MSC-250 2½-AXIS SERVO CONTROLLER

USER'S GUIDE

INDUSTRIAL INDEXING SYSTEMS, Inc.

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1) Added Appendix C - Declaration of Conformity

2) Section 1, page 1-22, dated February 1999, supersedes Section 1, page 1-22 dated August 1998.

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INTRODUCTION

The Industrial Indexing Systems Motion Control System MSC-250 is a microprocessor-based, position-loop controller. It is a dual 32-bit technology, 2½-axis, closed-loop controller that works with separate servo drives, motors, and encoder feedback devices to accurately fix the position of the motor shafts.

The MSC-250 controller is part of the MSC family of controllers and peripheral equipment produced by Industrial Indexing Systems. It uses the same Macroprogram control language already familiar to users of the MSC-850 family of controllers and is fully compatible with this family of controllers.

This manual describes proper installation, operation, and troubleshooting procedures for the MSC-250 controller. The manual assumes no prior knowledge of Industrial Indexing System equipment. It does assume knowledge of proper mechanical, electrical, and electronic maintenance and safety procedures. If the equipment is used in a manner not specified in this manual, the protection provided by the equipment may be impaired. Information in this manual is subject to change without prior notification.

The manual uses a variety of highlighted blocks to emphasize important information. Always pay careful attention to this information. The types of highlighted blocks used are:

> ## WARNING
> **USED TO ALERT THE READER TO ACTIONS OR CONDITIONS WHICH MIGHT PRESENT HAZARDS OR CAUSE INJURY TO PERSONNEL.**

> ## CAUTION
> **USED TO ALERT THE READER TO ACTIONS WHICH MIGHT CAUSE LOSS OF MATERIALS OR DAMAGE TO EQUIPMENT.**

> ## NOTE
> **Used to identify unusual or unexpected conditions or to point out the need for alternate procedures. It is also used for emphasis when a CAUTION or WARNING is not required.**

This manual describes the controller and some related devices. For completeness, this manual also describes various aspects of related feedback devices and drives. However, as sold, the MSC-250 controller only includes the controller, a line cord, and manual. All other items are optional — and must be specified separately — to allow total design flexibility. Connecting cables can be specified with any desired length (although there are

some limits on communication and feedback cable lengths) or with just connectors and no cable for user assembly.

Industrial Indexing Systems fully supports all equipment it manufactures and supplies. If there are any problems with this equipment or if assistance is required for installation or operation, contact our Integrated Technical Services Department.

Assistance and training is available in our factory, for a fee. In addition, Industrial Indexing Systems can custom configure controllers for O.E.M. applications.

SECTION 1 – DESCRIPTION

The Industrial Indexing Systems MSC-250 is a microprocessor-based, position-loop servo controller. It is a dual 32-bit technology, 2½-axis, closed-loop servo controller that works with separate servo drives, motors, and encoder feedback devices to accurately fix the position of the motor shaft.

1.1 INDEXING DRIVE SYSTEM OVERVIEW

An indexing drive system (or indexing system) may be used in a variety of applications where accurate movement or positioning is required. A basic single-axis system consists of eight main components as illustrated in **Figure 1.1**.

1. Input Device: The input device provides data to the controller. It is the interface between the operator (or system computer or programmable logic controller) and the indexing system. In a given system, there may actually be several input devices.

2. Controller: The controller receives data from the input device and issues commands to the drive. It also accepts information from the feedback device. The programming and settings of the controller determine what types of commands are issued to the drive in response to the data inputs and feedback.
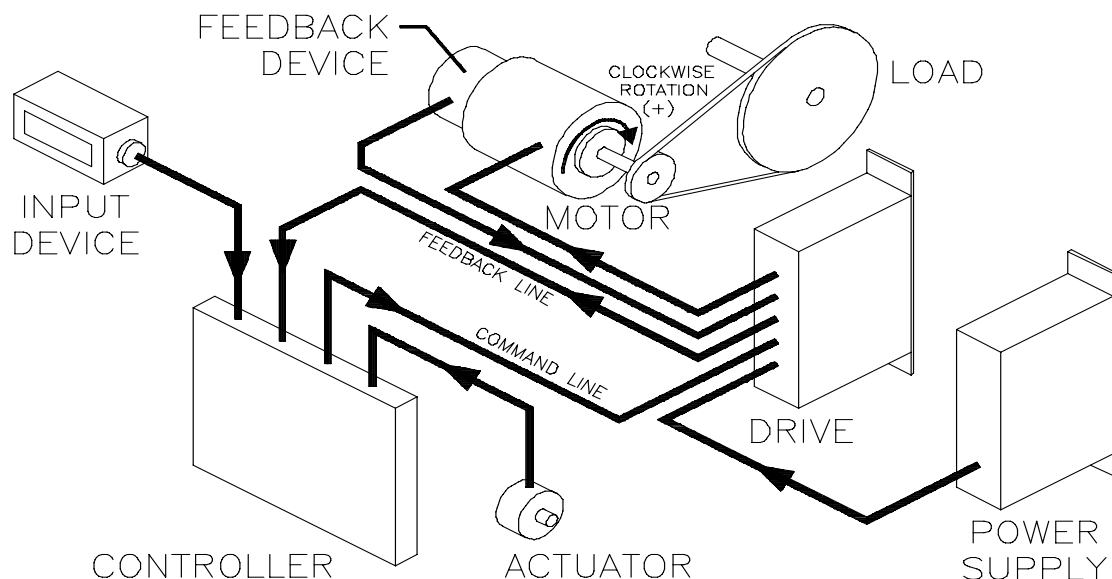
Figure 1.1 - Basic Indexing System

3.   Actuator: The actuator supplies the signal which causes the controller to initiate the specified sequences. It may be a separate device or part of a computer program from the Input Device.

4.   Power Supply: The power supply converts AC input power into DC power and conditions this secondary power so it can be used by the drive.

5.   Drive: The drive (also called a servo-amplifier) amplifies a low voltage velocity command signal from the controller into the necessary voltage and current to cause the motor shaft to rotate. The amount of power and polarity (positive or negative) of the voltage supplied to the motor is determined by the command signals from the controller.

6.   Motor: The motor is the device being controlled by the indexing system. The system controls the amount and speed of motor shaft rotation.
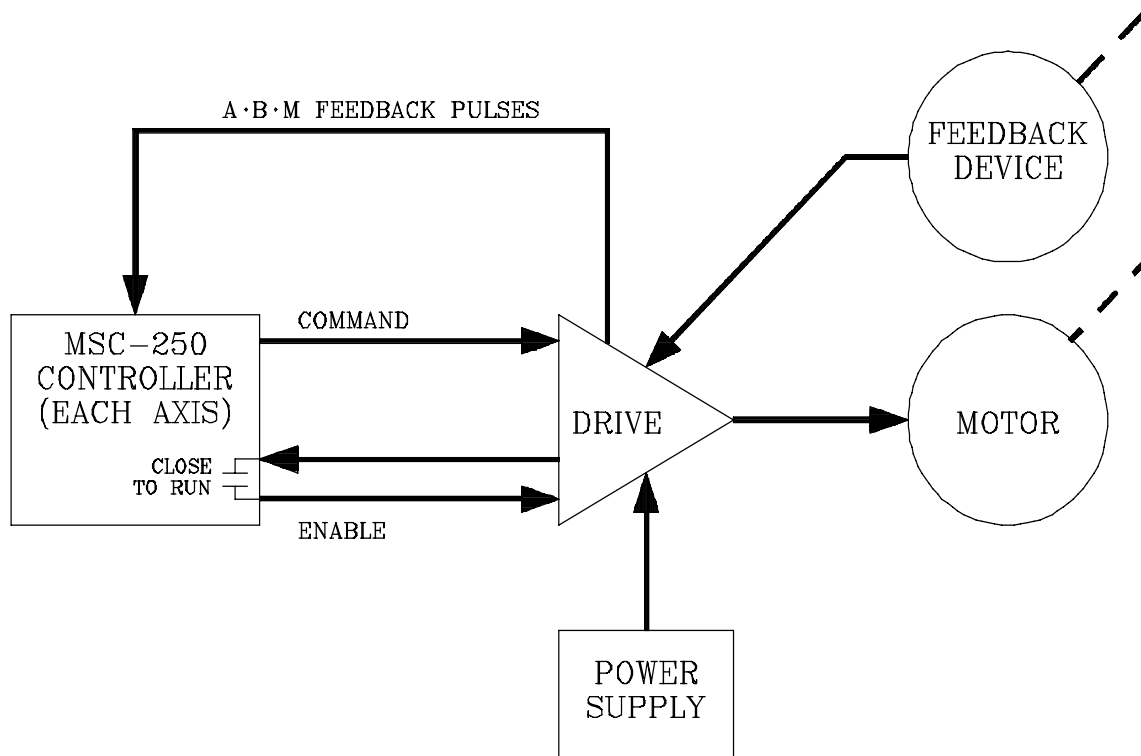
Figure 1.2 - Position Loop

7.   Load: The load is the object of the motion. It absorbs the work
                           energy of the motor.

8.   Feedback Device: The feedback device (always a shaft encoder or equivalent
                          A×B×M signal device with the MSC-250 servo controller)
                          monitors the position of the motor shaft and sends this
                          information to the controller. (Refer to Section 1.2.1.1 for
                          additional details on the feedback device.)

The objective of the indexing system is to accurately control the position and speed of
rotation of a motor shaft at any given time. This control may be used to move the load a
specific distance (index) or to a specific location (position). It also may be used to move
the load in a pattern duplicating the motion that would be produced by the action of
mechanical cam, remembering that motion can occur in both clockwise and
counterclockwise directions.
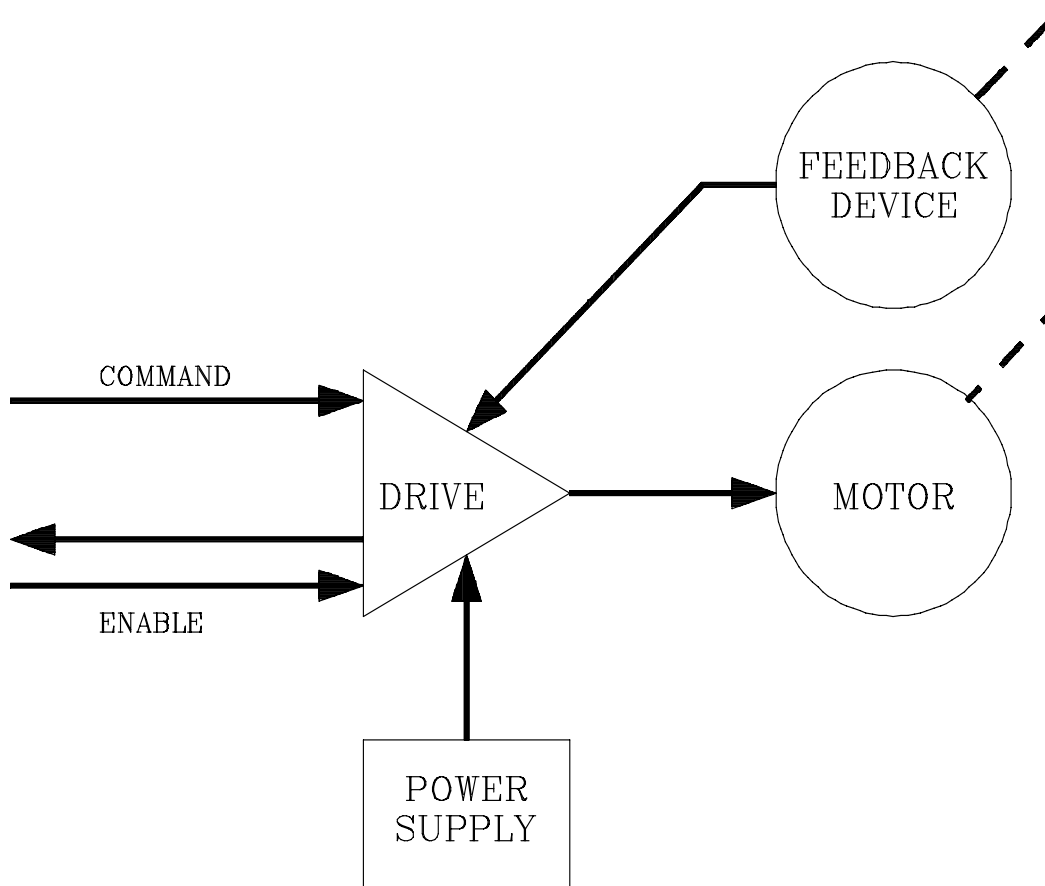
Figure 1.3 - Velocity Loop

The components of the basic indexing drive system form two information loops. The position loop is a closed-loop which consists of the controller, drive, motor, and feedback device. The controller, continually compares motor position, derived from the feedback pulses received from the drive, with the desired position calculated within the controller. Any difference between calculated position and actual position results in a corrective command signal being sent to the drive. The drive then corrects motor position by adjusting its velocity loop. The objective of the position loop is to keep the actual position equal to the commanded position.

The velocity loop is also a closed-loop system. The drive continually compares motor velocity, derived from the feedback device, with the magnitude of the command signal generated by the controller. Any difference causes the drive to alter the current to the motor, which in turn changes the motor velocity. The objective of the velocity loop is to keep actual velocity equal to commanded velocity.

The position loop and velocity loop are independent loops, but the controller uses the velocity loop to achieve movement to the desired position. When data is received by the controller specifying a movement, the controller calculates the time required to accelerate to maximum speed and to decelerate from maximum speed. It then calculates the time at maximum speed necessary to complete the movement. This information is then transmitted to the drive by the controller.

1.2   SYSTEM FUNCTIONS

The MSC-250 servo controller can simultaneously and independently regulate two motion axes. Programming of the motion control is supplied by a separate computer program or by a pre-programmed PROM (Programmable Read-Only Memory). Once loaded, the program is stored in non-volatile memory in the controller.

The controller uses two processors. One processor is labeled "Main Microprocessor" and the other is labeled "Axis Microprocessor" (refer to "Section 1.3 - Components"). These two processors communicate through two kilobytes of dual-port RAM (Random Access Memory) for maximum processing and communication speed. (Dual-port RAM is memory which is mapped in the same location on each processor and is simultaneously accessible by both processors.) The main microprocessor processes information from the operating program, communication ports, and I/O (Input/Output) modules. The axis microprocessor processes information from the feedback devices and sends commands to the drives.

NOTE

All operating commands used by the MSC-250 servo controller are part of the Industrial Indexing Systems' Macroprogram command language. Refer to the separate *Macroprogram Development System Instruction Book* for detailed information on the actual commands and use of Macroprogram control.

1.2.1   AXIS CONTROL

The MSC-250 can control one or two motion axes, providing precision position-loop control to each axis. The controller can provide indexing, positioning, cam following, and profiling control. It can also be used as a passive position sensing device. A third axis (referred to as a half axis) can only monitor information received from a master axis or controller or from the pseudo axis. It does not provide any control functions.

Each full axis can be controlled directly from the Macroprogram or can act as a slave, referencing its motion from angles supplied over the two Master Angle Buses provided in the controller. The information on the angle bus can come from one of five sources:

a. A pseudo-axis (internal) provided by the controller
b. A real axes
c. Another controller with angle information supplied through the fiber optics receiver
d. A master resolver with angle information supplied through the fiber optics receiver
e. A master encoder with angle information supplied through the fiber optics receiver

---

1.2.1.1   Position Feedback

Instructions from the Macroprogram provide the parameters for indexing and positioning. This motion information is processed and converted into voltage information which is sent to the drive to cause the motor to rotate to a desired position. At the same time, the encoder, which is mechanically connected to the motor shaft, sends information to the processor which indicates the actual position of the motor shaft. The difference between the actual position of the motor shaft, as indicated by the encoder, and the commanded position is called the "following error".

The feedback device is an A·B·M shaft encoder or electronic equivalent. The MSC-250 will accept inputs from a variety of encoders, but each drive system and its corresponding Macroprogram must be designed around a specific encoder line count.

WARNING

WHEN A SHAFT ENCODER IS REPLACED, ALWAYS USE AN IDENTICAL ENCODER. IF A DIFFERENT ENCODER LINE COUNT IS USED, THE MACROPROGRAM MUST BE REVIEWED AND POSSIBLY REVISED BEFORE THE SYSTEM IS OPERATED. FAILURE TO CORRECTLY MATCH THE MACROPROGRAM TO THE ENCODER BEING USED MAY RESULT IN IMPROPER SYSTEM MOVEMENT WHICH COULD CAUSE EQUIPMENT DAMAGE AND POSSIBLE PERSONAL INJURY.

The encoder produces current loop pulses of approximately 10 mA per channel. There are three channels.   Channels A and B are quadrature encoded with channel A leading channel B by 90° for clockwise shaft rotation. Channel M provides a marker once per encoder revolution. The pulses are square-wave signals (refer to **Figure 1.4**).

NOTE

On some encoders, channels A and B are designated channels 1 and 2. Always connect encoders so the leading channel for clockwise rotation is connected to channel A while the second quadrature channel is connected to channel B. The marker channel is always channel M (or "3" or "Z").

