be in the position loop, then the tests provided in paragraph 5.3 can be used to isolate the faulty component within the position loop. This includes the ACE-850 Encoder Axis Controller. If the problem is in the velocity loop. refer to the specific instruction book for the motor/drive components used in your system.

WARNING

High torque motors and high voltages can be dangerous. Use extreme caution when working around the motors and drive circuits.

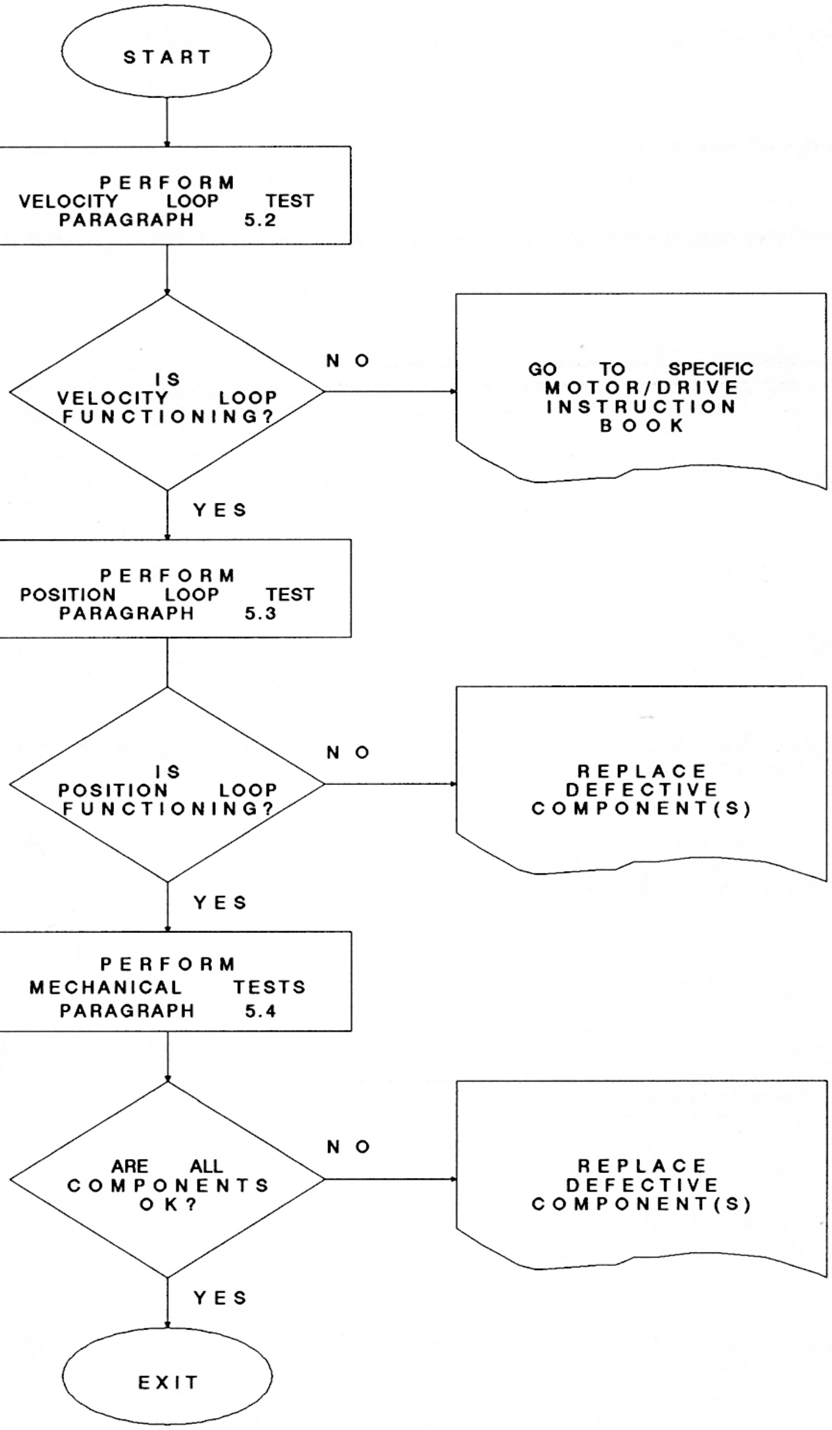


Figure 5-1 Overall Trouble Shooting Chart

5.2 Velocity Loop Functional Test

This test puts the drive amplifier and motion device in a velocity mode of operation. It is used to determine if the problem is in the velocity loop or the position loop. If all of the following tests pass, then the problem is in the position loop. The position loop can be tested by proceeding with the test described in paragraph 5.3. If any of the following tests fail, refer to the instruction book on the specific motor/drive package used in your system.

CAUTION

This test causes the motion device to move. Be sure that the mechanical load can accept movement in both directions without damaging the equipment.

