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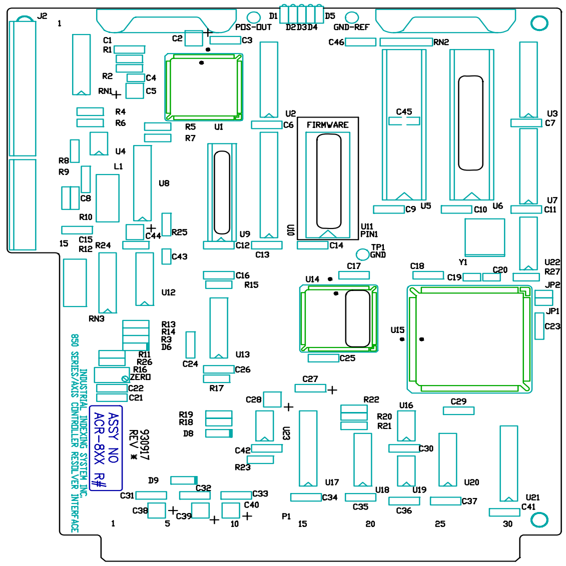
MOTION CONTROL SYSTEMS, MSC-SERIES MAY 1994



ACR-850 RESOLVER AXIS CONTROLLER

INSTRUCTION BOOK

INDUSTRIAL INDEXING SYSTEMS, Inc.

Revision - A

Approved By:

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1.0 INTRODUCTION

1.1 About this Instruction Book

This document is part of a series of books that support Industrial Indexing Systems' MSC-850/32 based Motion Control System. It provides product information about the ACR-850 Resolver Axis Controller including: a product overview, product description, product specifications, description of controls and indicators, and connection diagrams.

1.2 Product Overview

The ACR-850 Resolver 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-850/32 System Unit. It provides precision position loop control utilizing feedback data from the resolver connected to a motion control device (Figure 1-2).

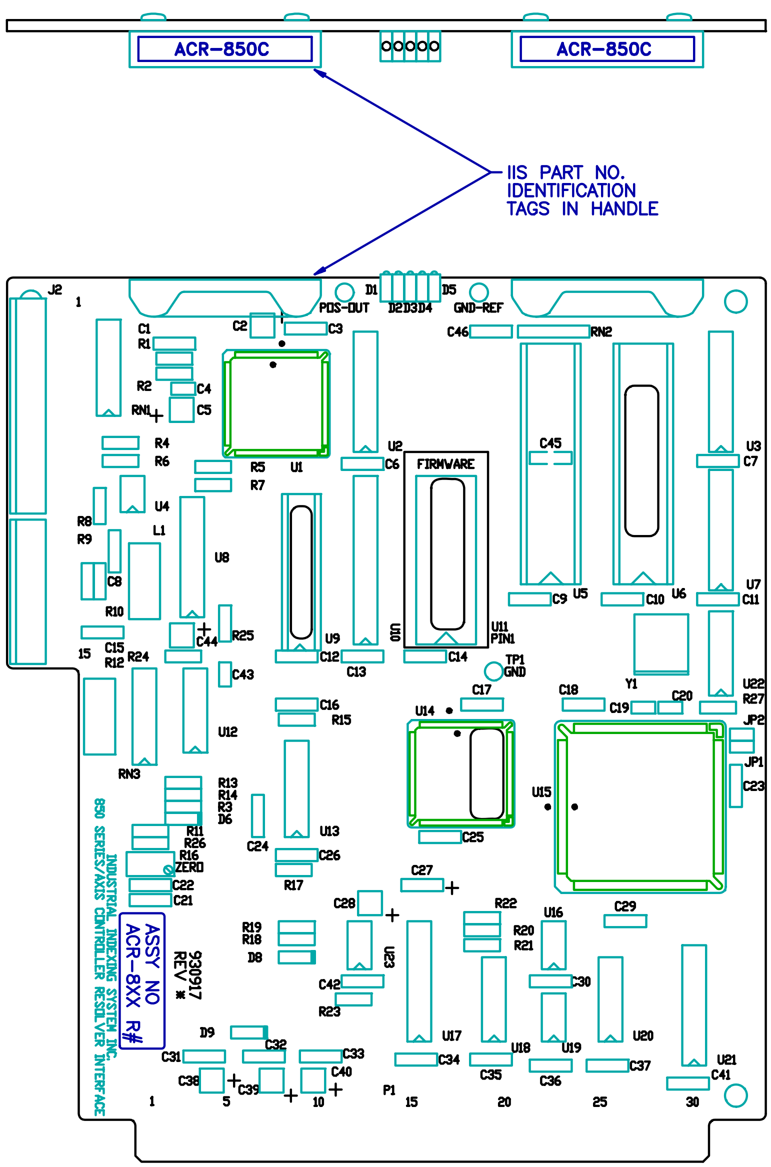

Figure 1-1 ACR-850 Resolver Axis Controller

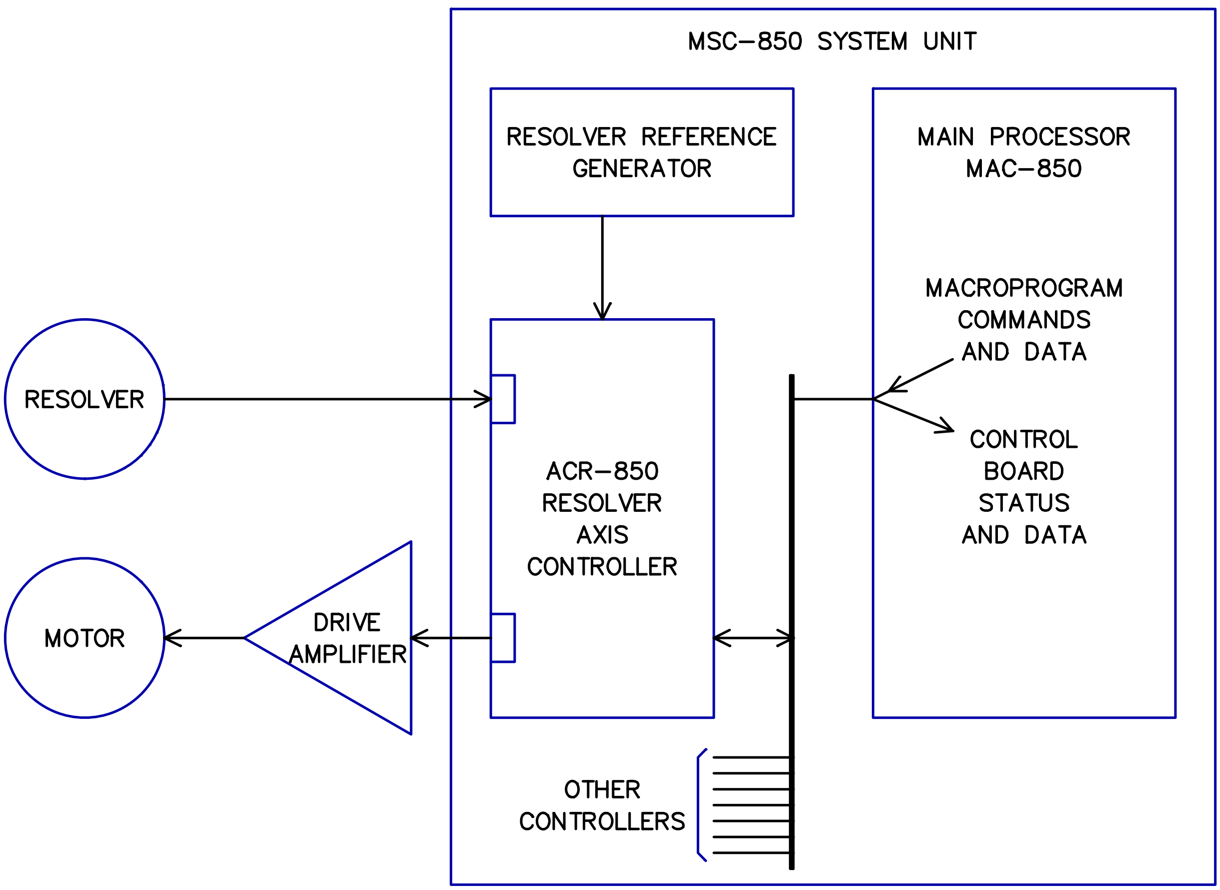

Figure 1-2 ACR-850 Position Loop Overview Diagram

2.0 DESCRIPTION

2.1 General

The ACR-850 Resolver Axis Controller is an intelligent circuit board that works in conjunction with a resolver connected to the shaft of the motion device. In combination, the two components produce an output signal that causes the shaft of 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 Resolver Functional Description

