

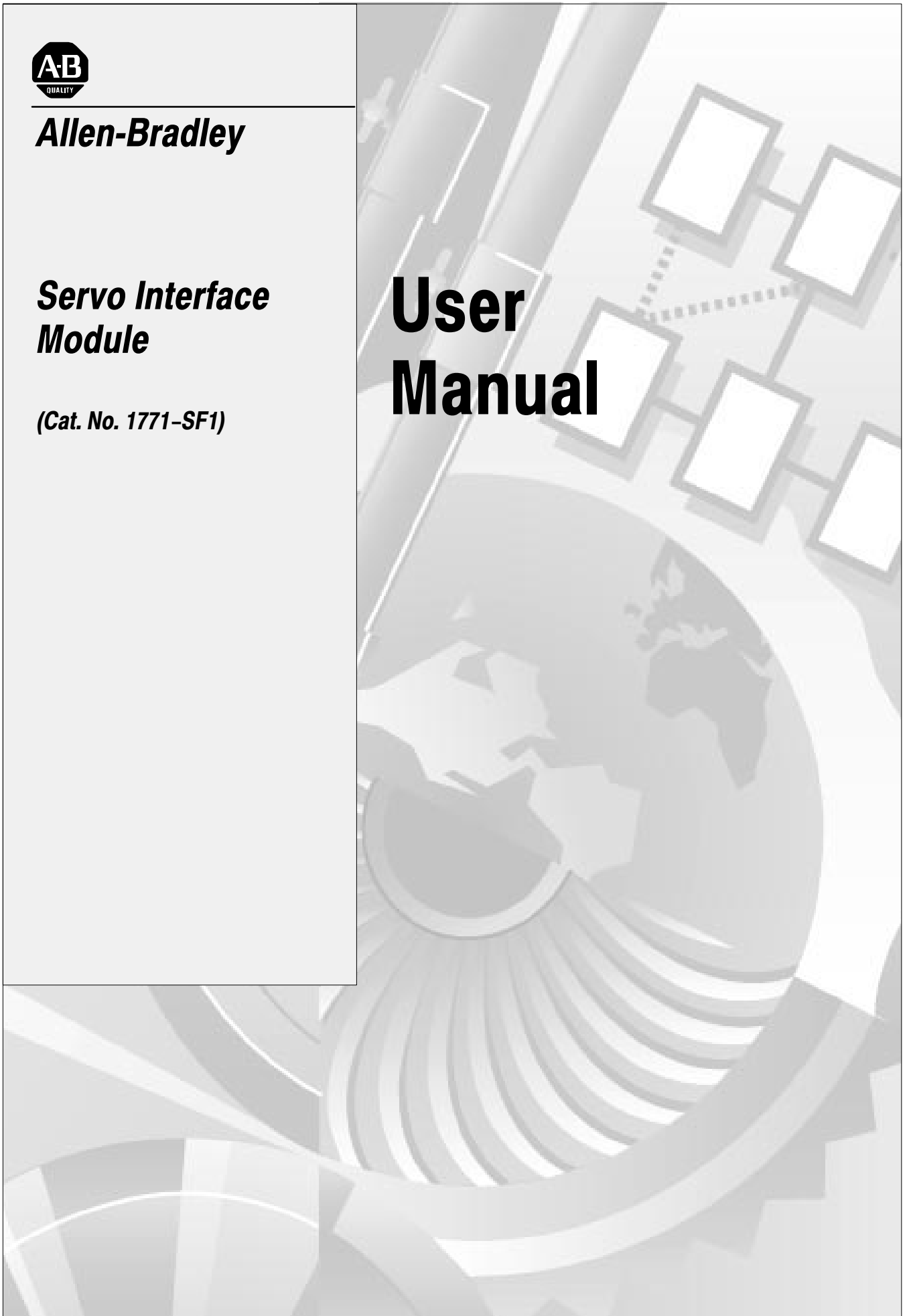


***Allen-Bradley***

***Servo Interface  
Module***

***(Cat. No. 1771-SF1)***

# **User Manual**



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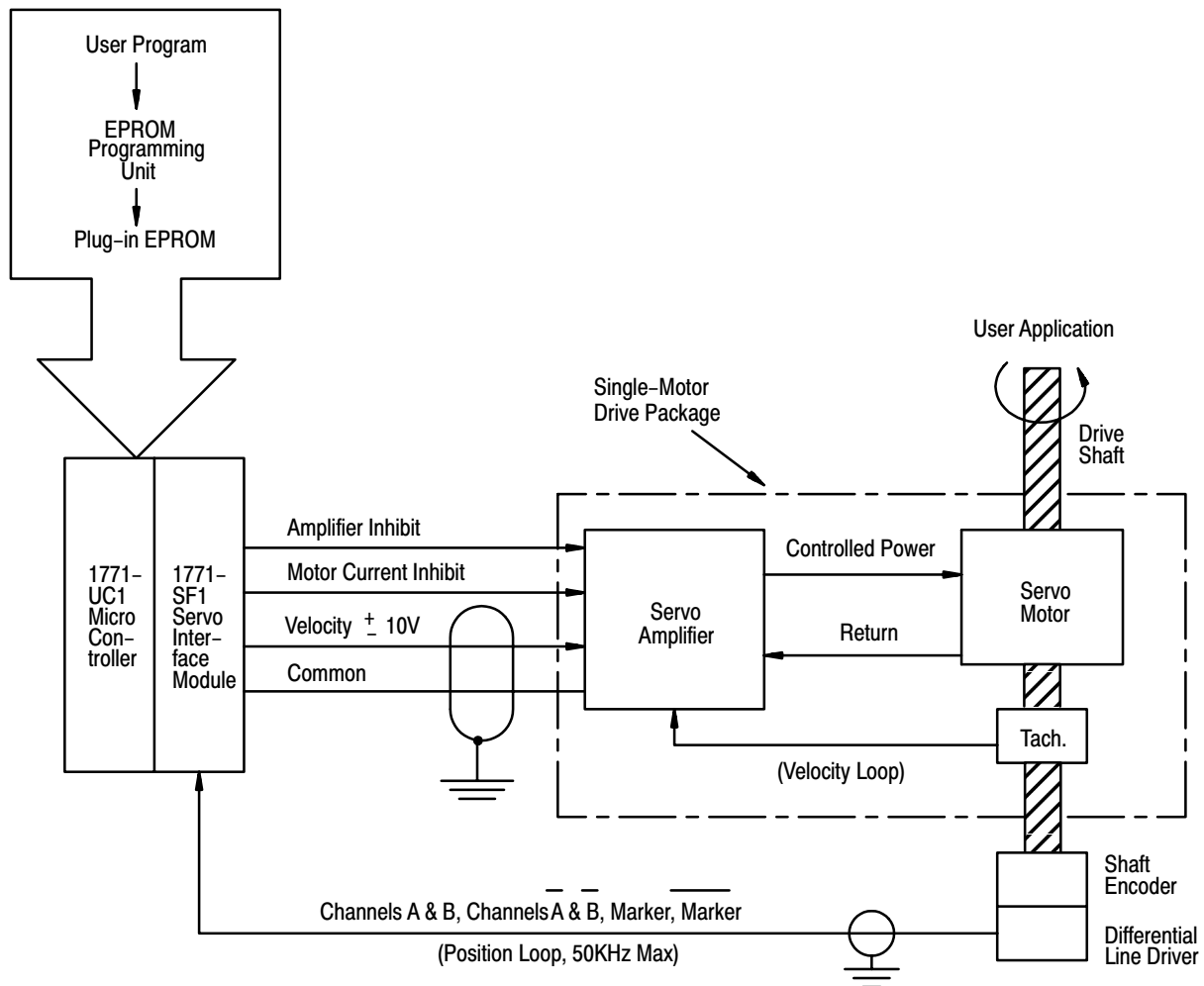
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## Introduction

### Description

The Allen-Bradley Servo Interface Module (Cat. No. 1771-SF1) when used with the Micro Controller (Cat. No. 1771-UC1) can control single axis positioning systems such as found in machine tool applications. When combined with a single motor variable speed drive package and a full quadrature encoder, this microprocessor-controlled servo drive system (Figure 1.1) can be programmed to cycle through precise speed and position profiles.