1. Turn off the power to the system.
2. Remove the 6-pin connector P4 from the ACE-850 Encoder Axis Controller in the System Unit.
3. Connect a jumper (Figure 5-2) between P4-2 (green wire) and P4-3 (white wire)
4. Apply power to the system.
5. The motion device should be at rest. A small amount drift is acceptable for the remainder of the test.
6. Using a Multimeter as a power source, set the Multimeter on the X1 Ohms scale.
7. While observing the shaft of the motion device, connect the red and black meter leads to P4-6 and P4-5 respectively (Figure 5-2). The shaft should rapidly accelerate in a counterclockwise direction.
8. Now remove either meter lead and observe the shaft of the motion device. The shaft of the motion device should quickly decelerate to a stopped position.
9. Reverse the meter leads at P4-6 and P4-5. The shaft of the motion device should rapidly accelerate in the clockwise direction.
10. Now remove either meter lead and observe the shaft to the motion device. The shaft should quickly decelerate to a stopped position.
11. If any of the previous tests fail, refer to the Instruction Book on the specific motor/drive package used in your system. If all tests pass, refer to paragraph 5.3.
12. Remove jumper and Multimeter leads.

5.3 Position Loop Functional Tests

The position loop (Figure 5-3) functional tests consist of two parts. The first test checks out the overall position loop. The second test determines whether the problem is in the 5V-dc Power Supply, the interconnecting cable, the encoder, or in the ACE-850 Encoder Axis Controller.

