Allen-Bradley

IMC S Class Compact Motion Controller

(Cat. No. 4100-999-122)

Installation and Setup Manual

Important User Information

Because of the variety of uses for the products described in this publication, those responsible for the application and use of this control equipment must satisfy themselves that all necessary steps have been taken to assure that each application and use meets all performance and safety requirements, including any applicable laws, regulations, codes and standards.

The illustrations, charts, sample programs and layout examples shown in this guide are intended solely for purposes of example. Since there are many variables and requirements associated with any particular installation, Allen-Bradley does not assume responsibility or liability (to include intellectual property liability) for actual use based upon the examples shown in this publication.

Allen-Bradley publication SGI-1.1, *Safety Guidelines for the Application, Installation, and Maintenance of Solid-State Control* (available from your local Allen-Bradley office), describes some important differences between solid-state equipment and electromechanical devices that should be taken into consideration when applying products such as those described in this publication.

Throughout this manual we use notes to make you aware of safety considerations:

ATTENTION: Identifies information about practices or circumstances that can lead to personal injury or death, property damage or economic loss.

Attention statements help you to:

- identify a hazard
- avoid the hazard
- recognize the consequences

Important: Identifies information that is critical for successful application and understanding of the product.

Preface

Chapter 1 – Safety

Chapter 2 – Introduction

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Chapter 4 – Installation and Hookup

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Preface

Read this preface to familiarize yourself with the rest of the manual. This preface covers the following topics:

- who should use this manual
- the purpose of this manual
- general safety precautions
- receiving and storage information
- Allen-Bradley support

Who Should Use this Manual

Use this manual if you are responsible for designing, installing, programming, or troubleshooting the Allen-Bradley IMC S Class Compact.

If you do not have a basic understanding of the Compact, contact your local Allen-Bradley representative for information on available training courses before using this product.

Purpose of this Manual

This manual is a installation and setup guide for the Compact. It gives you an overview of the Compact and describes the procedures you use to install, set up, use, and troubleshoot the Compact.

Safety Precautions

The following general precautions apply to the Compact:

ATTENTION: Only those familiar with the Compact and associated machinery should plan or implement the installation, startup, and subsequent maintenance of the system. Failure to comply can result in personal injury and/or equipment damage.

ATTENTION: This product contains stored energy devices. To avoid hazard of electrical shock, verify that all voltage on the capacitors has been discharged before attempting to service, repair, or remove this unit. You should only attempt the procedures in this manual if you are qualified to do so and familiar with solid-state control equipment and the safety procedures in publication NFPA 70E.

ATTENTION: The system integrator is responsible for local safety and electrical codes.

ATTENTION: An incorrectly applied or installed Compact can result in component damage or a reduction in product life. Wiring or application errors, such as undersizing the motor, incorrect or inadequate AC supply, or excessive ambient temperatures can result in malfunction of the product.

ATTENTION: This product contains ESD (Electrostatic Discharge) sensitive parts and assemblies. Static control precautions are required when installing, testing, servicing, or repairing this assembly. Component damage can result if ESD control procedures are not followed. If you are not familiar with static control procedures, refer to Allen-Bradley publication 8000-4.5.2, Guarding Against Electrostatic Damage or any other applicable ESD Protection Handbook.

Contents of this Manual

Chapter	Title	Contents
	Preface	Describes the purpose, background, and scope of this manual. Also specifies the audience for whom this manual is intended.
1	Safety	Lists safety information regarding the Compact.
2	Introduction	Provides a feature overview of the Compact.
3	Technical Overview	Provides a technical overview of the Compact.
4	Installation and Hookup	Provides information that allows you to install and hook up your Compact.
5	Understanding the IMC-S23x Setup	Provides information that allows you to understand the setup procedures for the Compact.
6	Setting Up your Compact	Provides setup procedures for the Compact.
7	Troubleshooting	Explains how to interpret and correct problems with your Compact.
Appendix A	Cable Information	Provides information about the cables used with the Compact.

Related Documentation

The following documents contain additional information concerning related Allen-Bradley products. To obtain a copy, contact your local Allen-Bradley office or distributor.

For	Read This Document	Document Number
A description and specifications for the Compact	Compact Motion Controller Product Data	4100-2.3
A user guide for GML programming to be used with the Compact.	GML Programming Manual	GML-DOC-S
An overview of the Flex I/O products	Flex I/O Product Profile	1794-1.14
Specifications for the Flex I/O products	Flex I/O Product Data	1794-2.1
An article on wire sizes and types for grounding electrical equipment	National Electrical Code	Published by the National Fire Protection Association of Boston, MA.
A complete listing of current Allen-Bradley documentation, including ordering instructions. Also indicates whether the documents are available on CD-ROM or in multi-languages	Allen-Bradley Publication Index	SD499
A glossary of industrial automation terms and abbreviations	Allen-Bradley Industrial Automation Glossary	AG-7.1
Schematics related to the Compact.	Schematics	4100-5.0.01

Compact Product Receiving and Storage Responsibility

You, the customer, are responsible for thoroughly inspecting the equipment before accepting the shipment from the freight company. Check the item(s) you receive against your purchase order. If any items are obviously damaged, it is your responsibility to refuse delivery until the freight agent has noted the damage on the freight bill. Should you discover any concealed damage during unpacking, you are responsible for notifying the freight agent. Leave the shipping container intact and request that the freight agent make a visual inspection of the equipment.

Leave the product in its shipping container prior to installation. If you are not going to use the equipment for a period of time, store it:

- in a clean, dry location
- within an ambient temperature range of -40 to 70° C (-40 to 158° F)
- within a relative humidity range of 5% to 95%, non-condensing
- in an area where it cannot be exposed to a corrosive atmosphere
- in a non-construction area

Allen-Bradley Support

Allen-Bradley offers support services worldwide, with over 75 Sales/Support Offices, 512 authorized Distributors and 260 authorized Systems Integrators located throughout the United States alone, plus Allen-Bradley representatives in every major country in the world.

Local Product Support

Contact your local Allen-Bradley representative for:

- sales and order support
- product technical training
- warranty support
- support service agreements

Technical Product Assistance

If you need to contact Allen-Bradley for technical assistance, please review the information in the *Troubleshooting* chapter first. Then call your local Allen-Bradley representative. For the quickest possible response, we recommend that you have the catalog numbers of your products available when you call. The Rockwell Automation Technical Support number is (**603**) **443-5419**.

Safety

Read This Manual

Read and understand this instruction manual. It provides the necessary information to allow you to install, connect, and set up your IMCñS/23x for safe, reliable operation.

ATTENTION: DANGEROUS MACHINERY!
Operation and maintenance of automatic equipment involves potential hazards. Control Operators, Setup Personnel, and Programmers should each take precautions to avoid injury.

Injury and entanglement may occur if hands and limbs come in contact with moving machinery. KEEP HANDS CLEAR of dangerous moving machinery. Loose fitting clothing or ties can become entangled in the machinery. These items should not be worn while operating, servicing, or programming the machine.

ATTENTION: HIGH VOLTAGES!
Electric shock can kill. Be sure the controller is safely installed in accordance with the Installation and Hookup Section of this manual. Avoid contact with electrical wires and cabling while power is on. The electrical cabinet should be opened only by trained service personnel.

ATTENTION: STATIC CONTROL!
The internal modules of the IMC S Class Compact motion controller contain staticñsensitive electronic components. Remove and handle the internal modules only at a staticñsafeguarded work area. Failure to do so may result in a drastically shortened life of your motion controller.

A disposable wristñstrap for grounding yourself is included with this product. Please follow the directions for use of this strap when removing and handling the motion controllers internal modules.

Introduction

IMC-S/23x Description

The IMC-S/23x is a compact, rugged, microprocessor-based two- or four-axis servo motion controller. By including the logic and field power supplies, the IMC-S/23x provides a completely programmable, stand-alone motion and logic controller suitable for a wide variety of industrial applications.

The IMC-S/23x, in conjunction with external drive systems and feedback encoders, provides two or four axes of closed-loop point-to-point positioning with profile (trapezoidal, parabolic, or S-curve), velocity, acceleration, and deceleration control as well as multi-axis linear, circular, or helical interpolation. The electronic gearing feature allows any axis to be slaved to another at a programmable ratio. The electronic cam feature allows coordinated motion profiles which are functions of time or position of another axis. Sophisticated phase shift, auto-registration, and auto-correction capabilities allow many complex motions and synchronizations to be easily programmed. General-purpose discrete I/O, analog inputs, analog outputs, etc. are provided by direct connection of Allen-Bradley Flex™ I/O modules. Up to eight Flex I/O modules–providing a total of 128 discrete I/O points–may be connected directly to the IMC-S/23x. Analog inputs and outputs can be substituted for discrete I/O blocks for increased I/O flexibility.

Application programming of the IMC-S/23x for any application is accomplished with GML, the exclusive Graphical Motion Control Language from Allen-Bradley. Using GML, over 100 different commands are available to completely customize operation of the IMC-S/23x for your specific application. Complete application programs are downloaded to the IMC-S/23x via a field-configurable RS-232C or RS-422 port where they are stored in non-volatile memory (write-protected battery-backed RAM).

A prompted, English-language machine setup procedure, complete hookup diagnostics, and improved Automatic Servo Setup routines for self-tuning the servo parameters make setting up the IMC-S/23x quick and easy.

A dedicated serial port–which can be field-configured for RS-232, RS-422, or Allen-Bradley DH-485 communications–is provided for the man-machine interface (MMI). Connection of the MMI device is via an AT-compatible DB-9 connector (RS-232 or RS-422) or RJ-45 connector (DH-485), both located on the front panel. If DH-485 is not used, a multi-unit addressing scheme (Multidrop) allows up to eight IMC-S/23x motion controllers to share a single RS-422 communication channel in sophisticated multi-axis systems. The address of each unit is set by a recessed front panel rotary switch.

The Remote I/O option allows the IMC-S/23x to communicate directly with an A-B PLC® via Remote I/O using both discrete and block transfers. The AxisLink option allows axes on other IMC S Class controllers or ALECs (AxisLink Encoder Converter modules) to be used as master axes for electronic gearing and cams. This ability provides real-time coordination for distributed, multi-axis systems in electronic gearing, cam, lineshaft, and synchronization applications.

Features

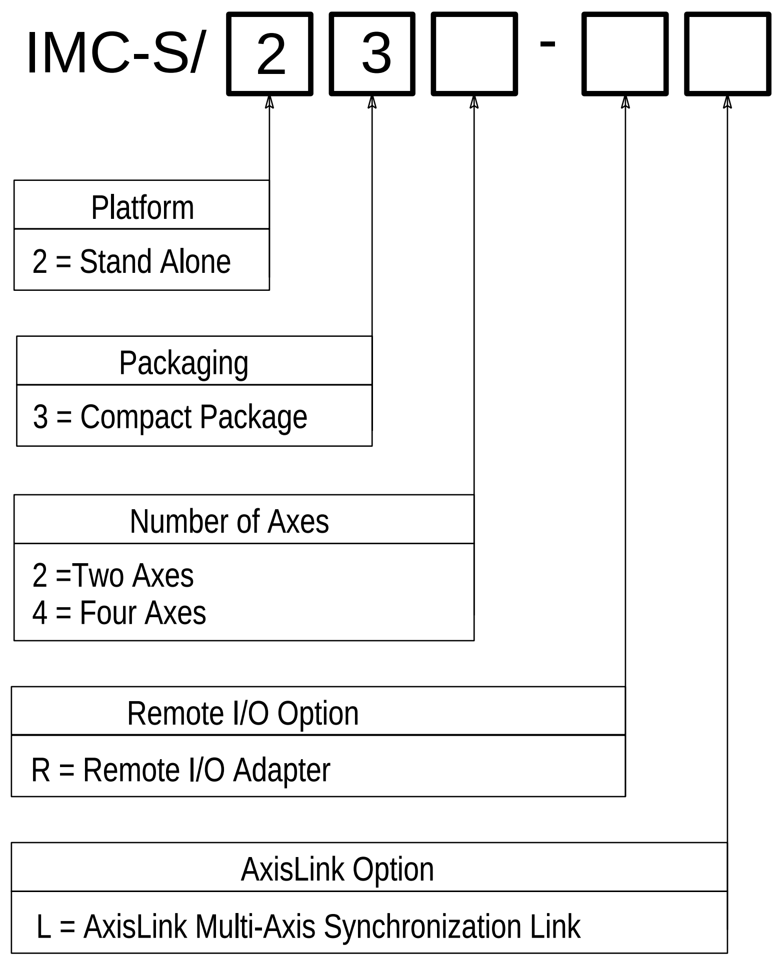
- Powerful graphical software development system (GML) makes application programming easy and fun.
- State-of-the-art Intel i960 RISC microprocessor.
- Fast application program execution (most commands executed in less than 1 µs) ensures highest machine performance and productivity.
- Completely digital–no potentiometers or other adjustments required; will not drift with time temperature or humidity.
- Multitasking operating system allows simultaneous execution of up to 10 tasks for efficient utilization.
- Electronic gearing for synchronization of any axis to another at a programmable ratio. Ratio may be specified as a floating-point number of integer fraction (1/3, 3/10 etc.).
- Electronic cam for coordinated motion profiles on one or more axes. Profiles may be position versus time or slave axis position versus master axis position.
- Sophisticated phase shift and advance/retard capabilities for electronic gears and cams allows complex motions to be easily programmed.
- Auto-registration and auto-correction make high-speed registration applications easy.
- Exclusive Imaginary Axis provides additional command-only axis for precise generation of master motion in master-slave applications or correction moves in registration and synchronization applications.
- Concurrent, independent, or synchronous motion on all axes. Interpolated motion on up to three axes.

- Wide position, speed, acceleration, and deceleration ranges for precise control.
- Separately programmable acceleration and deceleration rates for maximum versatility.
- Trapezoidal, parabolic, and S-curve velocity profiles.
- Rotary mode with electronic unwind allows unlimited position range for rotary axes.
- Merge motion function allows seamless transition between all types of motion.
- Most motion parameters (including master axis for electronic gears and cams) can be changed on-the-fly with no delays.
- Powerful floating-point math capabilities including transcendental functions (sin, cos, log, etc.).
- Sophisticated Nested Digital Servo Control Loop with automatic servo setup for quick and easy servo tuning.
- Isolation of all external connections from the microprocessor logic for reliable performance.
- 4 MHz maximum feedback count rate allows high speed operation without sacrificing resolution.
- Encoder loss detection protects operators and machinery from damage in the event of encoder feedback failure.
- Isolated 16-bit DACs for smooth motion. Software offset correction eliminates drift with analog servo drives.
- Field-configurable servo outputs allow independent selection of ±10V or ±150 µA signal format for each axis.
- Programmable position lock and position error tolerances for servo fault protection.
- Programmable directional software travel limits for enhanced overtravel protection.
- Velocity Feedforward to reduce following error.
- Four optically isolated limit switch inputs for a home switch, positive and negative overtravel switches, and a drive fault signal for each axis.
- Relay-contact drive enable output for each axis.
- Optically isolated high-speed position registration input for each axis for position synchronization and registration applications.
- CPU Watchdog with front-panel LED indicator for fail-safe protection.

- AxisLink option allows real-time axis coordination between controllers for distributed, multi-axis systems.
- Non-volatile storage (write-locked battery-backed RAM) of application program, setup parameter and default variable values.
- Memory Lock keyswitch on front panel prevents accidental or unauthorized changes to application program, default setup parameters, and default variable values.

Model Numbering System

The IMC-S/23x is available as a two- or four-axis motion controller with optional Remote I/O Adapter and AxisLink. The complete model number is specified as shown below:



Pre-Engineered Cable Assemblies

Pre-engineered cable assemblies are used for connecting the Flex I/O, servo amplifiers, feedback devices, axis-specific (dedicated) I/O, and the CPU watchdog. The table below shows the available cable assemblies.

ATTENTION: Do not attempt to make any electrical connections to the IMC-S/23x while the power is on! Doing so risks damage to the IMC-S/23x, external components, and your health!

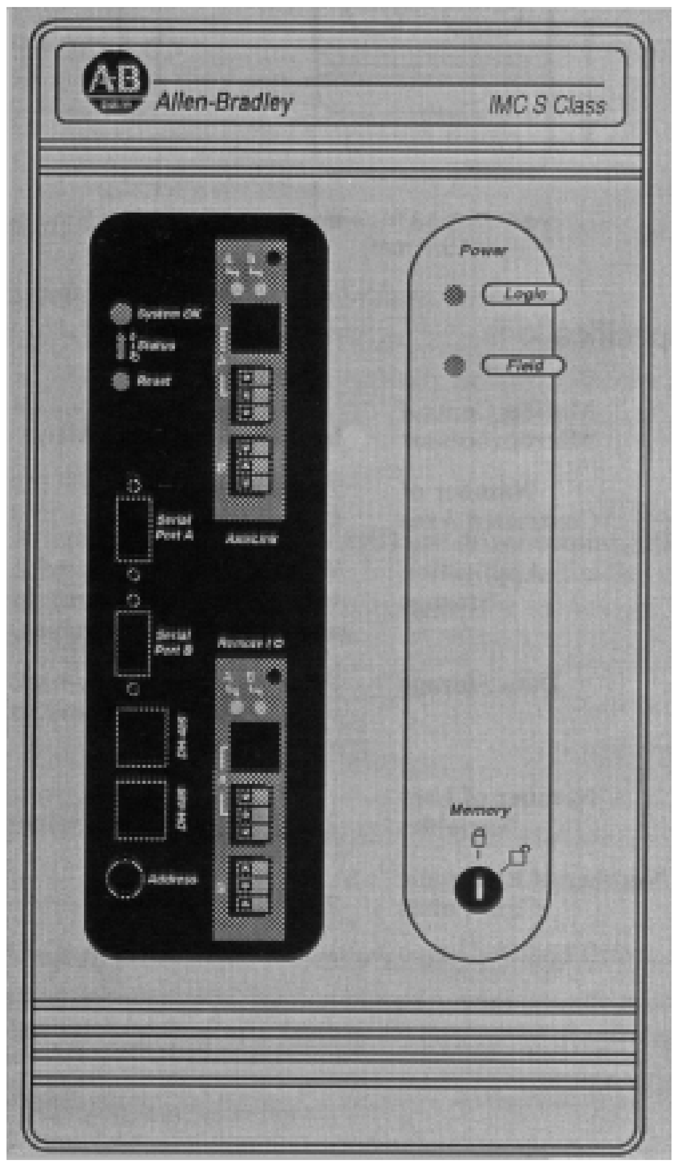
IMC S/23x Pre-Engineered Cable Assemblies

Catalog Number	*Used to Connect. . .*	*Length (ft)*	*(m)*	*Number Required*
4100-CCF1 **or**	Flex I/O	1	0.3	1 per S Class
4100-CCF3		3	1	
4100-CCS15F	Servo and Feedback	15	4.5	1 per Axis
4100-CCAQB	1391B-ES or 1391-DES	-	-	1 per Axis
4100-CCA15F	Dedicated Discrete I/O	15	4.5	1 per Axis
4100-CCW15F	CPU Watchdog	15	4.5	1 per S Class
4100-RCS3T	REC Interface	3	1	1 per Axis

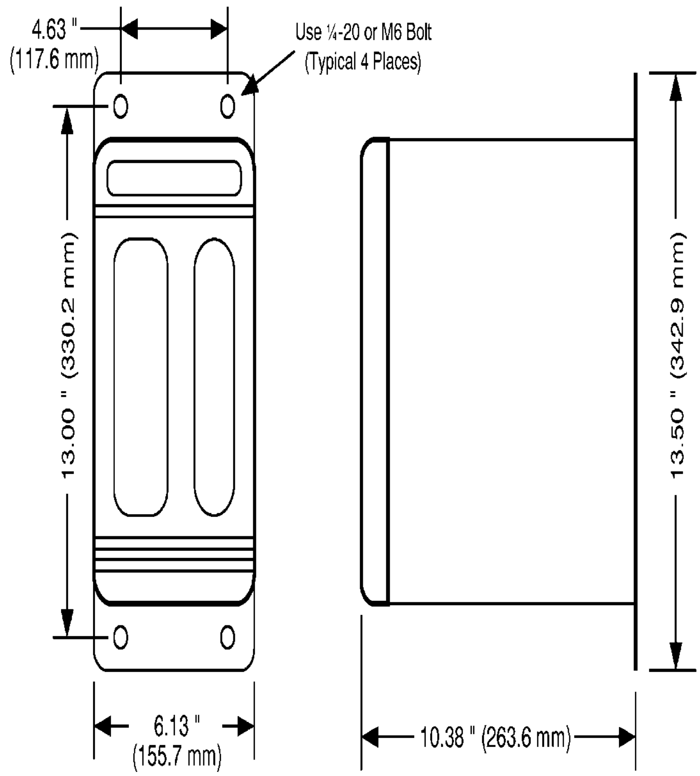
Mechanical Specifications

Front Panel Layout

(IMC-S/23x-RL model shown.)