**Figure 1.1**  
Typical Microprocessor-Based Servo Control System



**User Considerations**

Operating features described in this manual must be totally programmed in the user software (Z-80A opcodes) of the accompanying micro controller. The servo interface module has the capability to perform as described, provided that the software of the micro controller has been completely developed. The user must assume full responsibility for performing all systems engineering, programming, and software support associated with the micro controller/servo interface module and intended application.

## Component Interfacing, Module Preparation, and Installation

### General

This chapter describes the necessary characteristics of user-provided components, preparation and installation of the module and wiring considerations. Refer to the Micro Controller Users Manual (Publication No. 1771-6.5.5) for installation of the micro controller module.

### Component Interfacing

The servo interface module must be compatible with other components of the control system, including the differential line drivers, shaft encoder and servo drive package containing the servo motor control amplifier. Required characteristics of these components are stated below.

### Encoder

An encoder should have the following characteristics for monitoring the rotational direction and position of a drive shaft.

- Full quadrature, 90° out of phase (typical).
- Maximum frequency to the servo interface module is 50 KHz for Channels A, B, and marker.

### Differential Line Drivers

Line drivers with the following characteristics can be used to transmit encoder quadrature pulses to the servo interface module.

- Differential outputs for Channel A, Channel B, and marker.
- TTL Source and Sink Currents = 15 mA max.
- TTL Output Voltage = 2.4V (min.) high  
= 0.6V (max.) low

### Servo Drive Package

Outputs available to the servo motor control amplifier must be compatible with the following control voltage and current levels.

- TTL output to inhibit the motor current.
- TTL output to turn OFF the servo drive amplifier.
- TTL Output Voltage = 2.4V (min.) high  
= 0.6V (max.) low
- TTL Sink Current = 12 mA (max.)

- TTL Source Current = 7.9mA @ 2.4V
- +10 to -10V DC analog output for forward or reverse proportional motor speed control.

### Isolation

None of the terminals of the servo interface module are protected against misapplication of AC, DC, or reverse DC.



**CAUTION:** Do not apply voltage or current sources to the terminals of the servo interface module except those specified for the terminals. Damage to the module may result.

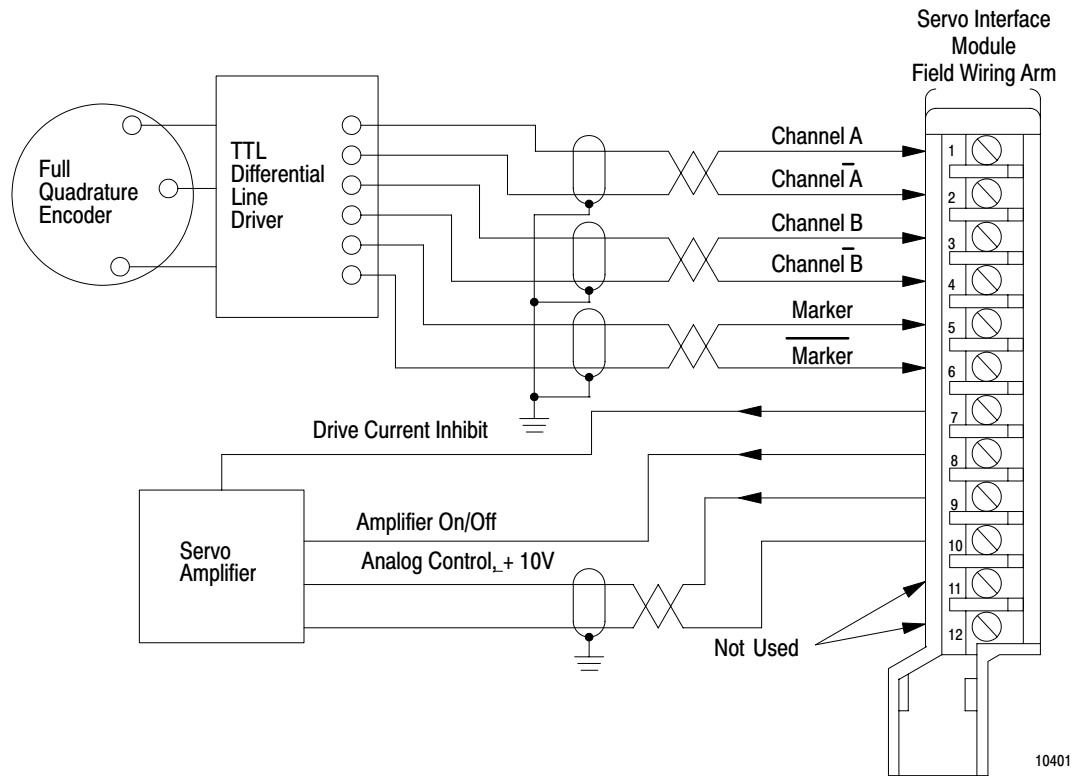
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If voltages are misapplied and damage is done to the terminal-side of the module, the system-side including the data bus to the micro controller is protected to 500V DC maximum isolation from the terminal side of the module.