Each edge (change in state) of the quadrature-encoded square waves is counted by an interface circuit. Thus, the change from low to high is one edge and the change from high to low of the same pulse is a second edge. The counting of edges plus the 90° offset of the two pulse streams provide position and direction sensing with a resolution equal to four times the encoder line count. Other line counts can be used with software scaling of parameters.
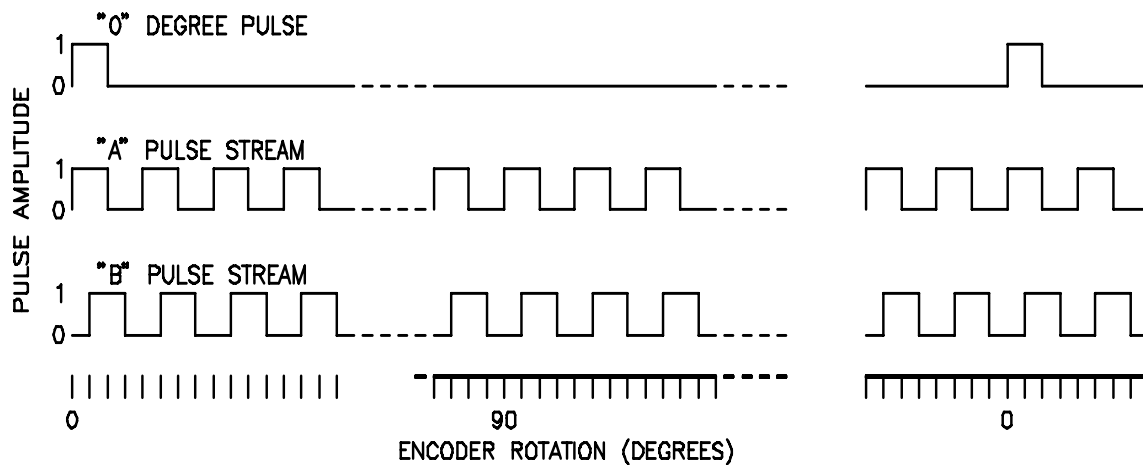
Figure 1.4 - Typical Encoder Pulse Patterns

Encoders may have different line counts per one revolution of the encoder. This line count is an important factor in determining 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 reduced. The standard line count assumed by the MSC-250 controller and the Macroprogram software is 1024 pulses per revolution.

> **NOTE**
>
> **To use encoders with line counts other than 1024, the values for RPM and acceleration must be properly scaled to provide accurate motor shaft movement (refer to the *Macroprogram Development System Instruction Book*).**

The marker provided by channel M is also a square-wave signal. However, different encoders use markers of varying duration. The marker bit may go high (positive amperage) for a single pulse width, for 90° of encoder shaft revolution, or for 180° of encoder shaft revolution. When this pulse goes high in a clockwise rotation (or low in a counterclockwise rotation), the controller uses the state change to mark the "0.00" absolute reference point.

The encoder is not an absolute position sensing device. When first powered up, the encoder shaft position in its rotation cannot be determined until the marker bit is recorded. Rather, the position at power up is referred to as "local mode home" or "0.0" as opposed to absolute 0.00. The controller can determine actual movement from this local home position by counting pulses.

When the absolute position of the system must be known, the system must be initialized after it is powered up. For encoders with marker bits less than 180° of encoder shaft rotation, use the **find_mark_cw** and **find_mark_ccw** commands to initialize the system and determine the absolute system position. For encoders with marker bits of 180° of encoder shaft rotation, use the **find_tm_cw** and **find_tm_ccw** commands. (Refer to the *Macroprogram Development System Instruction Book* for complete command instructions.)

NOTE

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.

1.2.1.2   POS OUT Signal

The position of the encoder, as understood by the controller, is translated into a "POS OUT" voltage signal based on a digital compensation gain algorithm. This algorithm has four variable components of Proportional Gain, Integral Gain, Derivative Gain, and Feed Forward Gain values which respectively represent the Proportional, Integral, Derivative, and Feed Forward terms of the algorithm.

With standard values of Proportional Gain = 16, Integral Gain = 0, Derivative Gain = 0, and Feed Forward Gain = 0, the POS OUT voltage signal is +5 VDC at the 90° encoder shaft position and +10 VDC at the 180° encoder shaft position for clockwise shaft rotation. The signal is -5 VDC at the 90° encoder shaft position and -10 VDC at the 180° encoder shaft position for counterclockwise shaft rotation. However, the Proportional Gain value can be set to produce a voltage signal of from 10 VDC per 1/32 revolution of the encoder shaft to 10 VDC per 8 turns of the encoder shaft. (Refer to the *Macroprogram Development System Instruction Book* for information on setting the digital compensation values.)

1.2.1.3   Pseudo Axis

The pseudo axis is an imaginary, perfect motor which can be controlled by the software of the MSC-250. The desired position of the pseudo-axis motor is determined by the Macroprogram and the resulting position signal perfectly reflects the desired position at any given time. This perfect-position information can then be used by the real axes as reference information for their own movements or it can be used to actuate programmable limit switches or other I/O functions. The pseudo axis information can be broadcast (transmitted) on either or both of the controller master angle buses.

1.2.1.4 Master Angle Buses

The MSC-250 controller has two master angle buses which can be used for reference by the real axes. The information on the two buses may be the same, although it is usually different, or the buses may not be used at all by the controller. These options are all programmable by the system designer. (Refer to the *Macroprogram Development System Instruction Book* for information on using the axis controller or fiber optic receiver as a slave and sending and receiving information on the master angle buses.)

When the master angle buses are used, the angle information on the bus comes from one of three sources:

1. As discussed above, the angle information on the bus may come from the pseudo axis generated by the Macroprogram. At any specific time, the information on the bus represents the angular position of the perfect motor controlled by the pseudo axis.

2. The angle information on the bus may come from the position of one of the MSC-250 axes, real or passive. This information is determined from the encoder information processed by the controller. Real axis information represents the actual position of the motor ¾ not the theoretical position ¾ and will reflect any differences in this position from the theoretical.

3. The angle information on the bus may come from another controller. This information is received at the fiber optics receiver and broadcast on the desired bus or buses based on the Macroprogram. This information may reflect a real axis or a pseudo axis. (Refer to the specific manuals for the MSC-850 Motion Control System family of products for information on using a controller as a master and sending the information over the fiber optic path.)

The real axes can receive reference position information from either master angle bus. The Macroprogram can also direct the axis to receive reference information from first one bus and then the other.

1.2.2 ANALOG INPUT/OUTPUT CHANNELS

The MSC-250 provides a 12-bit analog input/output subsystem which has one ±10 VDC input channel and one ±10 VDC output channel. This subsystem also provides one +10 VDC reference signal and one -10 VDC reference signal. These reference signals can be used as a voltage source for potentiometer inputs. (Refer to **"Section 2 - Installation"** for appropriate connection diagrams.)

The analog input channel may be used as either a single-ended (ground referenced unbalanced) channel or as a differential (isolated ground balanced) channel. Under Macroprogram control, the user may select an analog offset value and a maximum slew

rate value (refer to **Figure 1.5**). For each analog input cycle, the A/D (Analog-to-Digital) converter reading is added to the offset value. The rate of change of the resulting sum is limited by the slew rate value. This limited result is sign extended to a 32-bit value and made available to the Macroprogram.

The analog output channel provides a ±10 VDC output channel with its common referenced to controller ground. Under Macroprogram control, the user may select an analog offset value and a maximum slew rate for the analog output channel (refer to **Figure 1.5**). For each analog output cycle, the analog output value specified in the Macroprogram is added to the analog offset value and the slew rate limit applied. The resulting value is output to the D/A (Digital-to-Analog) converter.

A pair of voltage reference signals are available for connection to a potentiometer. Each reference provides nominally +10 VDC and -10 VDC and each can deliver up to 10 mA of current.

1.2.3 INPUT/OUTPUT MODULES

The MSC-250 controller has 16 on-board locations for I/O (Input/Output) modules (refer to **Figure 1.6**). In addition, two IOE-850 I/O Expanders of 16 positions each can be daisy-chained from the INPUT/OUTPUT EXPANDER PORT to provide an additional 32 I/O locations. Any of the 48 positions can be used for either an AC or DC input or output module.

When equipped with an input module, the controller will monitor the location for a specific change in state of the module, as directed by the Macroprogram, and will perform specific actions when the state change occurs.   When equipped with an output module, the
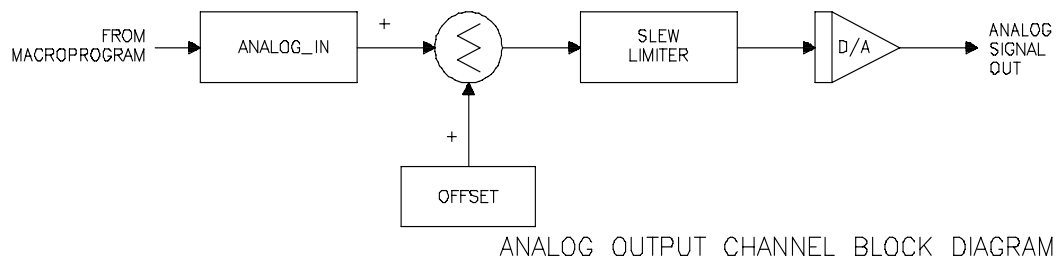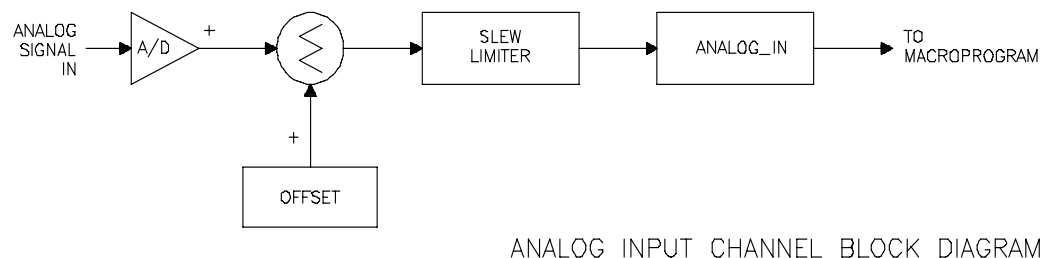
Figure 1.5 - Analog Input and Output Channel Block Diagrams

ON—BOARD I/O MODULE SOCKETS

ON—BOARD I/O CONNECTOR PORTS
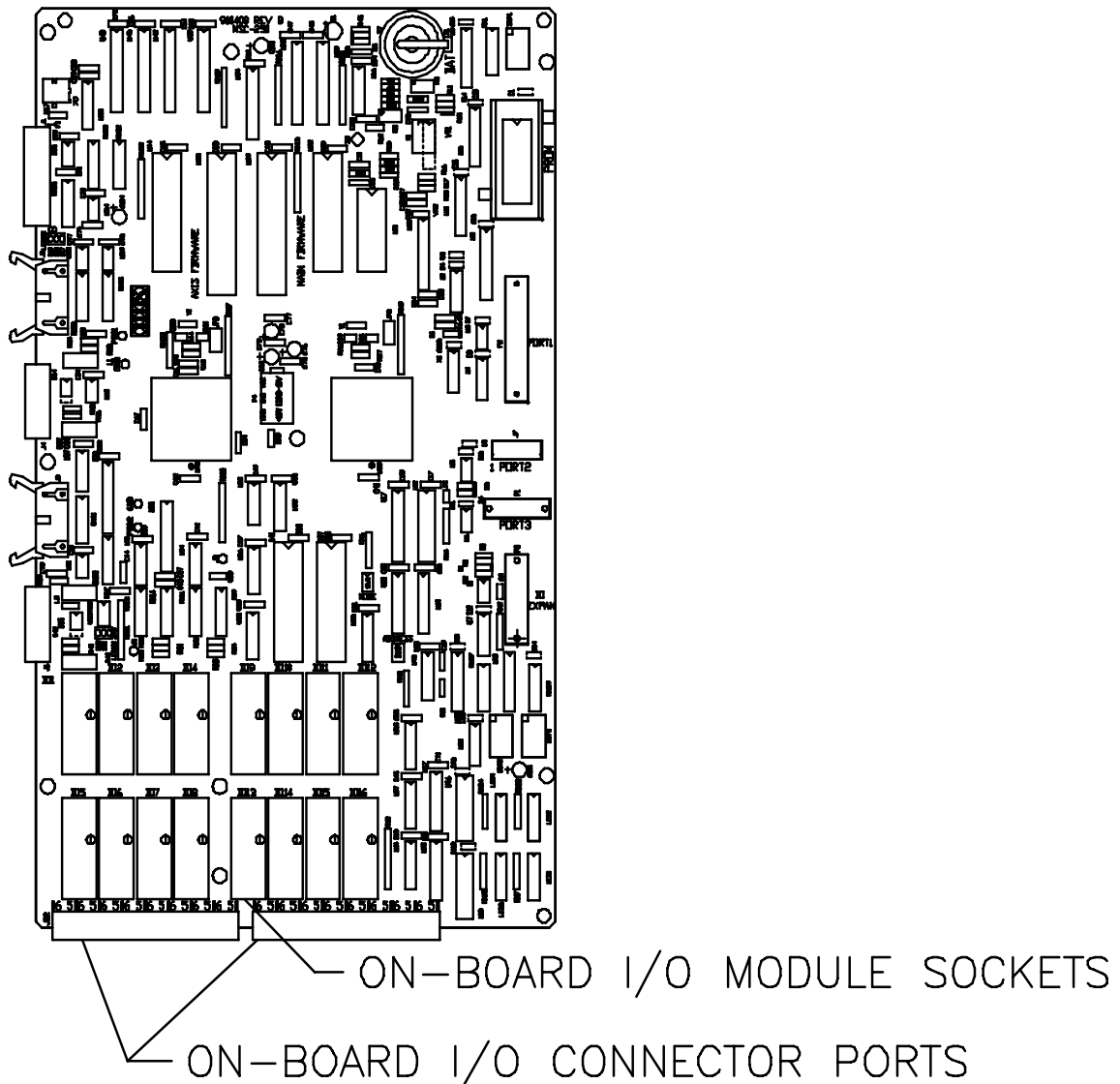
Figure 1.6 - Input/Output Module Locations

controller will change the state of the module at the location, as directed by the Macroprogram. Monitoring of each of the module locations is supplied by a status indicator on the front of the controller (refer to "Section 1.3 - Components).

In addition to I/O functions, one of the sixteen position groups — either the controller board or one of the I/O expanders — can be used for programmable limit switches (PLS). These limit switches can be actuated at master angle bus positions specified by the Macroprogram. (Refer to the *IOE-850 I/O Expander Instruction Manual* for additional information on use of these modules for I/O module and PLS functions.)

> **NOTE**
>
> **Only one of the three groups of sixteen module locations can be used for programmable limit switches at a time. Of the sixteen locations in the single group, there are no use restrictions. Any of the sixteen can be used as PLS locations with the balance used for I/O modules or left empty.**

1.2.4 PROGRAMMING

The MSC-250 servo controller uses the Macroprogram command language developed for Industrial Indexing Systems' MSC family of motion control products. This command language can be used on any IBM™-compatible personal computer running under the MS-DOS™ environment to create the necessary program to operate the controller. Industrial Indexing Systems, Inc. provides a software system to assist the designer in creation of these programs.

The system is the Macroprogram Development System. This software tool provides an effective environment for creating Macroprograms for the MSC family of motion controllers. Program development consists of creating and editing text files containing the appropriate program instructions, compiling these files to generate executable programs, and on-line program debugging. In addition, the Macroprogram Development System provides aids for disk file maintenance and configuration.

The Macroprogram Development System includes a software package called the MSC Tool Kit which simplifies the use of the system. The MSC Tool Kit allows simple entry and editing of programs while providing on-line documentation describing the purpose and format of each Macroprogram Language instruction. For additional information, refer to the *Macroprogram Development System Instruction Book*.

Once a program has been created, it can be loaded to the controller memory directly from the computer or from a PROM loaded into the controller PROM POCKET (refer to "Section 1.3 - Components" and "Section 3 - Operation"). Once loaded, the program is stored in non-volatile memory so it will not be lost if the power is turned off. This memory is protected by a lithium battery. The program will remain in memory until a new program is entered or the battery backup is removed.

> **NOTE**
>
> **The PROM can also be used by the controller as a data access or storage (read or write) location (refer to "Section 3 - Operation").**

1.3   COMPONENTS

Figure 1.7 shows the various connectors and status indicators of the MSC-250 controller. Several of the connectors are attached to the printed circuit board of the controller and protrude through the side or bottom of the controller cabinet. These connectors are shown as dotted lines to indicate their relative position, even though they are not really visible from this view.