Mounting and Clearance Dimensions



General Specifications

Motion Control Microprocessor	Intel 80960SB @ 16 MHz.
Number of Controlled Axes	2 (Axis 0 and Axis 1) IMC-S/232...models. 4 (Axis 0, 1, 2, and 3) IMC-S/234...models.
Application Storage	Write-lockable battery-backed RAM (Random-Access Memory) with 10 year (minimum) battery life for application program (32K) and setup parameter values.
Data Storage	Write-lockable battery-backed RAM (Random-Access Memory) with 10 year (minimum) battery life for cam table and default user variable values.
Number of User Variables	2,000 user-definable; values stored as 64-bit floating-point numbers.
Number of Electronic Cam Points	26,000 total.

Environmental Specifications

Storage Temperature	-40°C to 70°C (-40°F to 158°F).
Operating Temperature	0°C to 50°C (32°F to 122°F).
Maximum Humidity	95% non-condensing.

Electrical Specifications

AC Power Input	90 - 132 or 175 - 264 Volts AC, 47 - 63 Hz, 3 Amperes maximum.
AC Fuse	3A Dual Element Time Delay (Slow Blow) 1/4 x 11/4
I/O Power Input	18 - 36V DC, 3A maximum (24V nominal).
I/O Fuse	3A Dual Element Time Delay (Slow Blow) 1/4 x 11/4

Encoder Input Specifications

Number of Encoder Inputs	2 (Axis 0 and Axis 1) IMC-S/232...models. 4 (Axis 0, 1, 2, and 3) IMC-S/234...models.
Type of Encoder Input	Incremental AB quadrature; optically isolated, differential with marker channel.
Encoder Interface IC	AM26LS32 or equivalent.
Compatible Encoder Types	Differential, TTL-Level (5V DC) line driver outputs, with or without marker; including the following Allen-Bradley devices: 845F-SJxZ14-xxYx... 845F-SJxZ24-xxYx... 845H-SJxx14xxYx... 845H-SJxx24xxYx... 845K-SAxZ14-xxY3 845K-SAxZ24-xxY3 845P-SHC14-xx3 845T-xx12Exx... 845T-xx13Exx... 845T-xx42Exx... 845T-xx43Exx...
Decode Modes	4X Quadrature, Step/Direction, Count Up/Count Down.
Maximum Encoder Frequency	4,000,000 counts per second (4 MHz). This is equivalent to a channel frequency of 1 MHz in 4X quadrature decode mode.
Input Impedance	7 kΩ minimum (each input).
Encoder Power	5 or 12 Volts DC at 1 Ampere (total) available from IMC-S/23x. Voltage selection by internal switch.

Servo Output Specifications

Number of Servo Drive Outputs	2 (Axis 0 and Axis 1) IMC-S/232...models. 4 (Axis 0, 1, 2, and 3) IMC-S/234...models.
Type of Output	Isolated analog voltage or current; individually field-configurable via internal switch for each axis.
Output Range	±10 Volts DC or ±150 µA (minimum).
Resolution	16 bits, 305 µV or 4.58 µA per bit.
Output Impedance	220Ω resistive for voltage output; 56Ω maximum load impedance for current output.
Output Offset	±80 µV maximum. Compensated to 0 volts via software setup procedure.

Dedicated Discrete I/O Specifications

Number of Dedicated Discrete Inputs	10 (5 each for Axis 0 and 1) IMC-S/232...models. 20 (5 each for Axis 0, 1, 2, and 3) IMC-S/234...models
Dedicated Discrete Input Functions	Home Limit Switch, Positive Overtravel Limit Switch, Negative Overtravel Limit Switch, Drive (Amplifier) Fault, Position Registration.
Input Type	Optically isolated.
Operating Voltage	24 Volts DC nominal; 28V DC maximum. 24 Volts DC nominal; 28V DC maximum or 5 Volts DC nominal; 10V DC maximum for position registration inputs.
Input ON Current	12 µA per input (nominal); 2.5 µA for position registration inputs.
Input Impedance	2 kΩ (resistive) per input; 8.8 kΩ (resistive) for 24V position registration inputs.
Input Response Time	5 µs maximum; 1 µs maximum for position registration inputs.
Number of Dedicated Discrete Outputs	4 (2 each for Axis 0 and 1)IMC-S/232...models. 8 (2 each for Axis 0, 1, 2, and 3)IMC-S/234...models.
Dedicated Discrete Output Function	Drive (Amplifier) Enable. Absolute Position Strobe.
Output Type	Normally-open relay contacts (Drive Enable); Optically isolated, floating, solid-state relay (Position Strobe).
Operating Voltage	0.010 - 40 Volts DC; 24V DC nominal for drive enable outputs, 5.10± 0.10 Volts DC for position strobe outputs.
Output Current	1 Ampere per output maximum for drive enable outputs; 10 µA per output maximum for position strobe outputs.

Serial I/O Specifications

Number of Serial Channels	2 (Serial Port A and Serial Port B).
Channel Type	Optically isolated RS-232C or RS-422; each channel individually configurable via internal switch.
Information Code	ASCII (American Standard Code for Information Interchange).
Baud Rate	User-selectable up to 128k Baud (RS-422). User-selectable up to 115.2k Baud (RS-232C).
Number of Start Bits	1.
Number of Stop Bits	1.
Word Length	8 bits total; 7 data bits plus 1 parity bit.
Parity	Space parity transmitted; Receive parity ignored (may be Mark, Space, Even, or Odd).
Duplex	Full or half (user-selectable).
Data Synchronization	XON (Control-Q)/XOFF (Control-S).
Front-Panel Connectors	IBM-PC/AT compatible 9-pin D-type female.
RS-422 Termination	User-selectable 220Ω resistor via internal switch.

DH-485 Specifications

Number of DH-485 Channels	1; replaces Serial port B when used.
Channel Type	Optically isolated half-duplex RS-485.
Baud Rate	9,600 or 19.2k Baud (user-selectable).
Front-Panel Connectors	Two RJ-45 jacks (+24V is *not* provided).
RS-485 Termination	User-selectable 220Ω resistor via internal switch.
Node Address	User-selectable between 0 and 31 inclusive.
Node Type	Token-passing master.
Accessible Data Files	1 Binary file (B3) for up to 16,384 bits 1 Integer file (N7) for up to 1,024 16-bit values 1 Floating-point file (F8) for up to 512 32-bit values 1 ASCII string file (A) for up to 2,048 characters 9 user-configurable files; each can be individually configured as any of the above types or as a BCD file for floating point simulation (required for certain A-B MMI devices).

Flex I/O Compatibility Specifications

Maximum Number of Flex I/O Modules	8.	
Compatible Modules	1794-IB16	16 24V DC Discrete Inputs
	1794-IA8	8 115V AC Discrete Inputs
	1794-IE8	8 Current/Voltage Analog Inputs
	1794-OB16	16 24V DC Discrete Outputs
	1794-OA8	8 115V AC Discrete Outputs
	1794-OE4	4 Current/Voltage Analog Outputs
	1794-IE4XOE2	4 Current/Voltage Analog Inputs 2 Current/Voltage Analog Outputs
S Class Interface	Direct-no 1794-ASB or other adapter required.	

Servo Performance Specifications

Servo Loop Sample and Update Rate	250 Hz to 2 kHz for each of 2 or 4 axes.
Maximum Feedback Frequency	4 MHz (4,000,000 feedback counts per second).
Absolute Position Range	± 1,000,000,000 feedback counts for Linear AxisAxis:Linearlinear axes; R for rotary axes.
Absolute Position Resolution	15 position unit digits or 32 feedback count bits, whichever is less.
Speed Range	0.00001 feedback counts per servo update to 4,000,000 feedback counts per second.
Speed Resolution	15 position unit digits or 15 feedback count bits, whichever is less.
Acceleration/ Deceleration Range	0.00001 feedback counts per servo update2 to 4,000,000,000 feedback counts per second2.
Acceleration/Deceleration Resolution	15 position unit digits or 15 feedback count bits, whichever is less.
Electronic Gearing Gear Ratio Range	0.00001:1 to 9.99999:1 (slave counts : master counts).
Electronic Gearing Gear Ratio Resolution	8 position unit digits or 32 feedback count bits.
Servo Gain Resolution	32 bit floating point.
Servo Output Limit Range	0 to 100%.
Servo Output Limit Resolution	305 µ (voltage output); 4.58µA (current output).

Servo Gain Units

IMC-S/23x Servo Gain Units

Gain	*Description*	*Units*
P	Proportional Gain	$\frac{\textit{Counts per Millisecond}}{\textit{Count of Error}}$
I	Integral Gain	$\frac{\textit{Counts per Millisecond2}}{\textit{Count of Error}}$
V	Velocity Gain	$\frac{\textit{Millivolts}}{\textit{Count per Millisecond}}$
F	Feedforward Gain	$\frac{\textit{Counts per Millisecond}}{\textit{Count per Millisecond}}$
	Deadband Compensation	*Volts*
	Offset Compensation	*Volts*

Remote I/O Adapter Specifications

IMC-S/23x-R and IMC-S/23x-RL models only.

Baud Rate 57.6K, 115.2K or 230.4K (User-selectable).

Rack Address User-selectable between 0 and 31 decimal.

Rack Width User-selectable in quarter-rack increments (1/4, 1/2, 3/4, Full).

I/O Group Address User selectable as shown below:

IMC-S/23x Remote I/O Adapter Addressing

Type of Transfer	*I/O Group*									
Block	0	2	4	6	0	2	4	0	2	0
Discrete	1	3	5	7	1	3	5	1	3	1
Discrete					2	4	6	2	4	2
Discrete					3	5	7	3	5	3
Discrete								4	6	4
Discrete								5	7	5
Discrete										6
Discrete										7
Starting I/O Group	*0*	*2*	*4*	*6*	*0*	*2*	*4*	*0*	*2*	*0*
Rack Width	*1/4*				*1/2*			*3/4*		*Full*

Number of Discrete I/O Bits

12 dedicated inputs,
12 dedicated outputs,
User-defined as shown below:

IMC-S/23x Remote I/O Adapter
Number of User-Defined Discrete I/O Bits

Rack Width	*Inputs*	*Outputs*
1/4	*4*	*4*
1/2	*36*	*36*
3/4	*68*	*68*
Full	*100*	*100*

Maximum Block Transfer Length

64 words (128 bytes).

Block Transfer Data Types

User Variable values,
Axis Data Parameter value,
Axis Data Bit state,
Master Cam Position Point values,
Master Cam Time Point values,
Slave Cam Position Point values,
Axis or System Variable value.

Block Transfer Data Formats

32-bit (double-word) 2s complement integer,
16-bit (single-word) 2s complement integer,
32-bit (8-digit) signed BCD,
32-bit IEEE floating-point,
Word-swapped 32-bit (double-word) 2s complement integer,
Word-swapped 32-bit (8-digit) signed BCD,
Word-swapped 32-bit IEEE floating-point.

AxisLink Specifications

IMC-S/23x-L and IMC-S/23x-RL models only.

Baud Rate	Standard and extended node configurations	1 megabit per second.
	Extended length configuration	500 kilobit per second.
Cable Type	Standard and extended node configurations	Allen-Bradley 1770-CD RIO cable (Belden 9463 or equivalent).
	Extended length configuration	Belden 9182, Carol C8014 or equivalent.
Cable Length	Standard and extended node configurations	25 meters (82 feet) maximum total. Minimum of 1 meter (3 feet) between controllers.
	Extended length configuration	125 meters (410 feet) maximum total. Minimum of 1 meter (3 feet) between controllers.
Number of Motion Controllers	Standard and extended length configurations	8 maximum for a total of 32 possible axes.
	Extended node configuration	16 maximum for a total of 64 possible axes.
Addressing	Standard and extended length configurations	User-selectable address via rotary selector switch on front panel.
	Extended node configuration	User-selectable address via GML.
Number of Virtual Master Axes	Standard configuration	4 maximum total; 1 per motion controller maximum. Any axis on any motion controller can be a virtual master axis to any other motion controller. Each motion controller can define a total of two separate axes on any other motion controllers as virtual master axes, but only one can be active at any time. A total of four different axes can be active as virtual master axes at any time.
	Extended length and extended node configurations	2 maximum total; 1 per motion controller maximum. Any axis on any motion controller can be a virtual master axis to any other motion controller. Each motion controller can define a total of two separate axes on any other motion controllers as virtual master axes, but only one can be active at any time. A total of two different axes can be active as virtual master axes at any time.
Type of Virtual Master Axes	All configurations	2: Command and Actual. Each virtual master axis may be defined to report its command or actual position.
Slave Axes	Standard and extended length configurations	31 maximum total per virtual master axis (3 local + 4 x 7 other motion controllers = 31).
	Extended node configuration	63 maximum total per virtual master axis (3 local + 4 x 15 other motion controllers = 63).

Number of Discrete I/O	All configurations	112 inputs maximum total and 16 user-definable outputs per motion controller. Any motion controller can read the 16 discrete outputs of any other motion controller, giving a maximum total of 7 x 16 = 112 discrete inputs per motion controller. For extended node configuration, discrete I/O can still only be obtained from a maximum of 7 other controllers (112 inputs maximum total), not from all 15 other controllers available in a 16 node maximum extended node configuration.
Discrete I/O Response	All configurations	≤1 millisecond.

Technical Overview

Digital Control Loop

Each axis of the IMC-S/23x utilizes a powerful Nested Digital Servo Control Loop to provide servo positioning control and compensation of a servo actuator. The servo actuator can be a DC motor, a brushless DC motor, an AC motor (with the appropriate drive electronics), or a hydraulic cylinder or motor.

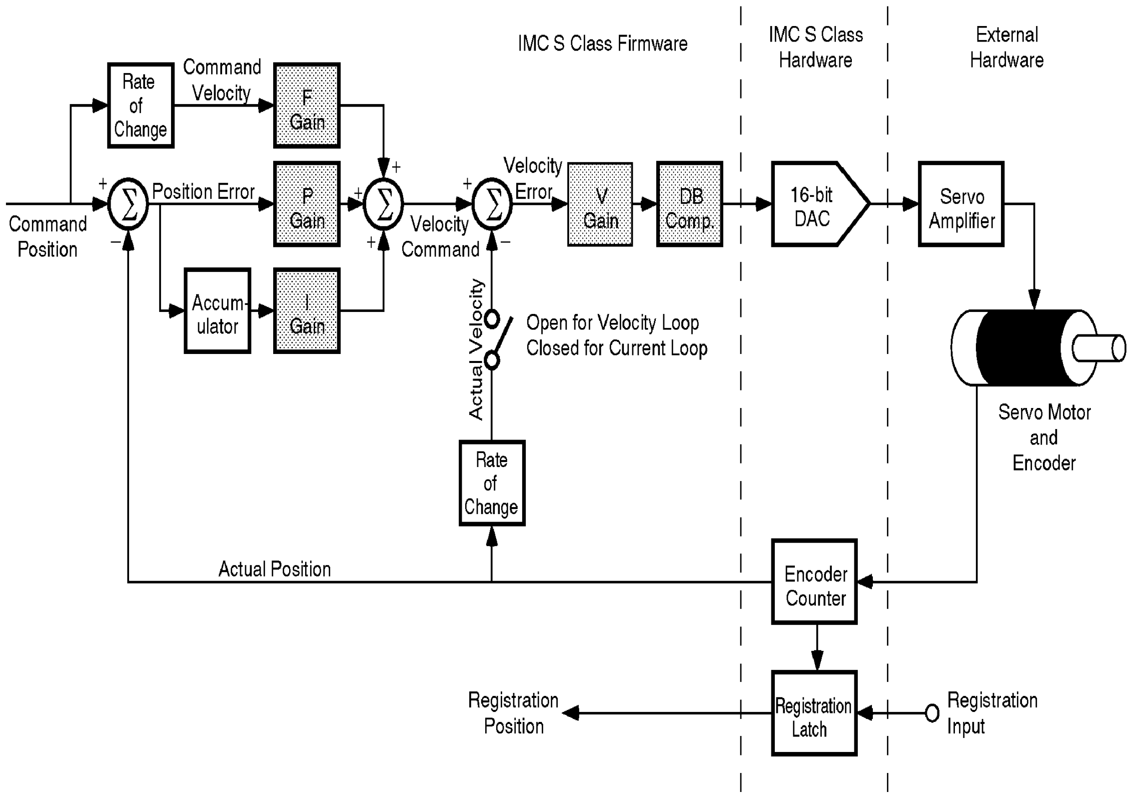
The Nested Digital Servo Control Loop utilizes state-of-the-art digital hardware and software to perform the functions necessary to establish a closed loop servo system. The only external elements needed to complete the servo loop are:

- Actuator (Brushless DC Motor, Hydraulic Cylinder, etc.)
- Servo Amplifier for Actuator
- Digital Incremental Encoder (Quadrature type)

The digital approach to motion control has numerous advantages over conventional analog servo control techniques. Digital feedback eliminates the need for potentiometers in the control loop with their associated adjustment labor and drift. Furthermore, the Nested Digital Servo Loop is microprocessor-based. Microprocessor design reduces the system parts count, increases system reliability, and greatly increases the flexibility of the control.