### Wiring

The line drivers and the servo amplifier of the motor drive package should be wired to the field wiring arm connector of the servo interface module as shown in Figure 2.1.

**Figure 2.1**  
**Typical Connection Diagram**



**Cable Recommendations**

The cable distance between the servo interface module and the differential line drivers should not exceed 40 feet. Use a twisted conductor pair within a shielded braid (Belden #8761 or equivalent) for connections to the line drivers. Use a 14 gauge conductor for the analog output to the servo amplifier and make this connection as short as possible to minimize the voltage drop in the cable.

**Shield Connection**

Belden 8761 or equivalent cable has a foil shield with a bare stranded drain wire. The shield should be connected to earth ground at one end of the cable only. This can be at the customer end of the cable or at an I/O chassis mounting bolt or stud. At the other end of the cable, the shield should be cut short and taped back to insulate it from any electrical contact. This is to guard against unwanted radiated electrical noise and ground current loops.

The common terminal of the servo interface module should not be used for the shield connection. This terminal is a common with respect to the analog output, TTL outputs and pull-up resistors on the differential inputs.



**WARNING:** Do not use the common terminal of the servo interface module field wiring arm for the shield connection. Unpredictable operation could occur with resulting damage to equipment and/or injury to personnel.

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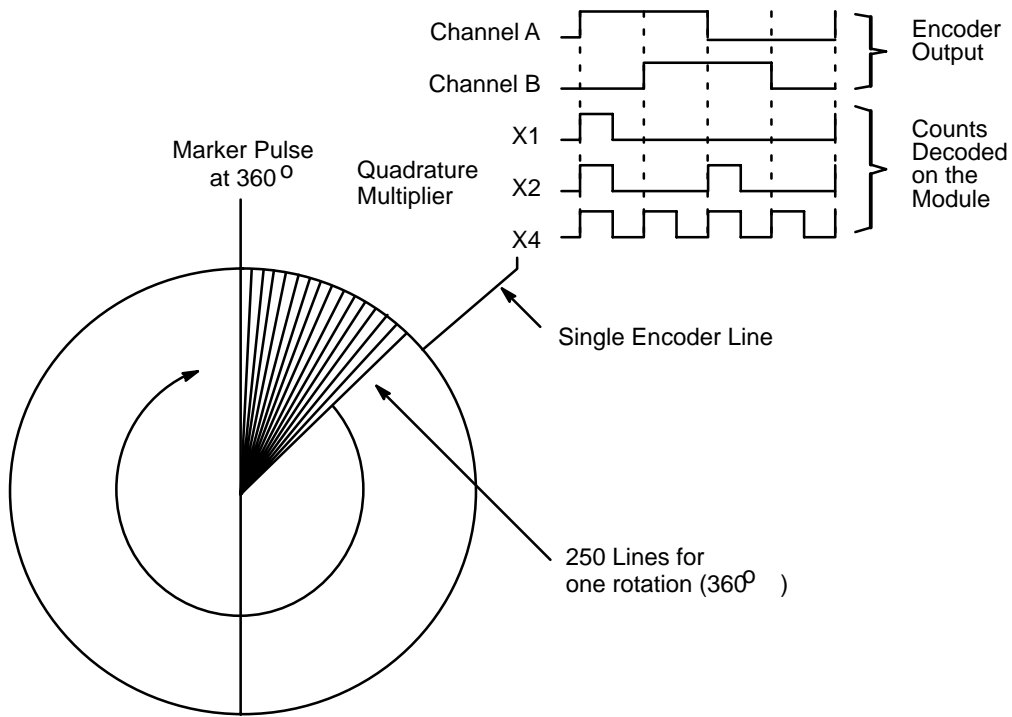
## Module Preparation