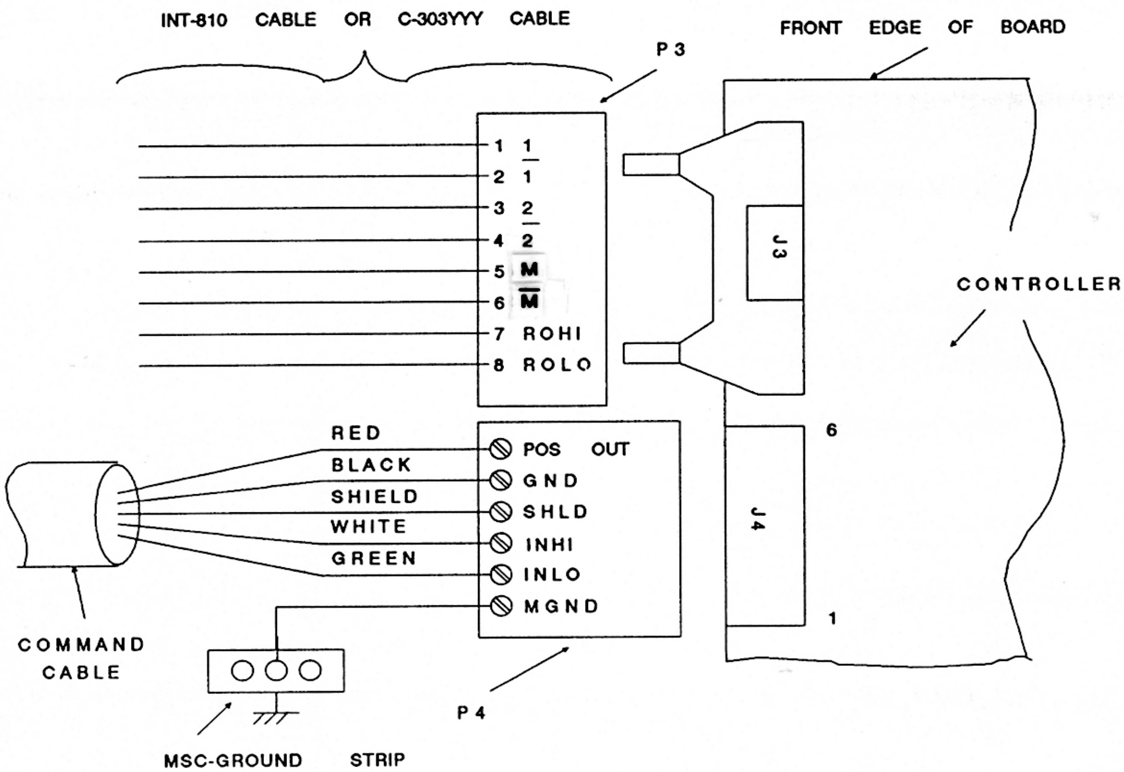


Figure 5-2 Connector Plug P4 Pin Identification

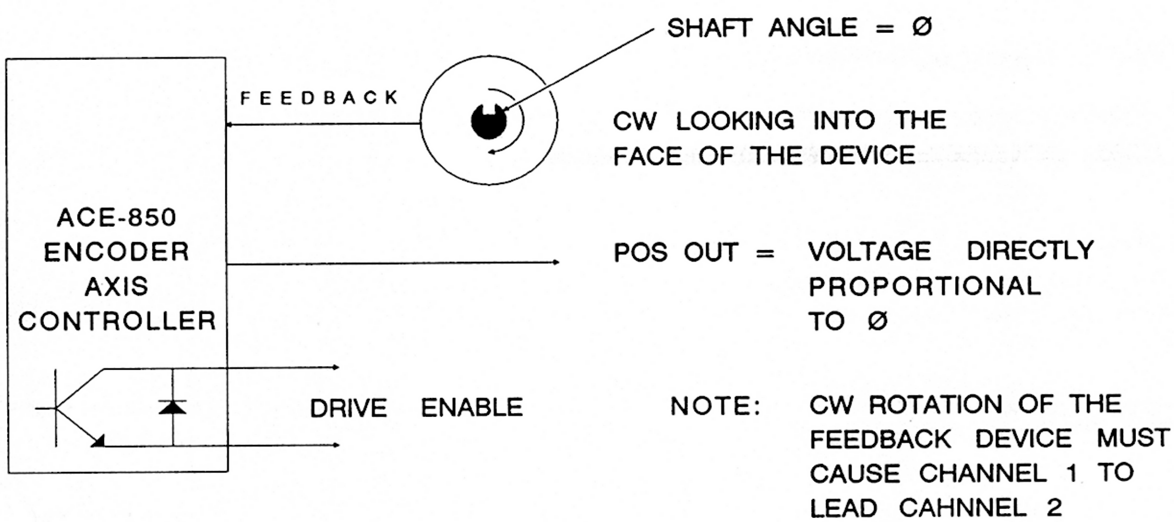


Figure 5-3 Position Loop Components

5.3.1 Position Loop Functionality Verification Tests

This test verifies that the position loop is malfunctioning. If at any time during the test abnormal results are obtained, go directly to paragraph 5.3.2 to determine the faulty component within the position loop.

1. Turn off power to the System.
2. Remove Connector P4 from the ACE-850 Encoder Axis Controller in the System Unit.
3. Apply power to the System.
4. Place the MSC-850 System Unit in the test mode (refer to the Macroprogram Development System Instruction Book.
5. Set a Multimeter on the 10V-dc scale.
6. Connect the red and black meter leads to test points TP1 (POS) and TP2 (GND) respectively (Figure 5-4).