The Nested Digital Servo Loop synthesizes a velocity (rate) loop as well as the required position loop in software using only the position information provided by the encoder (or other feedback device). No analog tachometer is required to provide complete stabilization and positioning control of the motor and load. In addition, velocity feedforward is provided to reduce the intrinsic following error of the position loop when the motor is moving.

A functional block diagram of the Nested Digital Servo Loop is shown below. The following sections discuss, in detail, each block in this diagram.



Encoders

The IMC-S/23x interfaces to rotary or linear quadrature-type incremental encoders to provide both position and velocity feedback. The most common type of such encoders are optical; they utilize a light source and an alternately clear and opaque disc or scale to generate their output.

When operating at a fixed speed, quadrature-type incremental encoders generate two square wave outputs, usually referred to as Channel A and Channel B, which are approximately 90° out of phase with one another. Proper phasing of these two channels can be checked by driving the encoder at a fixed speed and displaying the two encoder outputs on a dual channel oscilloscope.

Encoders are available with a variety of different output driver configurations. The IMC-S/23x interfaces directly to differential line driver encoders providing TTL (5V) level signals. In addition, the encoder inputs are optically isolated and powered from a separate power supply contained within the IMC-S/23x. Encoder loss circuitry detects when any of the encoder connections have broken.

Often a third output channel is available from the encoder. This so-called "marker" output is also known as Channel Z, 0, or C. The marker output from an encoder is a pulse that occurs at one specific point on the encoder disc (rotary encoders) or slide (linear encoders). Therefore, the marker may be used to establish a precise absolute position reference. Note that for rotary encoders, the marker provides a position reference within one revolution of the encoder. For multi-turn applications, other means must be used in conjunction with the marker pulse to determine the absolute position. The IMC-S/23x can interface to encoders with marker pulse outputs of either active-high or active-low polarity.

Encoder Counter

The encoder counter circuitry is identical for all axes and consists of optically-isolated AM26LS32 input buffers, programmable decode logic, and 16-bit encoder counters contained within the CX2216.

Once buffered and isolated, the two TTL-level encoder signals (Channel A and B) are connected to the CX2216 which decodes them using 4X quadrature logic (4 counts per encoder line). After decoding, the count signals are sent to the encoder counter in the CX2216, which keeps a record of the number of counts and the direction of encoder motion. The IMC-S/23x software extends the encoder counters to 32 bits giving a total position range of ±1,000,000,000 encoder counts.

A quadrature type encoder generates four counts for every line on the encoder disc or slide. The sequence in which the counts are generated is determined by the direction that the encoder is moving, and the encoder counter increments or decrements accordingly.

The maximum encoder rate for any digital control is determined by many factors, including the sample rate of the control loop, the size of the encoder counters, and pulse rate limitations of the digital circuitry. The maximum encoder count rate, or *encoder bandwidth*, for the IMC-S/23x, is 4.0 Megahertz.

Every servo sample period, the microprocessor reads the encoder counter for each axis and computes a count increment by subtracting the previous counter value from the present counter value. This count increment represents the distance the axis has traveled in the preceding millisecond. This value is then used to update the 32-bit actual position.

Software Feedback Calculations

Every servo sample period, the IMC-S/23x microprocessor also does a complete position feedback calculation for each axis by first computing the difference between the actual position and the command position. This quantity is called the Position Error. The intent of every closed loop position servo system is to drive this position error to zero.

To accomplish this, the position error is multiplied by a programmable P (Proportional) Gain term and used to generate a velocity command. In addition, when the axis is not moving, position error is accumulated (integrated) and multiplied by the I (Integral) Gain term and added into the velocity command. This allows the IMC-S/23x to compensate for static disturbances that would otherwise keep the position error from becoming zero. Such static disturbances include static friction (so-called Sticktion) and gravity effects on vertical axes.

Integral Gain is also effective in reducing the tracking error between the master and slave axis when the electronic gearing feature is used. The integral term is deactivated, however, when performing commanded motion (moves and jogs) to improve servo stability and decrease overshoot.

To create a stable position servo loop without using an analog tachometer, damping is provided by synthesizing a tachometer in software. This is accomplished by calculating the rate of change of encoder position to generate the actual velocity. The actual velocity is compared to (subtracted from) the command velocity to generate the velocity error. This velocity error is then multiplied by the programmable V (Velocity) Gain and used to drive the motor to reduce the velocity error (and thus the position error also) to zero. With servo drives incorporating a true tachometer loop, the software velocity loop is disabled.

After being multiplied by the V gain, the velocity error is range limited and then sent out to a 16-bit DAC (Digital-to-Analog Converter to generate the ±10 volt or ±150 mA signal for use by the drives.

In use, the servo output ranges between ±10 volts or ±150 mA, depending on the setting of the drive output type switch. The maximum output can also be clamped to less than the above full scale values. This servo output limit is fully programmable.

In addition, deadband compensation is provided to compensate for friction effects when using current-loop servo amplifiers. Deadband compensation adds a programmable value to the magnitude of the servo output signal (i.e. when the velocity error is positive, the DB compensation value is added, and when the velocity error is negative, the DB compensation value is subtracted).

Finally, drive offset compensation is provided to allow compensating for the inevitable offset and drift in analog servo amplifiers. Drive offset compensation adds a programmable value to the magnitude of the servo output signal.

Each of the gain terms mentioned above has a unique influence on the closed loop dynamics of the system. By adjusting the P, I, and V gains, it is easy to tailor the system dynamics to meet specific needs. The three programmable control gains influence the closed loop dynamics in the following way:

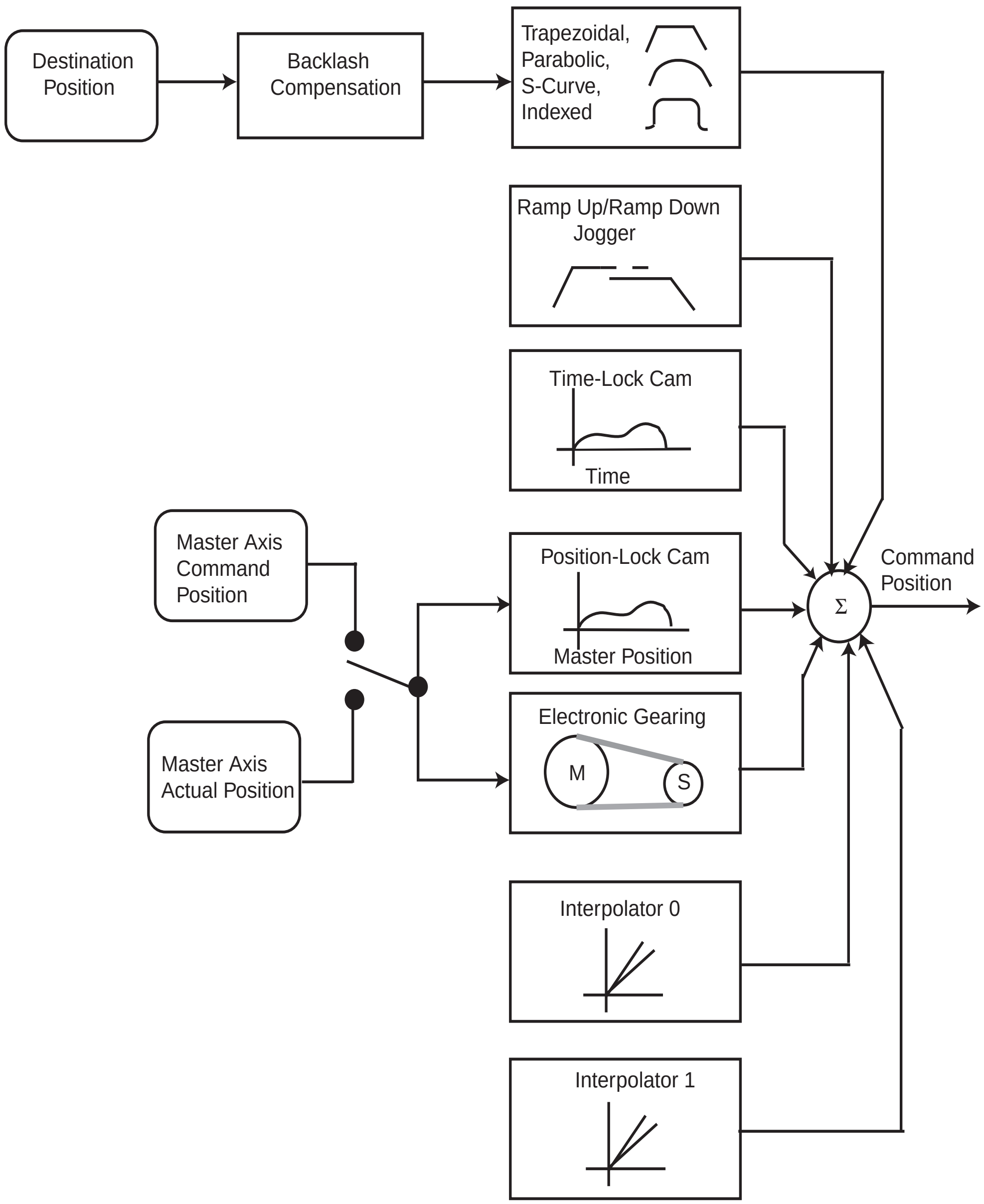
Proportional Gain	⇒	Elastic Stiffness
Integral Gain	⇒	Static Disturbance Compensation
Velocity Gain	⇒	Damping

Servo Amplifiers and Motors

Each axis of the IMC-S/23x can interface to a standard servo amplifier operating in current (torque) or velocity (tach) mode which accepts a ±10V DC command. Servo amplifiers are available from Allen-Bradley as well as other manufacturers to drive DC, brushless DC or AC motors in a wide range of powers. The IMC-S/23x can also interface to hydraulic servo and proportional valves which accept ±150 mA signals.

High Level Motion Functions

Because servo action forces the actual position to track the command position, sophisticated indexing, jogging, and electronic gearing functions are easily implemented through software control of the command position. These high level motion functions are shown below and explained in the following paragraphs.



Indexing and Jogging

The indexer moves the axis using either a trapezoidal, parabolic, or S-Curve (controlled jerk) velocity profile. Axis velocity, acceleration, and deceleration are completely programmable. The trapezoidal profile is the most common type of move and results in a smooth acceleration to the desired speed and a smooth deceleration to the desired destination position. Parabolic and S-curve profiles are provided for use where minimum stress on the mechanics is more important than minimum index time.

The jogger produces constant speed motion of the axis in either direction. The velocity and the acceleration rate are programmable. The indexer and jogger also provide the ability to change speeds and index positions while the axis is moving. The jogger also allows changes in the acceleration or deceleration ramp while jogging. Furthermore, electronic gearing may be combined with index and jog motion to create complex motion profiles and synchronizations.

Backlash Compensation

Another high level motion function is Backlash Compensation. This technique–called Unidirectional Approach–overcomes mechanical backlash by always approaching the destination position from the same direction. When approaching the destination position from the opposite direction, the axis moves past the destination position by a programmable Backlash Offset, reverses, and then moves back to the destination position. Since the axis always approaches the destination position from the same direction, the mechanical backlash is always taken up in the same direction ensuring accurate positioning.

Electronic Cam

The electronic cam feature provides the IMC-S/23x with the ability to execute coordinated motion profiles. This is accomplished by programming a table of position values which describe the desired profile, and then executing the table as required. Electronic cams may be defined in terms of axis position(s) versus time (time-lock cams) or position of the slave axis versus position of the master axis (position-lock cams).

Electronic Gearing

Electronic gearing allows any axis to be programmed to track another axis at a specified ratio. By convention, the axis that is tracking is called the *slave*, while the axis that is being tracked is called the *master*. Thus, the master axis is equivalent to the input shaft, and the slave axis to the output shaft in a mechanical transmission.

Electronic gearing is accomplished by first reading the master axis' actual position and computing the distance increment from the previous reading. This increment is then multiplied by a programmable gear ratio and added to the slave axis' command position. In this way the slave axis is forced to track the master axis according to the specified gear ratio. The slave axis may be programmed to move in the same or the opposite direction from the master axis.

Electronic gearing ratios may be specified as a number between 0.00001:1 and 9.99999:1. Alternately, the gear ratio may be specified as a pair of integer values–a numerator and denominator– representing the exact ratio of slave axis feedback counts to master axis feedback counts. The ability to specify numerator/denominator gear ratios makes it possible to perform electronic gearing using an irrational gear ratio such as 1/3 with no accumulated error.

By combining the jog and electronic gearing capabilities of the IMC-S/23x, the slave axis may be smoothly accelerated and decelerated into and out of electronic gearing motion. This merged motion capability is equivalent to a software clutch.

Interpolation

Two independent interpolators for all axes allow any two or three axes to be moved as a group along a linear, circular, or helical path. Motions from the two interpolators may be combined with each other or with other types of motion. Motion segments may be blended to one another to accomplish continuous path motion as long as they are tangent at their intersection.

Velocity Feedforward

The IMC-S/23x is capable of providing velocity feedforward to reduce following error. Following error is the servo position error that is present when the axis is moving at a commanded speed. Without velocity feedforward, a following error necessary to produce sufficient output to drive the motor at the commanded speed will always exist. Many applications require that the following error be near zero over the entire speed range of the motor. Velocity feedforward may be used to satisfy this requirement.

Velocity feedforward is provided by pre-computing the command velocity as the rate of change with respect to time of the command position. The command velocity is then scaled by the F Gain (Feedforward Gain) and added to the velocity command. By adjusting the F Gain it is possible to produce, from the feedforward term alone, the required velocity command to drive the motor at the desired speed. Thus, only a little position error is needed to "fine tune" the motor speed and position.

Velocity feedforward is very useful in electronic gearing applications, since no position error between the master and slave axes exists with mechanical gears. Using velocity feedforward also allows the position loop integrator (I Gain) to respond more quickly to changes in speed.

CPU Watchdog

The IMC-S/23x provides a CPU Watchdog that monitors the health of the motion control microprocessor. In the event of a processor malfunction or other fault, the CPU watchdog is immediately disabled. To reset the Watchdog, the IMC-S/23x must be reset, either by cycling power, or by pressing the Reset button on the front panel.

An LED labeled "System OK" is provided on the IMC-S/23x front panel to visually monitor the state of the CPU watchdog. This green LED is lit under normal operation, and goes out when the watchdog is deactivated. A relay driven by the CPU watchdog provides normally open and normally closed contacts on the Watchdog connector for wiring into the machine’s E-Stop string or other fail-safe circuit.

Software Overtravel Limits

The IMC-S/23x can be configured to range check the command position of each axis to ensure that the axis is operating within its limits. These software travel limit values are fully programmable. When an overtravel condition occurs, the IMC-S/23x either disables the feedback loop and disables the amplifier, or decelerates the axis to a stop. In either case, further motion in the offending direction is inhibited.

Serial Communication

Serial communication with the IMC-S/23x is via either an RS-232C or RS-422 serial link to one of two ports. If configured for RS-232C, operation up to 19.2K baud is possible, while ports configured for RS-422 can operate at up to 128K baud. A PC/AT-compatible 9-pin D-type connector is provided for each serial port on the front panel. In general, the GML software development system for application programming is connected to serial port A while a serial operator interface device or runtime display is connected to serial port B.

The IMC-S/23x can be configured to operate in Multidrop Mode allowing up to eight controls to share a single RS-422 communications link. This is accomplished by using two special non-echoed commands to activate individual units to respond to commands issued by the operator interface device or host computer. Each IMC-S/23x is assigned its own unique address via a recessed front-panel rotary selector switch.

DH-485 Communication

The IMC-S/23x communicates with other devices over DH-485 by reading and writing data into and out of data files. Data from local files (in the motion controller) is transferred to and from remote files (in other devices). In the motion controller, up to 13 different local files of five different types can be used. Each type of file contains a different number of elements and is equivalent to a different SLC file type as shown below.

IMC S Class DH-485 Local File Types

S Class File Type	*Elements*	*Element Numbers*	*Equivalent to SLC File Type*
Binary	Words/Bits	0 - 1023	B
Integer	16-bit Values	0 - 1023	N
Floating	Floating Point Values	0 - 511	F
ASCII	Characters	0 - 2047	A
BCD	BDC Values	0 - 1023	D

Axis-Specific Discrete I/O

Each axis of the IMC-S/23x has associated with it four optically-isolated inputs which provide a direct interface for a home switch, overtravel (positive and negative) switches, and a drive fault signal (usually an output from the amplifier). In addition, a relay-contact drive enable output is provided for each axis to enable and disable the amplifier under program control. The four discrete inputs are completely de-bounced and can be connected directly to limit switches which operate on 24V DC. Inputs can be from mechanical limit switches, proximity switches, or PLC outputs.

Each axis of the IMC-S/23x can be individually programmed to operate with or without these discrete inputs enabled. If enabled, each discrete input can be individually programmed to operate with normally open (NO) or normally closed (NC) limit switch contacts.

Home Limit Switch Input

Home limit switches are used in conjunction with two of the four programmable homing sequences. When a homing sequence is enabled, the IMC-S/23x executes it under program control. See the Setup section of this manual for a complete description of the available homing sequences.

Overtravel Limit Switch Inputs

Overtravel limit switches can be used to enforce the mechanical safe travel limits during machine operation. Assuming that the overtravel function is enabled, the IMC-S/23x may be programmed to either provide a status, disable the feedback loop, and deactivate the drive enable output of the affected axis, or stop motion and decelerate the axis to a stop when an overtravel limit switch is tripped.

Drive Fault Output

The drive fault inputs may be connected to the fault outputs (if provided) on the amplifiers for each axis. This allows the IMC-S/23x to react to a fault in the amplifiers themselves. Like the other discrete inputs, the drive fault input may be enabled and disabled from the application program, and may be configured to operate with active-high or active-low drive fault outputs. When a drive fault input is activated, assuming the function is enabled, the IMC-S/23x stops all motion on the particular axis and deactivates the appropriate drive enable output.

Drive Enable Output

The drive enable output for each axis allows the IMC-S/23x to disable the axis amplifiers in the event of a motion fault. Since it uses a floating normally-open relay contact, the drive enable output can be connected to amplifiers having either active-high or active-low enable or disable inputs.

Position Registration Inputs

Special, high-speed, optically-isolated inputs on the IMC-S/23x (one per axis) provide a direct interface for position registration sensors. The position registration inputs are unfiltered to minimize propagation delay for speed-critical position registration applications and can be directly connected to sensors (or encoder markers) operating on 5V or 24V DC.

When a position registration input is activated, assuming the position registration feature is enabled, the current actual position of the axis is immediately latched in hardware into a special registration latch. The latched registration position is then available within the application program for calculations.

Status LEDs

Three general purpose status LEDs are provided on the front panel of the IMC-S/23x. Labeled Status 0, 1, 2, these LEDs are used to indicate the results of the power-up diagnostics performed whenever power is applied to the IMC-S/23x. If the IMC-S/23x passes its power-up diagnostics, all three status LEDs are turned off and the CPU watchdog LED (System OK) is turned on. At this point, the three status LEDs may be used by the application program for any desired purpose.