A resolver is similar to a variable transformer. It has five windings: two are used to form a rotory transformer, one is a rotor primary winding, and the other two are stator secondary windings (Figure 2-1). The rotor winding is excited with a 2.6 KHz sine wave generated by a resolver reference generator located on the motherboard of the System Unit. As the rotor of the resolver turns, the energy generated in the two stator windings is sent to a resolver to digital (R/D) converter circuit located on the ACR-850 Resolver Axis Controller.

The R/D converter is a 12-bit resolution circuit which divides one revolution of the resolver shaft into 4096 parts. This provides absolute position of the shaft. One part is equal to 0.0879 degrees on the shaft.

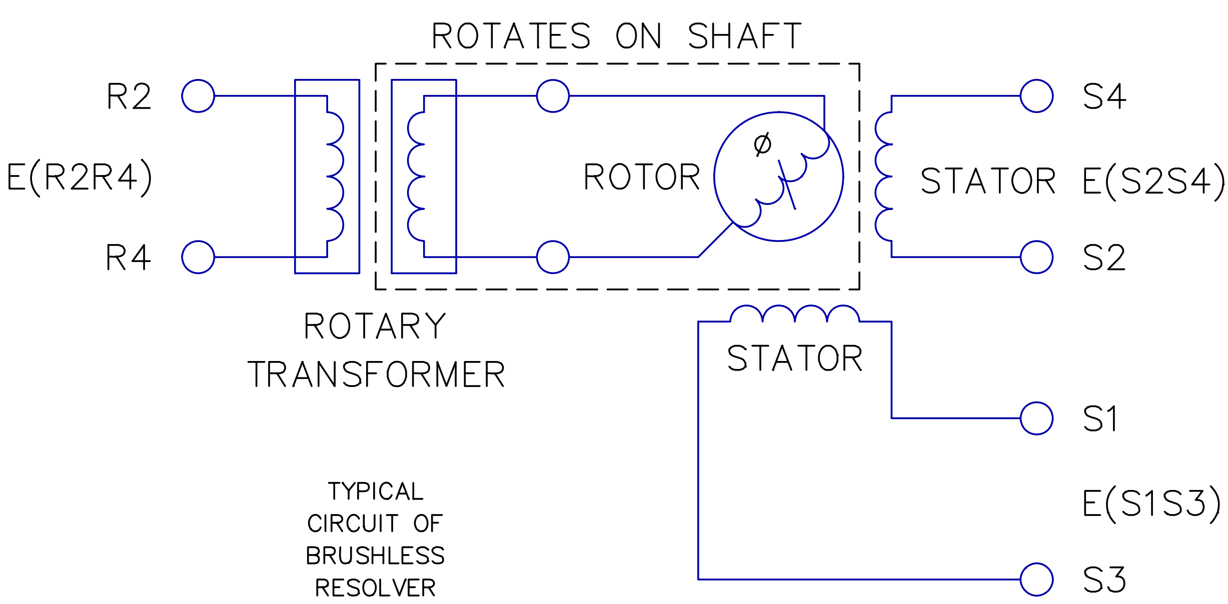

Figure 2-1 Resolver Windings Physical Relationship

The electrical characteristics of the resolver, operating as an absolute position device, are fixed by the relationship of the rotor winding relative to the position of the stator windings. A pair of voltages, (Figure 2-2) whose amplitudes are proportional to the sine and cosine of the angular position of the shaft, are produced. The R/D Converter decodes the phase difference between these voltages and the reference excitation and produces a digital value as the absolute angle of the resolver. The digital value will track to the shaft angle within a few milliseconds of power being applied.

The resolver has an absolute position reference point known as the zero position and can be changed by mechanically changing the shaft alignment between the resolver and the driving shaft. Resolvers which are an integral part of a brushless type motor cannot be changed because they are set at a position based on the commutation parameters of the motor.

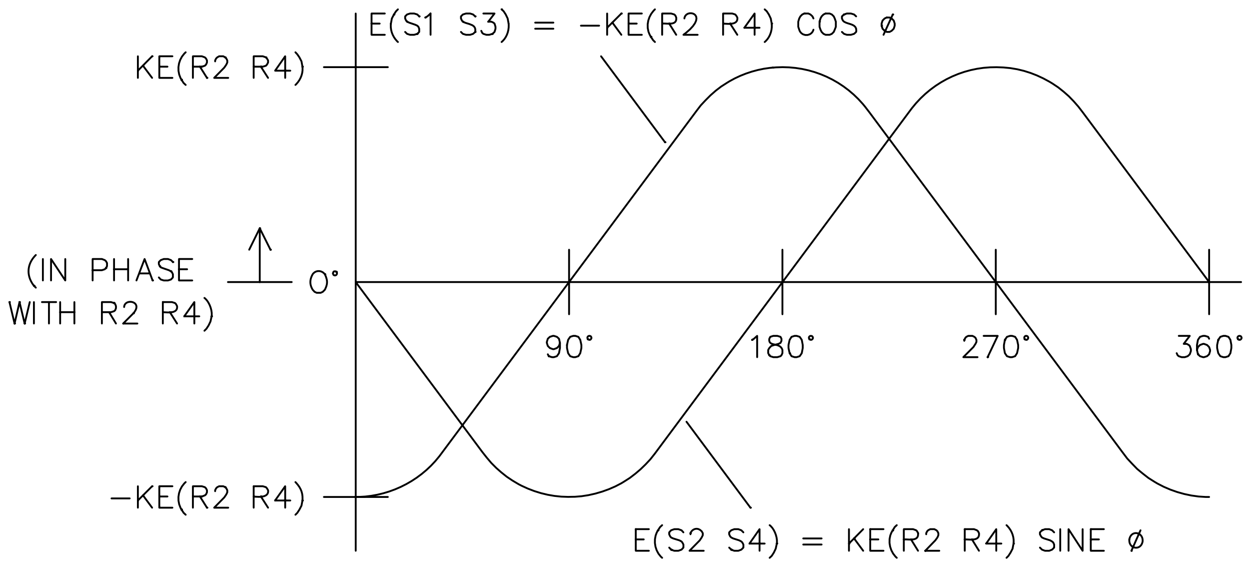

Figure 2-2 Resolver Output Voltages Relationship

2.3 Position Loop Control Functions

2.3.1 Overall Position Loop Description

The ACR-850 Resolver Axis Controller (Figure 2-3) is the heart of the position loop. 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 the feedback from the resolver. The command generator produces a command position which represents the speed, the acceleration rate, the direction, and the 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 that powers the motion device. The shaft of the motion device and the shaft of the resolver are mechanically connected. As the resolver turns to this new position, the actual position (feedback signal) once again matches the command position 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 resolver shaft and the commanded position is known as the following error voltage.