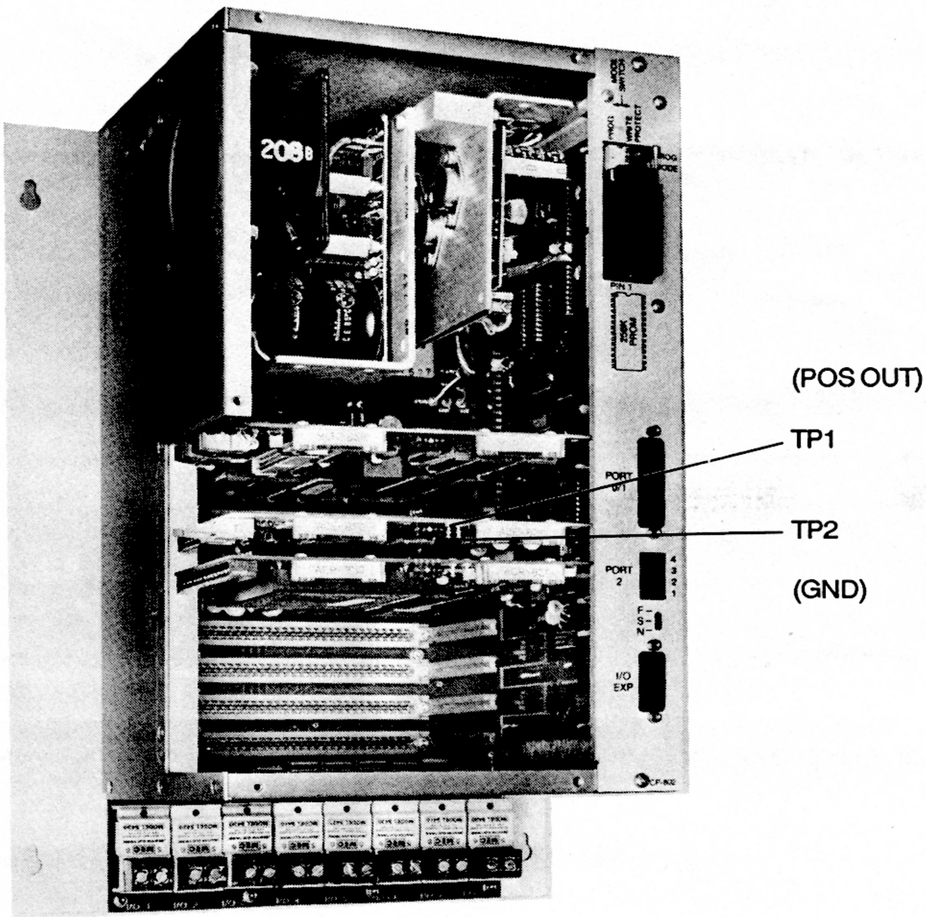


Figure 5-4 Location Of Test Points TP1 and TP2

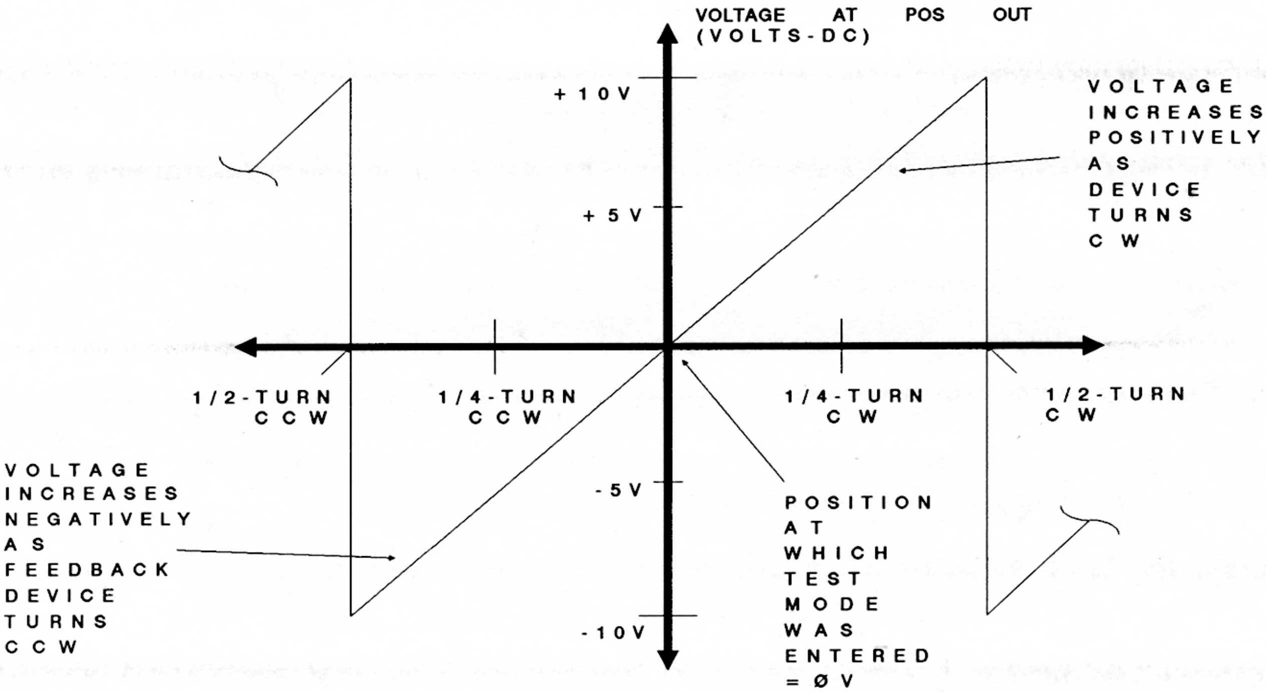


Figure 5-5 Voltage Versus Encoder Displacement in Test Mode

7. With the motor at rest, the voltage reading on the meter should be 0.00V dc +/-0.1V dc.

8. Rotate the motor shaft clockwise 1/4 turn while observing the meter which should smoothly increase (Figure 5-5) to approximately 5V dc.

9. Rotate the motor shaft back to its original at-rest position and observe that the voltage smoothly returns to 0.00V dc.

10. Reverse the meter leads at Test Points TP1 and TP2.

11. Rotate the motor shaft 1/4 turn counterclockwise and observe that the meter again increases smoothly to approximately 5V dc.

12. Continue to turn the motor shaft in the counterclockwise direction. The voltage should increase to +10.00V dc, and as the shaft is rotated beyond the 1/2 turn point, the voltage should abruptly switch to -10V dc. As the shaft is continued to be moved, the voltage should decrease to 0.00V dc upon reaching the 1 full turn position.

NOTE

If the voltage polarities are opposite to those shown in Figure 5-5, the encoder channels may be reversed.

5.3.2 Encoder Versus Power Supply Versus Cable Test

1. Set a Multimeter on the 10V-dc scale.
2. Connect the red and black meter leads to pins 13 and 14 respectively of the INT-810 Interconnection Module (Figure 5-2).
3. The meter should indicate 5V dc +/-0.25V dc. If an out of specification reading is obtained, replace the 5V-dc Power Supply.
4. Reconnect the red and black meter leads to pins 1 and 2 respectively.
5. Move the encoder shaft to find two different voltages; one being 0.8V dc or less and the other being 2.5V dc or more. If an out of specification reading is obtained, replace the encoder.
6. Reconnect the red and black meter leads to pins 4 and 5 of the INT-810 Interconnection Module.
7. Move the encoder shaft to find two different voltages; one being 0.8V dc or less and the other being 2.5V dc or more. If an out of specification reading is obtained, replace the encoder.
8. Set the Multimeter on the low Ohms scale.
9. Refer to Figure 5-6 and check for shorts between conductors or opens within conductors. If either opens or shorts are suspected, replace the interconnecting cable.
10. Visually inspect the INT-810 Interconnection Module and its ribbon cable for properly seated connections and for physical damage.
11. If all of the tests pass, replace the controller in the system unit.