If all three status LEDs are not off after power-up, the IMC-S/23x did not pass its power-up diagnostics, and the CPU watchdog is not activated. In this case, the code shown on the three status LEDs indicates the specific test which failed.

General Purpose Discrete I/O

The IMC-S/23x provides a direct connection to Allen-Bradley Flex I/O for use as general-purpose I/O. The Flex I/O modules which may be used with S Class motion controllers are shown in the table below.

IMC S Class Compatible Flex I/O Modules

Catalog Number	*Description*	*For Additional Information See...*
1794-IB16	16 24V DC Discrete Inputs	1794-2.1
1794-IA8	8 115V AC Discrete Inputs	1794-2.1
1794-IE8	8 Analog Inputs	1794-2.1
1794-OB16	16 24V DC Discrete Outputs	1794-2.1
1794-OA8	8 115V AC Discrete Outputs	1794-2.1
1794-OE4	4 Analog Outputs	1794-2.1
1794-IE4XOE2	4 Current/Voltage Analog Inputs 2 Current/Voltage Analog Outputs	1794-2.1

Up to eight separate modules, selected from the table above, may be connected to the motion controller in any order. For specific information on connecting I/O devices to each of the Flex I/O modules, see the appropriate Flex I/O publications listed above.

The Imaginary Axis

The IMC-S/23x also provides an imaginary axis in addition to the two or four physical axes on each controller. The imaginary axis is an internal (software) axis which has no servo loop and no connection to a drive, encoder, or discrete I/O. It is used only as a master axis for physical axes to synchronize them when no physical or virtual axis is available. As such, it can be thought of as a built-in virtual axis not requiring AxisLink. The "output" of the imaginary is its command position–it has no actual position. All of the high-level motion functions discussed earlier are available for the imaginary axis.

Remote I/O (Optional)

IMC-S/23x-R and IMC-S/23x-RL models include an Allen-Bradley Remote I/O Adapter. This option allows certain aspects of the unit to be controlled and monitored from an Allen-Bradley PLC using a Remote I/O scanner. The IMC-S/23x appears to the PLC as a quad-density intelligent module in a Remote I/O rack. Both discrete and block transfer functions are available.

AxisLink (Optional)

IMC-S/23x-L and IMC-S/23x-RL models include AxisLink, which allows axes on other IMC S Class controllers and ALECs (AxisLink Encoder Converter modules) to be used as master axes for electronic gearing and cams. In addition, 16 discrete outputs per motion controller are available to other motion controllers via AxisLink for sequencing and program synchronization.

Installation and Hookup

Introduction

The IMC-S/234 provides four physical axes called Axis 0, 1, 2, and 3. The IMC-S/232 provides two physical axes (Axis 0 and Axis 1), and therefore only two servo amplifiers are required for this unit. Connections for each axis are made to separate but identical connectors on the top and bottom panels of the unit.

Pre-engineered cable assemblies are used for all connections to external devices except the main AC power and the 24V DC I/O power, which use pluggable terminal blocks. See Pre-Engineered Cable Assemblies in the Introduction section of this manual for information on the available assemblies. This section *only* describes connecting the IMC-S/23x using the pre-engineered cable assemblies. If you are making your own cable assemblies, refer to Appendix A for cable wiring information.

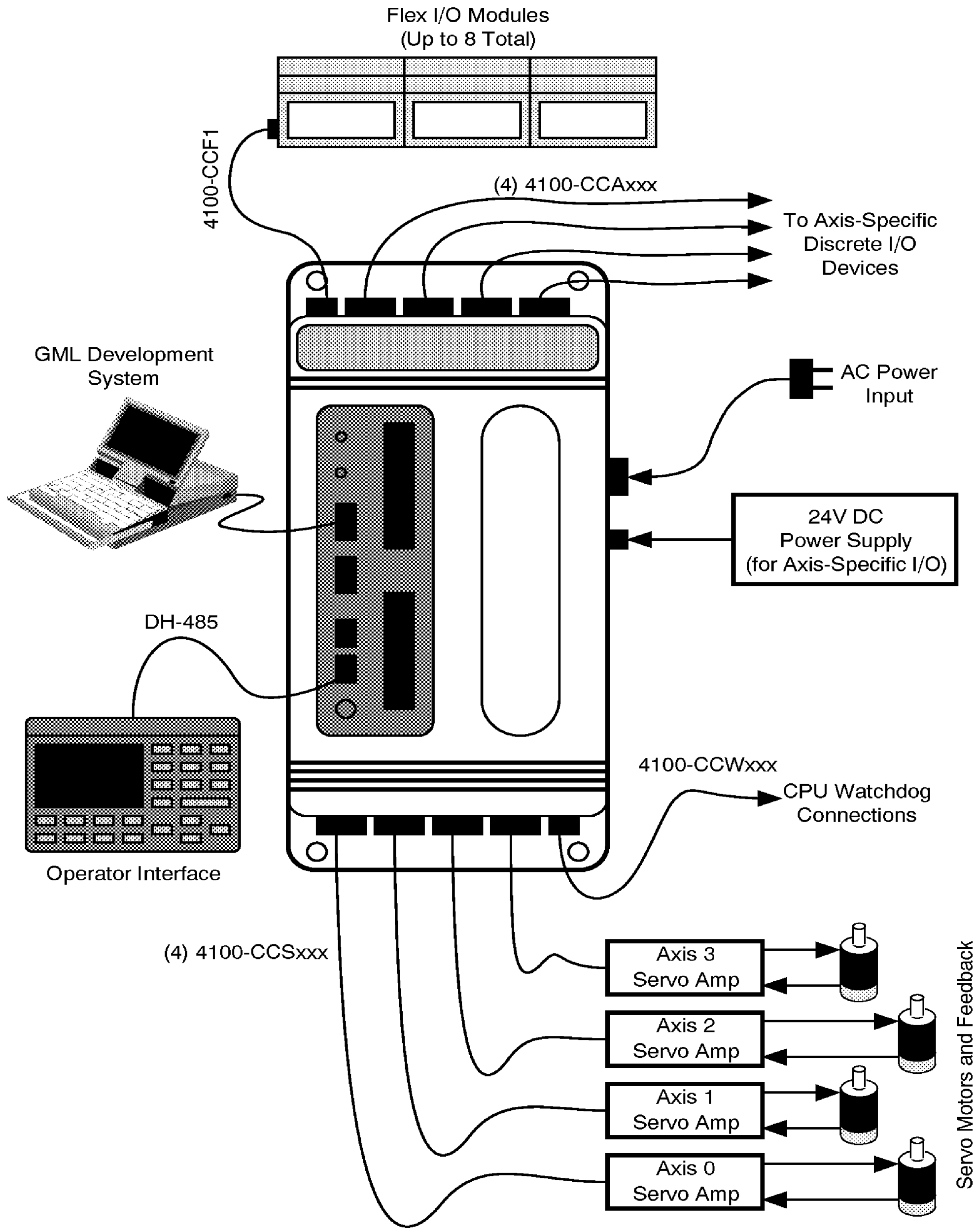
ATTENTION: Do not attempt to make any electrical connections to the IMC-S/23x while power is connected! Doing so risks damage to the IMC-S/23x, external components, and your health!

Before attempting to use the IMC-S/23x, configuration switches inside the unit must be set as required and the following connected:

AC mains power
24V DC power
Servo drives and feedback encoders
RS-232 or RS-422 terminal or computer

The following sections explain the setup of the internal configuration switches and the specific connections required.

As shown below, the servo drive and feedback devices attach to the bottom panel of the IMC S Class Compact while the axis-specific (dedicated) I/O devices attach to the top panel. Power input terminal blocks are on the right side of the unit.



Complying with European Union Directives

The information contained in this document pertains to the following Allen-Bradley products:

- 4100-234-RL
- 4100-234-R
- 4100-234-L
- 4100-234
- 4100-232-RL
- 4100-232-R
- 4100-232-L
- 4100-232

If these products are installed within the European Union or EEA regions and have the CE mark, the following regulations apply.

EMC Directive

These apparatuses are tested to meet Council Directive 89/336 Electromagnetic Compatibility (EMC) in accordance with Article 10 (1). The following standards apply in whole:

- EN 50081-2 EMC-Generic Emission Standard, Part 2-Industrial Environment
- EN 50082-2 EMC-Generic Immunity Standard, Part 2-Industrial Environment

The products described in this document are intended for use in an industrial environment and are not intended for use in a residential, commercial or light industrial environments.

Low Voltage Directive

These apparatuses are tested to meet Council Directive 73/23/EEC Low Voltage Directive. The following standards apply in whole or in part:

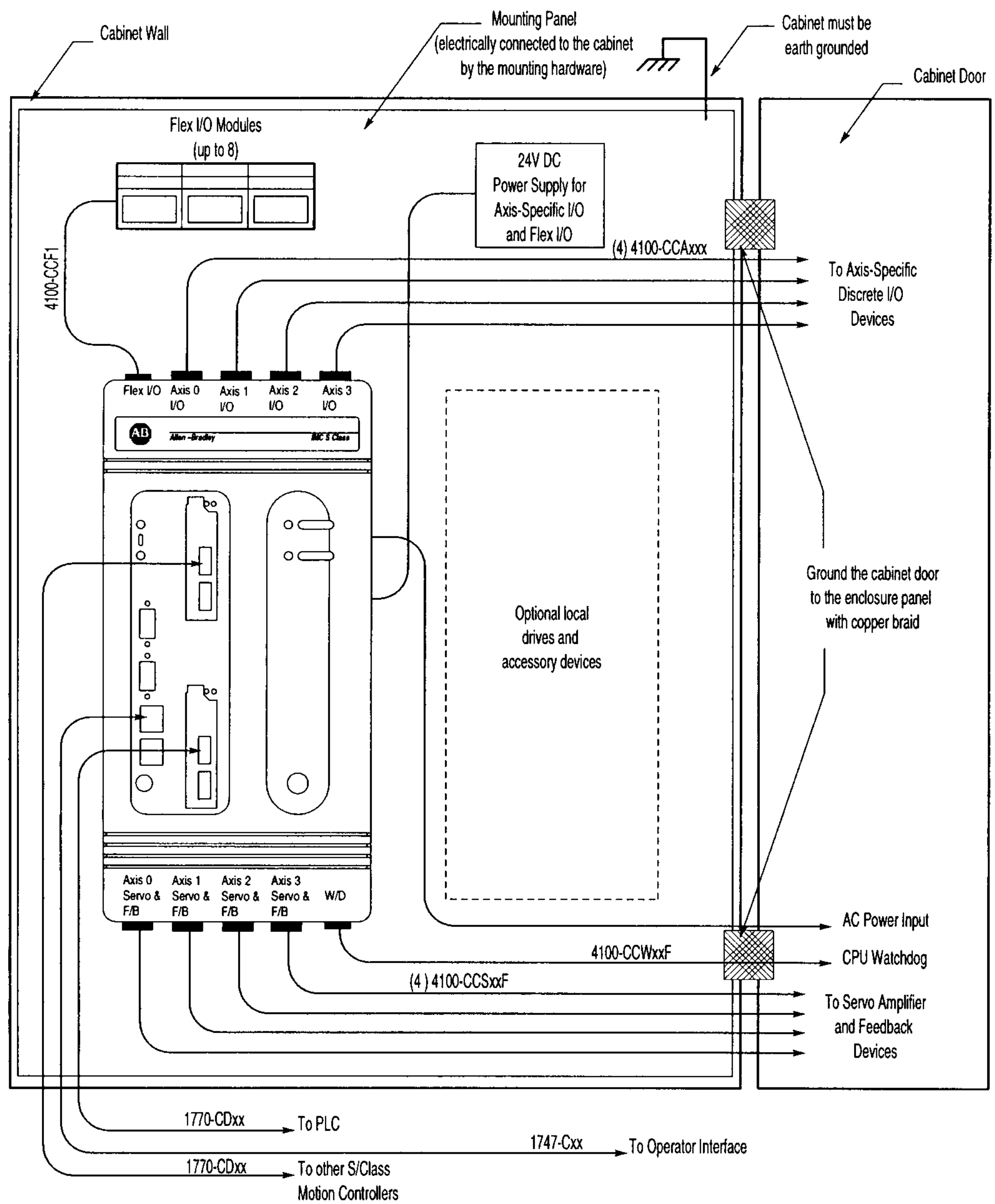
- EN 60204-1 Safety of Machinery-Electrical Equipment of Machines, Part 1-Specification for General Requirements

To meet CE requirements, the following additions are required:

- You must mount the Bulletin 4100 Compact in an IP 54 rated metal enclosure on a metal panel.
- You must bond all equipment.
- You must use the specified Allen-Bradley cables.
- The IMC-S/23x is designed to function without maintenance when operated in the environment specified in this manual.
- Under normal conditions, the IMC-S/23x should not require any periodic maintenance. However, if conditions are less than ideal and any superficial dust has accumulated on the controller over time, remove it carefully. Also, it is recommended to periodically inspect all cables for abrasion and all connectors for proper seating.

Refer to Figure 5.1 for grounding and wiring information.

Figure 5.1
Suggested Bulletin 4100 Compact Motion Control System Configuration for Meeting CE Requirements



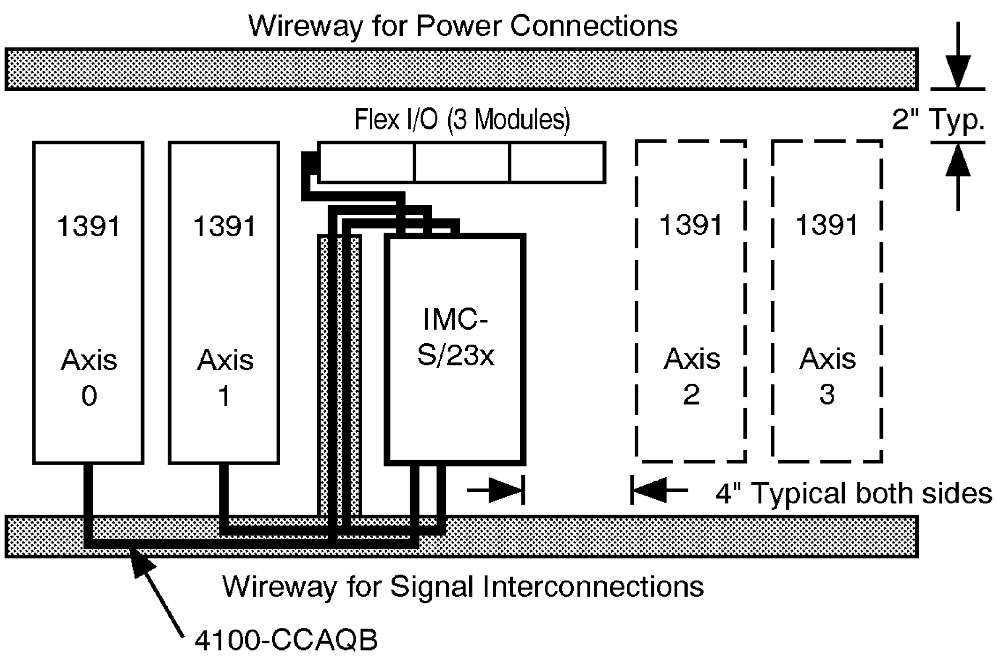
A/C and I/O fuse types: 3A Dual Element Time Delay (Slow Blow) (1/4 in. by 1 1/4 in.).

Important: Input power is to be wired in accordance with local regulations.

Installing the IMC-S/23x

The IMC-S/23x should be mounted to a panel inside an electrical cabinet or enclosure. For best performance, it should be mounted as close as practical to the servo drives with which it is being used. This minimizes the length of cable required to interconnect the units, thus minimizing the risk of electrical noise pickup. See the Introduction section of this manual for mounting and clearance dimensions.

The recommended panel layout for using the IMC-S/23x with Allen-Bradley 1391B-ES or 1391-DES AC servo drives is shown below. Panel layouts for use with other servo drives should be similar. Be sure to keep the power and signal wires segregated in separate wireways for maximum noise immunity.



Each axis of the IMC-S/23x connects to a 1391 drive via a 4100-CCAQB pre-engineered cable assembly. Both ends of this cable assembly are terminated in the appropriate mating connectors for the motion controller and the drive. The 4100-CCAQB cable assembly replaces *both* the 4100-CCSxxF and the 4100-CCAxxF when used with a 1391B-ES or 1391-DES servo drive. Axis-specific dedicated I/O not required by the servo drive (home input, overtravel inputs, drive fault input, and registration input) are available via 15 foot (4.5 meter) flying leads for termination to user devices or a user-supplied terminal block.

Configuring the IMC-S/23x

Before applying power to the IMC-S/23x or connecting external devices, the unit must be configured for your application. The IMC-S/23x is configured via switches on the motion controller and power supply modules inside the unit, as shown in the table below.

IMC-S/23x Configuration Switches

To Configure...	*Use This Switch...*	*On This Module*
Serial Ports	*SW1*	Motion Controller
Axis 0 and 1 Regist. Inputs	*SW2*	Motion Controller
Axis 2 and 3 Regist. Inputs (IMC-S/234 models only)	*SW1*	Motion Controller Expander Board
Encoder Power Voltage	*SW5*	Power Supply
Axis 0 and 1 Servo Output	*SW3*	Power Supply
Axis 2 and 3 Servo Output	*SW4*	Power Supply

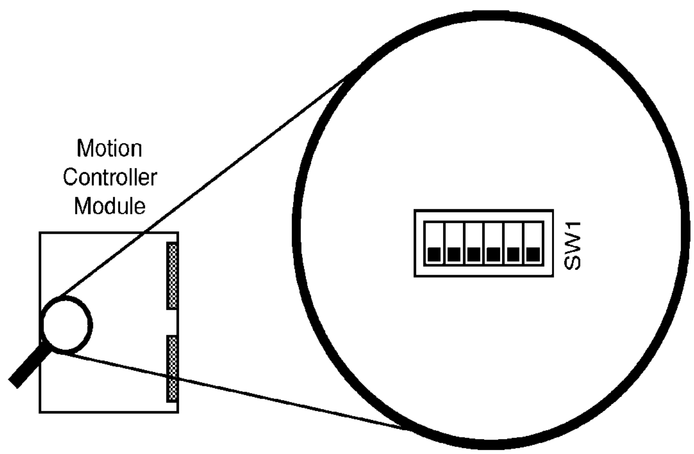
ATTENTION: Do not use a pencil to change configuration switch settings. The graphite may permeate the switch, causing it to malfunction.

To verify or change any of the configuration switch settings, open the front panel of the IMC-S/23x by loosening the captive thumbscrews on the top and bottom of the front panel and swing the panel out of the way to the left. Remove either the motion controller module (the leftmost module with the black sub-panel) or the power supply module (the rightmost module) by removing the top and bottom screws. Slide the module out of the rack carefully and place it face up on a static-safe work surface. Configure the switches for your application as explained following and then replace the module in the IMC-S/23x.