1.3.1 STATUS INDICATORS

1.   SYSTEM STATUS Display: This 7-segment LED (Light Emitting Diode) with decimal place indicates the status of the main processor. Each number displayed represents a specific status code. (Refer to "Section 3.2 - Controller Use and Status" for the meaning of these codes.) An illuminated decimal point indicates that the program is running.
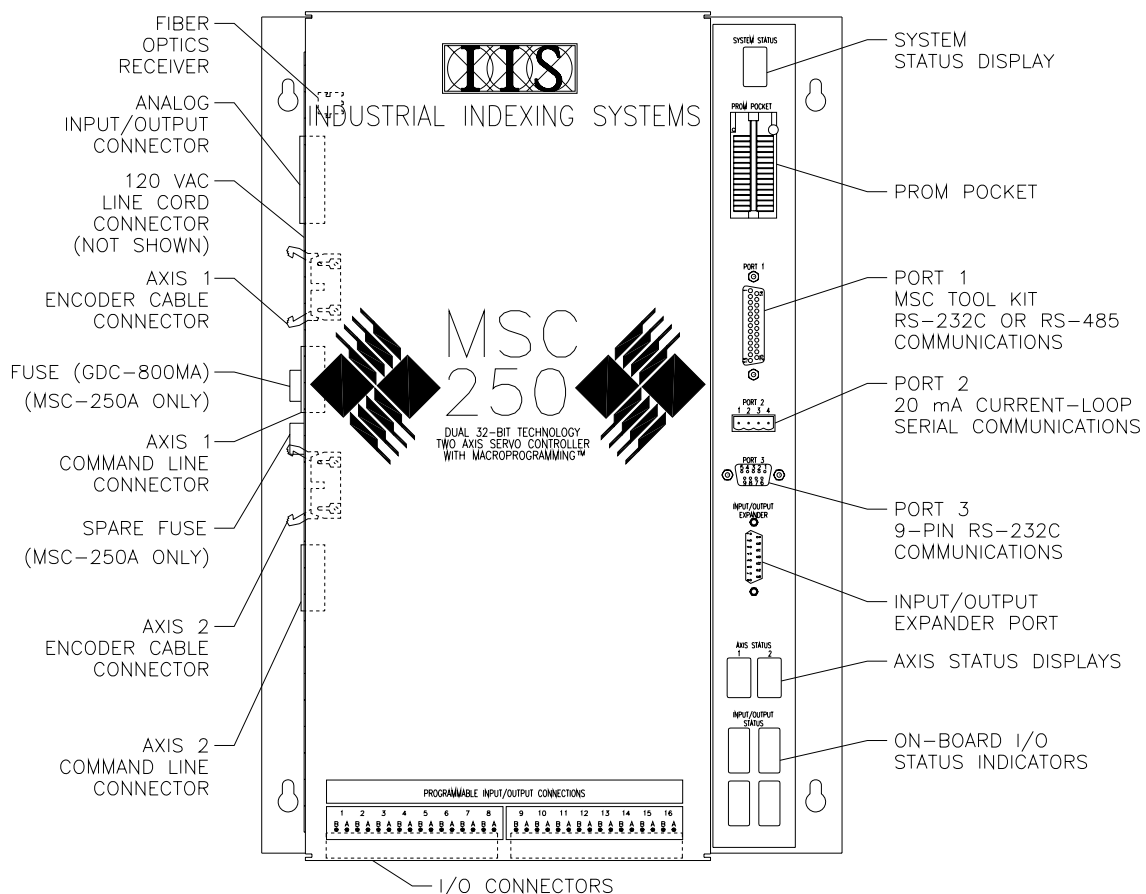

Figure 1.7 - Connectors and Status Indicators

2.   AXIS STATUS Displays: One 7-segment LED with decimal place indicates the status for each of the axes. Each number displayed represents a specific status code. (Refer to "Section 3.2 - Controller Use and Status" for the meaning of these codes.) An illuminated decimal point indicates that the drive for that axis is enabled.

3.   On-board I/O Status Indicators: There is one LED position for each of the 16 on-board I/O locations. When the I/O module is accessed, an LED will illuminate beneath the number of the I/O location. If no module is present, the illumination will be dim. If the module is present, the illumination will be bright.

1.3.2 CONNECTORS

1.   PROM POCKET: This 28-pin ZIF (Zero Insertion Force) socket accepts PROMs for program input and data storage.

2.   PORT 1:   This 25-pin serial communications port can use either an RS-232C serial communications protocol or an RS-485 multidrop addressable protocol. It is used for communications with the computer using the MSC Tool Kit program. The ADDRESS switch on the printed circuit board must be set to allow proper communications. (Refer to "Section 2 - Installation" for proper cable pin-outs for this port.)

3.   PORT 2:   This 20 mA current-loop serial port is used for communication with the Industrial Indexing Systems' OPI-1 and similar current-loop communications devices. It is accessible through the Macroprogram language for sending and receiving data and commands. (Refer to "Section 2 - Installation" for proper cable pin-outs for this port.)

NOTE

An RS-232C to 20 mA converter is available from Industrial Indexing Systems, Inc. This converter allows the user to take advantage of the high-isolation characteristics of the 20 mA current-loop communications protocol.

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4.   PORT 3:   This is a 9-pin D-connector RS-232C serial communications
                            port. It is accessible through the Macroprogram language for
                            sending and receiving data and commands. (Refer to "Section
                            2 - Installation" for proper cable pin-outs for this port.)

5.   INPUT/OUTPUT EXPANDER PORT: This 15-pin D-connector is a serial
                            communications port used to daisy-chain the IOE-850 I/O
                            Expanders to the controller. It utilizes a proprietary
                            communications protocol.

6.   Command Cable Connector: There is one six-pin command cable connector for
                            each real axis controlled by the MSC-250. It is used to
                            communicate indexing commands to the drive amplifier. (Refer
                            to "Section 2 - Installation" for proper cable pin-outs for this
                            connector.)

7.   Encoder Cable Connector: There is one ten-pin connector for each real axis
                            controlled by the MSC-250. It is used to communicate the
                            encoder feedback signals to the controller axis processor.
                            (Refer to "Section 2 - Installation" for proper cable pin-outs for
                            this connector.)

8.   Line Cord Connector: This 3-pin connector (supplied with system unit) provides the
                            attachment point for the C-800006 connector cable used to
                            supply 120 VAC input power and earth ground connection to
                            the MSC-250 servo controller. (Refer to "Section 2 -
                            Installation" for proper connections to this port.)

                            Adjacent to the incoming line are two fuse holders. The one
                            closest to the line cord is wired, and the second one holds a
                            spare fuse.

9.   Analog Input/Output Connector: This connector (supplied with system unit) provides
                            contacts for one analog input channel, one analog output
                            channel, and a reference voltage. Use of these input and
                            output channels is controlled by the Macroprogram.

10.   Fiber Optics Receiver: This receiver is used to receive the protocol for master angle
                            passing from the Industrial Indexing Systems' EFC-100
                            encoder-to-fiber-optics converter, RFC-100 resolver-to-fiber-
                            optics converter, and MCF-850 function card.

11.   I/O Connectors: These connectors (supplied with system unit) are used for the
                            physical connection of the devices actuating and being
                            actuated by the on-board input and output modules. (Refer to
                            "Section 2 - Installation" for appropriate input and output
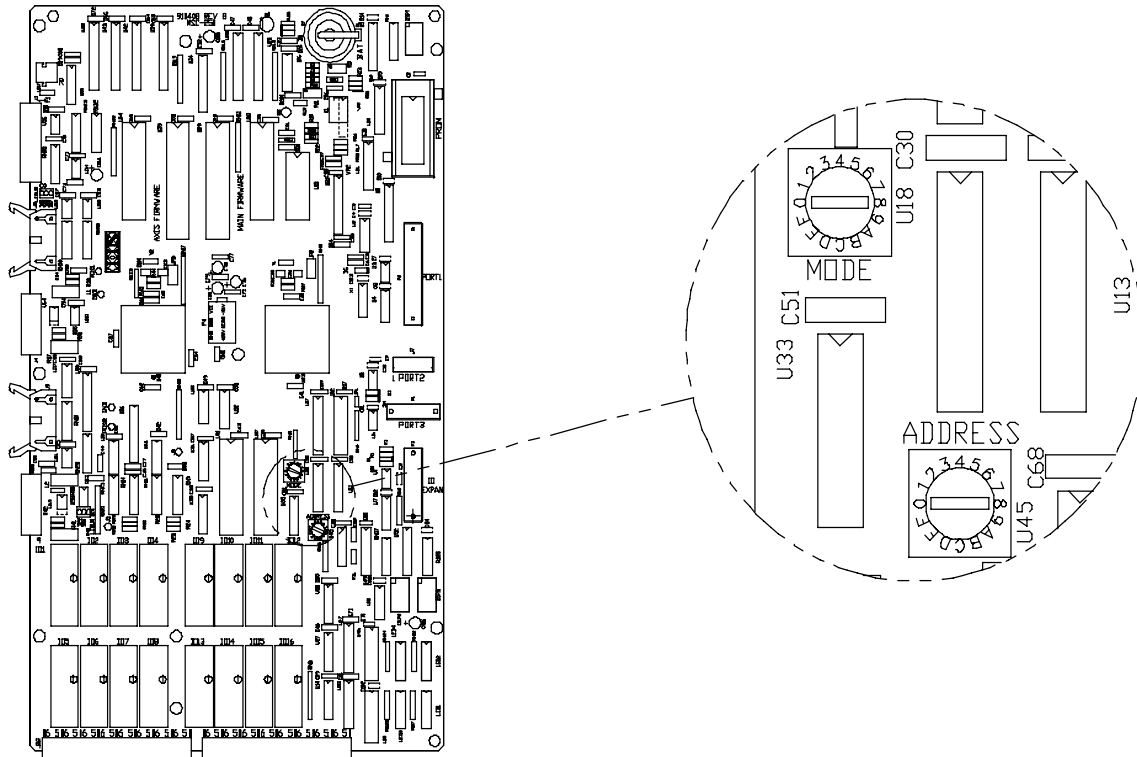   connections.)

Figure 1.8 - ADDRESS and MODE Selector Switches

1.3.3 SELECTOR SWITCHES

There are two 16-position rotary selector switches on the MSC-250 circuit board as indicated in **Figure 1.8.**

1.   ADDRESS: This selector switch is used in conjunction with communications PORT 1. If this switch is in the "0" position, the port will communicate using the RS-232C serial communications protocol. Any of the other positions ¾ 1 through F ¾ are used to designate the node number of the controller when it is used for RS-485 serial communications.

2.   MODE: This selector switch is used to determine the operating mode of the controller.

Normal Operation = Port 1, 2, & 3 default to 9600 Baud - Packet Protocol.

Position 0   =   Normal Operation
Position 1   =   Test Mode 1
Position 2   =   Test Mode 2
Position 3   =   Test Mode 3
Position 4 - 9 =   Reserved

The Ports not mentioned in the following setting definitions stay at their "Normal Operation" defaults.

Position A   =   Normal Operation
Position B   =   Port 3 = 19200 Baud - Packet Protocol.
Position C   =   Port 3 = 38400 Baud - Packet Protocol.
Position D   =   Port 1 = 19200 Baud - Packet Protocol.
Position E   =   Port 1 = 38400 Baud - Packet Protocol.
Position F   =   Reserved

These above port settings are only power up defaults, and can be changed by the users' Macroprogram at any time.

1.3.4 TEST POINTS AND LED INDICATORS

There are a variety of test points and LED indicators on the MSC-250 circuit board which are used for diagnostic and trouble-shooting purposes (refer to **Figure 1.9**). Procedures for use of these items are discussed in "Section 4 - Maintenance".

1.　　　POS and GND Test Points: There is one set of test points for each axis (refer to **Figure 1.10** and **Figure 1.11**). Place a meter between these test points to measure the POS OUT signal of the axis. (Refer to "Section 4 - Maintenance" for applications involving the use of these test points.)
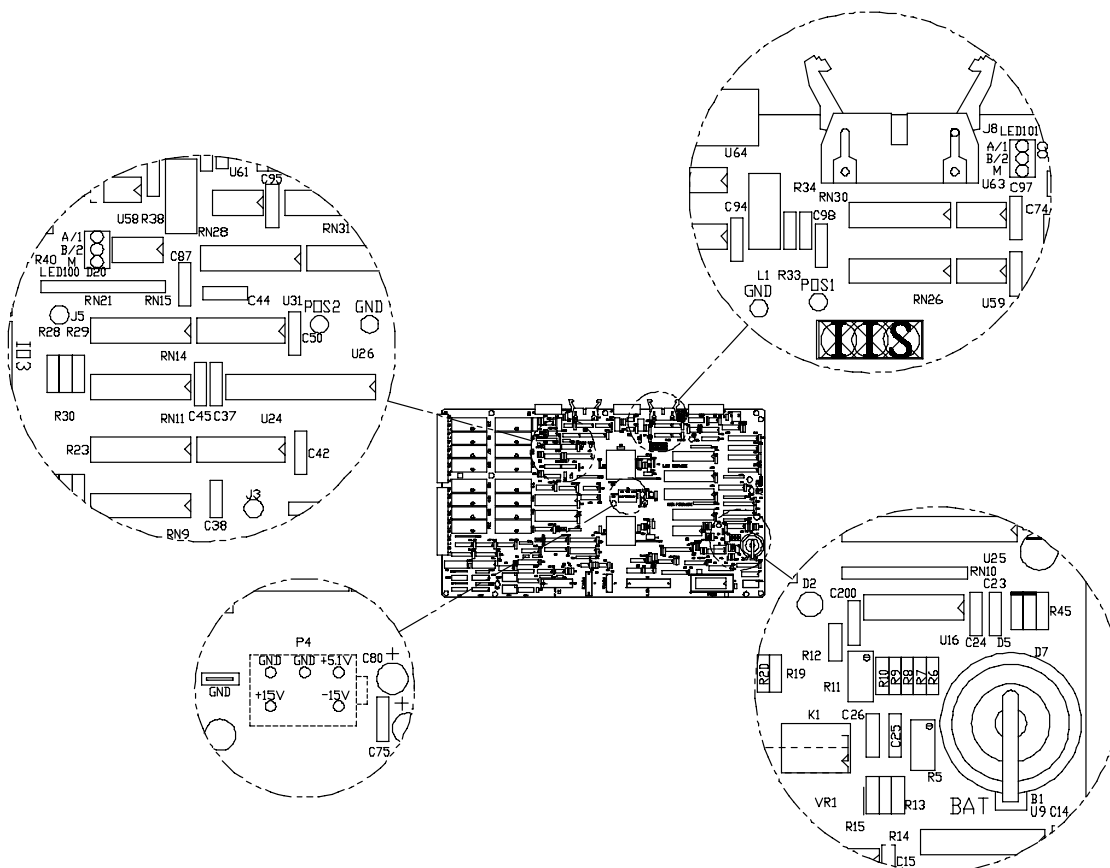

Figure 1.9 - Circuit Board Test Points

2.   Encoder Signal Monitor: There is one set of three LED encoder signal indicators for each axis (refer to **Figure 1.10** and **Figure 1.11**). One LED is assigned to each channel of the encoder and illuminates each time the channel generates a pulse. The quadrature channels (1 and 2) will flash very rapidly while the encoder shaft is turning. The indicator for the marker channel will flash once per encoder-shaft revolution.
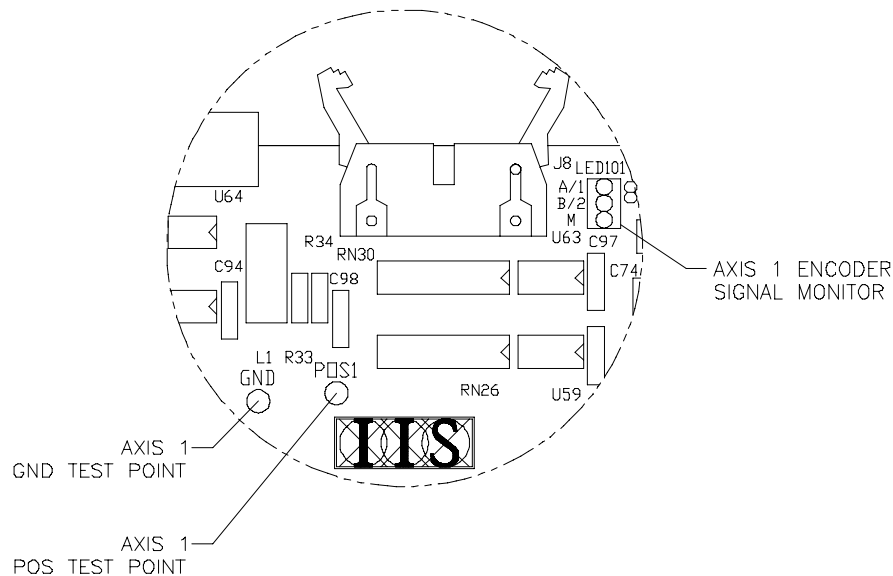

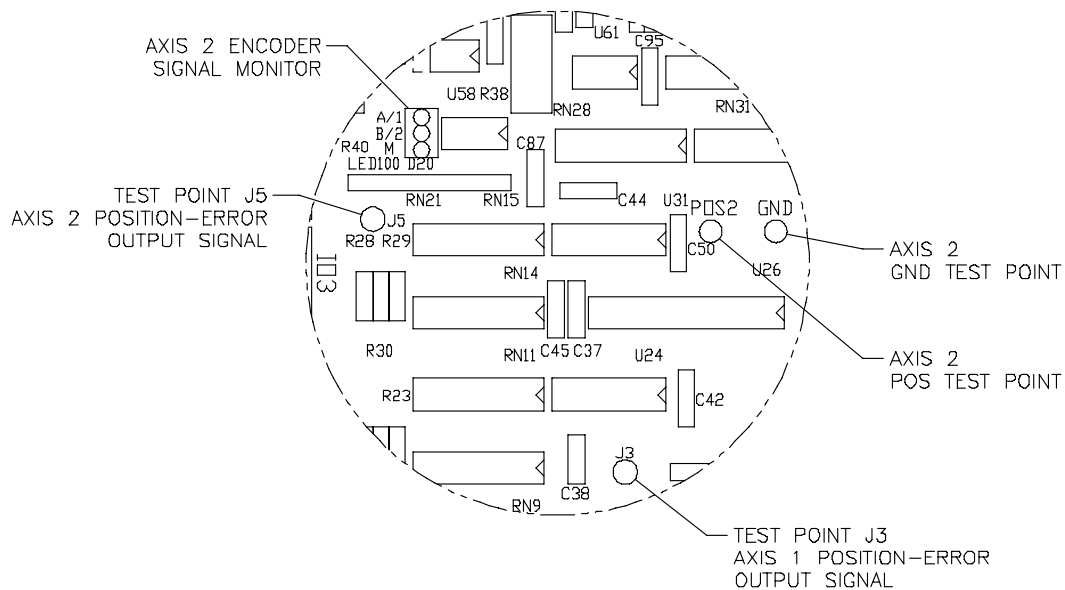**Figure 1.10 - Axis 1 Test Points and Indicators**

Figure 1.11 - Axis 1 and Axis 2 Test Points and Indicators

3. Position-error Output Signal: One test point for measuring the following error is provided for each axis (refer to **Figure 1.11**). J3 is the test point for axis 1 and J5 is the test point for axis 2. (Refer to "Section 4 - Maintenance" for applications involving the use of these test points.)