NOTE

Before reapplying operational power, remove meters leads and connect all cable connectors removed during testing.

5.4 Mechanical Components Test

This Test Checks the mechanical componente of the Motion Control System.

1. Check for intermittent wirings faults.
2. Check for a loose mechanical coupling between the motor and the positional feedback encoder.
3. Check the motor brushes, if applicable.
4. Make sure that the systems frictional load on the motor has not changed.
5. Do the set-up proceudre in the instruction book on the specific motor/drive package for the system.

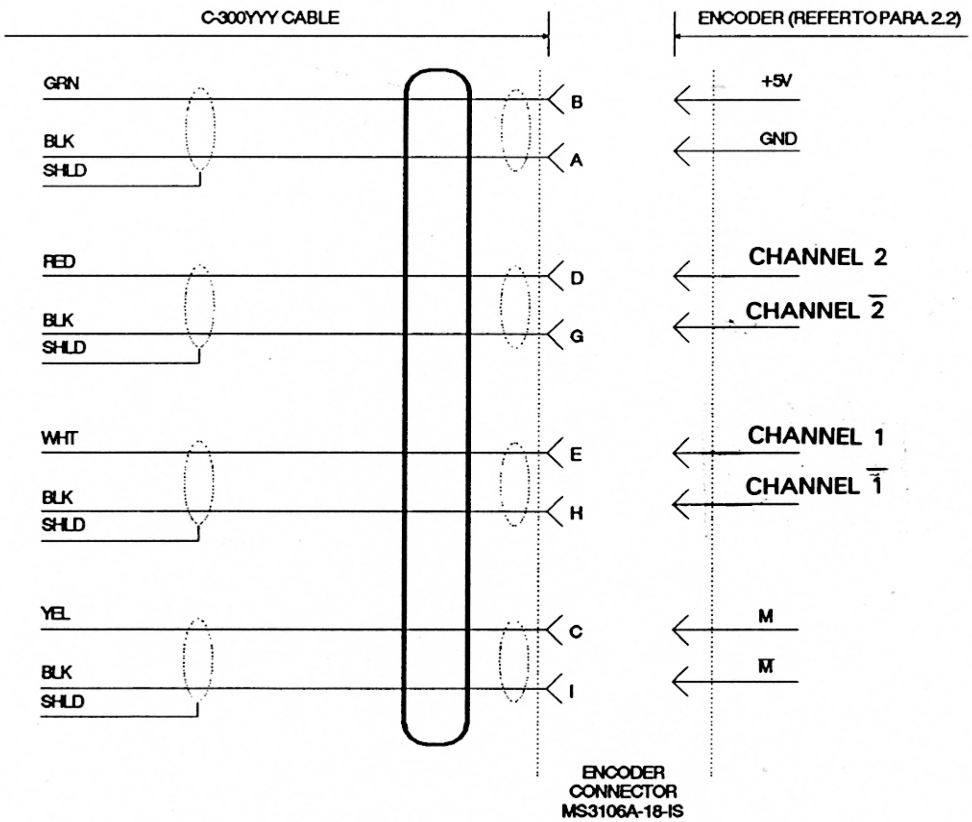


Figure 5-6 C-300YYY Interconnecting Cable, Wiring Diagram

6.0 CONNECTION DIAGRAMS

6.1 General

Good grounding of the controller is essential for proper operation. Figure 6-1 illustrates the MSC Ground Strip typical location to which P4-1 must be connected.

This section also contains the connection details of the INT-810 Connection Module (Figures 6-2 and 6-3). The electrical connections for the controller to encoder and controller to drive amplifier for both brush and brushless type motors are given in Figure 6-4.