Prior to installation, the multiplication factor for counting the encoder quadrature pulses must be set internally. The quadrature pulses are transmitted through the differential line drivers to the terminals of Channels A and B. An additional complementary set of equal but logically opposite pulses are transmitted by the drivers to the terminals of Channel A and Channel B. The servo interface module can be set to count either 1, 2, or 4 of the quadrature pulse edges for each quadrature set depending on the desired positioning precision (Figure 2.2). The desired multiplier, x1, x2, or x4 can be set manually by inserting the pair of Burg pin jumpers on selected pairs of terminals. The jumpers are located on the printed circuit board inside the module. They are accessible by removing the cover plates according to the following procedure:

- Remove the four slotted screws from the label-side of the module.
- Remove the left and right cover plates.
- Place the printed circuit board on a table, solder side down.
- The pair of Burg pin jumpers are located in the center of the component-side of the printed circuit board and are identified by the labels JPR1 and JPR2.
- Position the jumpers according to Figure 2.3.

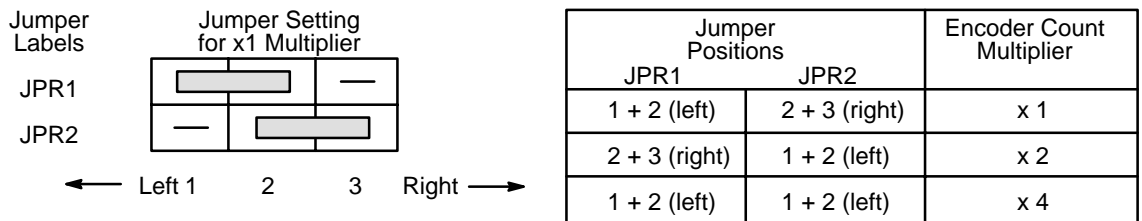


**Figure 2.2**  
**Example Encoder Diagram (250 Line)**



10403

**Figure 2.3**  
**Burg Pin Jumper Selection**



10402

## Module Installation

The module should be located in the I/O slot adjacent to the Micro Controller (Cat. No. 1771-UC1). If located further down the rack, propagation delays due to longer signal paths along the backplane could degrade performance. High-speed communication between the micro controller and servo interface module necessitates this location.

The servo interface module must be used with the micro controller. It cannot operate with PC processors or adapters.

The servo interface module can be used in the same I/O rack with any of the standard AC and DC 1771 I/O modules. However, it must not be used in an I/O rack containing microprocessor-based I/O modules. The only exceptions to this are the following microprocessor-based I/O modules which do not interfere with the operation of the servo interface module.

- 8-Bit Analog Input Module (Cat. No. 1771-1E)
- Encoder/Counter Module (Cat. No. 1771-IJ/IK)



**CAUTION:** The Servo Interface Module (Cat. No. 1771-SF1) will operate only when paired with the Micro Controller (Cat. No. 1771-UC1).

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**WARNING:** Avoid placing microprocessor-based 1771 I/O modules (except as noted) in the same I/O rack with the servo interface module. Unpredictable operation could occur with resulting damage to equipment and/or injury to personnel.

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## Keying

Plastic keying bands shipped with each I/O chassis provide an easy method for keying and I/O slot to accept only one type of module. Use of the keying bands is strongly recommended.