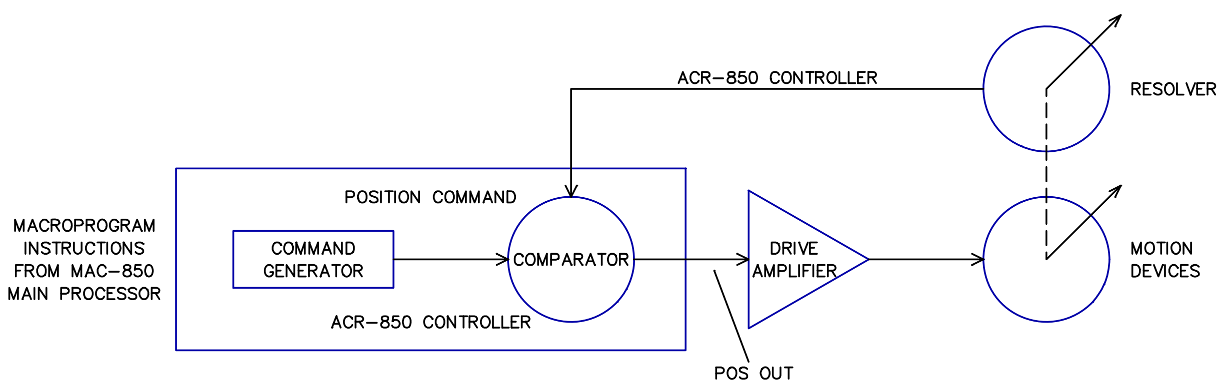

Figure 2-3 Position Loop Block Diagram

2.3.2 ACR-850 Resolver Axis Controller Description

The controller (Figure 2-4) is a microprocessor based board running under the control of a unique IIS operating system. The analog signals from the resolver are digitized by an on-board Resolver to Digital (R/D) Converter. Instructions from the Macroprogram running in the MAC-850 Main Processor (Figure 2-1) send data over the Command Bus (C-Bus) to configure the command generator of the controller. The 24-bit wide digitized signals from the R/D Converter and the output of the command generator are parallel processed. The microprocessor with its operating system perform the multiple functions of position command generation, comparator, and PID digital compensation to produce the POS OUT signal. With the standard default gain in the digital compensation algorithm, the POS OUT voltage is +/-5 Volts (ccw versus cw respectively) at the 90 degree position of the resolver shaft and +/-10 Volts at the 180 degree position.

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 POS OUT signal of 20 Volts per 1/16th of a turn of the resolver shaft to 20 Volts per 16 turns of the resolver shaft. Refer to the Macroprogram Development System Instruction Book for further information about the setting for the digital compensation values.

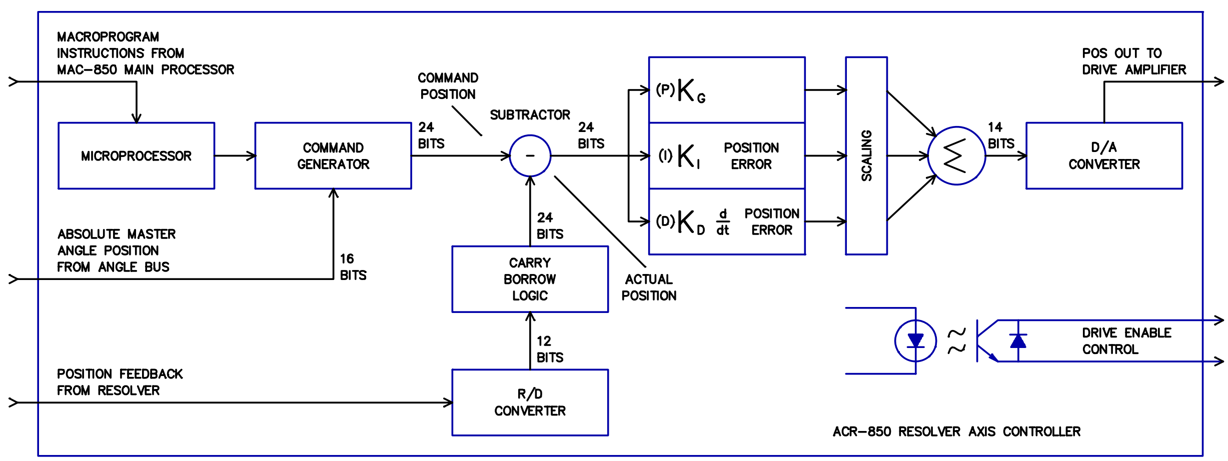

Figure 2-4 ACR-850, Functional Block Diagram

The controller can communicate over 2 Angle Buses located on the motherboard in the System Unit for a master/slave relationship. The controller can be designated as the master controller (talker) by the Macroprogram or the controller can be a slave controller (listener) as directed by the Macroprogram. 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.

As a passive position sensing device, the controller can be used to monitor the motion of other machines. 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 angle of the resolver. Zero volts is zero degrees on the resolver shaft. The transition from +10 Volts to -10 Volts represents 180 degrees angle of the resolver. Any time the System Unit is powered up the Macroprogram can obtain the absolute position and speed of the resolver shaft.

When 'drive_on' 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 signal being monitored is connected to the input module which optically 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.