4. Voltage Test Points: The voltage test point block and additional ground loop are available for checking the system voltages used by the controller (refer to **Figure 1.12**).
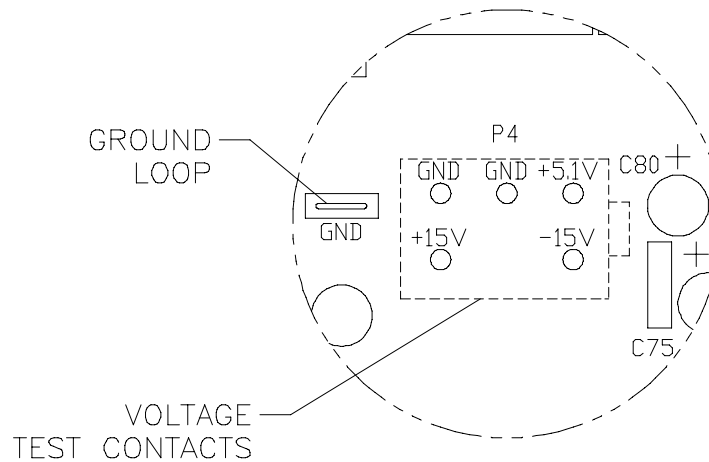

Figure 1.12 - Voltage Test Contacts

5. Low Input Line Power Indicator: LED indicator D2 will illuminate whenever input line power is reduced to a point that could result in improper controller operation. The status indicator on the cover of the controller will also display an error code.

CAUTION

THE TWO POTENTIOMETERS INDICATED IN FIGURE 1.13 CONTROL USE OF BATTERY POWER TO PROTECT THE NON-VOLATILE MEMORY REQUIRED TO MAINTAIN THE OPERATING PROGRAM IN THE CONTROLLER. THESE POTENTIOMETERS ARE FACTORY SET AND MUST NOT BE ADJUSTED. IMPROPER ADJUSTMENT OF THESE POTENTIOMETERS COULD RESULT IN LOSS OF PROGRAM MEMORY.
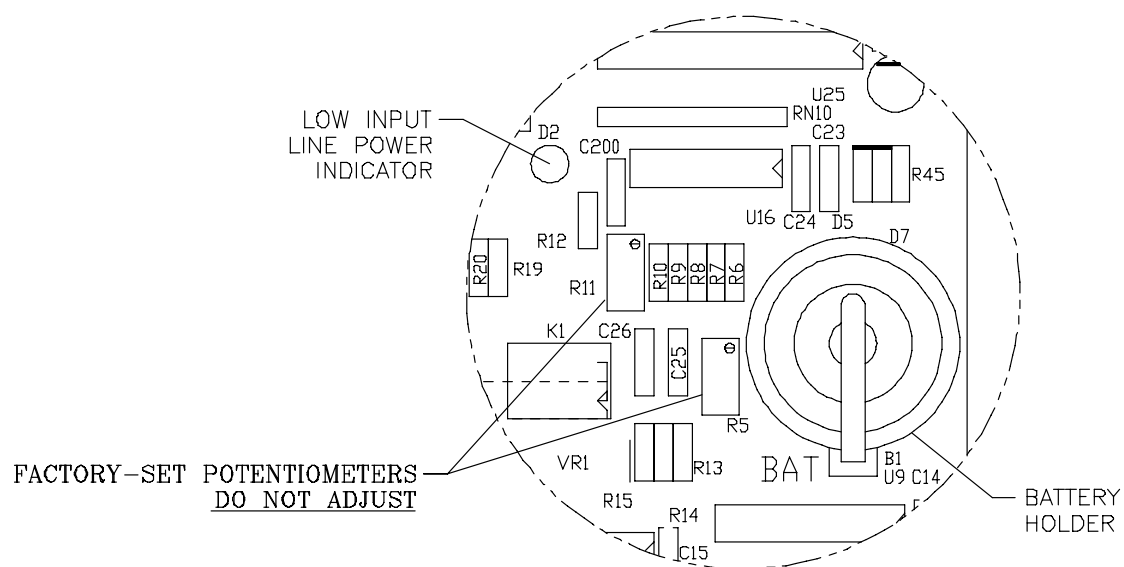

Figure 1.13 - Low Input Line Power Indicator

1.4   SPECIFICATIONS

1.4.1 PHYSICAL CHARACTERISTICS

SIZE: 15.24" high x 9.34" wide x 5.00 deep

WEIGHT: 11.25 lbs. [5.1 kg.]

OPERATING TEMPERATURE: 32°F to 140°F [0°C to 60°C]

OPERATING HUMIDITY: 30% to 90% non-condensing

INPUT POWER: 115 VAC ±15VAC, 48 to 62 Hz, 2 Amps
This device is intended to be connected to a category II type power source. (Fused with GDC-800MA)

BATTERY: CR2477 or DL2430

1.4.2 PERFORMANCE CHARACTERISTICS

DRIVE ENABLE CONTROL: Optically isolated
Off Voltage = 30 VDC
On Voltage = 1.5 VDC. 20 mA

DRIVE COMMAND OUTPUT: PID loop with 2.048 KHz digital signal processing sample rate

FEEDBACK DEVICE: Digital quadrature encoder with marker
    Marker Types: 1/2 Revolution = MSB
1/4 Cycle = A & B

LINE RECEIVER: Isolated Differential Receiver - required drive of 10ma or 4V drop accross inputs.

POSITIONAL RANGE: +2,147,483,648/-2,147,483,649 counts

POSITIONAL ABSOLUTE ACCURACY: ±1 count

ACCELERATION/DECELERATION RATE: 16 to 3,276,800 counts/second/second

SPEED   0.266 to 245,760 counts/second

DECODING: Fixed quadrature (x4) at 400 KHz max.
SERIAL COMMUNICATION: PORT 1:   RS-232C or RS-485 multi-drop (Packet
                                           Protocol) 9600 Baud, 1 Stop Bit, 8 Data
                                           Bits, No Parity
                              PORT 2:   20   mA   Current   Loop,   ASCII
                                           Programmable
                              PORT 3:   RS-232C, ASCII Programmable

1.4.3 PROMS

ACCESS TIME: 150 nanoseconds maximum

PACKAGE TYPE: SGS Thompson TS27C256_
                                           Toshiba TC57256_
                                           National Semiconductor NMC27C256_
                                           Signetics 27C256_

NOTE

**The PROM package types shown are those which have been tested
by Industrial Indexing Systems, Inc. and found satisfactory for this
application. Equivalent PROMs from other manufacturers may also
be acceptable.**

1.4.4 ANALOG INPUT CHANNELS

ANALOG INPUT CHANNEL:
    Type   Unbalanced or Balanced
    Voltage Range   -10 Volts to +10 Volts
    Resolution   12 bit (1 part in 4096)
    Accuracy   10 bit
    Update Rate   1 millisecond loop
    Input Impedance   10K Ohm Single-ended

ANALOG OUTPUT CHANNEL:
    Type   Unbalanced
    Voltage Range   -10 Volts to +10 Volts
    Resolution   12 bit (1 part in 4096)
    Accuracy   10 bit
    Update Rate   1 millisecond loop
    Output Drive   10 mA Maximum

VOLTAGE REFERENCE SOURCE:
    Type   (1) +10V Ground Referenced
                                           (1) -10V Ground Referenced
    Voltage Reference   ±10 V ±0.5 V at 10 mA Maximum

DIGITAL FILTERING (Slew Control):
    Unit   Bits per 10 Milliseconds
    Range (programmable)   1 to 2048 bits
    Resolution   1 part in 2048 bits

1.4.5 INPUT/OUTPUT MODULES

I/O INTERFACE: 16 positions, on-board, discrete
                                          32 positions, on expansion modules
                                        (16 Programmable Limit Switches max.)

DC INPUT MODULE (**HSI-250**)
    (High Speed Input)

JUMPER INSTALLED
    Input Voltage Range   4.5 to 8 VDC
    Input Current at Max. Line   28 ma
    Input allowed for No Output

JUMPER CUT
    Input Voltage Range   9 to 24 VDC
    Input Current at Max. Line   38 ma
    Input allowed for No Output
    Isolation Input-to-output   2500 V_{rms}
    Turn-on Time   6 ms
    Turn-off Time   6 ms

DC INPUT MODULE (**IDC15**)
    Input Voltage Range   10 to 32 VDC
    Input Current at Max. Line   25 ma
    Input allowed for No Output   1 ma (3 V)
    Isolation Input-to-output   4000 V_{rms}
    Turn-on Time   5 ms max.
    Turn-off Time   5 ms max.

DC Input Module - High Speed (**HSI-250**)
    Input Voltage   5vdc or 15vdc Jumper Selectable
    Input Current at Max. Line   25 ma
    Input Allowed For No Output   2 V
    Isolation Input-to-output   2500 VAC
    Turn-on Time   100u Sec max.
    Turn-off Time   100u Sec max.

AC INPUT MODULE (**IAC15**)

Input Voltage Range	12 to 140 VAC
Input Current at Max. Line	11 ma
Input allowed for No Output	3 ma (45 V)
Isolation Voltage (Input-to-output)	4000 V_{rms}
Turn-on Time	20 ms max.
Turn-off Time	20 ms max.

NOTE

Do not use the IAC15 module for applications intended to be used in the European Community.

DC OUTPUT MODULE (**ODC15**)

Operating Voltage Range	5 to 60 VDC
Current Rating (at 70°F)	2 amps
One Second Surge	5 amps
Output Voltage Drop	1.6 max.
Off-state Leakage at Max. Voltage	1 ma
Isolation Voltage (Input-to-output)	4000 V_{rms}
Turn-on Time	100 microseconds
Turn-off Time	750 microseconds

AC OUTPUT MODULE (**OAC15**)

Operating Voltage Range	12 to 140 VAC
Current Rating (at 70°F)	2 amps
One Cycle Surge	80 amps peak
Minimum Load Current	20 ma
Output Voltage Drop	1.6 max. peak
Off-state Leakage at Nominal Voltage (60 Hz)	5 ma_{rms}
Isolation Voltage (Input-to-output)	4000 V_{rms}
Operating Frequency	25 to 65 Hz
Turn-on Time	100 microseconds
Turn-off Time	750 microseconds

NOTE

Do not use the OAC15 module for applications intended to be used in the European Community.

SECTION 2 − INSTALLATION

The MSC-250 servo controller is designed for use in custom indexing systems. Therefore, each installation may vary, depending on the application. The instructions in this section are general guidelines to assist in the design and installation of the controller. Specific cables and optional equipment indicated on the illustrations are for reference only and may not required.

2.1 MOUNTING

The controller is designed for surface mounting on a wall or in an electrical cabinet. It must be protected from adverse environmental conditions such as dust, moisture, and vibration. It must also be protected from excessive heat or cold. If mounted in an electrical cabinet, provide adequate ventilation to maintain temperature and humidity within allowable limits (refer to "Section 1.4 - Specifications").

For applications that are to be delivered to Europe and must meet the European standards, the controller must be installed inside an electrical cabinet.

The controller mounts flat against a wall or panel using four mounting key-hole slots in the back of the unit (refer to **Figure 2.1**).

> **NOTE**
>
> **Allow a minimum of 3" clearance on all sides of the controller. Extra clearance may be desired on the left, right, and bottom to allow easier insertion of cable connectors.**

1.   Select the desired position for the controller and lay out the locations for the (4) mounting bolts as shown in **Figure 2.1**.

2.   If panel mounted, provide clearance holes or tapped holes for (4) #10 machine screws for mounting the controller. If wall mounted, provide the necessary anchors for (4) #10 mounting screws.

3.   Locate the controller in position and attach to the wall or panel using (4) #10 screws.

> **NOTE**
>
> **The larger holes in the mounting plate slots allow the plate to be placed over the heads of #10 socket-head cap screws. If these are used, the screws may be started in the holes before the controller is placed in its final location.**

4.   Mount any auxiliary equipment following the directions in the instruction manuals provided with the equipment.
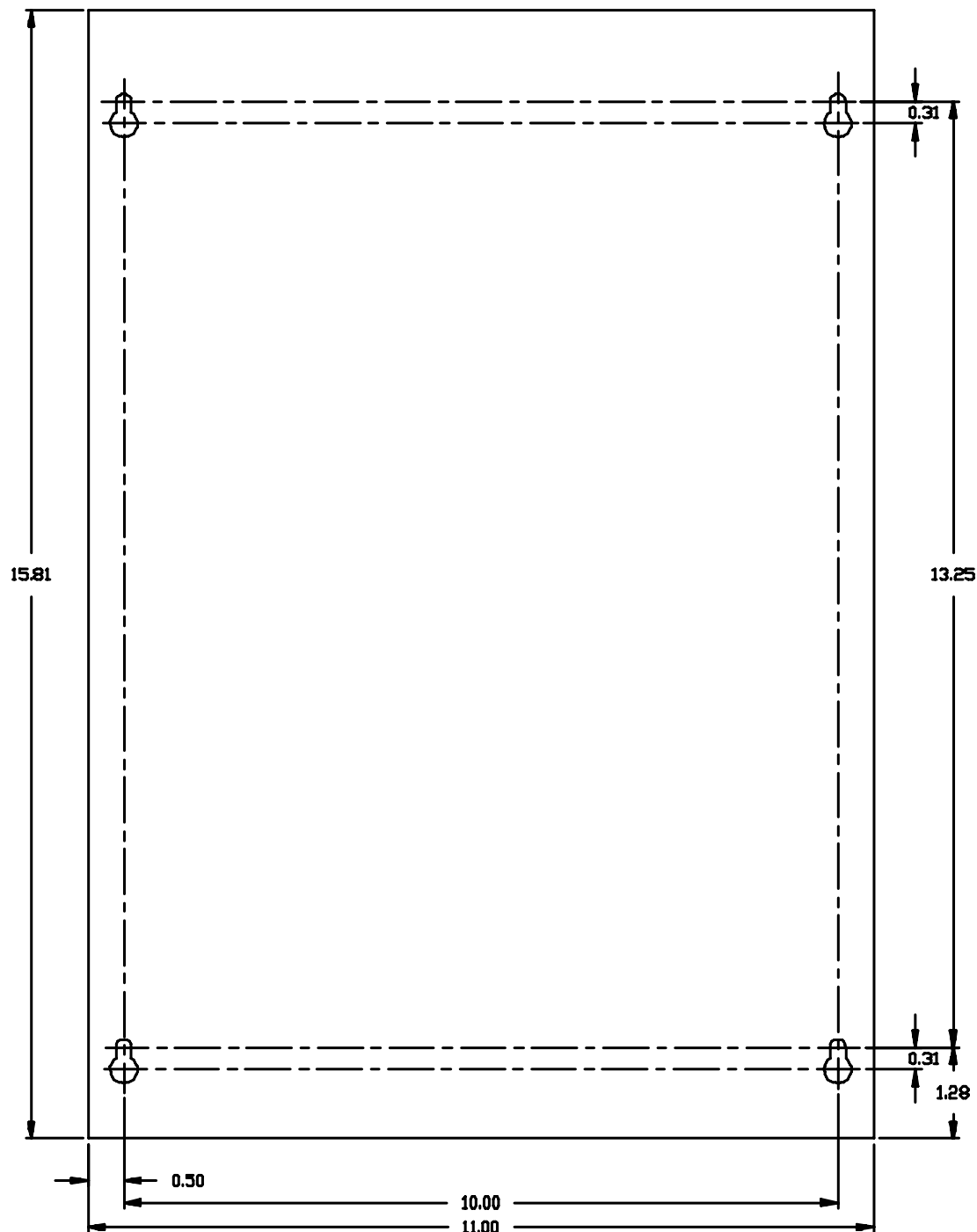
Figure 2.1 - Mounting Dimensions

2.2 ELECTRICAL CONNECTIONS

WARNING

IT IS THE RESPONSIBILITY OF THE CUSTOMER TO MAKE SURE THE INSTALLATION COMPLIES WITH ALL NATIONAL, STATE, AND LOCAL CODES INCLUDING THE NATIONAL ELECTRIC CODE (NEC).

CAUTION

THE MSC-250 CONTROLLER AND ALL RELATED ELECTRONIC EQUIPMENT MUST BE CONNECTED TO A SEPARATE EARTH GROUND — NOT PLANT ELECTRICAL GROUND. MAKE ALL CONNECTIONS WITH SHIELDED CABLES AND CONNECT THE SHIELDS TO THE EARTH GROUND. FAILURE TO PROVIDE THIS EARTH GROUND COULD RESULT IN ELECTRICAL DAMAGE TO THE EQUIPMENT.

Since there are several connections required to the single earth ground, it is recommended that an MSC ground strip be installed. This terminal strip is connected to earth ground and has capacity for several wire connections. It should be located as close as possible to the MSC-250 controller.