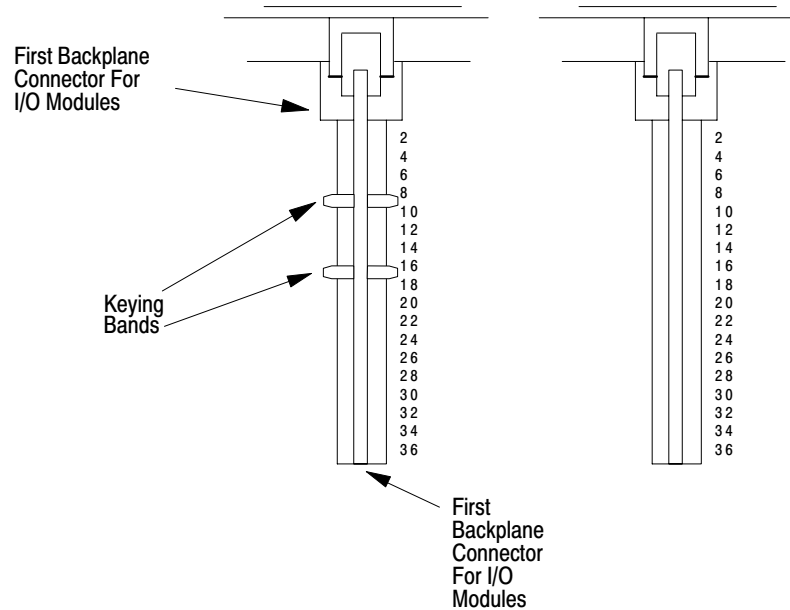
The module is slotted in two places on its rear edge. The position of the keying bands on the backplane connector must correspond to the slots to allow insertion of the module so that only the servo interface module will fit in this slot.

Refer to Figure 2.4. Snap the keying bands on the upper backplane connectors between these numbers printed on the backplane:

- 8 and 10
- 16 and 18

Needlenose pliers can be used to insert or remove keying bands.

**Figure 2.4**  
Keying Diagram



## Specifications

### Counter Input

- Differential
- Full quadrature encoder

### Counter Range

- 0-255<sub>10</sub>
- Marker input is latched and reset by user program.

### Max. Input Frequency

- 50 KHz, any channel

### TTL Input/Output Voltage

- 0.6 V max. low voltage
- 2.4 V min. high voltage

### TTL Input Current

- 15mA per line driver channel (differential inputs only)

### TTL Output Current

- 7.9mA @ 2.4V as source
- 12mA max. as sink

### Number of TTL Outputs

- Two

### Analog Output (Single Channel to Servo Amplifier)

- -10V to + 9.995V
- -5mA to +5mA max.

### Max. Cable Distance

- 40 ft. encoder input
- 40 ft. TTL output
- 5 ft. analog output

### Ambient Temperature Rating

- Operational : 0° to 60° C (32° to 140°F)
- Storage : -40° to 85°C (-40° to 185°F)

### Relative Humidity Rating

- 5% to 9% (without condensation)

## Programming and Operation

### General

The servo interface module controls the operation of a single motor servo drive package in accordance with commands received from the micro controller. Outputs to the servo amplifier of the drive package include:

- -10.000 to 9.995V analog output signal for proportional motor speed and direction control.
- A TTL output to limit the drive current from the servo amplifier to the motor.
- A TTL output signal to turn the servo amplifier ON or OFF.

The servo interface module also monitors motion by counting quadrature pulses from a shaft encoder. The pulses represent the rotational position of the encoder shaft or servo motor drive shaft. The servo interface module sends an interrupt signal to the micro controller every time the accumulated counts of quadrature pulses equal a preset target value. This signal can be used to minimize the programming required to monitor and control the position of the drive shaft.

Differential line drivers convert the single-ended encoder signal to differential pulses for Channels A, B, and Marker of the module. The driver also transmits a complement set of pulses (equal but logically opposite) to Channel A, Channel B, and Marker channel.