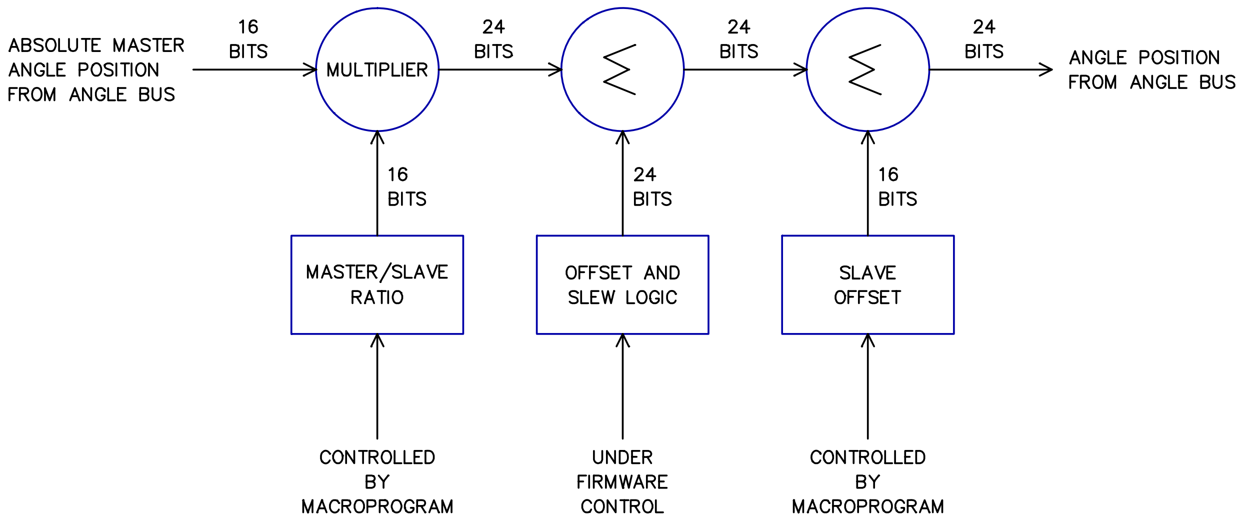

Figure 2-5 Electronic Gearbox Command Generator

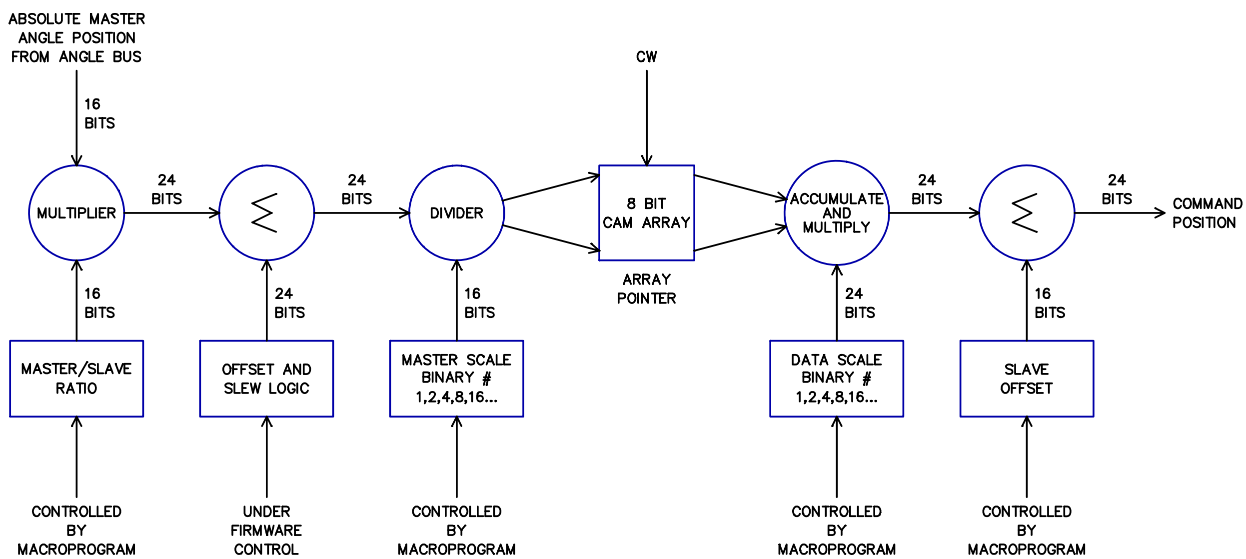

Figure 2-6 Electronic Cam & Gearbox Command Generator

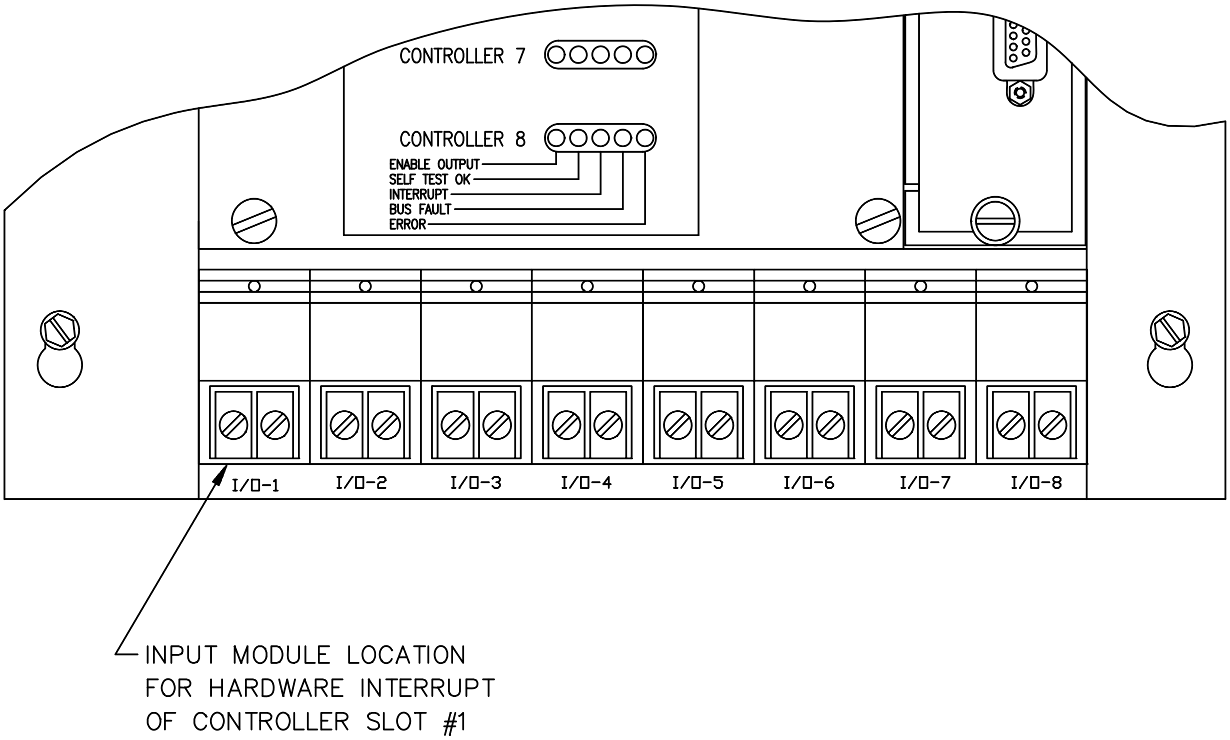

Figure 2-7 On-board I/O Module to Controller Slot Relationship

2.5 Status and Fault Indicators

2.5.1 Power-up Fault Detection

On power-up, the controller's microprocessor, memory, and multiply/divide circuit are put through a series of tests. If the controller passes the 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 in the controller. A start-up retry should be attempted and if the same combination of indicators are lighted, then the controller can be suspected as being faulty.

2.5.2 Operational Fault Detection

The ACR-850 Resolver 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;

- If no motion is commanded, the controller will not allow the resolver to be more than 17 degrees from its commanded position.
- If motion is commanded, the controller will not allow the resolver to be more than 180 degrees from its commanded position.

The following error limits of 17° and 180° are "GAIN" depended limits. When the "GAIN" is modified by the macroprogram, the following error limits are adjusted automatically. The default values of 17° and 180° correspond to the default "GAIN" value of 16. See the Macroprogram Development System Instruction Book on how to modify the "GAIN" using the digital compensation instruction referred to as 'digi-comp'.

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 a 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 the controller or main processor is detected, the BUS FAULT indicator will come on.

If, during normal operation, a following error fault is detected, the ERROR 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 (POS OUT)	+/-10V dc @ 10mA
Digital Compensation	PID loop with 1KHz Digital Signal Processing Sample Rate
Feedback Device	Brushless Resolver (Control Transmitter type)
Resolver Reference Signal	2.6 KHz @ 8V RMS
Resolver Feedback Signals	8V RMS Differential input

3.2 Performance Characteristics

Positional Range	+/-2047 Revolutions in 1/4096 revolution increments
Positional Absolute Accuracy	+/-10 min of arc
Positional Repeatability	+/-5 min of arc
Acceleration/Deceleration Range	0.004 to 800 revolutions/sec/sec
Speed Range	0.004 to 3600 RPM in 1 RPM increments +/-1% accuracy of set speed
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 ACR-850 Resolver 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 ACR-850 Resolver Axis Controller. All parameters and functional control are established by the Macroprogram.

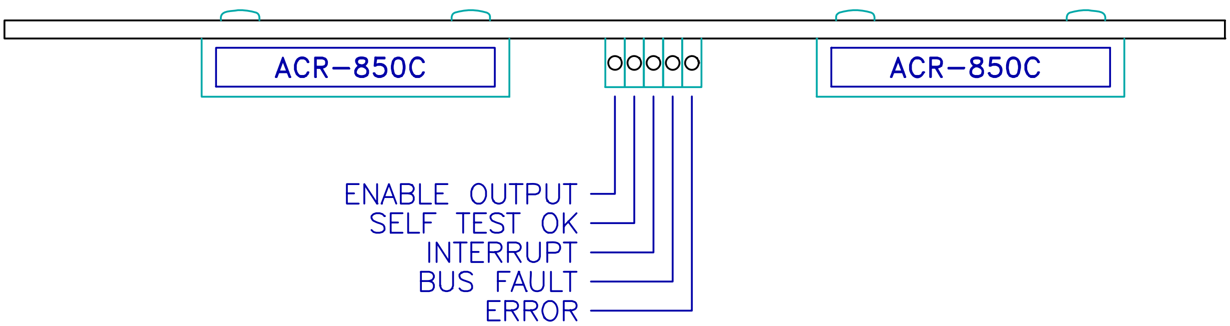

Figure 4-1 Identification of Status Indicators

PANEL MARKING	DESCRIPTION	OBSERVED INICATION	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.
		Flashing	The controller is executing self tests.
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.