1. Locate an MSC ground strip in a convenient location near the controller and related system equipment.

WARNING

THE EARTH GROUND WIRE MUST BE NO SMALLER THAN THE MINIMUM ALLOWABLE ELECTRICAL GROUND CABLE FOR THE SUM OF THE LOADS BEING CONNECTED.

---

1. Connect the MSC ground strip to earth ground using copper wire appropriately sized for the equipment being grounded.

2. Supply a separate terminal location for connecting incoming 120 VAC electrical power. **DO NOT APPLY INCOMING POWER AT THIS TIME!**

3. Connect the 110V power cable that is provided for the MSC-250.

    a. Plug the connector end of the power cable into the receptacle on the side of the MSC-250 controller.

    b. Attach the ground wire from the power cable to the MSC ground strip.

---

c.   Attach the brown and light blue power and the green with yellow stripe
      neutral wires from the cable to the appropriate terminals on the 120 VAC
      terminal strip.

2.2.1 INPUT/OUTPUT MODULES

Use of input and output modules will depend on the design of the system. 16 I/O module
locations are provided on the controller and 32 more can be added using IOE-850 I/O
Expanders. Each location can be equipped with any of five input or output modules. The
IDC15 and HSI-250 are DC input modules and the IAC15 is an AC input module. Similarly,
the ODC15 is a DC output module and the OAC15 is an AC output module.   For
applications that are intended for use in the European Community, use only the I/O
modules that require 60 vdc or less. (IAC15 and OAC15 must not be used for European
applications.)
Figure 2.2 shows the proper connections for each type of input and output module. Note
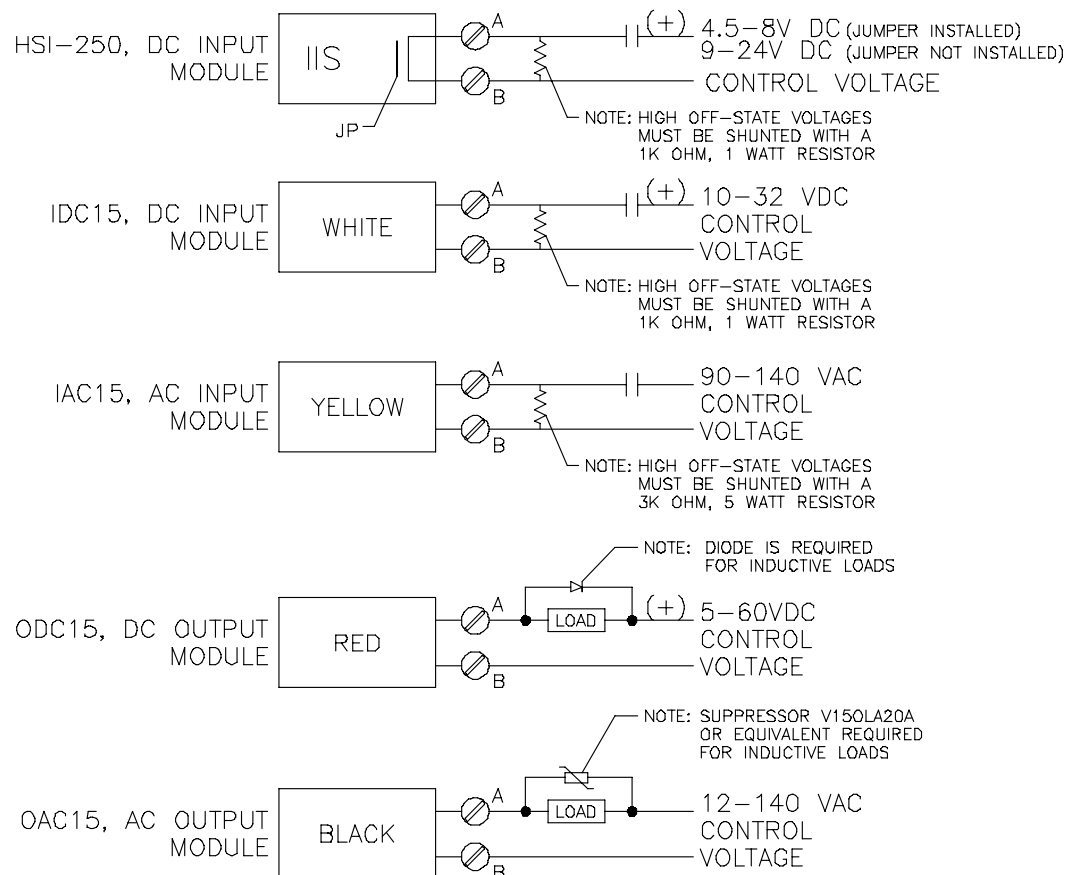
Figure 2.2 - Input and Output Module Connections

the use of resistors, diodes, and suppressors. These must be supplied by the customer. An illustration on the bottom of the MSC-250 front panel shows the appropriate connection points for the "A" and "B" terminals of each I/O module location (refer to **Figure 2.3**).

NOTE

The sixteen module locations on the controller or either IOE-850 I/O Expander may also be used as programmable limit switches. Refer to the *IOE-850 I/O Expander Instruction Manual* and *Macroprogram Development System Instruction Book* for additional information.

PROGRAMMABLE INPUT/OUTPUT CONNECTIONS

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

B A B A B A B A B A B A B A B A   B A B A B A B A B A B A B A B A
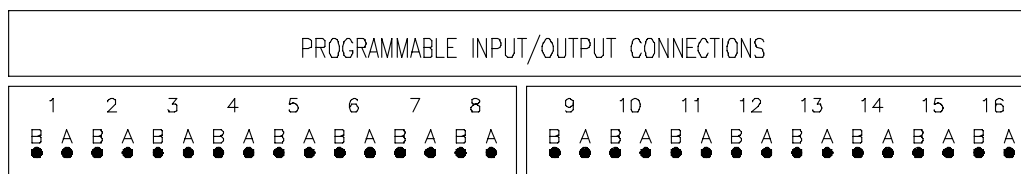
Figure 2.3 - Programmable Input/Output Connections Label

1. Insert the appropriate input or output module in each assigned I/O module location.

2. If using one or two IOE-850 I/O Expanders, attach the appropriate cables to daisy-chain the modules to the MSC-250 controller and to each other.

3. Make the proper system connections between the input and output devices and the "A" and "B" connector locations for each I/O module location.

2.2.2 SYSTEM INTERCONNECTIONS

The system connections for the MSC-250 servo controller will also depend on system design. **Figure 2.4** shows typical system interconnections for the controller, drives, and encoders. Axis 1 connections are shown with the optional INT-810 interface module. This module has ribbon cable inputs to match the connectors on the MSC-250 and terminal outputs to facilitate customer wiring. Axis 2 connections are shown without the interface module. Such a connection would run direct cables as illustrated.

The pinouts for the encoder cable connector and drive cable connector are shown in **Figure 2.4**. These are repeated in the sequence of pinout illustrations which follow along with the pinouts for the communication ports. The balance of these instructions assume all ports and connectors are used although this may not be the actual case.
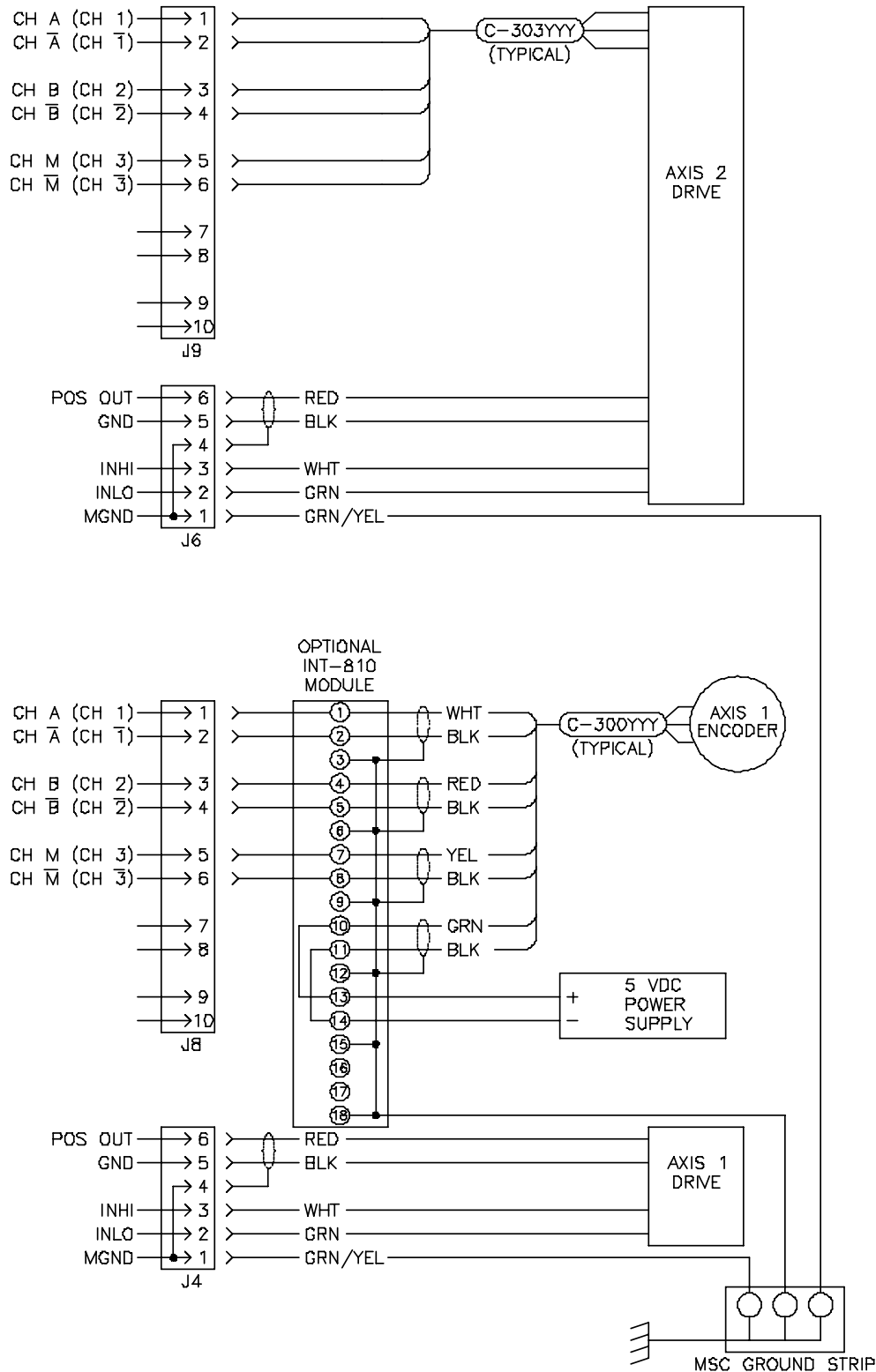
Figure 2.4 - Typical System Interconnections

1.	For each axis, connect the encoder to the controller.

    a.	Connect the encoder end of cable C-303yyy to the encoder. Make sure the connector is securely seated.

    b.	Connect the other end of cable C-303yyy to the encoder cable connector on the MSC-250 controller. Make sure the connector is securely seated.
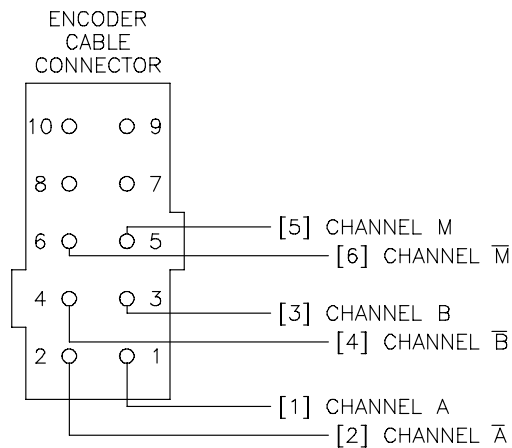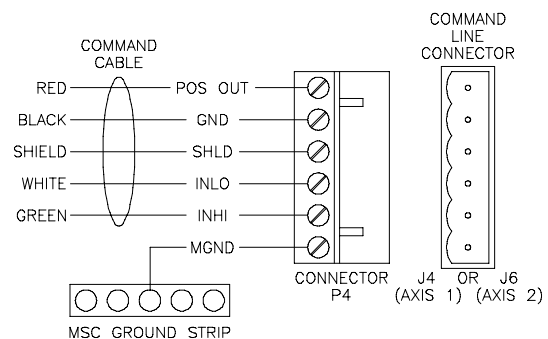

Figure 2.5
Encoder Cable Connector Pinouts

OR

    a.	If the INT-810 interface is used, connect the encoder end of cable C-300yyy to the encoder. Make sure the connector is securely seated.

    b.	Connect each wire of cable C-300yyy to the correct terminal of the INT-810 interface module (refer to **Figure 2.4**) and plug the encoder connector from the INT-810 into the encoder cable connector on the MSC-250 controller. Make sure all wires terminals are tight and that the connector is securely seated.

2.	For each axis, connect the drive to the controller.

    a.	Connect the drive end of the command cable to the drive. Make sure the connector is securely seated.

    b.	Connect the other end of the command cable to the command line connector on the MSC-250 controller. Make sure the connector is securely seated.

Figure 2.6
Command Line Connector Pinouts

3.   If using the INT-810 interface module, connect the 5 VDC power supply to the proper terminals on the interface module (refer to **Figure 2.4**).

4.   Connect the communications cables from PORT 1, PORT 2, and PORT 3 to their respective communication devices. Refer to the pinouts shown in **Figure 2.7**, **Figure 2.8**, and **Figure 2.9**, respectively.
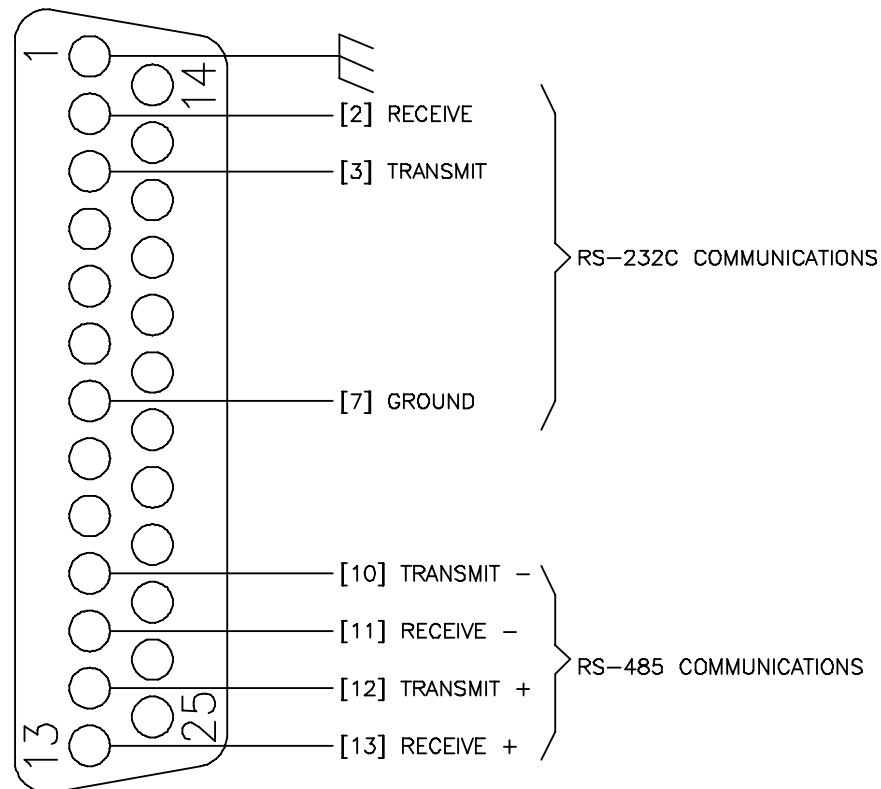
Figure 2.7 - PORT 1 Pinouts

NOTE
The last device in an RS-485 multidrop communications chain must have a 120 ohm, 1/4 watt terminating resistor connected between "Receieve -" and "Receive +".
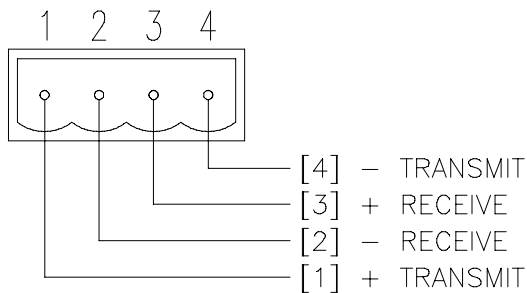
Figure 2.8
PORT 2 Pinouts
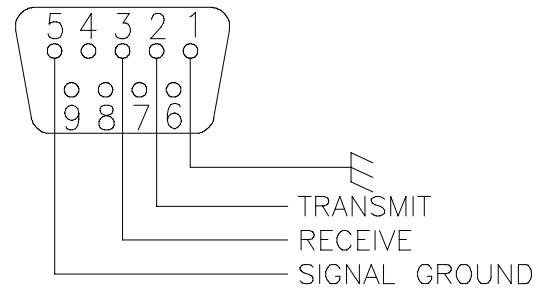
Figure 2.9
PORT 3 Pinouts

5.   Connect the analog input/output
        channels and reference voltages.

        a.   Connect the controller end of
                the cable for the analog input
                and output channels to the
                analog input/output connector
                (refer to **Figure 2.10**).