Configure the Serial Ports

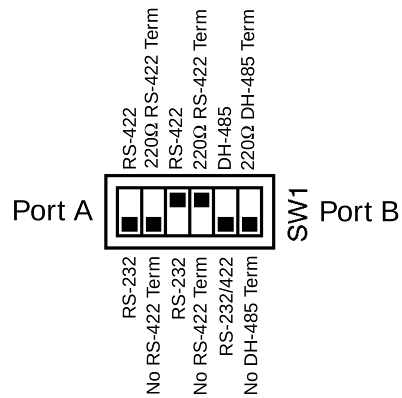
Serial port A may be independently configured for RS-232 or RS-422 operation and serial port B may be independently configured for RS-232C, RS-422, or DH-485 operation via switch SW1 on the motion controller module inside the IMC-S/23x. If RS-422 or DH-485 is selected, the port may also be configured to use or not use a termination resistor.

The serial port configuration switch layout is shown below. In IMC-S/23x-RL models, the switches are between the AxisLink and RIO boards (on the main board).

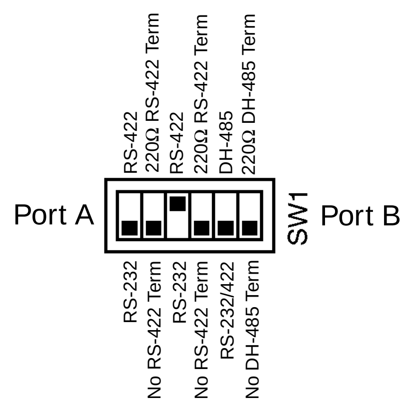


The leftmost switch selects RS-232 (down) or RS-422 (up) communications for serial port A. If RS-422 communications are selected, the next switch to the right determines whether the port is terminated (up) or not (down) with a 220 W resistor. If RS-232 communications are selected, the port should not be terminated (second switch down). The next pair of switches provide the same selections for serial port B. The rightmost pair of switches determines whether port B is used for RS-232/RS-422 communication (down) or DH-485 communication (up) and whether the DH-485 port is terminated (up) or not (down) with a 220 W resistor. As shipped from the factory, both ports are configured for RS-232C operation, as shown in the figure above.

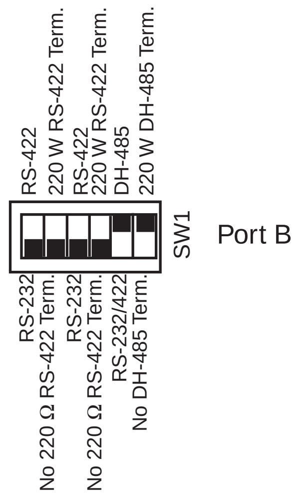
To configure either serial port for RS-422 communications, carefully move the first (port A) or second (port B) pair of switches to their up positions using a pen, small screwdriver, etc. For example, the figure below shows serial port A configured for RS-232 and serial port B configured for RS-422.



In Multidrop applications, *only* the first and last IMC-S/23x on the RS-422 line should be terminated. All intermediate IMC-S/23x controllers should *not* have their multidrop serial port terminated. For example, the figure below shows serial port A configured for RS-232 and serial port B configured for RS-422 *without* termination.



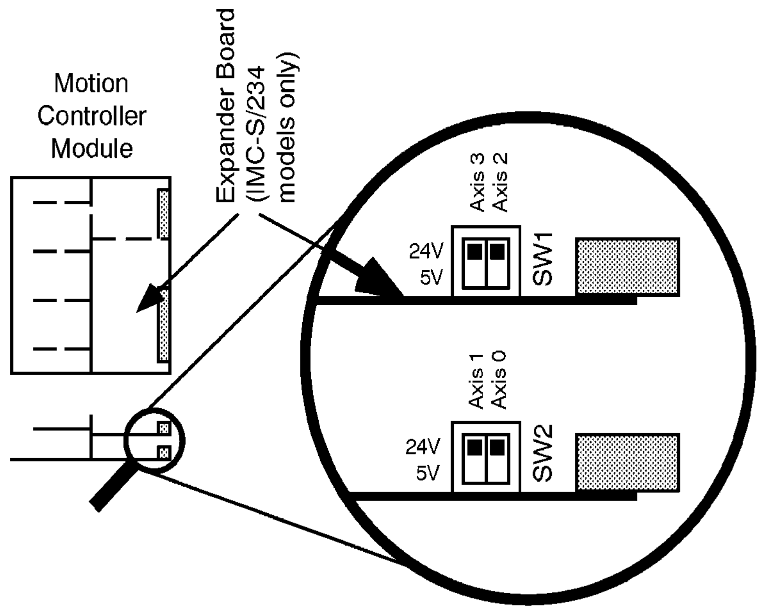
To configure serial port B for DH-485 communications, carefully move the rightmost pair of switches to their up positions using a pen, small screwdriver, etc. For example, the figure below shows serial port A configured for RS-232 and serial port B configured for DH-485.



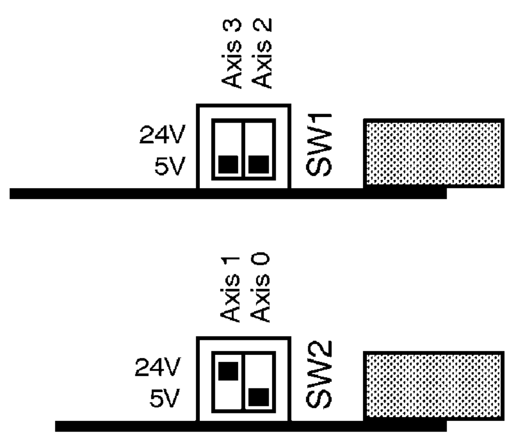
Refer to the Allen-Bradley publication "Data Highway/Data Highway Plus/DH-485 Cable Installation Manual" (1770-6.2.2) for information on proper DH-485 cable termination. If termination is *not* required in your application, move the rightmost switch to its down position and replace the motion controller module.

Select the Registration Input Voltage

Each axis of the IMC-S/23x may be individually configured to interface directly with either 5V or 24V DC registration sensors via switches on the motion controller module. SW2 on the main board selects the registration input voltage for axes 0 and 1, and SW1 on the expander board selects the registration input voltage for axes 2 and 3. The IMC-S/23x is shipped from the factory configured for 24V registration sensors for all axes (all switches up), as shown below.

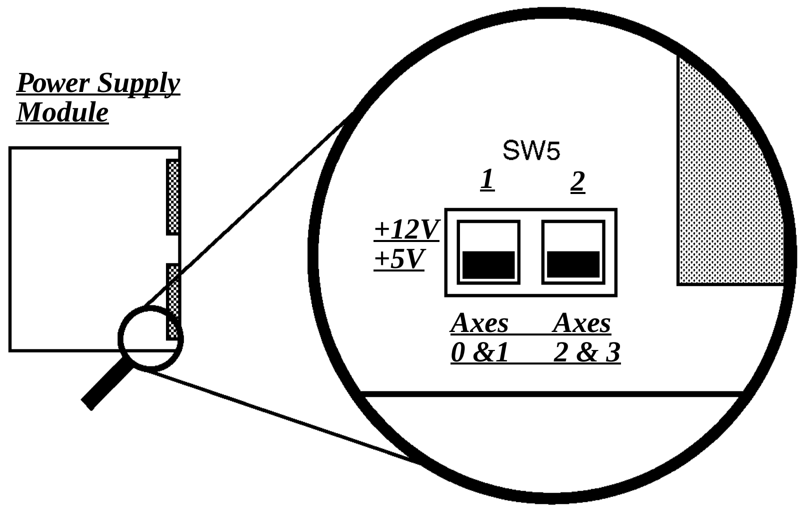


To use 5V registration sensors with any axis, carefully move the appropriate switch to its down position using a pen, small screwdriver, etc. For example, the figure below shows axis 1 configured for 24V registration sensors and all other axes configured for 5V sensors.

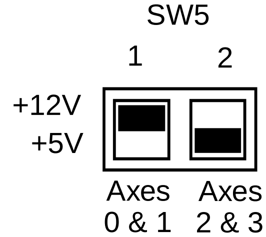


Select the Encoder Power Voltage

The IMC-S/23x may be configured to provide either 5V or 12V DC power (at 1 Ampere total maximum) for the axis feedback encoders via switch SW5 on the power supply module. SW5-1 selects the encoder power voltage for axes 0 and 1, and SW5-2 for axes 2 and 3. Regardless of the encoder power voltage selected, however, the encoder *outputs* must be 5V (TTL) level signals. The IMC-S/23x is shipped from the factory configured for 5V encoder power for all axes (both switches down), as shown below.



To select 12V encoder power voltage for either axes 0 and 1 or axes 2 and 3, carefully move SW5-1 or SW-2 (respectively) to its up position using a pen, small screwdriver, etc. For example, the figure below shows axes 0 and 1 configured for 12V encoder power and axes 2 and 3 configured for 5V encoder power.



If you are using an Allen-Bradley 845 series incremental encoder, use the table below to determine the proper encoder power voltage switch setting.

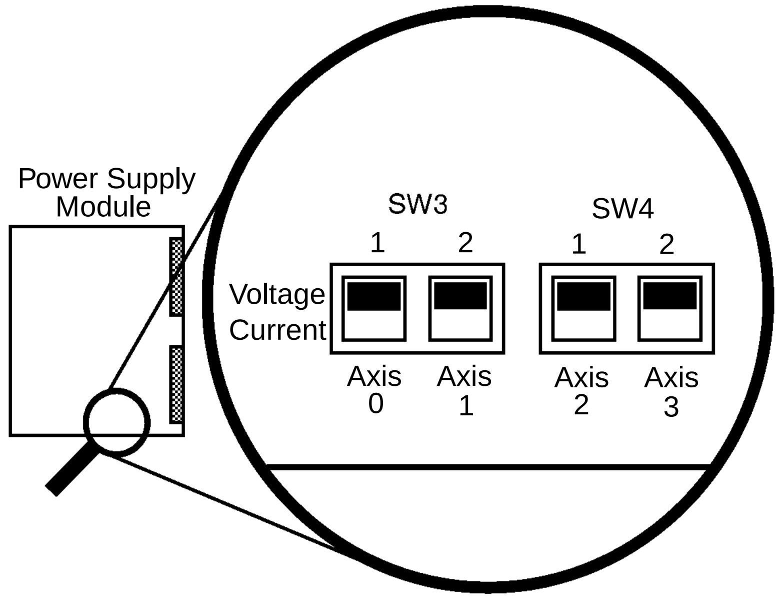
IMC-S/23x Encoder Voltage Switch Settings for Allen-Bradley Encoders

Allen-Bradley Encoder Model	*SW5*
845F-SJxZ14-xxYx... 845F-SJxZ24-xxYx...	Down (5V) Up (12V)
845H-SJxx14xxYx... 845H-SJxx24xxYx...	Down (5V) Up (12V)
845K-SAxZ14-xxY3 845K-SAxZ24-xxY3	Down (5V) Up (12V)
845P-SHC14-xx3	Down (5V)
845T-xx12Exx... 845T-xx13Exx... 845T-xx42Exx... 845T-xx43Exx...	Down (5V) Down (5V) Up (12V) Up (12V)

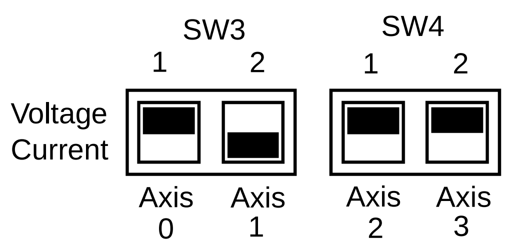
Encoders in a given family not shown in the table above are *not* compatible with the IMC-S/23x and should not be used.

Select the Servo Output Format

Each axis of the IMC-S/23x may be individually configured to provide either a ±10V (voltage) or ±150 mA (current) servo output signal via switches on the power supply module. SW3 selects the servo output format for axes 0 and 1, and SW4 for axes 2 and 3. The IMC-S/23x is shipped from the factory configured for ±10V servo output for all axes (all switches up), as shown below.



If you are using hydraulic servo or proportional valves with any axis, carefully move the appropriate switch to its down position using a pen, small screwdriver, etc. For example, the figure below shows axis 1 configured for ±150 mA (current) servo output and all other axes configured for ±10V (voltage) servo output.



Serial Communications Devices

The IMC-S/23x provides two optically-isolated serial ports called Serial Port A and Serial Port B. These ports are accessible through the 9-pin AT-compatible DB-9 connectors on the front panel. Both front panel connectors are pinned out identically, so connection to either port is the same.

ATTENTION: Do not connect anything to Serial Port B if you are using DH-485.

Serial port A is used for communicating with the GML development system and serial port B is used for a serial operator interface device for setup and actual machine operation if DH-485 is not used. When DH-485 is used, serial port B on the motion controller is used for DH-485 communication and the normal built-in operator interface functions of the IMC S Class are unavailable. When DH-485 is used, do not make any connections to serial port B on the motion controller.

Serial Communication Protocol

When configured for RS-232 or RS-422, both serial ports communicate using the standard ASCII character codes at a user selectable baud rate. As shipped from the factory, both serial ports are configured for a baud rate of 9600. Configure serial communications devices for the serial protocol defined below for proper operation with the IMC-S/23x:

IMC-S/23x Default Serial Communication Protocol

Parameter	*Value*
Baud Rate	9600 (others may also be specified)
Start Bits	1
Stop Bits	1
Word Length	8 (7 Data Bits plus Parity)
Parity	Ignored (May be Even, Odd, Mark, or Space)
XON/XOFF	ON

Connecting RS-232 Devices

When an IMC-S/23x serial port is configured for RS-232 operation (see Configuring the IMC-S/23x earlier in this section), RS-232C compatible serial communications devices may be connected to it using readily-available RS-232C cables. To prevent damage to the IMC-S/23x or the serial device, make sure that the serial port is configured for RS-232 operation before connecting RS-232 compatible devices.

ATTENTION: Configure the serial port for RS-232 operation before connecting RS-232 compatible devices.

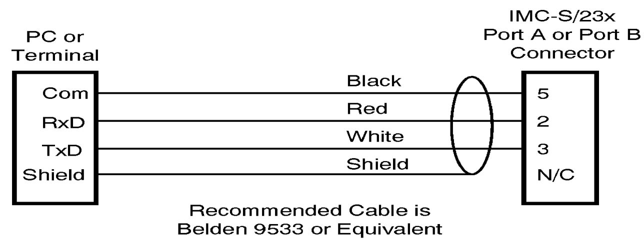
The pinout of each serial port is identical and shown for reference in the table below.

IMC-S/23x RS-232 Serial Port Pinout

DB-9 Pin	*Signal*	*Description*
1	*-*	Do Not Connect
2	*TxD*	Transmitted Data
3	*RxD*	Received Data
4	*DTR*	Data Terminal Ready
5	*Com*	Signal Common
6	*DSR*	Data Set Ready
7	*RTS*	Ready To Send
8	*CTS*	Clear To Send
9	*N/C*	No Connection

Note that the hardware handshaking signals (RTS/CTS and DSR/DTR) for both serial ports are jumpered inside the IMC-S/23x. This allows the use of standard RS-232C cables with serial devices which require hardware handshaking.

If you are making an RS-232C cable, only four conductors are required. Construct the cable as shown below, making sure to use the correct mating connector for your PC or terminal. The mating connector for the IMC-S/23x is a standard male 9-pin D-type (AMP P/N 205204-1).



Most serial communication devices (PCs, PC compatibles, and terminals) use one of two types of RS-232C connector. These are the standard DB-25 (25-pin) connector and the smaller DB-9 (9-pin) connector introduced on AT-compatible PCs. The pinouts for the DB-25 and DB-9 and the DB-9 to DB-9 connectors are given in the tables below.

Typical RS-232C Connector Pinout

Signal	*DB-25 Pin*	*DB-9 Pin*
Com	*7*	*5*
RxD	*3*	*2*
TxD	*2*	*3*
Shield	*1*	*N/C*

Typical RS-232C Connector Pinout

Signal	*DB-9 Pin*	*DB-9 Pin*
Com	*5*	*5*
RxD	*2*	*2*
TxD	*3*	*3*

Connecting RS-422 Devices

When an IMC-S/23x serial port is configured for RS-422 operation (see Configuring the IMC-S/23x earlier in this section), RS-422 compatible serial communications devices may be connected to it using pre-made RS-232C/RS-422 cables. To prevent damage to the IMC-S/23x or the serial device, make sure that the serial port is configured for RS-422 operation before connecting RS-422 compatible devices.

ATTENTION: Configure the serial port for RS-422 operation before connecting RS-422 compatible devices.

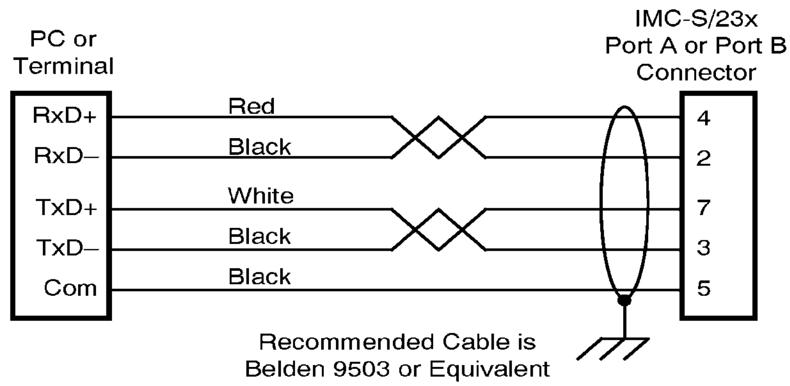
The pinout of each serial port is identical and shown for reference in the table below.

IMC-S/23x RS-422 Serial Port Pinout

DB-9 Pin	*Signal*	*Description*
1	*TxD+*	Transmitted Data (+)
2	*TxD-*	Transmitted Data (-)
3	*RxD-*	Received Data (-)
4	*TxD+*	Transmitted Data (+)
5	*Com*	Signal Common
6	*TxD+*	Transmitted Data (+)
7	*RxD+*	Received Data (+)
8	*RxD+*	Received Data (+)
9	*N/C*	No Connection

If your application ultimately requires the use of multiple IMC-S/23x controllers on the same RS-422 communications link (multidrop), connect each one to a serial communications device (PC, terminal, etc.) for setup *individually* before enabling multidrop. This assures that each IMC-S/23x is operating properly before being connected to the multidrop link. The Setup section of this manual describes the setup of multidrop systems.

If you are making an RS-422 cable, five conductors are required. Construct the cable as shown below, making sure to use the correct mating connector for your PC or terminal. The mating connector for the IMC-S/23x is a standard male 9-pin D-type (AMP P/N 205204-1).



Be sure that the TxD+/- and RxD+/- pairs are twisted as shown above for best noise immunity.

Connecting Encoders

The IMC-S/23x provides optically-isolated, differential line receiver (AM26LS32) encoder inputs for all axes. Differential-output line driver encoders must be used–single-ended encoders are not compatible.