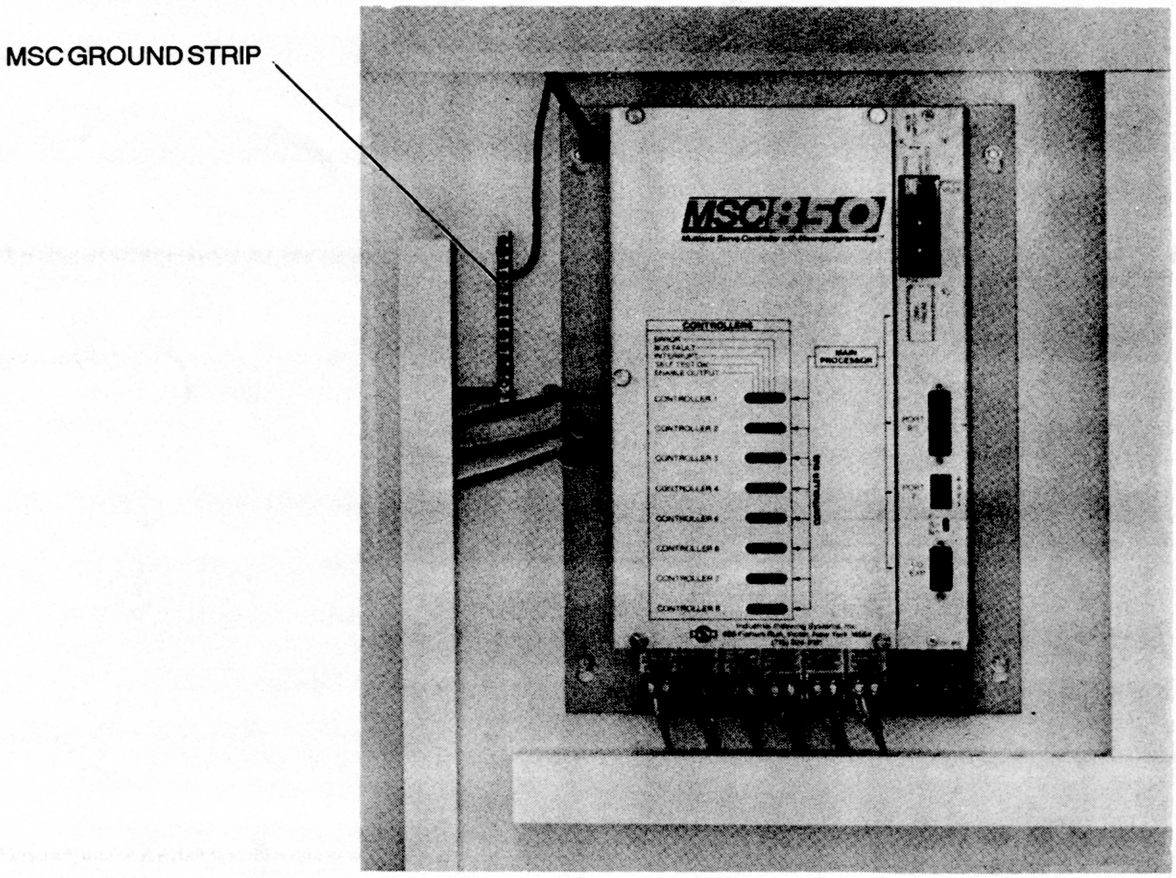


Figure 6-1 MSC Ground Strip

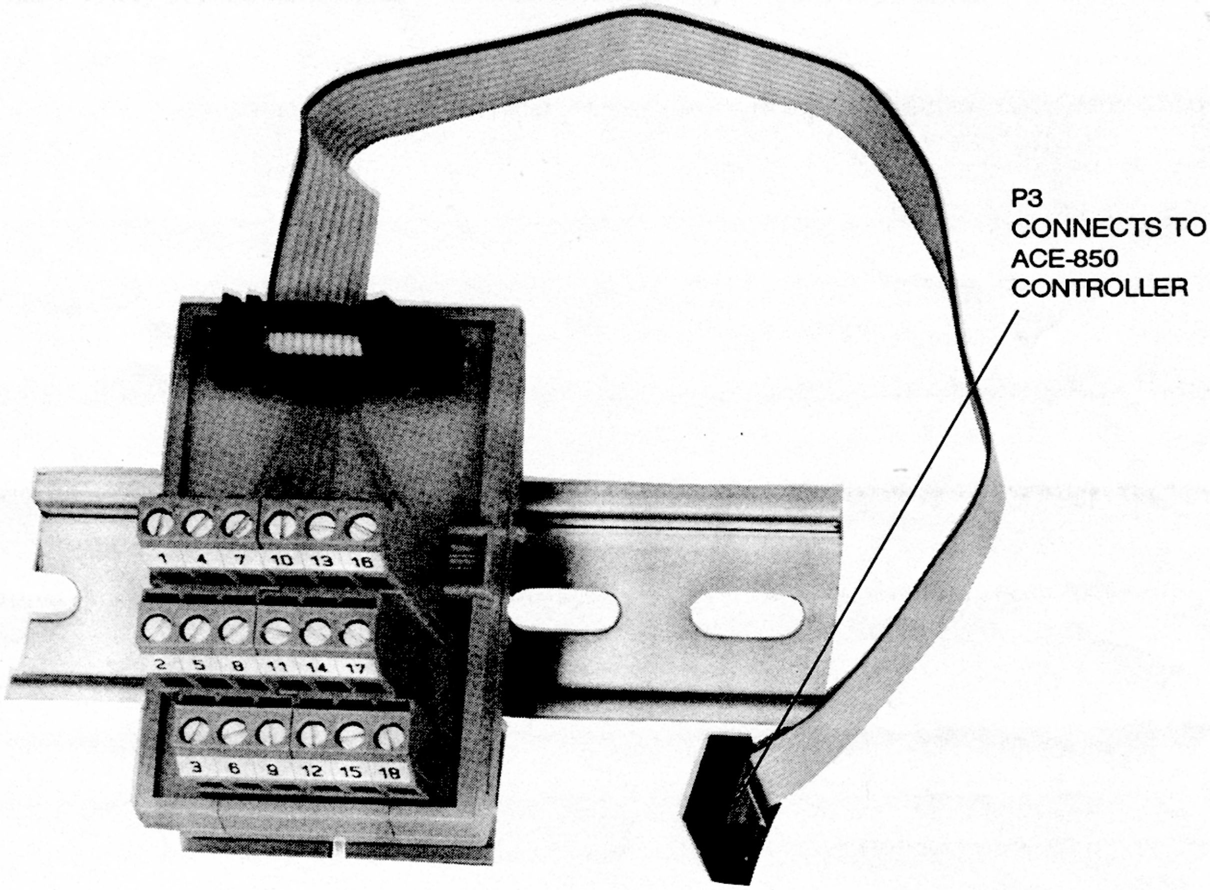


Figure 6-2 INT-810 Interconnection Module, Overview

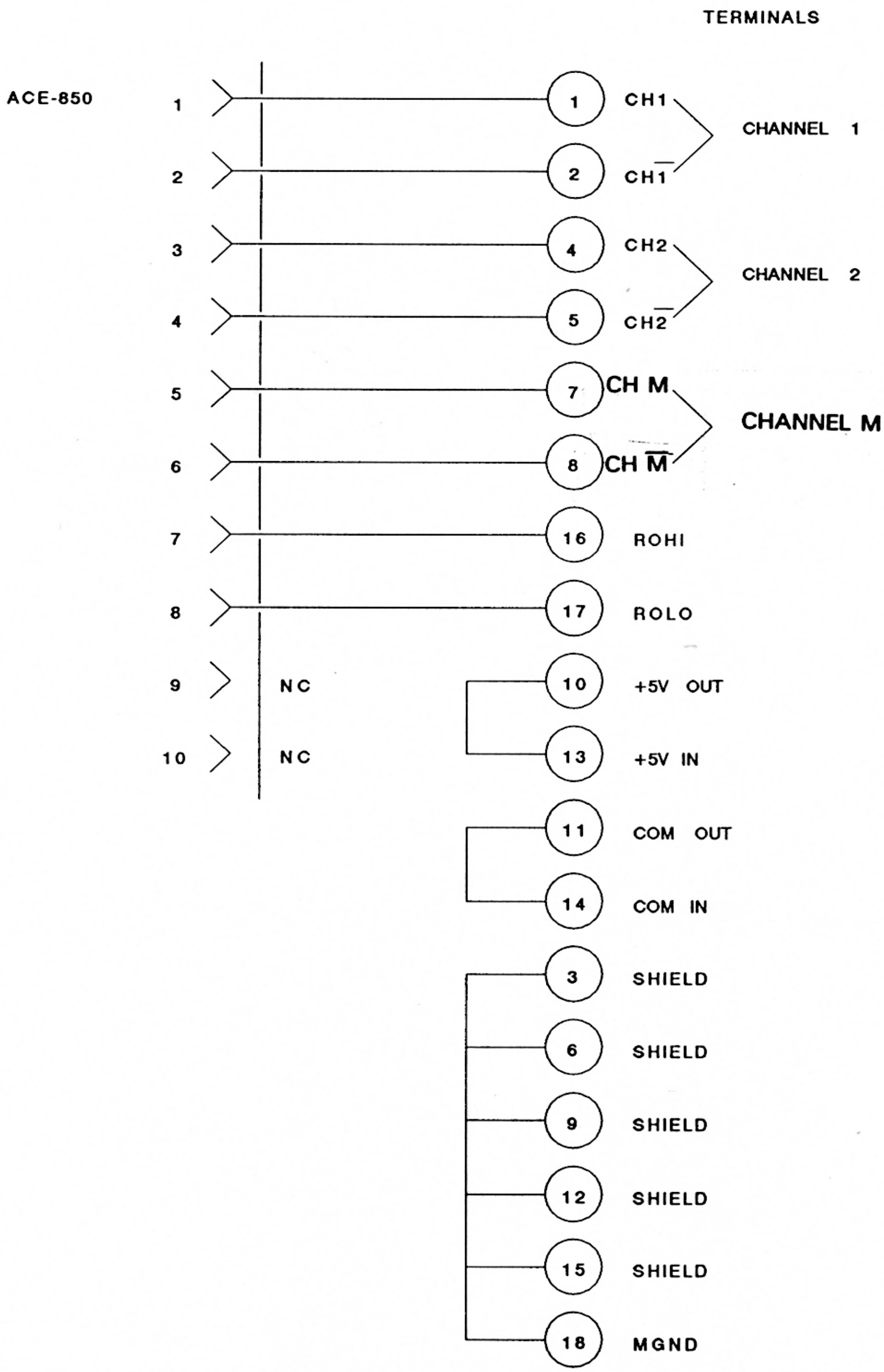


Figure 6-3 INT-810 Interconnection Module, Connection Details