        b.   Connect any analog input, or
                analog output to the other
                end of the connector cable
                (refer to **Figure 2.11**).

        c.   If a potentiometer input is to
                be used, connect the
                potentiometer to the cable as
                shown in **Figure 2.11**.
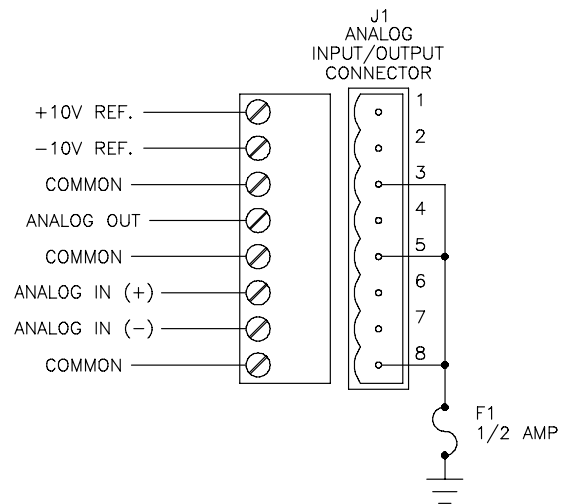
Figure 2.10
Analog Channel Connections

WARNING
DOUBLE CHECK ALL WIRING CONNECTIONS. MAKE SURE ALL ARE PROPER AND SECURE. IMPROPER CONNECTIONS COULD RESULT IN SYSTEM MALFUNCTIONS.
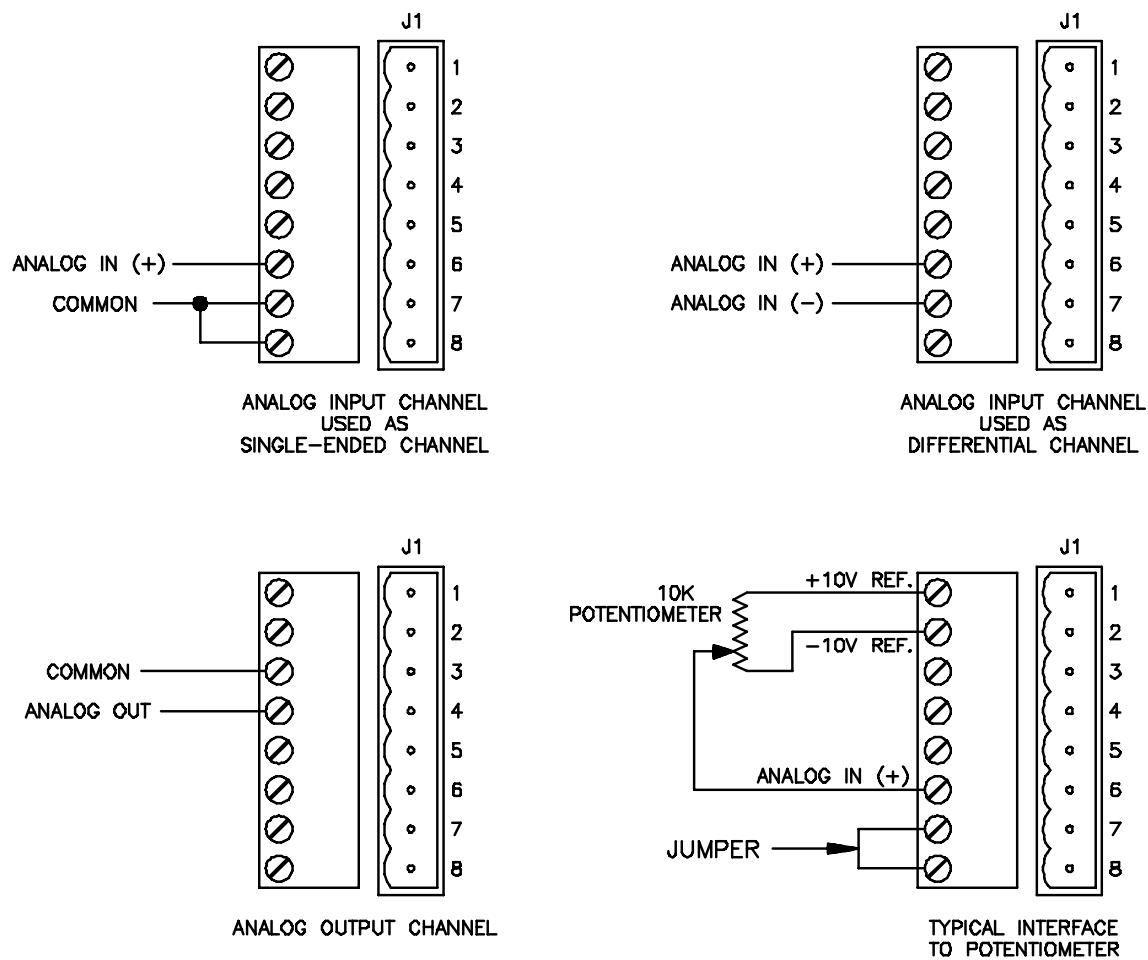
Figure 2.11 - Typical Analog Input/Output Channel Connections

SECTION 3 – OPERATION

The operation sequence of the MSC-250 servo controller is provided by the Macroprogram stored in its memory. Other than the specific procedures for loading the program into memory and certain setup and test procedures, there is no operator control over the MSC-250 functions.

3.1 CONTROL PROGRAM

The control program consists of Macroprogram commands as assembled by the MSC Tool Kit. Refer to the *Macroprogram Development System Instruction Book* for details on constructing the Macroprogram.

3.1.1 PROGRAMMING CONSIDERATIONS

When creating a Macroprogram for the MSC-250 controller, the programmer must know the specific type of encoder which will be used with each axis. If this information is not correct, the motor being controlled will travel the wrong distance when an indexing or positioning command is given. It will also travel at the wrong speed and have the wrong acceleration and deceleration.

> ## WARNING
> **INCORRECT PROGRAMMING AND INCORRECT ENCODER SPECIFICATIONS COULD CAUSE IMPROPER MOVEMENT WHICH MAY RESULT IN EQUIPMENT DAMAGE OR PERSONAL INJURY.**

The Macroprogram will support any quadrature encoder. The standard encoder, around which the command language is fashioned, has 1024 pulses per revolution, a 1/4-cycle marker pulse, channel A leading channel B for clockwise rotation, a Proportional Gain value of 16, an Integral Gain value of 0, a Derivative Gain value of 0, and a Feed Forward Gain Value of 0 (refer to "Section 1.2.1 - Axis Control"). However, even these standard values must be properly used in the Macroprogram to achieve proper motor-shaft movement.

When establishing the Macroprogram, the two real axes are designated Axis 1 and Axis 2 to correspond to the designation of the controller. The pseudo axis and Programmable Limit Switch functions (refer to "Section 1.2 - System Functions") are designated as Axis 3 in the Macroprogram. The analog input and output functions are referenced as Axis 4. The two real axes have encoder feedback signals. The pseudo axis, because it represents a perfect motor, does not have a feedback signal.

Each I/O module location has a specific address. Each location can be used as either an input or an output location. In addition, the locations in any one group of 16 I/O module locations can be used for programmable limit switches.

PORT 1 is used for communication with the MSC Tool Kit. However, PORT 2 and PORT 3 are addressable by the program for communication with other devices during control operations.

The PROM POCKET location can hold a PROM with the program which is to be used by the controller. The program can also be written so data is stored to a PROM in the PROM POCKET, or so data is retrieved from the PROM, or both. Although data can only be written to the PROM once, it can be retrieved from the PROM as often as necessary.

> **NOTE**
>
> **For additional information on creating the system control Macroprogram, refer to the *Macroprogram Development System Instruction Book*, the *IOE-850 I/O Expander Instruction Manual* and the instruction manuals for any other accessories being used in the system.**

3.1.2 LOAD MACROPROGRAM TO MEMORY

The MSC-250 has 32,000 bytes of non-volatile memory for storage of the control program. This memory location is protected by a lithium battery to maintain the information when the power is turned off to the controller. Once a control program is loaded into memory, the MSC-250 will continue to use the program until a new program is loaded.

The program can be loaded into memory directly from a personal computer communicating through PORT 1. It can also be loaded from a PROM placed in the PROM POCKET.

> **NOTE**
>
> **The PROM can be "burned in" using the PROM POCKET in the MSC-250 controller and direct communication from the MSC tool kit. This prom can then be used to load the program to other controllers. Refer to the *Macroprogram Development System Instruction Book* for instructions on preparing and using the PROMs.**

3.1.2.1   Load Program From MSC Tool Kit

1.   Turn off all power to the controller.

2.   Open the controller cover and set the ADDRESS selector switch to "0" for RS-232C communications (refer to **Figure 3.1**). For RS-485 communications, set the switch to location "1" through "F" depending on the address of the controller on the communications network.
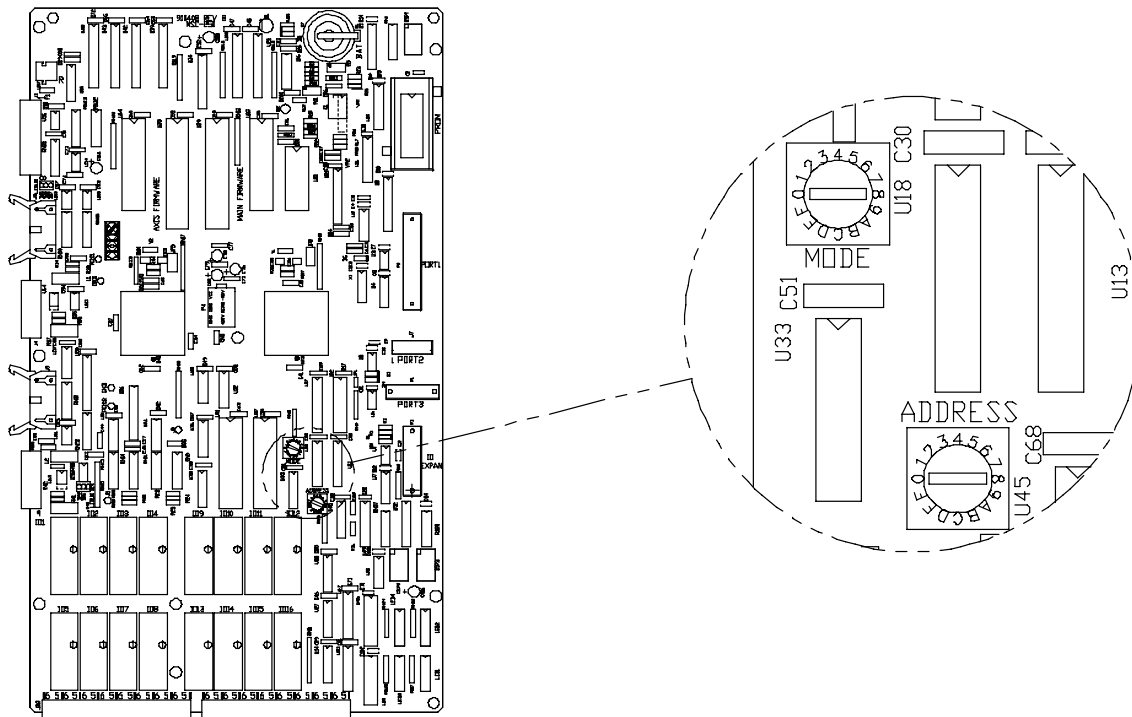

Figure 3.1 - ADDRESS and MODE Selector Switches

3.   Make sure the MODE selector switch is set to the desired power-up configuration (refer to **Figure 3.1**).
      Normal operation = Port 1, 2, & 3, default to 9600 Baud - Packet Protocol.

      Position 0 = Normal Operation.

      The Ports not mentioned in the following setting definitions stay at their "Normal Operation" defaults.

      Position A = Normal Operation
      Position B = Port 3 = 19200 Baud - Packet Protocol.
      Position C = Port 3 = 38400 Baud - Packet Protocol.
      Position D = Port 1 = 19200 Baud - Packet Protocol.
      Position E = Port 1 = 38400 Baud - Packet Protocol.
      Position F = Reserved

      These above port settings are only power up defaults, and can be changed by the users' Macroprogram at any time.

4.   Close and latch the controller cover.

5.   If necessary for data collection or if the program is to be burned in to a PROM, open the PROM POCKET by moving the handle to a position perpendicular to the pocket. Load a PROM into the PROM POCKET and close the latch on the pocket by moving the pocket handle to a position parallel to the pocket.

6.   Turn on power to the controller.

7.   Follow the instructions in the *Macroprogram Development System Instruction Book* to load the program to non-volatile memory.

3.1.2.2   Load Program From PROM

1.   Turn off all power to the controller.

> **NOTE**
>
> **Make sure the ADDRESS selector switch is set to "0" for RS-232C communications. For RS-485 communications, the switch must be set to location "1" through "F" depending on the address of the controller on the communications network. Make sure the MODE selector switch is set to "0" (refer to Figure 3.1).**

2.   Open the PROM POCKET by moving the handle to a position perpendicular to the pocket. Load a PROM into the PROM POCKET (note pin 1 location in diagram below) and close the latch on the pocket by moving the pocket handle to a position parallel to the pocket.

PIN 1 ─────

PROM POCKET
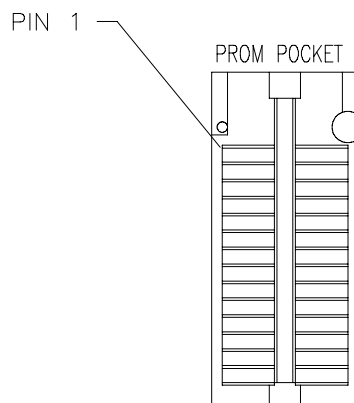
3.   Turn on power to the controller. If the first file on the PROM contains a Macroprogram, that Macroprogram will be loaded into memory, execution of the program will begin, and the MSC-250 AUTOSTART bit will be set. In future applications, with the PROM removed, the MSC-250 will start execution of this Macroprogram as soon as power is applied to the controller.

> **NOTE**
>
> **If a PROM containing a Macroprogram as the first file is in the PROM POCKET when power is applied to the controller, this file will always be loaded to memory, even if there is a valid Macroprogram already in memory with the AUTOSTART bit set.**

3.2   CONTROLLER USE AND STATUS

As discussed in Section 1, the MSC-250 servo controller is extremely flexible in its uses for indexing system control. Depending on how the Macroprogram is written and how the system is designed, it can be used in a variety of applications.

1.   The controller can directly control one or two real axes with encoder feedback.

2.   The controller has a pseudo-axis whose position can be broadcast on one or two master angle buses. Either or both real axes can then use this pseudo axis as a reference.

3.   The feedback signal from either real axis can be broadcast over either or both master angle buses, or the feedback signal from one real axis can be broadcast over one master angle bus and the feedback signal from the second real axis can be broadcast over the second master angle bus. As required by the Macroprogram, each axis can periodically reference the other.

4.   A position signal from another controller can be received at the fiber optics receiver and transmitted over one or both master angle buses. Either or both real axes can then reference this signal.

> **NOTE**
>
> **While an axis is using a master angle bus for reference, the axis is acting as a "slave" and the axis or controller supplying the reference signal is acting as the "master".**

During controller operations, the status of the controller processors and axes are displayed on the SYSTEM STATUS and AXIS STATUS displays. If there is an error or fault, the code for this will also be displayed on the appropriate STATUS display (refer to **Figure 3.2** and **Figure 3.3**).

> **NOTE**
>
> **If the decimal point is illuminated in the SYSTEM STATUS display, it indicates that the macroprogram is running. If the decimal point is illuminated in the AXIS STATUS display, it indicates that the axis is enabled.**

SYSTEM STATUS

A NORMAL

L PROGRAM LOAD

C SYSTEM RESET

- LOW POWER

P PROM READ

U PROM WRITE

H TEST MODE

PROGRAM ERRORS

1 ILLEGAL COMMAND

o STACK OVERFLOW

u STACK UNDERFLOW

n SYS_FAULT

r SYS_RETURN

L ILLEGAL ARGUMENT

SYSTEM ERRORS

0 FIBER OPTIC

1 COM PORT 1

2 COM PORT 2

3 COM PORT 3

4 PROM WRITE

5 PROM READ

6 I/O EXPANSION

7 AXIS TIMEOUT

SYSTEM FAULTS

A SYSTEM HARDWARE RESET

E NV MEMORY LOSS

F AXIS PROCESSOR

7 SYSTEM PROCESSOR

Figure 3.2 - Main System Status and Fault Codes

AXIS STATUS

A NORMAL

L MASTER/SLAVE LOCK

h AWAITING HARDWARE INTERRUPT

H TEST MODE

PROGRAM ERRORS

1 INVALID COMMAND

o CALCULATION ERROR

r DATA OUT OF RANGE

AXIS ERRORS

0 ENCODER CHANNEL A LOSS

1 ENCODER CHANNEL B LOSS

2 SERVO FOLLOWING ERROR

3 MARKER LIMIT

4 NO ENCODER FEEDBACK

AXIS FAULTS

8 AXIS HARDWARE RESET

F AXIS PROCESSOR

7 SYSTEM PROCESSOR

Figure 3.3 - Axis Status and Fault Codes

SECTION 4 − MAINTENANCE

> ## WARNING
> DISCONNECT ALL POWER AND FOLLOW PROPER LOCK-OUT PROCEDURES BEFORE ATTEMPTING REPAIRS OR ADJUSTMENTS TO THIS EQUIPMENT. ALLOW ONLY PROPERLY TRAINED PERSONNEL TO SERVICE THIS EQUIPMENT.