ATTENTION: Set encoder power switches for 5V or 12V encoder power before connecting encoders.

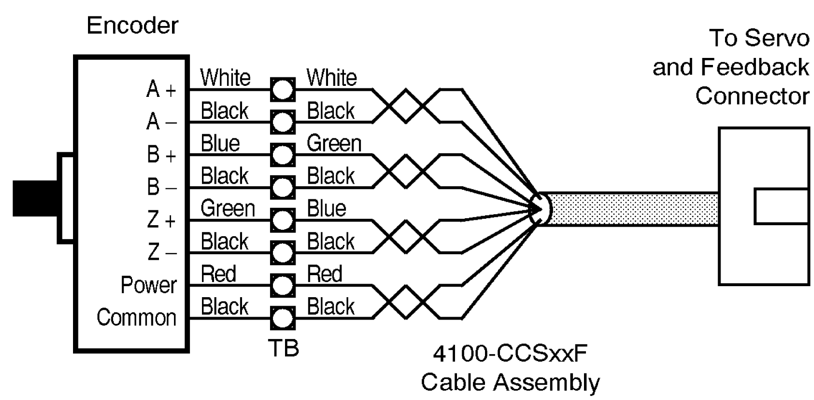
Encoder power is also provided by the IMC-S/23x and can be selected as either 5V or 12V depending on the requirements of the encoder as explained in Select the Encoder Power Voltage earlier in this section. Regardless of the encoder power voltage selection, however, the encoder outputs must be 5V (TTL) level signals. The encoder power supply in the IMC-S/23x is capable of supplying a total of 1 Ampere to power all the encoders connected to the IMC-S/23x.

Allen-Bradley 1391B-ES and 1391-DES Drives

If you are using 4100-CCAQB pre-engineered cable assemblies from Allen-Bradley to connect the IMC-S/23x to Allen-Bradley 1391B-ES or 1391-DES AC servo drives, select 5V encoder power (the factory setting) and refer to Appendix A for connection information.

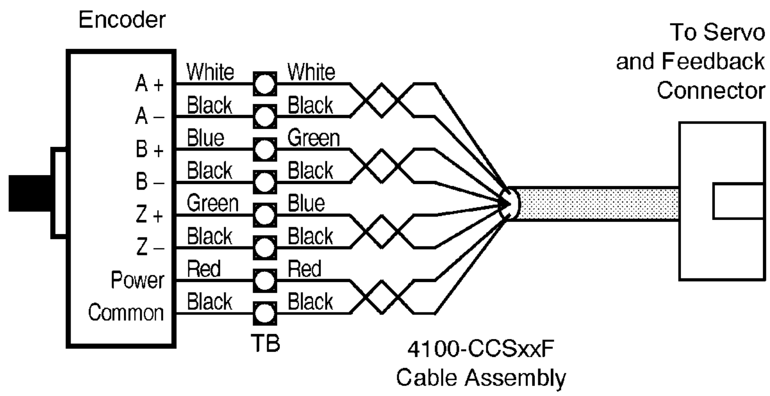
Allen-Bradley 845F, 845H, and 845T Encoders

If you are using Allen-Bradley 845F, 845H-, or 845T incremental encoders (see Select the Encoder Power Voltage earlier in this section for compatible models), connect them to the IMC-S/23x using a separate 4100-CCSxxF pre-engineered cable assembly for each axis as shown below.



Allen-Bradley 845K Encoders

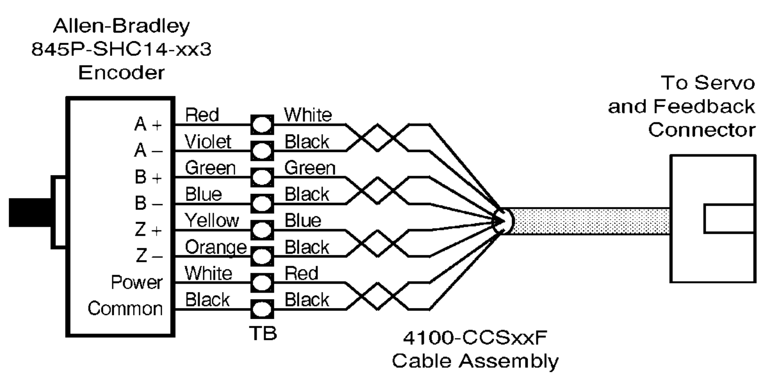
If you are using Allen-Bradley 845K-SAxZx4-xxY3 incremental encoders, connect them to the IMC-S/23x using a separate 4100-CCSxxF pre-engineered cable assembly for each axis as shown below.



Note that a user-supplied terminal block (TB) or intermediate connector is required to connect the 845K's integrated cable to the 4100-CCSxxF cable assembly.

Allen-Bradley 845P Encoders

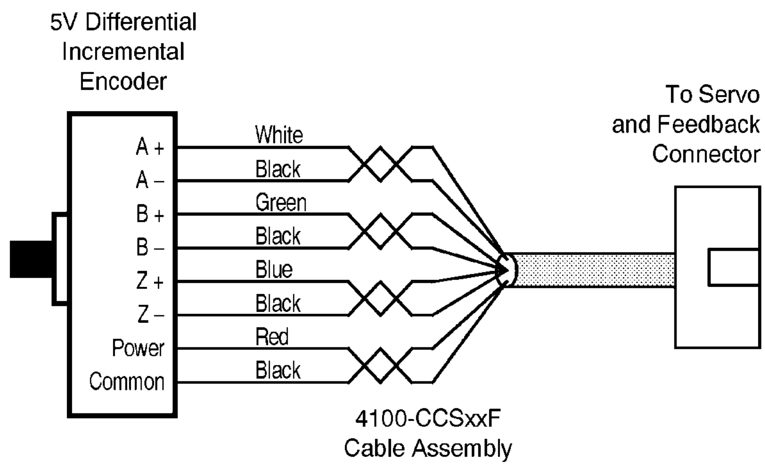
If you are using Allen-Bradley 845P-SHC14-xx3 incremental encoders, connect them to the IMC-S/23x using a separate 4100-CCSxxF pre-engineered cable assembly for each axis as shown below.



Note that a user-supplied terminal block (TB) or intermediate connector is required to connect the 845P's integrated cable to the 4100-CCSxxF cable assembly.

Other Encoders

If you are not using Allen-Bradley 1391B-ES or 1391-DES servo drives or Allen-Bradley 845 encoders, connect each encoder to the IMC-S/23x using a separate 4100-CCSxxF pre-engineered cable assembly for each axis as shown below.



Connecting Servo Amplifiers

The IMC-S/23x can be used with any commercially available servo amplifier that accepts a ±10 volt analog input signal. Each axis must be connected to its own amplifier. Before connecting servo amplifiers to the IMC-S/23x, connect each amplifier to its motor and set up the drive system as outlined in the amplifier manufacturer's manual. Be sure that the drive system is operating correctly before connecting it to the IMC-S/23x.

ATTENTION: Set the servo output format switches for Voltage before connecting servo amplifiers.

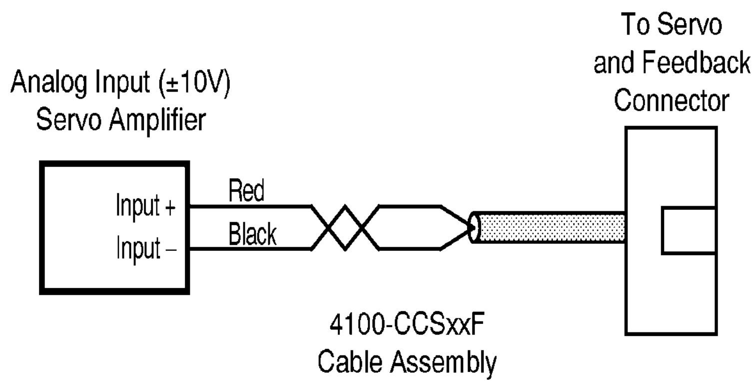
Each axis of the IMC-S/23x may be individually configured to provide either a ±10V (voltage) or ±150 mA (current) servo output signal as explained in Select the Servo Output Format earlier in this section. For servo amplifiers, ensure that the appropriate axes are set for voltage output.

Allen-Bradley 1391B-ES and 1391-DES Drives

If you are using 4100-CCAQB pre-engineered cable assemblies from Allen-Bradley to connect Allen-Bradley 1391B-ES or 1391-DES AC servo drives to the IMC-S/23x, select voltage servo output format (the factory setting) and refer to Appendix A for connection information.

Other Servo Amplifiers

If you are not using Allen-Bradley 1391B-ES or 1391-DES servo drives, connect each servo amplifier to the IMC-S/23x using the same 4100-CCSxxF pre-engineered cable assembly as used for that axis' encoder, as shown below.

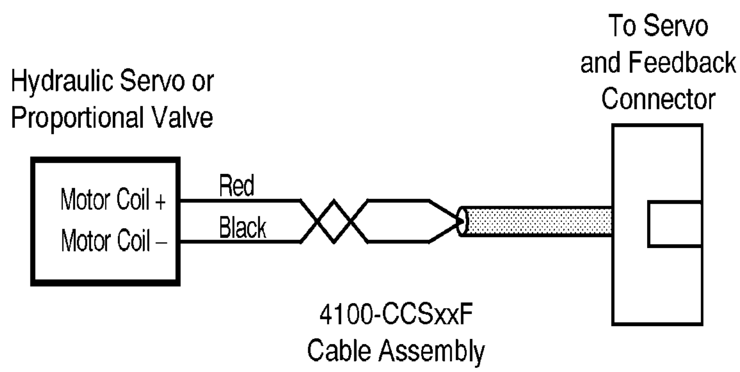


Connecting Hydraulic Valves

The IMC-S/23x can also be used with any commercially available hydraulic servo or proportional valve that accepts a ±150 mA analog input signal. Each axis of the IMC-S/23x may be individually configured to provide either a ±10V (voltage) or ±150 mA (current) servo output signal as explained in Select the Servo Output Format earlier in this section. For hydraulic valves, ensure that the appropriate axes are set for current output. Each axis must be connected to its own valve.

ATTENTION: Set the servo output format switches for Current before connecting hydraulic valves.

Connect each hydraulic valve to the IMC-S/23x using the same 4100-CCSxxF pre-engineered cable assembly as used for that axis' encoder, as shown below.

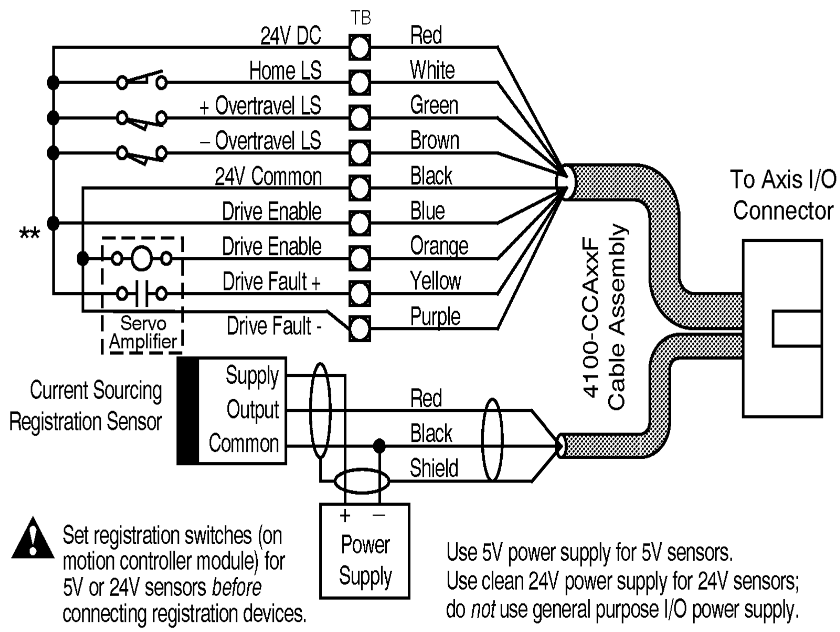


For full ±150 mA current output from the IMC-S/23x, the impedance of the servo valve motor coil must be less than 56 W .

Connecting Axis-Specific Discrete I/O

The IMC-S/23x provides home and overtravel limit switch inputs and a drive fault input for each axis. These axis-specific discrete inputs are optically isolated and filtered to eliminate switch bounce. In addition, the IMC-S/23x provides a normally open relay contact drive enable output for each axis.

Connect axis-specific I/O to the IMC-S/23x using a separate 4100-CCAxxF pre-engineered cable assembly for each axis as shown below.



**The Drive Enable/Fault diagram shown is for a typical Amplifier with a 24 VDC Enable Input and a normally open Drive Fault output.

The I/O power supply connected to the IMC-S/23x (see Connect the I/O Power Supply later in this section) provides 24V DC at up to 3 Amperes total maximum for powering the axis-specific discrete I/O. This power is available on the Red and Black conductors in the 4100-CCAxxF cable assembly as shown above. Note that a user-supplied terminal block (TB) is generally required to connect the I/O devices to the 4100-CCAxxF cable assembly.

The Drive Enable Outputs

Many servo amplifiers provide a drive enable/disable input which can be used by the IMC-S/23x to disable the drive whenever feedback is turned off. The drive enable outputs (one for each axis) of the IMC-S/23x provide a normally open relay contact capable of conducting up to 1 Ampere at up to 40V DC (24V DC nominal) for this purpose.

While the figure shown earlier uses the drive enable output to switch 24V DC into a drive enable relay coil, if your servo amplifiers provide an active-low TTL, CMOS, or 24V DC level drive enable input, each drive enable output may be connected directly to the appropriate servo amplifier. If your servo amplifiers provide a drive *disable* input, use the drive enable output to switch 24V DC into a drive enable relay coil, and connect the normally closed contacts of the relay to the appropriate servo amplifier.

The Drive Fault Inputs

Many servo amplifiers also provide a fault output which can be used by the IMC-S/23x to disable feedback and take the appropriate action if a fault in the drive system occurs. The drive fault inputs (one for each axis) of the IMC-S/23x require 12 mA at 30V DC maximum (24V DC nominal) to provide this function.

If your servo amplifiers provide an open-collector, open-drain, or dry contact drive fault signal, connect each drive fault input to the servo appropriate amplifier as shown in the previous figure. If your servo amplifiers provide a 12V or 15V DC level drive fault signal, use it to drive a relay and connect the contacts from this relay to the appropriate drive fault input.

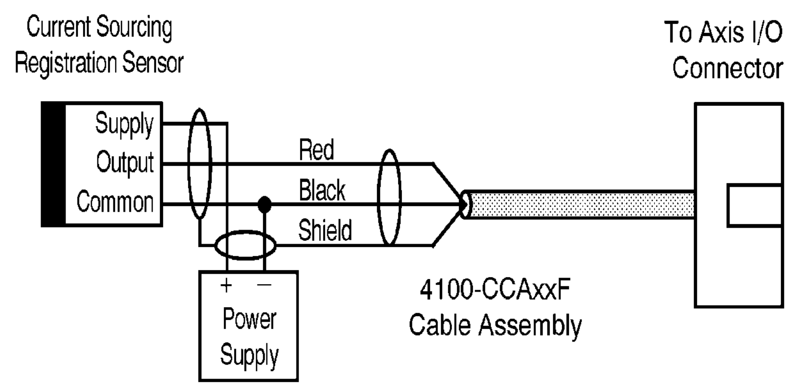
Connecting Registration Sensors

The IMC-S/23x provides a high-speed optically isolated registration input for each axis. These registration inputs require 2.5 mA at 5V DC (each) to operate.

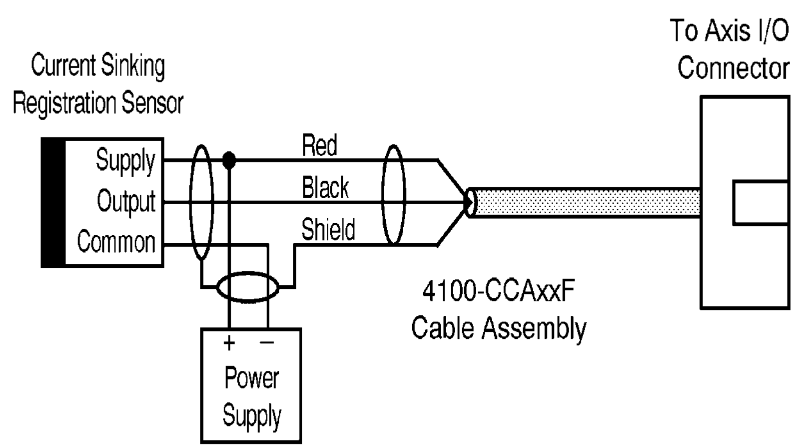
ATTENTION: Set the registration switches for 5V or 24V sensors before connecting registration devices.

Each registration input may be individually configured to interface directly with either 5V or 24V DC registration sensors as explained in Configure the Registration Inputs earlier in this section. To prevent damage to either the IMC-S/23x or the registration sensors, ensure that these switches are set properly before connecting registration sensors.

If you are using current sourcing proximity switches, registration sensors, or active-high encoder markers, connect them to the IMC-S/23x using the same 4100-CCAxxF pre-engineered cable assembly used for that axis' discrete I/O, as shown below.



If you are using current sinking proximity switches, registration sensors, or active-low encoder markers, connect them to the IMC-S/23x using the same 4100-CCAxxF pre-engineered cable assembly used for that axis' discrete I/O, as shown below.



ATTENTION: Use a clean 24V power supply for 24V sensors; do not use the general purpose I/O power supply.

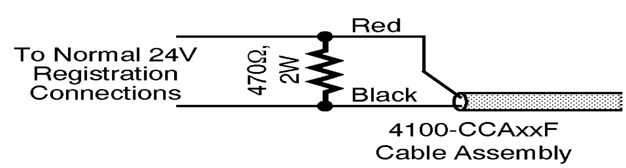
Use a clean 5V power supply for 5V registration sensors or a clean 24V power supply for 24V sensors. Do *not* use the 24V DC power supply connected to the IMC-S/23x for the axis-specific discrete I/O.

Using the Registration Inputs

The registration inputs on the IMC S Class are the most sensitive discrete inputs on the motion controller. Since they are used to latch axis position within 1 µs, they employ a faster optocoupler and are not filtered for switch bounce like the home, overtravel, and drive fault inputs. In applications which use a similarly fast registration sensor, this is not usually a problem. However, in some applications, the fast response and lack of filtering mean that extra precautions must be taken.

Since the registration inputs are–and have to be–sensitive because of their function, it is best to treat them not like discrete inputs but as you would treat a sensitive analog input. The registration inputs are floating (not referenced to any common) and are thus similar to a differential servo amplifier or encoder input. As with a servo amplifier or encoder input, best results are obtained by using shielded twisted-pair cable for all registration wiring as shown previously.

The registration input current is 2.5 mA when the input is activated. While this is a reasonable current for most 5V devices (the marker channel on an encoder for instance), it is quite low for typical 24V devices, making them more susceptible to interference. For these devices, the on current can be raised by a 470 Ω shunt resistor across the registration inputs, as shown below.