### Data Transfers

All data transfers between the micro controller and the servo interface module take place over the normal I/O 8-bit data bus on the backplane of the 1771 I/O rack. The transfer of each one of the following data bytes is initiated by a separately addressed read or write instruction from the micro controller. The enable commands are transmitted over the special DSEN lines described in the Micro Controller User's Manual (Publication No. 1771-6.5.5).

### DAC Data (Servo Motor Speed)

The servo interface module contains a Digital to Analog Converter (DAC) that sends a 0 to  $\pm 10$ V analog voltage to the servo amplifier of the motor drive package. The voltage controls the speed and rotational direction of the servo motor. The input to the DAC is a 12-bit binary number sent from the micro controller that allows the speed and rotational direction of the servo motor to be changed by user program. The DAC converts the

lower 11 bits to the 0 to 10V DC analog output. Bit 12 designates the sign + or - for forward or reverse motion. The resolution of the digital-to-analog conversion is  $\pm 10\text{V}/2048$  bits or approximately 4.883 mV/bit.

Table 3.A shows the relationship between the input binary number from the micro controller and the analog output voltage from the servo interface module for sample values. The binary number for any desired output voltage can be determined as follows:

### **POSITIVE OUTPUT**

1. Output voltage (volts) ” decimal equivalent of the binary number.  
 $4.883 \times 10^{-3}$  (volts/bit)
2. Convert the decimal equivalent to the binary number.
3. Take the complement of the binary number.

### **NEGATIVE OUTPUT**

1. Output Voltage (volts) ” decimal equivalent of the binary number.  
 $4.883 \times 10^{-3}$  (volts/bit)
2. Convert the decimal equivalent to the binary number.
3. Add 1 bit to the binary number.

Refer to the rpm/voltage chart provided by the servo motor manufacturer to complete the relationship between the DAC input binary number and servo motor speed and to determine the direction of rotation which is indicated by the sign bit.

**Table 3.A**  
**DAC Input/Output**

Sign Bit	Input Bit Pattern	Analog Output Voltage
0	111 1111 1111	-10.000V
0	111 1111 1110	-9.995V
0	111 1111 1100	-9.990V
0	000 0000 0011	-19.5mV
0	000 0000 0010	-14.6mV
0	000 0000 0001	-9.7mV
0	000 0000 0000	-4.9mV
1	111 1111 1111	0
1	111 1111 1110	+4.9mV
1	111 1111 1101	+9.7mV
1	111 1111 1100	+14.6mV
	(1)	
1	000 0000 0011	+9.985V
1	000 0000 0001	+9.990V
1	000 0000 0000	+9.995V
	(2)	(3)
(1) Low-TRUE Bit Patterns		(2)= MSBY (3) = LSBY

The 12 bit binary input to the DAC is transferred to two bytes using two write instructions. The Most Significant BYte (MSBY) is eight bits long. It can be loaded into memory location 600EH. DSEN Line 16 enables the transfer. The Least Significant BYte (LSBY) can be loaded into memory location 600DH. It contains data in the upper 4 bits. The lower 4 bits are not used. DSEN line 15 enables the transfer. DAC data is reset at power-up or by the data byte reset command (write location 600BH).

**Control Byte (Servo Motor Amplifier Inhibit)**

Bit 2 of the control byte is used to inhibit amplifier drive current to the servo motor. Bit 3 is used to turn OFF the servo motor amplifier. They are low = TRUE optically isolated TTL outputs.

A write instruction to memory location 600FH latches these bits. DSEN Line 17 enables the transfer from the servo interface module. The control byte is reset at power-up or whenever the data byte reset command is programmed.

### **Encoder Counter Values (Position Pulses)**

The encoder line drivers generate pulses for each encoder line. Assume that a 250 line encoder is used as in Figure 2.2. When the quadrature multiplier is x1, a counter increment of 1 means that the encoder shaft has turned through  $1.44^\circ$ . (This can be translated into the linear movement of a feed slide, proportional to the number of drive shaft threads per inch.) When either the x2 or x4 quadrature multiplier is used, one count is equivalent to a turn of  $.72^\circ$  or  $.36^\circ$ , respectively.