4.1 COMPONENT REPLACEMENT

Components which may require replacement on the MSC-250 include the battery and the firmware. The battery which protects the non-volatile memory must be replaced whenever the battery voltage drops below 2.6 V. This battery is located at the upper right of the MSC-250 circuit board (refer to **Figure 4.1**).

Industrial Indexing Systems, Inc. is continuously working to improve its products. Occasionally, these improvements are significant enough to warrant upgrades to existing controllers. These upgrades are supplied in the form of new firmware chips which must be replaced by the customer.

4.1.1 BATTERY REPLACEMENT

> ## CAUTION
> WHEN THE BATTERY IS REMOVED FROM THE CONTROLLER WITH ALL POWER TURNED OFF, ANY MACROPROGRAM STORED IN MEMORY WILL BE LOST. MAKE SURE THE MACROPROGRAM HAS BEEN BACKED UP ON A PROM OR CAN BE RESTORED FROM A PERSONAL COMPUTER BEFORE REMOVING THE BATTERY FROM THE CONTROLLER.

1. Turn off all power to the controller and open the cover.

2. Locate the battery on the circuit board and note the orientation of the positive and negative contacts of the battery.

3. Gently lift the metal spring clip which holds the battery in place and remove the old battery from the circuit board. **DO NOT FORCE THE SPRING CLIP UP TOO HIGH OR IT MAY BE DAMAGED.**

4.   Gently lift the spring clip and replace with a similar type battery. Make sure the contacts are properly oriented.
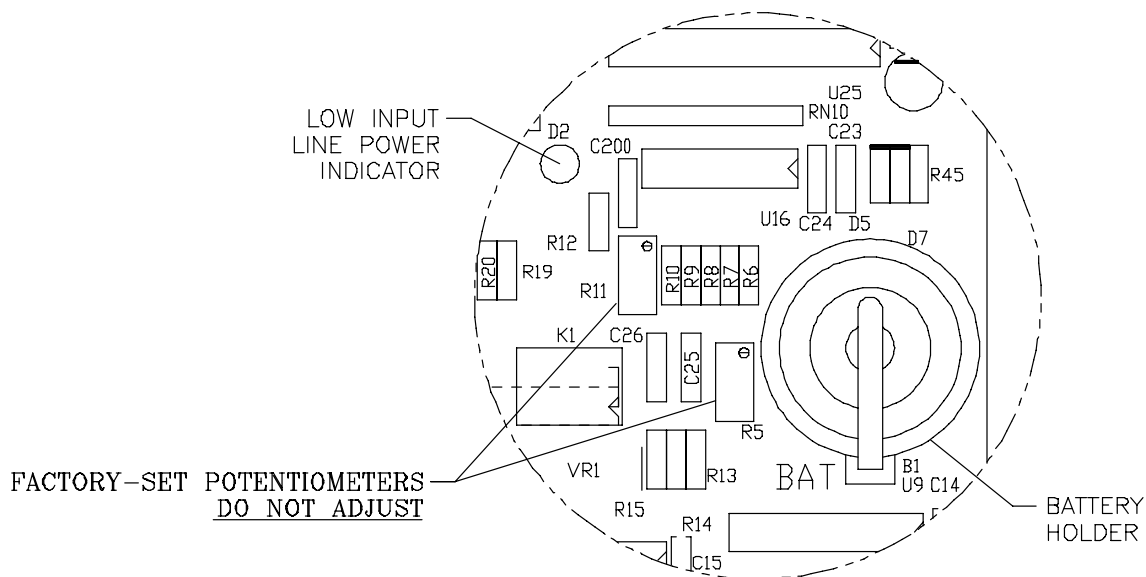
Figure 4.1 - Battery Holder

4.1.2 FIRMWARE REPLACEMENT

1.   Each firmware EPROM is located in a 40-pin LIF (Low Insertion-Force) socket on the controller circuit board (refer to **Figure 4.2**).

> **NOTE**
>
> **When shipped, the EPROM chips will be labeled as SFO5102R_ for the main firmware or SFO5103R_ for axis software where the "_" position represents a revision number. Each chip must be replaced in its proper socket. The main firmware is located in socket U33 and the axis firmware is located in socket U19 (refer to 1). If the wrong firmware is in the socket, a fault code will be displayed on the status LED.**

2.   Note the location of the #1 pin on the socket as indicated on the old EPROM chip in the socket.

3. Carefully remove the old processor chip by pulling straight up out of the socket so all sides of the chip move away from the socket evenly. Use of a properly-sized chip removal tool is recommended. **DO NOT PULL UP AT AN ANGLE OR UNEVENLY! DO NOT ROCK THE CHIP TO REMOVE IT FROM THE SOCKET!**
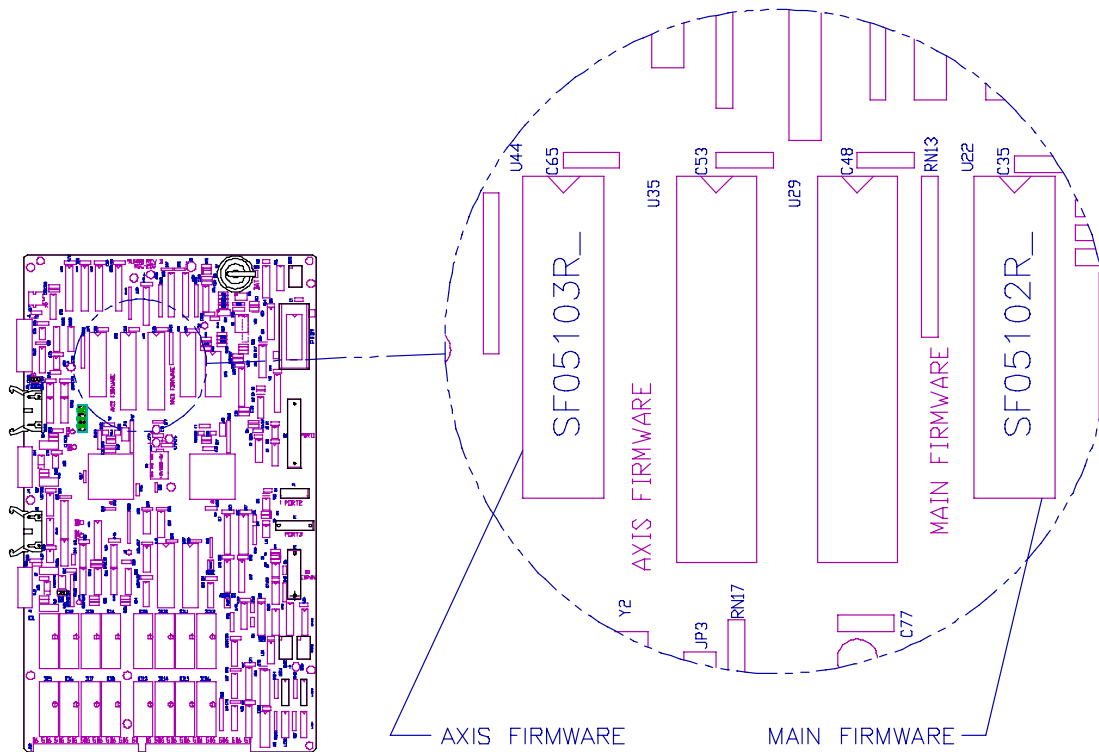
Figure 4.2 - Firmware Locations

4. Gently set the new chip on the LIF socket making sure the #1 pin is aligned in the correct socket.

5. Check to make sure all pins of the chip are started in the holes in the socket. **DOUBLE CHECK!**

6. Gently press the chip straight down into the socket. **DO NOT ROCK THE CHIP TO INSERT IT OR PRESS IN AT AN ANGLE!**

NOTE
As of January 1994, SFO5102R_ supersedes SFO5100R_ for the main firmware, and SFO5103R_ supersedes SFO5101R_ for the axis firmware.

4.2 TROUBLESHOOTING

The balance of this section is designed to assist trained personnel in identifying and correcting controller malfunctions. A prerequisite to the use of this troubleshooting guide is a thorough knowledge of the MSC-250 controller. When a problem occurs, first read the appropriate sections of this manual to make sure that the controller is installed properly and that it is being operated correctly.

CAUTION

WHEN ALL TROUBLESHOOTING FUNCTIONS ARE COMPLETED, MAKE SURE THE MODE SWITCH IS RETURNED TO THE 0 POSITION FOR NORMAL CONTROLLER OPERATION.

4.2.1 BASIC SYSTEM CHECKS

Most problems with the controller can be found by following a systematic sequence of observations and tests. Many start-up problems can be associated with improperly installed devices, loose or improper wiring connections, or improper settings.

All troubleshooting should include an initial check of various basic areas. For the MSC-250 controller, some of the areas to be checked include the following:

5. If this is an initial installation, check all installation procedures to make sure they have been followed properly.

6. Check to make sure 120 VAC power is being supplied to the controller and all system power supplies. Check to make sure plugs are securely inserted in their respective sockets and supply disconnects are turned on. Check all fuses.

7. Check the status displays to see if an error message is being displayed. Take appropriate corrective actions if an error message is displayed.

8. Check for loose or broken wires.

9. Check all serial and peripheral cable connectors to make sure they are securely seated in their respective sockets.

10. Check all input devices for proper settings.

11. Check for a loose mechanical coupling between the motor and the encoder.

12. Check each of the test points on the controller circuit board for the correct voltages (refer to **Figure 4.3**).
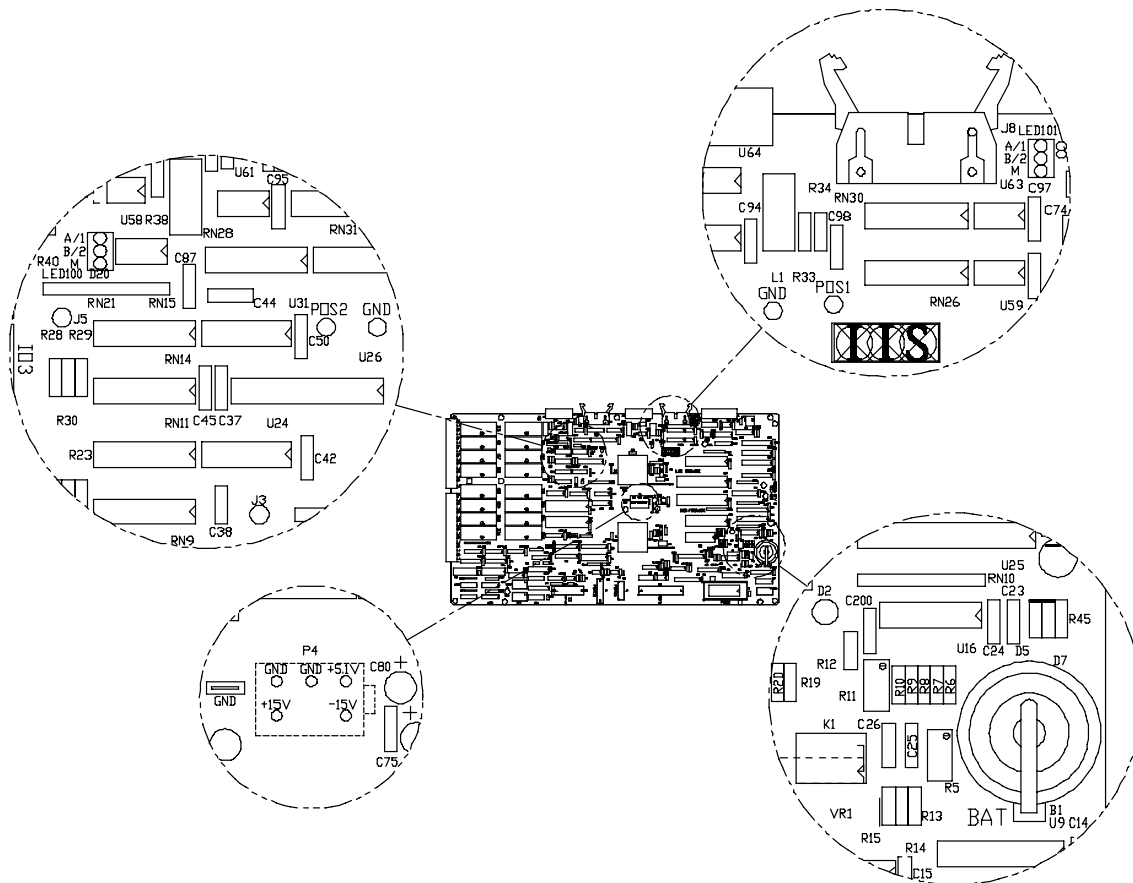
Figure 4.3 - Controller Circuit Board Test Points

a. System voltage between the +15 VDC and GND test points should read +15 ±0.15 VDC.

b. System voltage between the -15 VDC and GND test points should read -15 ±0.15 VDC.

c. System voltage between the +5.1 VDC and GND test points should read +5.1 +0.051/-0.00 VDC.

If the system problems are not resolved after checking these areas, proceed to the system test procedures detailed in "Section 4.2.2 - System Tests".

4.2.2 SYSTEM TESTS

The tests in this section are designed to be followed sequentially until the problem is found.

4.2.2.1 Velocity Loop Test

The velocity loop test removes the controller from the loop for the purpose of testing the motor, drive, and power supply. In this test, the drive is manually enabled and a velocity command voltage is applied to the amplifiers by means of a Volt Ohm Meter (V.O.M.) command input.

WARNING

THIS TEST CAUSES THE MOTOR TO TURN. MAKE SURE THAT THE MECHANICAL LOAD WILL ACCEPT MOVEMENT IN BOTH DIRECTIONS WITHOUT DAMAGE TO THE EQUIPMENT AND THAT ALL PERSONNEL ARE CLEAR BEFORE STARTING THIS TEST.

---

1.   Remove controller and system power.

2.   Open the controller cover and set the MODE selector switch to position 1. Close the cover.

3.   Remove the 6-Pin command line connector, for the axis to be tested, from the controller (refer to "Section 1.3 - Components").

4.   Restore power to the controller and system.

5.   Using a short jumper wire, temporarily short together the INLO (white wire) and INHI (green wire) terminals on the command line connector (refer to **Figure 4.4**). This step causes the drive (amplifier) to turn "On" manually.

**Figure 4.4
Controller Connectors**

6.   Apply system power. The motor should be stationary and should resist any attempt to turn the motor shaft.

> **NOTE**
>
> **Since this is a feedback system, there will always be some slight drift to the motor shaft when it is tested in this manner. However, the motor will not be free to be turned by hand.**

7.   Set an analog V.O.M. for use as an ohmmeter using the R´1 resistance scale or use a DC voltage source of approximately 0.5 VDC.

8.   Connect the positive meter lead to the POS OUT (red wire) command line connector terminal and the negative meter lead to the GND (black wire) command line connector terminal. This applies voltage (approximately 0.5 volts) into the drive input acting as a velocity command.

RESULT: **The motor should accelerate sharply to a controlled speed in a counter-clockwise direction and decelerate sharply when either meter lead is removed.**

9.   Reverse the meter leads to the POS OUT and GND command line connector terminals. This changes polarity of the velocity command.

RESULT: **The motor should accelerate sharply to a controlled speed in a clockwise direction and decelerate sharply when either meter lead is removed.**

10.   If all tests pass, the velocity loop is functioning correctly.

11.   Remove all system power, remove all temporary jumpers, replace all disconnected wires, and connect the command line connector to the controller.

Items to check if test fails:
    a.   Troubleshoot velocity loop according to manufacturer's recommendations.
    b.   Power supply voltages.
    c.   Motor armature wiring and polarity.
    d.   Feedback device wiring and polarity.

4.2.2.2   Position Loop Test

> **NOTE**
> **The Position Loop Test assumes a 1024 line encoder.**

The position loop test is used to verify that the MSC-250 controller and encoder are functioning properly. The controller and encoder are placed in a condition where the encoder signals are fed back to the controller. As the encoder is rotated, a corresponding voltage can be measured at the test points on the controller.

1.   Remove controller and system power.

2.   Open the controller cover and set the MODE selector switch to position 2.

3.   Remove the 6-Pin command line connector, for the axis to be tested, from the controller.

4.   Restore power to the controller and system.

> **WARNING**
>
> **THE COMMAND LINE CONNECTOR MUST BE DISCONNECTED FROM THE CONTROLLER TO MAKE SURE THE DRIVE DOES NOT BECOME ENABLED.**

5.   Connect a DC volt meter to the appropriate test points on the MSC-250 controller. Connect the positive meter lead to the POS OUT test point and the negative meter lead to the GND test point.

> **NOTE**
> **Full scale voltage for this test should not exceed ±10 VDC.**

6.   Apply system power.

7.   Manually turn the motor shaft until the meter reading is 0.0 VDC ±0.1 VDC.

8.   Turn the motor shaft 1/4 turn clockwise. The volt meter should indicate a voltage of +5 VDC ±1 VDC.

9.   Turn the motor shaft back to the starting point. The volt meter should indicate 0.0 VDC ±0.1 VDC.

10.   Turn the motor shaft 1/4 turn counterclockwise. The volt meter should indicate a voltage of -5 VDC ±1 VDC.

11.   Continue to turn the motor shaft in a counterclockwise direction. The voltage
       should increase negatively to -10.0 VDC ±1 VDC. When the motor has been
       turned 180 degrees from the starting point, the voltage will suddenly change
       polarity to +10 VDC. As the motor continues turning in a counterclockwise
       direction, the voltage will decrease toward 0.0 VDC. When the motor has been
       turned 360 degrees (back to the starting point), the voltage should again be
       0.0 VDC ±1 VDC. The cycle should repeat if the motor shaft continues to be
       turned in a counterclockwise direction.