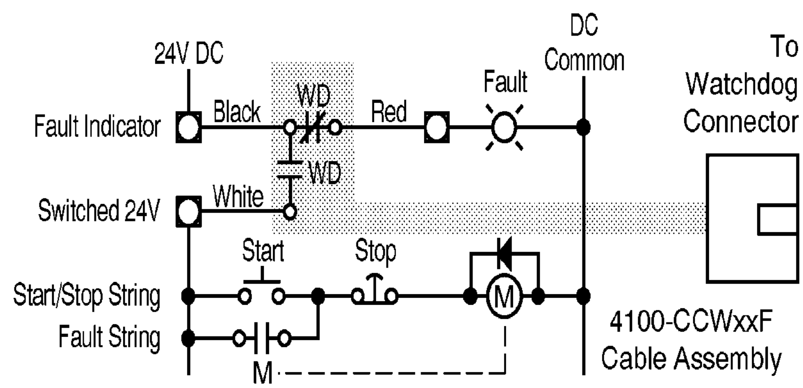


This resistor increases the current drawn from 24V registration sensors to over 50 mA. If your registration sensor can handle more on current, you can use lower resistance values, but be sure to check the power dissipation of the resistor and size it accordingly. Install the resistor as close to the end of the 4100-CCAxxF cable assembly as possible.

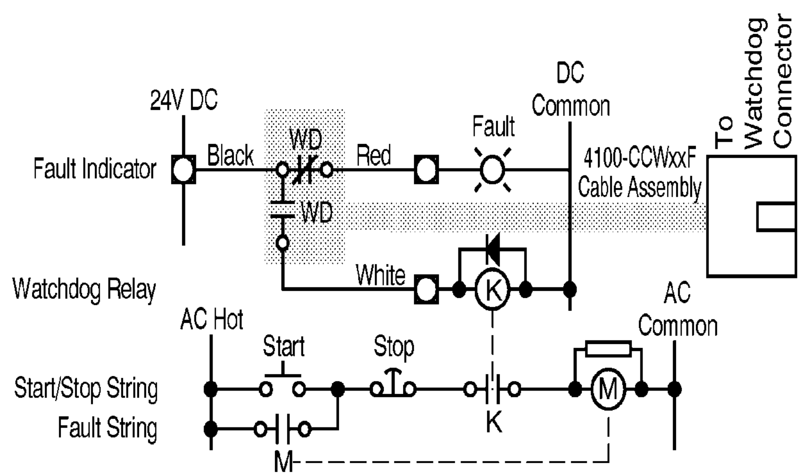
Connecting the CPU Watchdog

The IMC-S/23x provides a fail-safe CPU watchdog with relay-contact outputs for connecting into your machine's start/stop string or other protective circuit. Form-C (NO and NC) contacts are provided to allow external equipment to be disabled in the event of a control malfunction. The CPU watchdog relay is activated during normal operation and deactivates when there is a malfunction. A front-panel indicator (System OK) is illuminated whenever the CPU watchdog is activated. The CPU watchdog relay contacts are UL/CSA rated for 1 Ampere at 30V DC.

Connect the CPU watchdog contacts into the start/stop string of your machine using the 4100-CCWxxF pre-engineered cable assembly. The CPU watchdog contacts may be used directly in 24V DC start/stop strings; a typical connection is shown below.



An external relay driven from the CPU watchdog contacts must be used when switching AC. A typical connection for an AC start/stop string is shown below.



The connections shown in the figures above are typical only. They may be modified as required for your application if they cannot be used exactly as shown.

Connecting Flex I/O

Flex I/O modules connect directly to the IMC-S/23x using a 4100-CCF1 or 4100-CCF3 pre-engineered cable assembly. Plug the mini-D connector end of the 4100-CCF1 or 4100-CCF3 into the connector marked Flex I/O on the left of the top panel of the IMC-S/23x and the other end into the first Flex I/O module as shown in the general connection figure at the beginning of this section.

The Flex I/O modules which may be used with S Class motion controllers are shown in the table below.

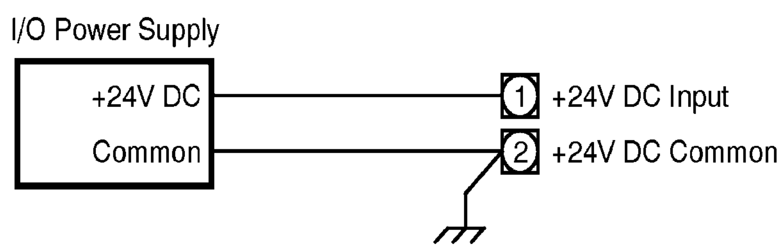
IMC S Class Compatible Flex I/O Modules

Catalog Number	*Description*	*For Additional Information See...*
1794-IB16	16 24V DC Discrete Inputs	1794-2.1
1794-IA8	8 115V AC Discrete Inputs	1794-2.1
1794-IE8	8 Analog Inputs	1794-2.1
1794-OB16	16 24V DC Discrete Outputs	1794-2.1
1794-0A8	8 115V AC Discrete Outputs	1794-2.1
1794-OE4	4 Analog Outputs	1794-2.1
1794-IE4XOE2	4 Current/Voltage Analog Inputs 2 Current/Voltage Analog Outputs	1794-2.1

Up to eight separate modules, selected from the table above, may be connected to the motion controller in any order. For specific information on connecting I/O devices and mounting Flex I/O modules, see the appropriate Flex I/O publications listed above.

Connect the I/O Power Supply

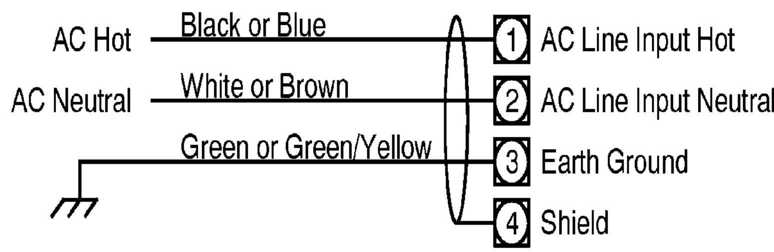
The IMC-S/23x requires a source of 24V DC power for the axis-specific discrete I/O. The I/O power supply must be capable of supplying enough current for all of the axis-specific discrete I/O (up to a maximum of 3 amperes). Connect the I/O power supply to the 24V DC power input (two position) terminal block on the right side of the IMC-S/23x as shown below.



Be sure to connect the common of the I/O power supply to earth ground as shown.

Connect the AC Power

The IMC-S/23x requires 3 Amperes (maximum) at 90 - 132 or 175 - 264 Volts AC (auto switching), 47 - 63 Hz, single-phase. This is compatible with the AC mains power in all countries. Connect AC power to the AC power input (four position) terminal block on the right side of the IMC-S/23x as shown below.



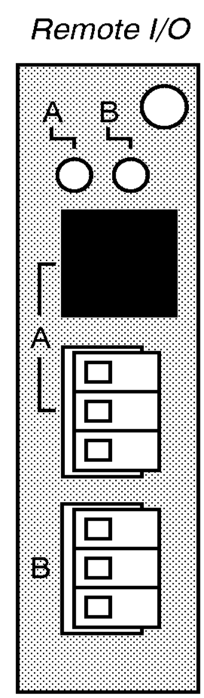
ATTENTION: The IMC-S/23x **must** be connected to earth ground as shown above for proper operation.

The IMC-23x requires that the earth ground terminal be connected to earth ground for proper operation. The internal noise filtering circuitry does not work properly without this connection and erratic or unreliable operation of the unit can result.

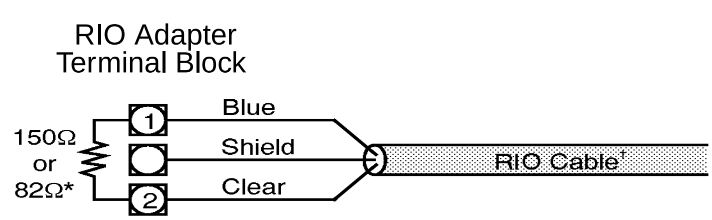
Connecting Remote I/O (Optional)

IMC-S/23x-R and IMC-23x-RL models include a Remote I/O (RIO) Adapter for connection to an Allen-Bradley PLC. On these models, the RIO cable is connected using a 3-terminal pluggable terminal block to either channel A or channel B of the Remote I/O Adapter front panel. The front panel of the Remote I/O Adapter is shown below.

ATTENTION: Even though the RIO Adapter front panel is identical to the AxisLink front panel, the two options are not interchangeable. Do not mix RIO and AxisLink connections or neither system will work properly.



Remove the 3-terminal pluggable terminal block from the RIO adapter and connect the RIO cable to it as shown below. If this IMC-S/23x is the last physical module on the RIO cable, also connect the appropriate terminating resistor as shown.



* Install termination resistor *only* if this is the first or last physical module on the RIO cable. Use 82Ω resistor only for 230k baud communications.

† A-B 1770-CD (Belden 9463 or Equivalent)

Plug the terminal block into the channel (A or B) on the RIO adapter which you wish to use for RIO communications. Either channel can be used–the selection is made in the Application Setup Menu. See the Setup section of this manual for information on configuring RIO operation.

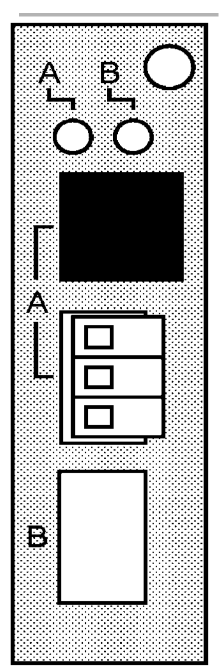
Connecting AxisLink (Optional)

IMC-S/23x-L and IMC-23x-RL models include AxisLink, which allows linking multiple IMC S Class controllers and ALECs (AxisLink Encoder Converter modules) together so that axes on one controller or ALEC can be used as master axes for electronic gearing and cams on other controllers. On these models, the AxisLink cable is connected to channel A of the AxisLink option using a 3-terminal pluggable terminal block on the AxisLink option front panel. The AxisLink option front panel is shown below.

Important: All nodes on the same AxisLink network should be operated at the same servo update rate.

ALECs cannot currently operate in extended length mode.

ATTENTION: Even though the front panel of the AxisLink option is identical to the RIO Adapter front panel, the two options are not interchangeable. Do not mix RIO and AxisLink connections or neither system will work properly.



AxisLink

ATTENTION: Even though AxisLink and RIO use the same cable, connections are not interchangeable. Do not mix RIO and AxisLink connections or neither link will work properly.

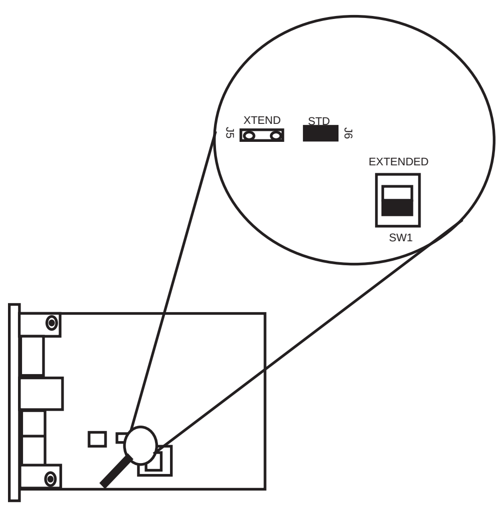
The AxisLink option can be operated in either of two configurations depending upon the cable length required between controllers. Refer to the AxisLink specifications in this manual for more information on the differences between the two configurations. The standard configuration is used for daisy-chain cabling with a maximum end-to-end distance of 1 to 25 meters (3 to 82 feet) and the extended configuration for daisy-chain cabling with a maximum end-to-end distance of 25 to 125 meters (82 to 410 feet). To use the AxisLink option in its extended configuration, the IMC-S/23x-L or IMC-S/23x-RL controller requires a firmware version of V3.2 or later for extended length and V3.5 or later for extended node (extended node also requires GML V3.9 or later). For both configurations, there is a 1 m (3 ft) minimum cable length between AxisLink nodes. The AxisLink option switch setting, termination resistors, and cabling are different for the two configurations and must be correct for proper AxisLink operation in the intended configuration.

Important: To use extended length mode, you need firmware V3.2 or later. To use extended node, you need V3.5 or later.

AxisLink Settings for Standard AxisLink Operation

Switch 1 (SW1) on the AxisLink board must be set to the non-EXTENDED setting (toward the edge of the board).

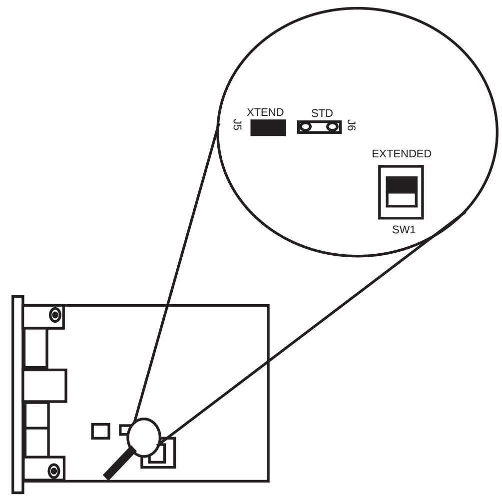
Jumper 6 (J6), labeled STD on the board, must be in place across both J6 pins if using onboard cable termination. Jumper 5 (J5) on the board should not be connected.



AxisLink Settings for Extended Length AxisLink Operation

Switch 1 (SW1) on the AxisLink board must be set to the EXTENDED setting (away from the edge of the board).

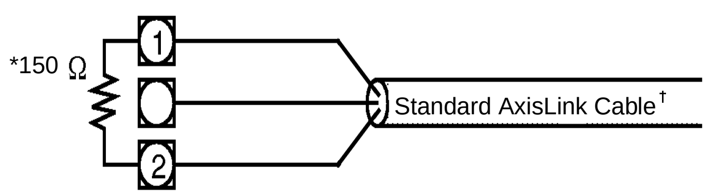
Jumper 5 (J5), labeled XTEND on the board, must be in place across both J5 pins if using onboard cable termination. Jumper 6 (J6) on the board should not be connected.



If you are not using the onboard termination resistors, both jumper 5 (J5) and 6 (J6) should not be in place across the pins on the board.

To connect the AxisLink option, remove the 3 terminal pluggable terminal block from the AxisLink connector and connect the AxisLink cable to it as shown below. If this IMC-S/23x is either the first or the last physical module on the AxisLink cable and the onboard cable termination resistors are not used, also connect a terminating resistor.

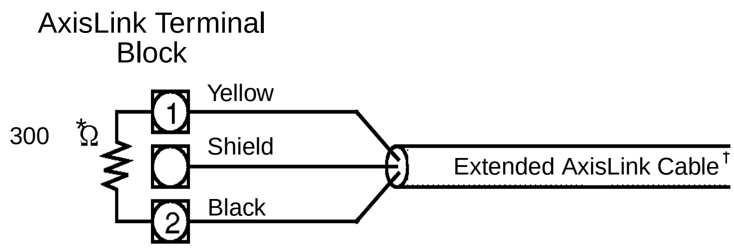
Standard Configuration Diagram



* Install termination resistor *only* if this is the first or last physical module on the AxisLink *and* if the onboard cable termination resistors are not used.

† A-B 1770-CD (Belden 9463 or Equivalent)

Extended Configuration Diagram



* Install termination resistor *only* if this is the first or last physical module on the AxisLink *and* if the onboard cable termination resistors are not used.

† Belden 9182, Carol C8014 or equivalent.

Plug the terminal block back into channel A on the front panel of the AxisLink option.

If you are using the standard or extended length AxisLink configurations, select the desired AxisLink address (0 - 7) for this motion controller using the Address selector switch on the front panel. Only positions 0 - 7 on this switch may be used as AxisLink addresses– do not select positions 8 or 9.

ATTENTION: Do not select position 8 or 9 on the Address selector switch.

Connecting DH-485 (Optional)

If serial port B has been configured for DH-485 communications (see Configure the Serial Ports earlier in this section), plug a 1747-Cxx DH-485 cable into either of the DH-485 connectors (RJ-45) on the IMC-S/23x front panel. The two DH-485 connectors are internally wired in parallel, so either one may be used. The second connector is provided to permit easy "daisy-chaining" of multiple devices on the DH-485 network. Connect the other end of the 1747-Cxx DH-485 cable into a PanelView 550 operator terminal or 1747-AIC DH-485 link coupler for connection to a DH-485 network.

The IMC S Class does not provide 24V DC power on the DH-485 connectors for powering external equipment. Refer to the Allen-Bradley publication "Data Highway/Data Highway Plus/DH-485 Cable Installation Manual" (1770-6.2.2) for more information on DH-485 cabling and the user manuals for other DH-485 devices for information on powering them.

ATTENTION: Do not connect anything to Serial Port B of the IMC-S/23x if you are using DH-485 communications.

When DH-485 is used, serial port B on the motion controller is used for DH-485 communication and the normal built-in operator interface functions of the IMC S Class are unavailable. When DH-485 is used, do not make any connections to serial port B on the motion controller.

Understanding IMC-S/23x Setups

This chapter shows you how to program your IMC-S/23x using the view mode window of the on-line manager in GML. If you are using the GML Definitions menu and function blocks to program your IMC-S/23x, refer to this chapter for additional information on programming features.

The Setup Menus

A user-friendly setup and diagnostic menu is built into the IMC-S/23x. This menu–which is itself subdivided into four separate submenus–greatly simplifies setting up the IMC-S/23x for a specific application or a specific machine. The four submenus are as follows:

- Application Setup Menu
- Machine Setup Menu
- Hookup Diagnostic Menu
- Servo Setup Menu

The setup menus cannot be accessed unless the controller's memory is unlocked via the front panel keyswitch. Make sure that the Memory keyswitch in is the (unlocked) position before proceeding with system setup. All parameter values entered in the setup menus are stored in this lockable memory.

Application Setup Menu

The Application Setup Menu contains parameters that define the configuration of the IMC-S/23x.

Machine Setup Menu

The Machine Setup Menu contains parameters which configure the IMC-S/23x for the specific machine being controlled.

Hookup Diagnostics Menu

The Hookup Diagnostics Menu is used to check and verify connections to external devices. Tests are included for checking encoders, drives and motors, and discrete and dedicated I/O. This menu also provides tests to automatically determine correct feedback polarity for proper closed-loop servo operation.

Servo Setup Menu

The Servo Setup Menu is used to tune the servo loop gains and dynamic parameters. It provides access to the automatic setup and self-tuning routines, and also allows manual tuning of all servo parameters. Each of these menus can be used at any time for diagnostic purposes.

All of the setup parameters available in the setup menus can also be set using the Definitions menu and the Online Manager in GML. See the GML Programming Manual for IMC S Class Motion Controllers (GML-DOC-S) for more information on using the Definitions menu.