Table 4-1 Description of Indicators

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

The position loop, consisting of the ACR-850 Resolver Axis Controller and the resolver, 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 resolver counterclockwise.

The Overall Trouble Shooting Chart (Figure 5-1) provides 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 ACR-850 Resolver Axis Controller is functioning properly, it is first necessary to determine 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 ACR-850 Resolver 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.

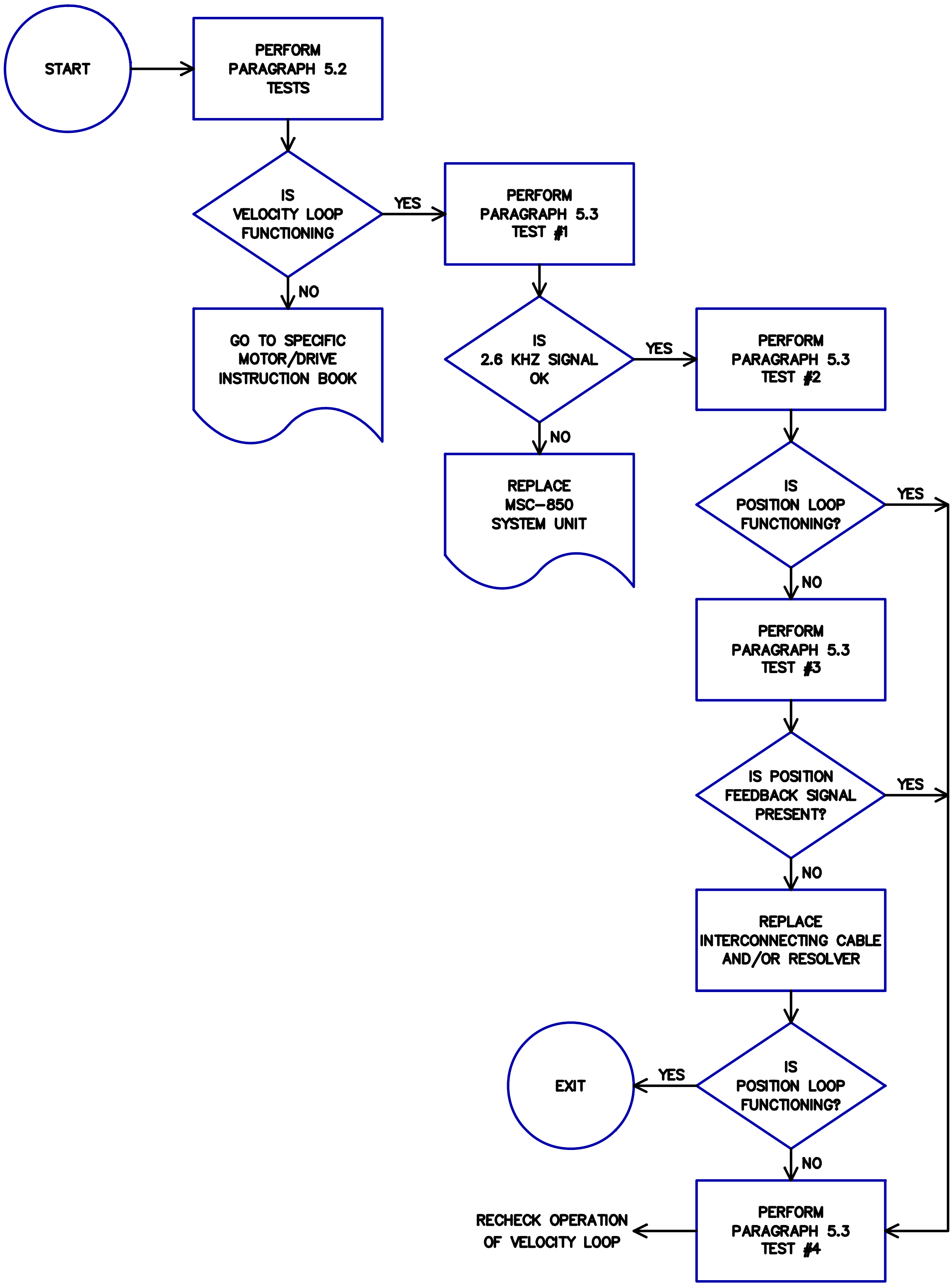

Figure 5-1 Overall Trouble Shooting Chart

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.

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 P2 from ACR-850 Resolver Axis Controller in the System Unit.
3. Connect a jumper between P2-13 (Figure 5-3) (green wire) and P2-14 (white wire).
4. Apply power to the system.
5. Motion device should be at rest. A small amount of 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 pins 10 and 11 of the P2 connector (Figure 5-3) respectively. 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 should quickly decelerate to a stopped position.
9. Reverse the meter leads at pins10 and 11 of the P2 Connector. The shaft of the motion device should rapidly accelerate in the clockwise direction.
10. Now remove either meter lead and observe the shaft of the motion device. The shaft should quickly decelerate to a stopped position.
11. Remove jumper and Multimeter leads.
12. 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 5.3.1, test #1.

5.3 Indicators

The postion loop (Figure 5-2) functional tests consist of four parts. The first test checks out the 2.6 KHz Resolver Reference Signal being generated in the System Unit. The second test checks out the overall control of the position loop. If the overall control test fails at any time during the procedure, go directly to the third test which determines whether the problem is in the resolver, the controller, or the interconnecting cable. The fourth test checks out the mechanical components such as bearing, etc.

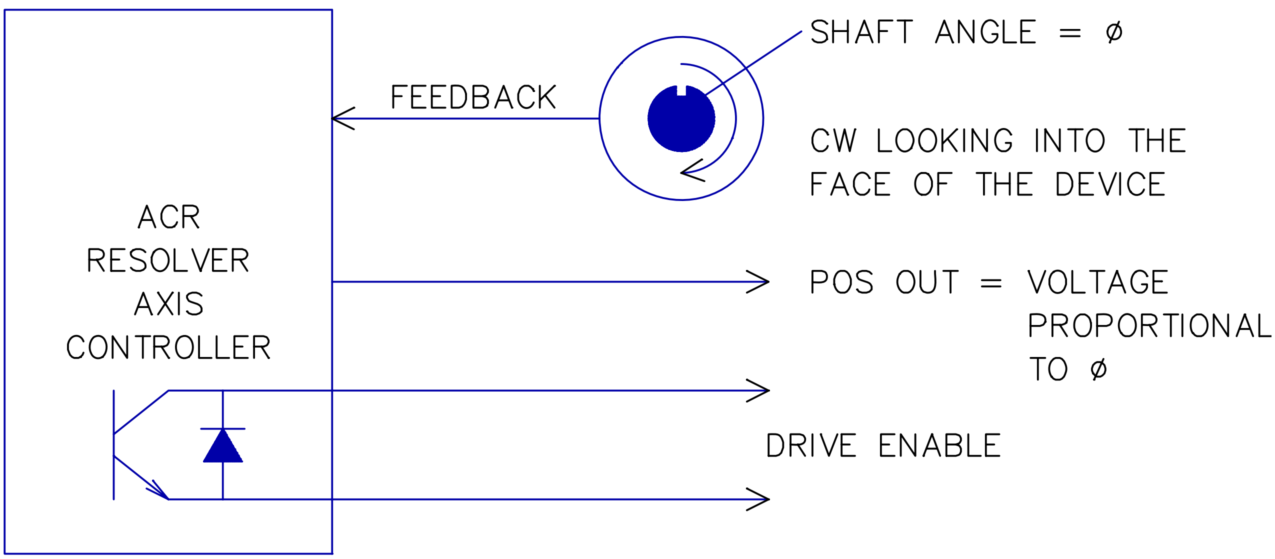

Figure 5-2 Position Loop Components

5.3.1 Test No. 1

This test checks the 2.6 KHz signal coming from the motherboard in the System Unit. If this test fails, replace the System Unit before running the rest of the tests.