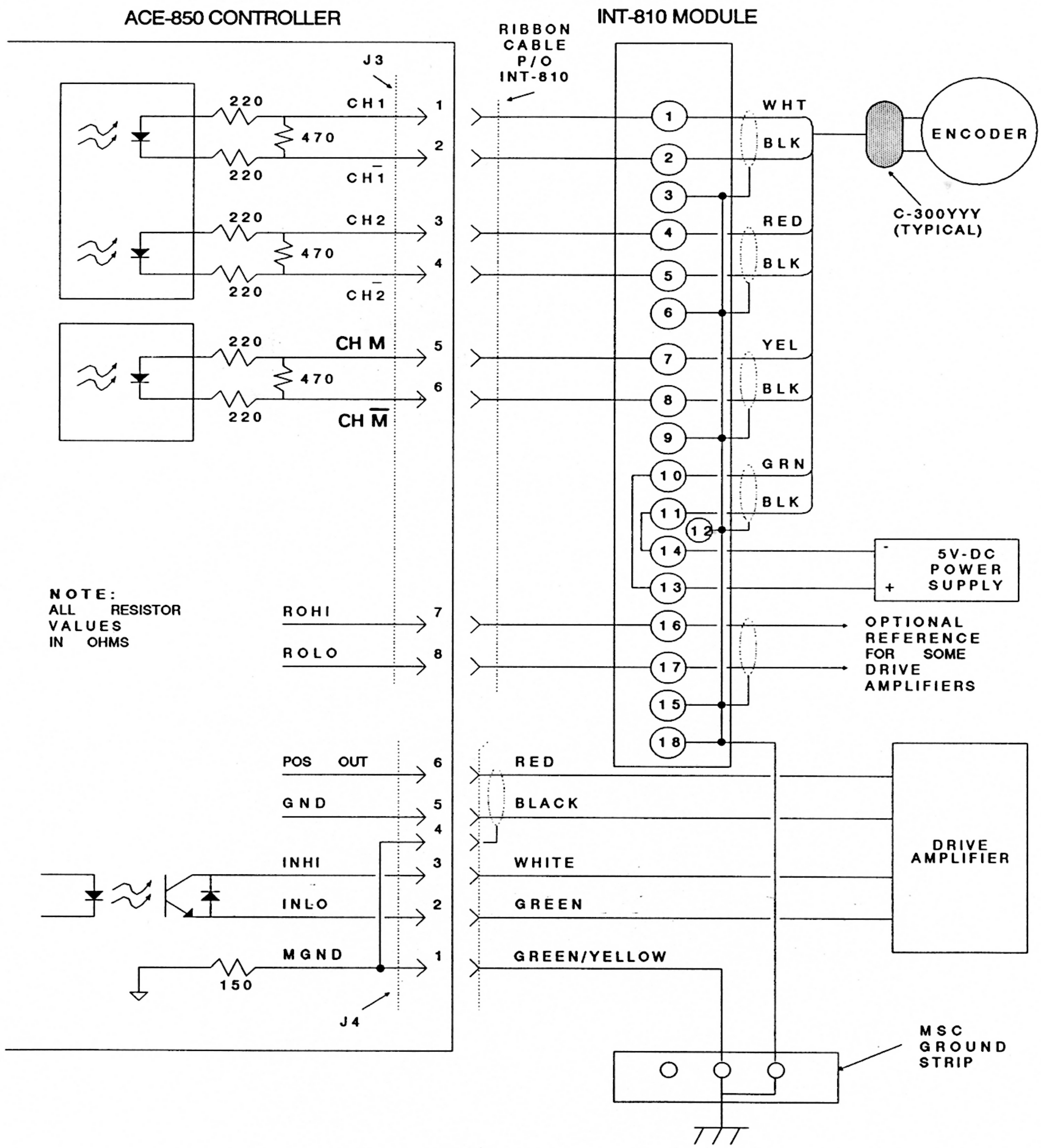


Figure 6-4 ACE-850 Controller, Electrical Connections

TRADEMARKS

Industrial Indexing Systems, Inc. reserves the following trademarks:

- o Macroprogram
- o MSC-850 System Unit
- o Macroprogram Development System

The following trademarks are used in this publication:

- o MEC is a trademark of the Master Electronic Co.
- o OPTO 22 is a trademark of OPTO 22.

IB-11B003

INDUSTRIAL INDEXING SYSTEMS INC.

626 FISHERS RUN
VICTOR, NEW YORK 14564

(585) 924-9181
FAX: (585) 924-2169