12.   Turn off all power, remove all temporary jumpers, replace all disconnected wires,
       and connect the command line connector to the controller.

13.   Failure of the above test (as shown by incorrect voltages or no voltages)
       indicates a problem in the position sensing circuitry (encoder, cable, or
       controller).

Items to check if test fails:
       a.   Secure encoder connections.
       b.   Encoder reference and feedback signals.
       c.   Failed controller board.
       d.   Failed encoder.
       e.   Open or shorts in encoder cables.
       f.   5 VDC Power Supply

4.2.2.3   Encoder Test

1.   Remove controller and system power.

2.   Open the controller cover and set the MODE selector switch to position 3.

3.   Apply power to the controller.

4.   Rotate the encoder (motor) slowly.

RESULT: **The channel 1 and channel 2 encoder pulse LEDs should flash at the
          same rate, but not at the same time. The channel 3 encoder pulse LED
          should flash once per revolution.**

Items to check if test fails:
       a.   Check that drive power is on for a shared encoder.
       b.   Make sure the feedback device connector is secure.
       c.   Check the cable for shorts.
       d.   Check the cable for breaks.

e.   Troubleshoot the drive of a shared encoder according to the manufacturer's instructions.

4.2.2.4   Encoder and Power Supply Test

This test is used when the INT-810 Interface module is used with the MSC-250 controller.

1.   Remove controller and system power.

2.   Open the controller cover and set the MODE selector switch to position 3. Close the cover.

3.   Apply power to the controller.

4.   Check the power supply connected to the INT-810 interface module.

   a.   Connect a DC volt meter set to the 10 VDC scale to terminals 13 and 14 on the INT-810 interface module. Connect the positive meter lead to terminal 13 and the negative meter lead to terminal 14.

   b.   The meter should read 5 VDC ±0.25 VDC.

   c.   If the reading is improper, replace the 5 VDC power supply.

5.   Check the encoder pulse channels.

   a.   Connect a DC volt meter set to the 10 VDC scale to terminals 1 and 2 on the INT-810 interface module. Connect the positive meter lead to terminal 1 and the negative meter lead to terminal 2.

   b.   Move the encoder shaft to find two different voltages. The greater voltage should be no less than +2.5 VDC. The lesser voltage should be no more than -2.5 VDC. If the readings are out of specification, replace the encoder.

   c.   Connect a DC volt meter set to the 10 VDC scale to terminals 4 and 5 on the INT-810 interface module. Connect the positive meter lead to terminal 4 and the negative meter lead to terminal 5.

   d.   Move the encoder shaft to find two different voltages. The greater voltage should be no less than +2.5 VDC. The lesser voltage should be no more than -2.5 VDC. If the readings are out of specification, replace the encoder.

   e.   Connect a DC volt meter set to the 10 VDC scale to terminals 7 and 8 on the INT-810 interface module. Connect the positive meter lead to terminal 7 and the negative meter lead to terminal 8.

  f. Move the encoder shaft to find two different voltages. The greater voltage should be no less than +2.5 VDC. The lesser voltage should be no more than -2.5 VDC. If the readings are out of specification, replace the encoder.

6. Check the encoder connection cable for shorts or breaks in the cable.
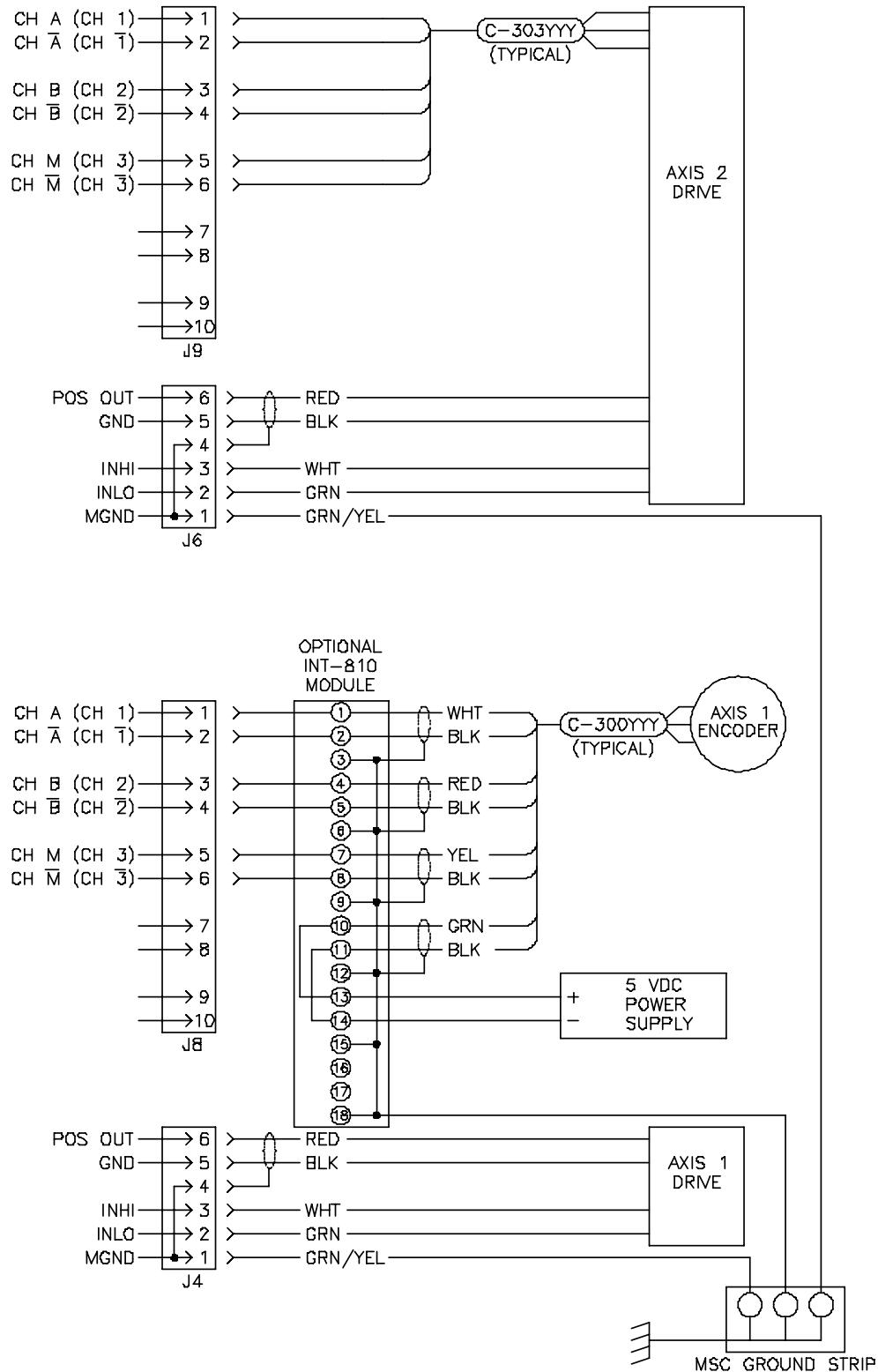
Figure 4.5 - Typical System Interconnections

4.2.2.5 Fiber Optic Light Transmission Test

1. Remove the fiber optic transmission line from the fiber optic receiver.

2. Visually check for the presence of light at the end of the fiber optic cable.

3. If no light is present at the receiver end of the cable, check the transmitter to see if light is present.

4. If light is present at the transmitter, but not the end of the fiber optics cable, replace the fiber optics cable. If light is not present at the transmitter, troubleshoot the source controller following manufacturer's instructions.

APPENDIX A - GLOSSARY

Actuator:
1. A device used to supply a signal causing the controller to initiate the specified sequences.
2. A device (such as a motor) which creates mechanical motion by converting various forms of energy to mechanical energy.

ASCII:
American Standard Code for Information Interchange

BAUD:
The number of bits per second that can be transmitted in computer communications.

BCD:
Binary Coded Decimal System. A system of number representation in which each digit of a decimal number is represented by a binary number.

Check Sum:
A sum of digits or numbers used in a summation check. (A summation check is an error-detecting procedure involving adding together all the digits of some number and comparing this sum to a previously computed value of the same sum.)

Closed Loop:
A regulating device in which the actuator position is sensed, and a signal proportional to this position (feedback position) is compared with a signal proportional to the desired actuator position (command position). The difference between these signals is the error signal. The error signal causes a change in the actuator so as to force this difference to be zero.

Communications:
The transmission of information from one device to another. The information can take many forms such as command signals, device status, and fault conditions.

Comparator:
A device where the feedback signal is subtracted from the command signal. The difference output of the comparator is called the error signal.

Controller:
The device which receives data from various input devices and issues commands to the drive.

Daisy Chain:
A means of connecting devices to a central processor by input/output buses which transmit in both directions simultaneously.

Edge triggered:
An electronic circuit which must sense the initial change in a voltage before it is actuated.

Encoder:
A type of feedback device which converts mechanical motion into electrical signals to indicate actuator position. The encoder typically produces an electrical pattern based on the interruption of a light source as a printed pattern is rotated between the source and a sensor. The interruptions are sensed and converted to electrical pulses. Actuator shaft position is determined by counting these pulses.

Feedback Device:
Device which monitors shaft position by sending signals to the controller as the shaft rotates.

Flag:
A bit in memory used by the programmer to evaluate action to be taken. A program branch may be executed depending on the true or false result of a bit test.

Gain:
A multiplication factor. When used with the MSC-250 controller, it is the factor used to increase or decrease the apparent number of counts per revolution.

High True:
A binary coded decimal condition where the binary digit "1" is the high logic voltage.

Home:
Absolute 0.00 or the point from which all absolute points are measured.

Host Computer:
A computer system whose function is to monitor and coordinate the processes of other devices. A host computer will typically coordinate motion control functions as well as their interaction with other machine processes.

Index:
To move the motor shaft an incremental distance from the current position.

Initialize:
To execute a series of Macroprogram instructions to teach a MSC axis controller an absolute zero reference.

I/O:
Input/Output. (Pertaining to all equipment and activity that transfers information into or out of a computer or similar device — such as the MSC-250 controller.)

Least Significant Bit:
The bit that carries the lowest value or weight in the binary notation for a numeral. The right-most bit in the binary word (notation).

LED: Light-Emitting Diode. Also known as solid-state lamp. A semiconductor diode that converts electric energy to light.

MSC Toolkit: The personal computer-based software package used to edit, compile, and debug Macroprograms developed for MSC controllers.

MSC-850: A multi-axis, programmable, servo motion controller capable of synchronously controlling from 1 to 8 axes.

Mode: The way in which the MSC-250 executes instructions. It is determined by the position of a 16-position selector switch.

Most Significant Bit: The bit that carries the greatest value or weight in the binary notation for a numeral. The left-most bit in the binary word (notation).

Nonvolatile Memory: A computer storage medium that retains information in the absence of power.

Optically Isolated: Indicates an I/O which uses a coupling device in which a light-emitting diode, energized by an input signal, is optically coupled to a photodetector.

Parameters: Predefined data which is used in the execution of instructions.

Peripheral: Various kinds of devices that operate in combination or conjunction with the MSC-250 controller but are not physically part of the controller.

PLC: Programmable Logic Controller.

Position: To move the motor to an absolute position in reference to a previously established 0.00 point (Home).

Position Error: The difference between the present actuator position (feedback) and the desired position (command).

Position Feedback: Present actuator position as measured by a position transducer.

POS OUT: Position Output (motor error output).

Programmable Logic
Controller:

An electronic device that scans on/off type inputs and controls on/off type outputs. The relationship between the inputs and outputs are programmable by the user.

Quadrature:

When relating to a shaft encoder, indicates that there are two oscillating outputs whose frequencies are 90° out of phase.

Resolver:

A type of feedback device which converts mechanical position into an electrical signal. A resolver is a variable transformer that divides the impressed AC signal into a sine and cosine output signal. The phase of these two signals represent the absolute position of the resolver shaft.

APPENDIX B - MACROPROGRAM COMMANDS

COMMAND	PARAMETERS
analog_in	controller#,channel#,variable
analog_out	controller#,channel#,value
analog_rt	controller#,channel#,value
analog_zo	controller#,channel#,value
begin_cam	
begin_data	
blk_io_in	input_flag#,variable
blk_io_out	output_flag#,variable
calc_cam_sum	controller#,starting element,ending element
calc_unit_cam	controller#,starting element,ending element
cam	value,value,etc.
cam_data	controller#,data_label,master_scale,data_scale
case	num
close	unit,status
clr_all_swi	
clr_bit	bit#,variable
clr_flag	user_flag#
clr_local	controller#
clr_swi	interrupt#
create	unit,file_name,status
data	value,value,etc.
declare	mode
default	
digi_comp	controller#,gain,integral,damp
dim	size
disable_hwi	controller#
disable_swi	
drive_off	controller#
drive_on	controller#
enable_hwi	
enable_swi	
end_cam	
end_data	
end_select	
equ	constant_expression
exec_profile	controller#
exit_select	
f_decel	controller#
find_mrk_ccw	controller#,counts
find_mrk_cw	controller#,counts

COMMAND	PARAMETERS
find_tm_ccw	controller#,counts
find_tm_cw	controller#,counts
get_act_spd	controller#,variable
get_cam_cnt	controller#,variable
get_cam_end	controller#,variable
get_cam_ptr	controller#,variable
get_cam_strt	controller#,variable
get_cam_sum	controller#,variable
get_com	controller#,variable
get_fol_err	controller#,variable
get_for_angle	controller#,channel#,variable
get_map	variable
get_map_stat	variable
get_mcf	controller#,variable
get_pls_mask	controller#,variable
get_pls_out	controller#,variable
get_pos	controller#,variable
get_pstat	controller#,status
get_space	unit,space,status
get_status	controller#
get_t_mark	controller#,state
get_time	variable
get_trap_pos	controller#,variable
get_volume	unit,data_area,status
gosub	subroutine_label
goto	address_label
if	compare1 operator compare2,address_label
if_bit_clr	bit#,variable,address_label
if_bit_set	bit#,variable,address_label
if_char	port#,address_label
if_flag_off	user_flag#,address_label
if_flag_on	user_flag#,address_label
if_io_off	I/O flag#,address_label
if_io_on	I/O flag#,address_label
if_no_char	port#,address_label
if_stat_off	status_flag#,address_label
if_stat_on	status_flag#,address_label
if_tmr_off	timer_flag#,address_label
if_tmr_on	timer_flag#,address_label
incr_offset	controller#,bits,ticks
index	controller#,distance
initialize	unit,data_area,status
input	text_label,length,decimals,value,user_flag

COMMAND	PARAMETERS
integer	
jog_ccw	controller#
jog_cw	controller#
let	variable=operand1 opcode operand2
let_byte	destination=source
load	unit,file_name,status
lock	controller#,lock#
l_track_spd	controller#,speed
master	controller#
msc_type	system_type
no_op	
open	unit,file_name,status
over_draw	controller#,speed,limit,distance
port_set	port#,baud,protocol
position	controller#,abs_position
prep_profile	controller#,data_label
preset	controller#,variable
print	text_label
print_num	length,decimals,value
p_vector	master_controller#,slave_controller#
rand_int	max_number,variable
ratio	controller#,ratio
read	unit,data_area,length,status
read_offset	controller#,variable
restart_at	address_label
return_sub	
save	unit,file_name,status
select	variable
set_ac_dc	controller#,rate
set_bit	bit#,variable
set_cam_ptr	controller#,value
set_flag	user_flag#
set_gl_ccw	controller#
set_gl_cw	controller#
set_home	controller#, offset
set_local	controller#
set_map	variable
set_mcf	controller#,variable
set_offset	controller#,value
set_pls_ang	controller#,on_angle,off_angle,module#
set_pls_cnt	controller#,count
set_pls_mask	controller#,variable
set_pls_time	controller#,time,module#

COMMAND	PARAMETERS
set_speed	controller#,speed
set_swi_mask	variable
set_tmr	timer_flag#,time
set_trig_cam	controller#,master_angle
set_trig_pw	controller#,master_angle
set_vgain	controller#,variable
stop_input	
swi_if_off	interrupt#,flag,subroutine_label
swi_if_on	interrupt#,flag,subroutine_label
switch_cam	controller#,start element,# of elements
sys_fault	
sys_return	
test_mode	controller#
text	"ASCII string"
track_spd	controller#,speed
trap_pos	controller#
turn_off	I/O flag#
turn_on	I/O flag#
unlock	controller#,mode#
vel_ccw	controller#
vel_cw	controller#
write	unit,data_area,length,status
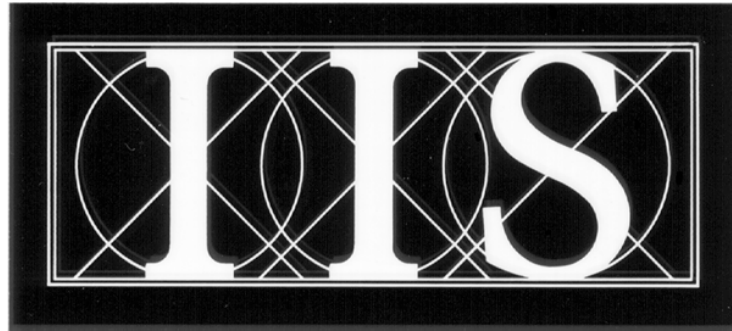
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