1. Turn off power to the system.
2. Remove the 6 pin connector from the ACR-850 controller in the System Unit.
3. Apply power to the system.
4. Set a Multimeter on the 10V-ac scale.
5. Connect the meter leads to P2-7 and P2-8 (white and black wires of cable, Figure 5-3).
6. The meter should intricate 8V ac +/-1V ac.
7. If an out of specification reading is obtained, remove P2 from the controller and connect the meters leads to J2-7 and J2-8 on the controller.
8. The meter should indicate 8V ac +/-1V ac.
9. If an out of specification reading is still obtained, replace the MSC-850 System Unit. If readings are correct, go on to the resolver test in paragraph 5.3.3.

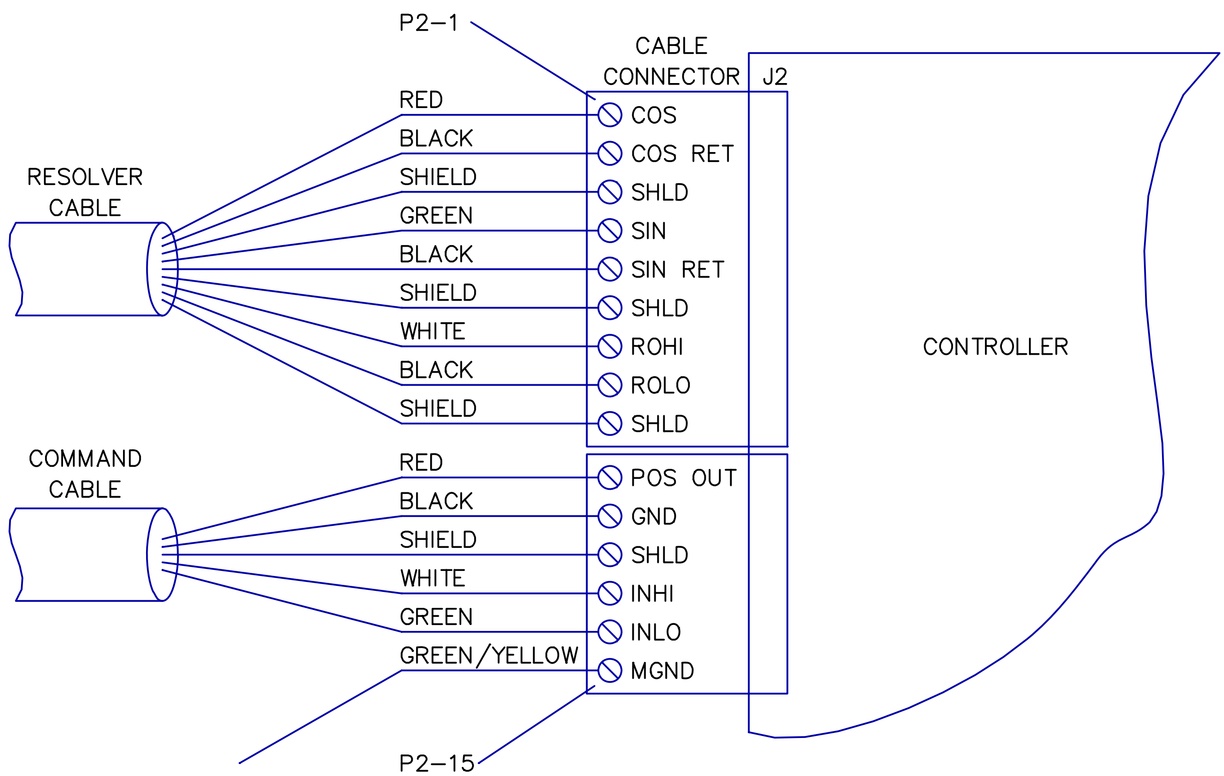

Figure 5-3 Connecting Meter Leads to Plug Pins

5.3.2 Test No. 2

This test checks out the controller, resolver, and interconnecting cable by having the controller read the resolvers output and by the controller providing an output voltage that is proportional to shaft angle. If any of these tests fail, perform the test in paragraphs 5.3.3 to determine the faulty component within the position loop.

1. Turn off power to the system.

2. Remove the 6 pin connector P2 from the ACR-850 Resolver Axis Controller in the System Unit.

3. Apply power to the system.

4. lace the MSC-850 System Unit in the test mode (refer to the Instruction Book for the Macroprogram Development System).