The micro controller can be programmed to read the accumulated value of the encoder counters in the servo interface module by a read instruction from memory location 6008H. A read from the encoder counters is usually performed when the encoder is halted or turning very slowly. A read from this location does not halt counter operation. DSEN Line 10 enables the transfer from the servo interface module. The encoder accumulated value is set to zero at power-up and after 255 counts. It also can be set to zero by the counter reset command which is a write to location 6009H.

### **Target Values (Position Interrupts)**

The target value determines at which count (in the accumulated count of encoder pulses) an interrupt will be sent to the micro controller. The target value is an 8-bit comparator preset ranging from 0-255. Target value interrupts can be counted to monitor and control the rotational position of the drive shaft.

A write instruction to memory location 600CH latches the target value. DSEN Line 14 enables the transfer from the micro controller to the servo interface module. The target value preset is reset to zero at power-up or by the data byte reset command (write location 600BH).

### **Special Servo Lines on the Backplane**

Four special backplane lines are used to monitor servo signals at the micro controller. The first three lines transmit the marker, A>B, and CCW/CW signals, respectively, to the status port of the micro controller. They are read at memory address 7000H. These signals are always on-line. The fourth line transmits the interrupts to the micro controller.



<b>Marker</b>	A low = TRUE signal is transmitted to status port bit 0 after the marker signal is latched by the servo interface module for each completed revolution of the encoder shaft. A write instruction to 600AH will reset this latched output.
<b>A &gt; B</b>	A low = TRUE signal appears at status port bit 1 whenever the target value (preset) is greater than the accumulated value of the counters counting the encoder pulses. The bit goes high when the accumulated value becomes equal to or greater than the target value.
<b>CCW/CW</b>	Generally, a low signal appears at status port bit 2 when the rotation of the encoder shaft is counterclockwise (CCW). A high signal will then indicate clockwise (CW) rotation. This relationship depends on system hardware and/or wiring polarity.
<b>Target Value Interrupt</b>	Whenever the accumulated value of the encoder counter becomes equal to the target value preset, an interrupt signal is sent to the micro controller. The vectored interrupt is generated by the counter/timer circuit (CTC Channel 2) in the micro controller. The interrupt condition is automatically reset by the micro controller during execution of the return from interrupt instruction (RETI). The micro controller must be programmed to perform this function.
<b>Programming the Servo Control Functions</b>	<p>The servo interface module controls the drive package in accordance with commands received from the micro controller module. All programming of the micro controller is written in the Z-80 instruction set. In order to transfer the information described in Paragraph 3.1 from or to the servo interface module, certain memory addresses have to be accessed in the micro controller.</p> <p>Whenever a Z-80 instruction is written to or read from a control function address for the servo interface module, the instruction will force low one of the corresponding special enable lines, DSEN 10-17. This signal instructs the servo interface module to latch data received from the 8-bit bidirectional backplane data bus (system write) or to place data on the data bus (system read). The control functions, their addresses and corresponding DSEN lines are tabulated in Table 3.B.</p>

**Table 3.B**  
**Servo Control Features**

<b>Control Function</b>	<b>Memory Address</b>	<b>DSEN Line</b>	<b>Comments</b>
DAC Data, MSBY	600EH Write	16	8-bit byte
DAC Data, LSBY	600DH Write	15	Upper 4 bits of byte
Target Value Preset	600CH Write	14	0-255 <sub>10</sub> in binary
Control Byte	600FH Write	17	Bit 2 limits drive current . Bit 3 turns OFF the servo amplifier.
Data Byte Reset Command	600BH Write	13	Resets DAC data, Target Value Preset and Control Byte by loading zeros (Also reset at power-up)
Read Counter Accum Value	6008H Read	10	0-255 <sub>10</sub> in binary
Counter Reset	6009H Write	11	Resets counters and decoder logic by loading zeros (Also reset at power-up).
Marker Latch Reset	600AH Write	12	Resets the Marker Latch
Refer to the Micro Controller Users Manual (Publication No. 1771-6.5.5) for additional information on developing the program to perform the various functions of the servo interface module.			



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