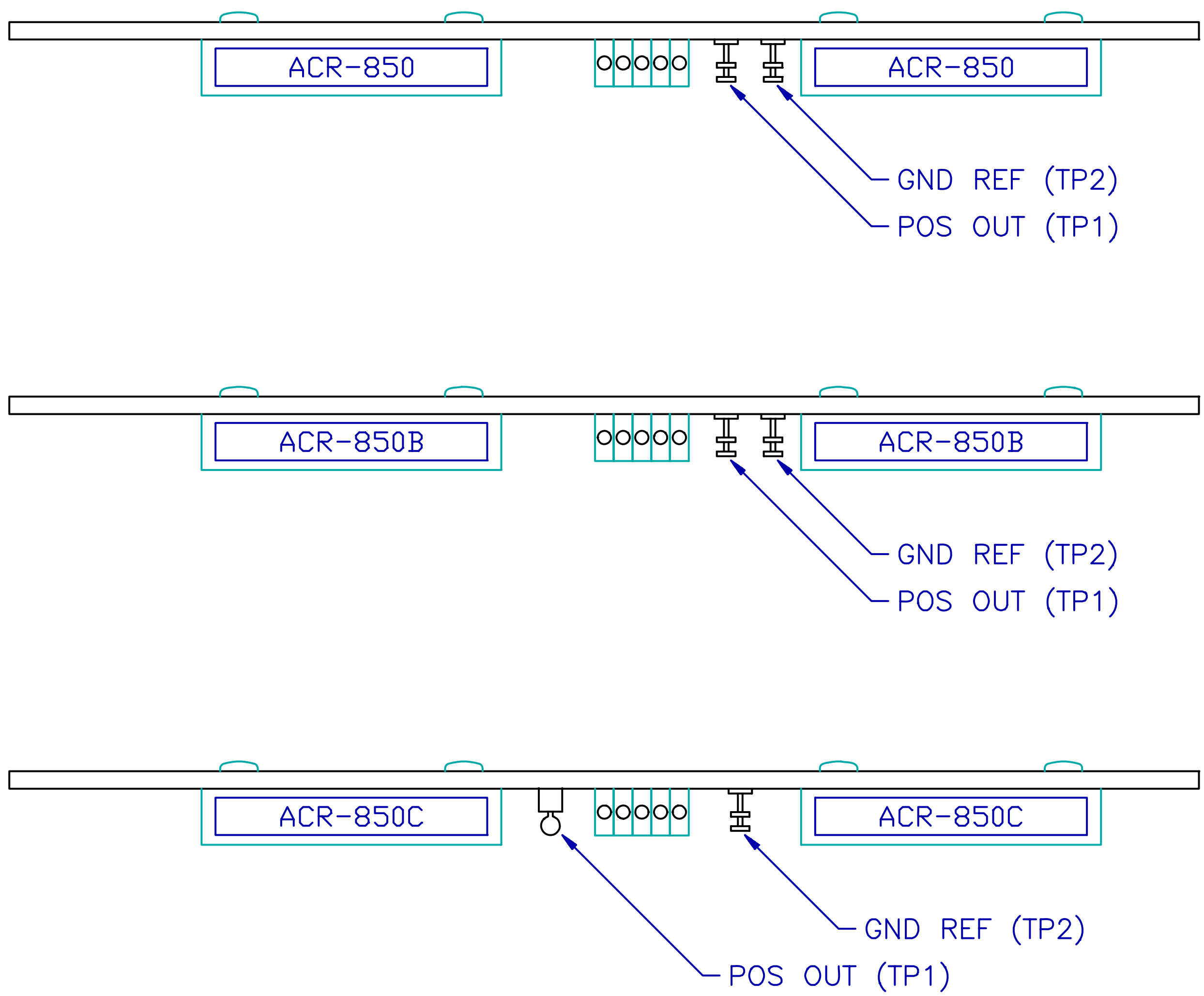

Figure 5-4 Location of Tests Points TP1 and TP2

5. Set Multimeter on the 10V-dc scale.

6. Connect the red and black meter leads to test points TP1 (POS OUT) and TP2 (GND) respectively (Figure 5-4).

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

8. Rotate the motor shaft clockwise 1/4 turn while observing the meter. The voltage 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 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.

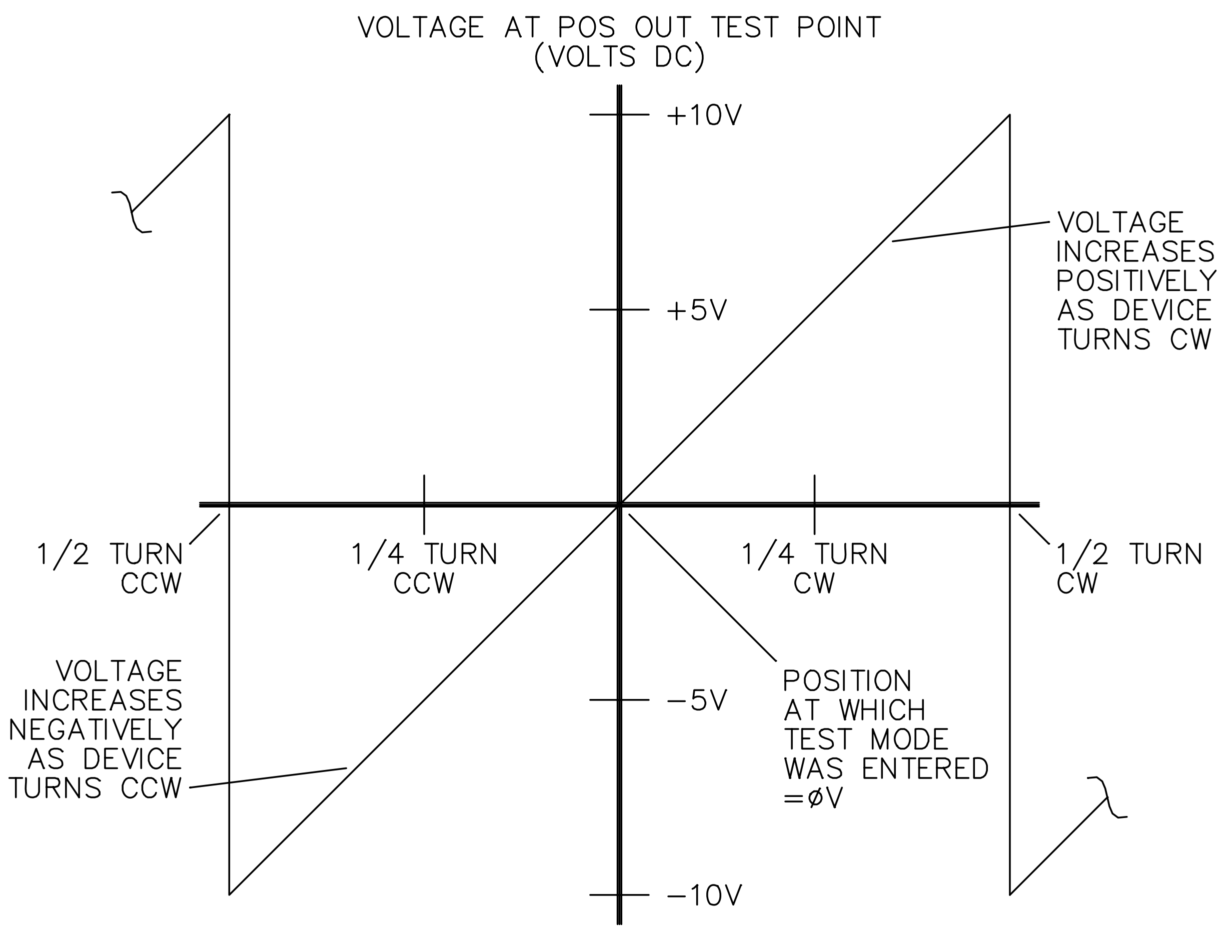

Figure 5-5 Voltage Versus Resolver Displacement Chart

5.3.3 Test No. 3

This test checks the operation of the resolver. If the test passes, replace the controller. If the test fails, replace the interconnecting cable and rerun the test. If the test still fails, replace the resolver..

1. Turn off power to the system.
2. Remove the 6 pin connector P2 from the ACR-850 controller in the System Unit.
3. With the 9-pin connector P2 connected to the controller, connect the meter leads to P2-1 and P2-2 (Figure 5-3).
4. Apply power to the system.
5. While observing the meter, rotate the motor shaft one full revolution. The voltage should rise to 8V ac +/-2V ac and fall to less than 1V ac twice per revolution.
6. Turn off power to the system.

7 With P2 connected to the controller, connect the meter leads to P2-4 and P2-5 (Figure 5-3).

8. Apply power to the system.
9. While observing the meter, rotate the motor shaft one full revolution. The voltage should rise to 8V ac +/-2V and fall to less than 1V ac twice per revolution.
10. Turn off power to the system.
11. Remove 9 pin connector P2 from the controller.
12. Apply power to the system.
13. Set the multimeter on the low Ohms scale for measurements of 300 Ohms or less.

NOTE

There are three sets of coils in the resolver. Steps 14, 15 and 16 check out all three coils and their related conductors in the interconnecting cable. In each step, check for a reading of somewhere between 20 Ohms and 300 Ohms.

14. Connect the meter leads to P2-1 and P2-2 and read the meter.
15. Connect the meter leads to P2-4 and P2-5 and read the meter.
16. Connect the meter leads to P2-7 and P2-8 and read the meter.
17. Set multimeter on high Ohms scale for measurements greater than 10K Ohms.
18. Measure P2-1 then P2-9 for greater than 10K Ohms to the MSC Ground Strip (Figure 6-1).
19. Measure P2-1 then P2-9 for 10K Ohms or greater between any two pins on the connector.

5.3.4 Test No. 4

This test checks the mechanical components of the Motion Control System.

1. Check for possible intermittent wiring faults.

2. Check for loose mechanical coupling between motor and positional feedback resolver.

3. Check motor brushes, if applicable.

4. Make sure that the system frictional load on the motor has not changed.

5. Do the set-up procedure outlined in the Instruction Book on the specific motor/drive package for the system.

NOTE

Remove all meter leads and connect all cable connectors removed during testing before reapplying operational power.

6.0 CONNECTION DIAGRAMS

6.1 General

This section contains the electrical connections for the controller to resolver and controller to drive amplifier for both brush and brushless type motors (Figure 6-1).

Good grounding of the controller is essential for proper operation. Figure 6-2 illustrates the MSC Ground Strip typical location to which P2-15 must be connected.

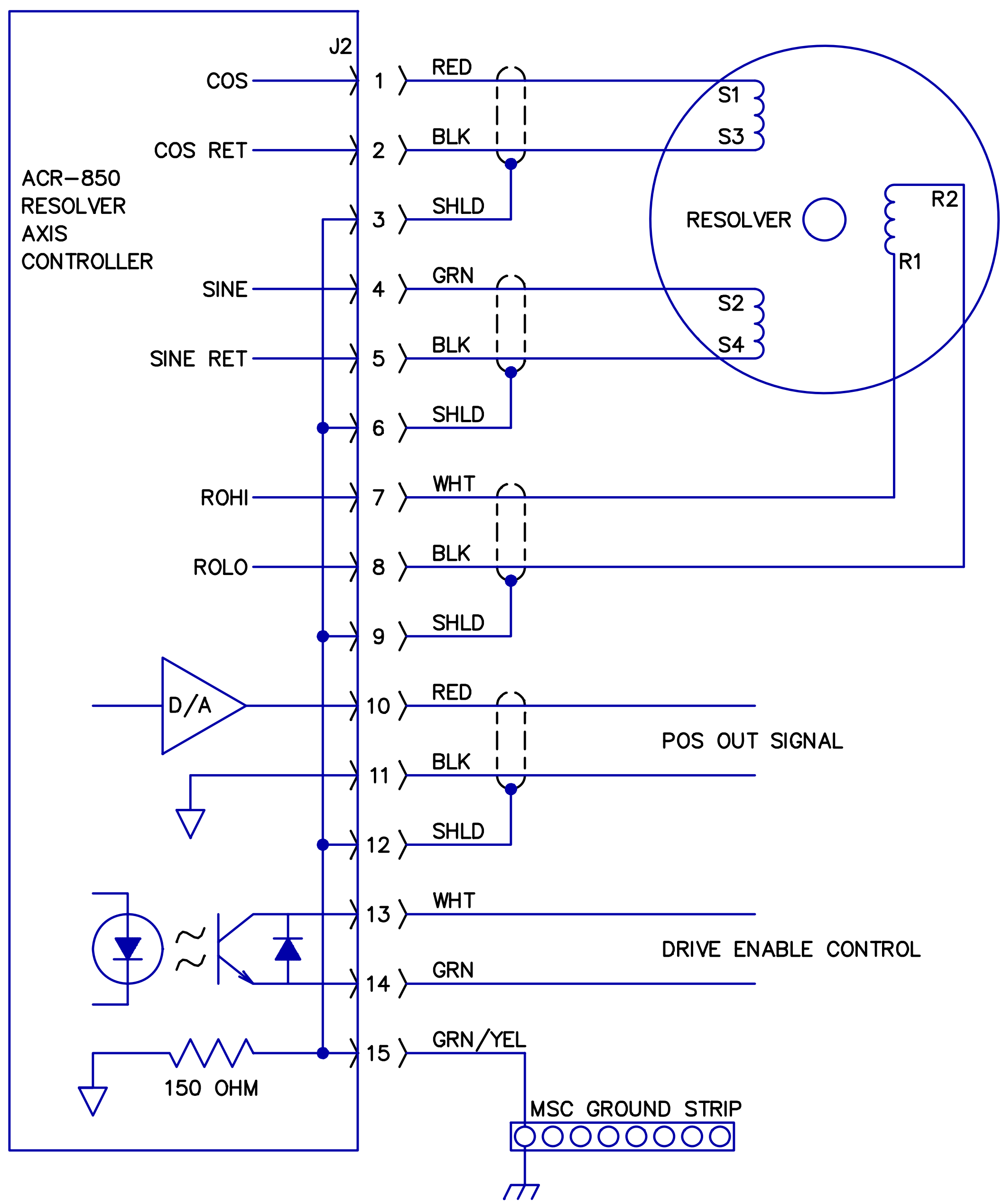

Figure 6-1 ACR-850 Controller, Electrical Connection

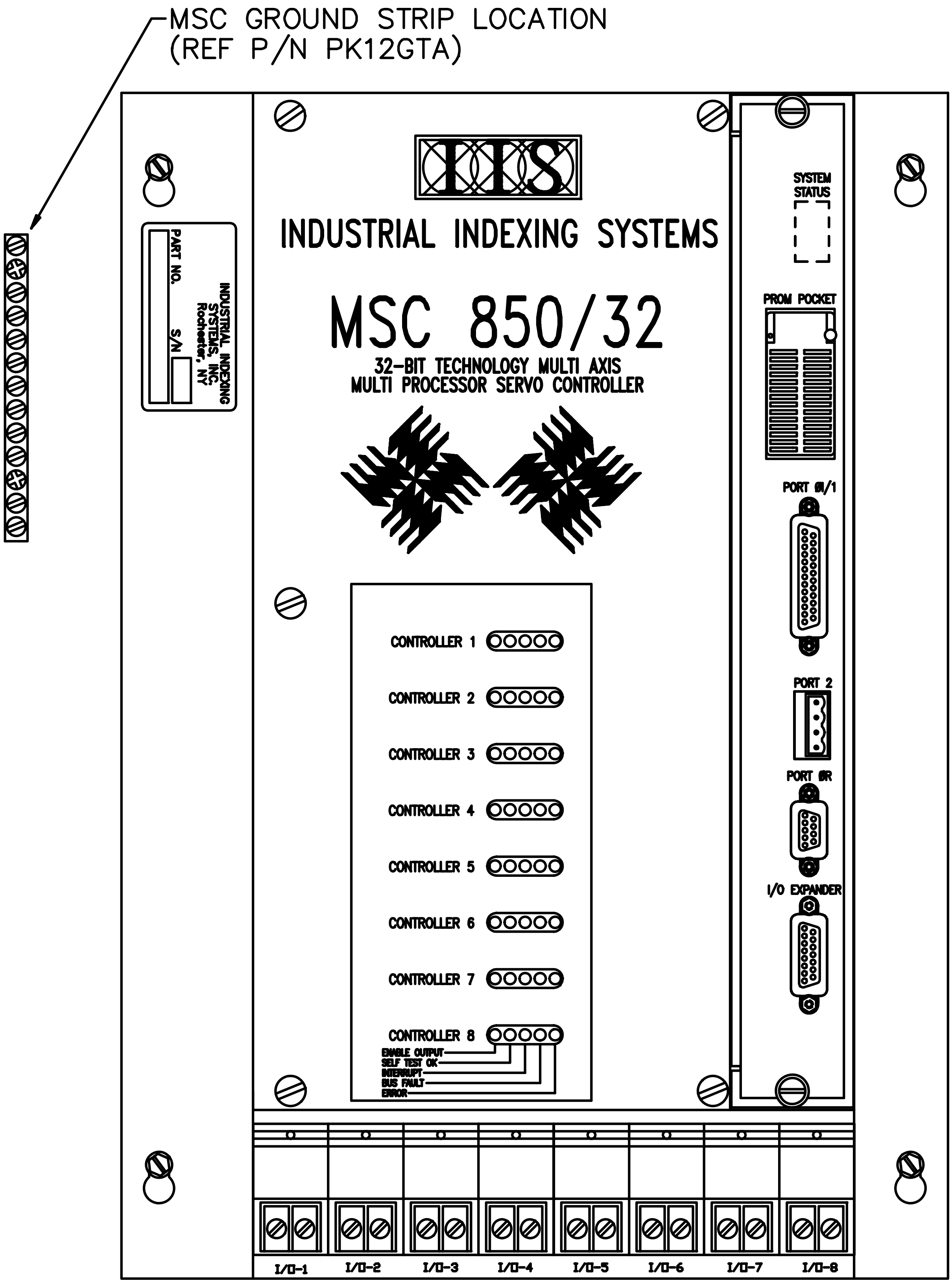

Figure 6-2 MSC Ground Strip

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