Using the Setup Menus

The user-friendly setup menus are accessed via the Online Manager in GML connected to serial port A.

After the terminal is connected, apply power to the IMC-S/23x and the Standard Operator Interface appears in the Display window in the Online Manager window. Refer to the Online Manager in the GML Programming manual for more information.

Passwords

To protect against unauthorized setup parameter changes, the IMC-S/23x requires a password before allowing access to the setup menus.

To get to the Setup menu, type **.S** and press ENTER . The Setup menu appears.

The setup password is an ASCII character string selected by the application programmer for each specific application. As shipped from the factory, the password is SET, but may be different for your specific application. If you type the password incorrectly, an Incorrect Password appears on the IMC-S/23x. Enter the setup menus again as described above and enter the correct password.

Toggling

The technique used to select the desired answer to questions in the setup menus is called *toggling*. Toggling is accomplished by pressing the **SPACE BAR** on a terminal or PC, which displays the next legal option or answer to the question.

► **TIP:** Toggle Choices are always English-language answers to questions and are displayed in all CAPITAL letters.

For example, the only legal answers to many questions are `YES` and `NO`, and thus these two choices are alternately displayed each time the **SPACE BAR** is pressed. When there are more than two answers to the question, toggling shows all the available choices sequentially, starting with the currently selected choice. To answer the question, toggle to the desired choice and press **ENTER**.

Disabling Feedback

When the correct password has been entered, if feedback is currently enabled on any axis, the following appears in the Display Window in the Online Manager window for all axes on which feedback is enabled:

```
Setup Password?
OK to Disable Axis # Feedback?  YES
```

After ensuring that disabling axis feedback will not injure yourself or the machine, press **ENTER** or **RETURN**.

Answering `NO` to this question immediately generates the following message

```
OK to Disable Axis # Feedback?  NO
Setups Require Feedback Off!
```

and exits the Setup menu with feedback still active.

Disabling DH-485

After disabling feedback on all axes, if DH-485 communications are used, the IMC-S/23x asks

```
Feedback Off
OK to Disable DH-485 Communication?
```

After ensuring that disabling the motion controller on the DH-485 network will not injure yourself or the machine, press **ENTER**.

Answering `NO` to this question immediately generates the following message

```
OK to Disable DH-485 Communication?  NO
Setups Require DH-485 Communications Off!
```

and exits the Setup menu with DH-485 still active.

Loading Setup Values

Next, the IMC-S/23x asks

```
OK to Disable DH-485 Communication?  YES
Load Setups from App Module?  NO
```

Toggle to `YES` and press **ENTER** to load the power-up values for all parameters. Answer `NO` to this question to edit or review the current *working* values of the setup parameters. The working parameter values may have been modified by the application program and thus be different from the power-up values.

Selecting a Setup Menu

After entering the setup menus as described above, selection of a specific setup menu is accomplished by advancing to the desired menu by pressing **ENTER** until the desired menu appears, toggling to `YES` and pressing **ENTER** again. If you go past the menu you want, continue pressing **ENTER** or press the **ESC** (Escape) key to exit the Setup menu and type **`.S`** again.

Selecting an Axis

After selecting a setup menu , you must select the axis to configure. The IMC-S/23x displays

```
Select:  AXIS 0
```

ATTENTION: Make sure to set **all** the parameters in **all** of the setup menus for **all** axes in your system!

The IMC-S/232 provides two physical axes called Axis 0 and Axis 1, while the IMC-S/244 provides four physical axes (Axis 0, 1, 2, and 3). All controllers also provide one imaginary axis . Controllers with AxisLink (IMC-S/23x-L and IMC-S/23x-RL models) provide two additional virtual axes (Virtual Axis 0 and 1) for use as remote master axes. Toggle to the desired axis and press **ENTER**.

After you have completed any of the setup menus for the selected axis, the IMC-S/23x asks:

```
Another AXIS?  NO
```

Toggle to `YES` to configure another axis.

Editing Parameter Values

In the setup menus, questions are asked that can be answered by toggling as described above. In addition, numeric values for setup parameters are requested. The desired values are entered by a process called *editing*.

Each setup parameter which requires a numeric value is displayed sequentially as shown below:

```
Parameter Name = Current Value
```

TIP: Editable parameter values are always numbers preceded by =.

To retain the current value for the displayed parameter, press **ENTER**. To change (edit) the value, type in the new value, followed by **ENTER**. When entering new parameter values, the decimal point (**.**) and the minus (**-**) keys may be used in addition to the digits **0** through **9**. If you make a mistake while entering the new value, press the **DEL** (delete) key to erase the entire value or the **BSP** (backspace) key on a terminal to erase just the previous character.

If an illegal parameter value (too big, too small, of the wrong sign, or containing too many digits) is entered, the terminal or PC beeps to alert you of the error and the value is changed to the closest legal value when you press **ENTER**. You can then enter another value directly by pressing **DEL** (delete) or **BSP** (backspace). Press **ENTER** again to accept the displayed value.

Application Setup Menu

The Application Setup Menu is password-protected to prevent unauthorized alteration of application-specific setup parameters.
A list of all the application setup menu parameters is included at the end of this section for reference.

Like the setup password, the application password is an ASCII character string selected by the application programmer for each specific application. As shipped from the factory, the application password is APP, but may be different for your specific application. If you type the password incorrectly, the IMC-S/23x exits the Setup menu. Enter the setup menu again as described above and enter the correct password.

Upload Inhibit

After entering the Applications Setup Menu, the IMC-S/23x asks:

```
Inhibit Program Upload?  NO
```

If you desire to prevent the uploading of the Application Program from memory, toggle to YES and press **ENTER**. This will prevent the Application program from being viewed or uploaded.

Note: If a hardware initialization is done with the keyswitch unlocked and *Upload Inhibit* set to YES, the Application program will be erased from the memory.

Editing the AxisLink Configuration

For IMC-S/23x-L and IMC-S/23x-RL models only, after the correct password has been entered, the IMC-S/23x asks

```
Edit AxisLink Config?  NO
```

Toggle to YES and press **ENTER** to configure AxisLink for your application.

Next the IMC-S/23x asks

```
Edit AxisLink Config?  YES
 AxisLink?  NO
```

Toggle to YES and press **ENTER** if you plan to use AxisLink in your application. If you do not need to use AxisLink, toggle to NO and press **ENTER**.

Editing the DH-485 Configuration

If the IMC-S/23x is configured for DH-485 communication (see Configuring the IMC-S/23x in the Installation and Hookup section of this manual), the motion controller next asks

```
Edit DH-485 Config?  NO
```

Toggle to YES and press **ENTER** to configure the motion controller for operation on the DH-485 network.

Next the IMC-S/23x asks

```
Edit DH-485 Config?  YES
 DH-485?  NO
```

Toggle to `YES` and press **ENTER** if you plan to use DH-485 in your application. To temporarily disable DH-485, toggle to `NO` and press **ENTER**. To permanently disable DH-485, the hardware must be re-configured (see Configuring the IMC-S/23x in the Installation and Hookup section of this manual).

Maximum Node Address

Enter the highest address of any device on the DH-485 network for the maximum node address. This is the highest address which will be polled as devices pass the token among masters on the DH-485 network. The smaller the maximum node address, the faster the throughput on the DH-485 network, since no time is spent polling devices which do not exist.

Network Node Address

Enter the desired address of the motion controller on the DH-485 network for the network node address. The specified address must be less than or equal to the specified maximum node address. If not, the message

```
Address Must be < than Max. Address!
Network Node Address?
```

is displayed and you must enter a new network node address.

Baud Rate

Toggle to the baud rate of the DH-485 network to which the motion controller is connected. Both 19,200 and 9,600 baud are available. Unless necessary for some other device, always use 19,200 baud for fastest communication.

Token Hold Factor

Toggle to the hold factor you want (1, 2, 3, or 4). Selecting the default of 4 gives the IMC-S/23x the largest time slice for sending and receiving.

Editing the Axis Setup Parameters

When the correct password has been entered, the IMC-S/23x asks

```
Edit Axis Setup Parameters?  NO
```

Toggle to `YES`, press **ENTER**, and select the desired axis as explained above to configure the axes for your application.

Axis Configuration

Each physical axis in the IMC-S/23x may be independently enabled or disabled `(NOT CONFIGURED)` as required by your application. In addition, an enabled axis may be configured as either a full closed-loop servo axis `(SERVO)` or for position monitoring only `(MASTER ONLY)`. Toggle to the desired configuration for the selected axis and press **ENTER**.

When an axis (physical or virtual) is configured for `MASTER ONLY`, the encoder input for that axis may be used as the master encoder for electronic gearing or cams, and questions relating to closed-loop operation are not asked in the following setup menus. When an axis is configured as a full closed-loop `SERVO` axis, all questions are asked.

Virtual Axes

Virtual axes provided by AxisLink are automatically configured for position monitoring only `(MASTER ONLY)`. The following message

```
Select:  VIRTUAL AXIS 0
A Virtual Axis is MASTER ONLY
```

is displayed when a virtual axis is selected. Functionally, AxisLink virtual axes are identical to extra encoder inputs on the motion controller. All setup parameters available for physical `MASTER ONLY` axes are also available for virtual axes unless mentioned otherwise.

To configure a virtual axis, first select the address of the controller or ALEC (AxisLink Encoder Converter module) and the physical or imaginary axis on that controller which is to be used for this virtual axis. When AxisLinking to an ALEC, always select `AXIS0`. Read the controller or ALEC address from the front panel Address selector switch of the appropriate controller or ALEC. If you select the address of the controller you are setting up, the message

```
Controller Address?  #
***   Cannot Select This Controller!
```

is displayed and you must select another address. The axis associated with an AxisLink virtual axis *must* be on another motion controller or ALEC.

ATTENTION: Do not select command axis type if the physical axis is configured as MASTER ONLY.

AxisLink virtual axes may be configured to provide either the actual or command position of the associated physical axis. Select the desired axis type for this virtual axis. If the associated physical axis is configured as `MASTER ONLY` on its resident motion controller, actual position is always provided, regardless of the selected axis type. If the virtual axis is AxisLinked to the imaginary axis in another motion controller, `COMMAND` axis type is automatically selected and the message

```
Axis on Controller #:  IMAGINARY
Axis Type is COMMAND
```

is displayed, since the imaginary axis does not have an actual position.

The direction of motion of virtual axes may also be defined to be the same as or opposite from the associated physical axis. In most cases, answer `SAME` to the `Relative Direction?` question so that the virtual axis directions are the same as the physical axis directions. If `OPPOSITE` is selected, motion of the physical axis in the positive direction results in virtual axis motion in the *negative* direction, and vice versa.

The Imaginary Axis

The imaginary axis can only generate command position and is automatically configured for command only operation. The following message

```
Select: IMAGINARY
Axis Type is COMMAND
```

is displayed when the imaginary axis is selected. Functionally, the imaginary axis is identical to a physical servo axis, except that it has no servo loop or physical connections. A conversion constant and unwind value (if the imaginary axis is configured as rotary) must be entered for the imaginary axis in the machine setup menu, and values for its maximum velocity, acceleration, and deceleration in the servo setup menu.

Rotary Axes

All configured axes may be defined as either linear or rotary axes. To define an axis as linear (the usual case), answer `NO` to the `Rotary Axis?` question. To define an axis as rotary, answer `YES`.

Rotary axes use a feature called electronic unwind to provide infinite position range by electronically "unwinding" the axis position whenever the axis moves through a complete physical revolution. Rotary axes request an unwind value in the machine setup menu.

Position Units

The IMC-S/23x allows user-defined engineering units rather than feedback counts to be used for measuring and programming all motion-related values (position, velocity, etc.). These position units can be different for each axis and should be chosen for maximum ease of use in your application. For example, linear axes might use position units of Inches, Meters, or mm while rotary axes might use units of Revs or Degrees.

The Position Units and Position Unit parameters are the ASCII text strings used in the machine and servo setup menus to request values for motion-related parameters. Enter the singular form of the unit as the Position Unit and the plural form for Position Units. A maximum of eight characters may be used to specify each string.

For example, to use units of inches for an axis, enter

```
Position Units = Inches
Position Unit = Inch
```

Display Fields

The runtime display as well as the machine and servo setup menus use fixed length fields to display and enter all motion-related values (position, velocity, etc.). Enter the desired total number of characters (not including the decimal point or sign) to be used for displaying position, velocity, and acceleration as the appropriate Field Length value. Specify the location of the decimal point (if necessary) for each type of parameter by entering the appropriate number of Decimal Digits (digits to the right of the decimal point). Up to 10 total digits may be used for the position display, 13 for the velocity display, and 15 for the acceleration display. MASTER ONLY axes do not request acceleration display values.

For example, on a linear SERVO axis with position units of Inches, specifying

```
Position Display Field Length = 6
 Number of Decimal Digits = 3
Velocity Display Field Length = 6
 Number of Decimal Digits = 3
Accel Display Field Length = 4
 Number of Decimal Digits = 0
```

provides a position display with three digits on either side of the decimal point, allowing values between ±999.999 inches to be displayed or entered in the machine and servo setup menus for this axis.

The Number of Decimal Digits must be greater than or equal to zero and less than or equal to Display Field Length.

Averaged Velocity Timebase

Specify the desired time in seconds to be used for calculating the displayed velocity of the axis. This value should be large enough to filter out the small changes in velocity which would otherwise result in an unstable and hard to read velocity display, but small enough to track significant changes in axis speed. Typically, a value between 0.25 and 0.5 seconds works well for most applications.

Move and Jog Profiles

The IMC-S/23x provides three types of motion profiles for moves and jogs on physical `SERVO` axes and the imaginary axis . These are the `TRAPEZOIDAL` (linear acceleration and deceleration), `S-CURVE` (controlled jerk), and `PARABOLIC`. Toggle to the desired selection and press **ENTER**.

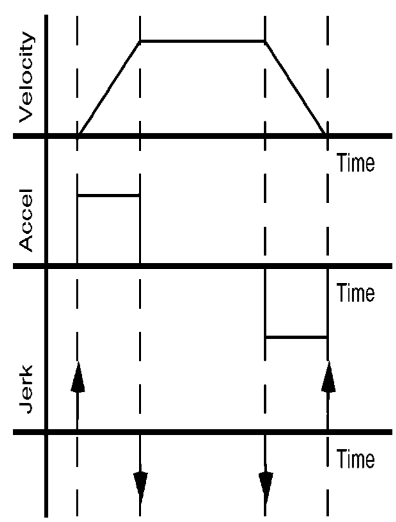
A guide to the effects of these three motion profiles on various application requirements is given below:

IMC-S/23x Velocity Profile Effects

Velocity Profile	*Acc/Dec Time*	*Motor Stress*	*Mechanical Stress*
Trapezoidal	Fastest	Worst	Worst
S-Curve	2X slower	Better	Best
Parabolic	2X slower	Best	Better

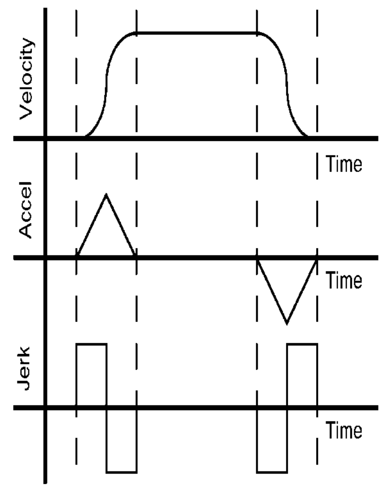
Trapezoidal

The trapezoidal velocity profile is the most commonly used profile since it provides the most flexibility in motion programming and the fastest acceleration and deceleration times.



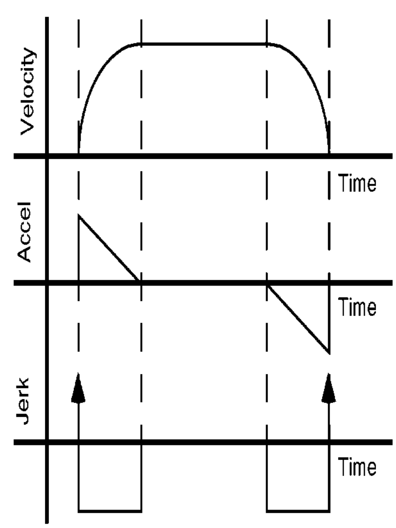
S Curve

S Curve velocity profiles are most often used when the stress on the mechanical system and load needs to be minimized. The S Curve profile, however, sacrifices acceleration and deceleration time compared to the Trapezoidal. In addition, the speed (velocity) of S Curve motion cannot be changed once the motion is started except to zero and the same acceleration and deceleration must be used.



Parabolic

A parabolic velocity profile is most often used to optimize the motor selection since it conforms most closely to the torque/speed curve for most motors. The parabolic profile, however, sacrifices acceleration and deceleration time compared to the trapezoidal profile. In addition, the speed (velocity) of parabolic motion cannot be changed once the motion is started except to zero and the same acceleration and deceleration rate must be used.



Backlash Compensation

The Backlash Compensation feature can be used on physical SERVO axes to compensate for the mechanical backlash found in many mechanical transmissions. In most applications, backlash compensation is not required, and thus should be disabled. Toggle to NO and press **ENTER** to disable backlash compensation.

UNIDIR APPROACH backlash compensation ensures that all moves–regardless of programmed motion direction–approach the final position from the *same* direction. The Approach Direction parameter determines from which direction the axis approaches the programmed destination position, while the Backlash Offset parameter determines the amount of "overshoot" necessary to take up the backlash when approaching from the opposite direction. Both of these parameters are entered in the machine setup menu under positioning configuration.

LOAD REVERSAL backlash compensation adds or subtracts a programmable offset to moves whenever the axis changes direction. The Backlash Offset parameter is entered in the machine setup menu under positioning configuration.

Editing the Axis Fault Action Configuration

After completing the axis setup parameters, the IMC-S/23x asks

```
Another Axis? NO
 Edit Axis Fault Action Configs? NO
```

Toggle to YES, press **ENTER**, and select the desired SERVO axis as explained above to configure the fault actions for each physical axis in your application. If the axis you have selected is not configured, the message

```
Select: AXIS #
***   This Axis is NOT CONFIGURED!
```

is displayed and you must select another axis. If the axis you have selected is configured as a MASTER ONLY axis, the message

```
Select: AXIS #
***   This Axis is MASTER ONLY!
```

is displayed and you must select another axis.

If you select the imaginary axis , the message

```
Select: IMAGINARY
***   This Axis is IMAGINARY ONLY!
```

is displayed and you must select another axis.

ATTENTION: Danger of axis runaway exists if `KILL DRIVE` is not selected as the fault action.

Each `SERVO` axis of the IMC-S/23x can be configured to respond to the various motion faults in different ways. If a fault action is set to `STOP MOTION`, then when the fault occurs, the axis immediately decelerates to a stop without disabling feedback or the drive enable output. A fault action of `STOP MOTION` is the gentlest reaction to a fault. It is usually used for less severe faults, since it is relatively easy to recover from a `STOP MOTION` fault action.

If `KILL DRIVE` is selected, when the fault occurs, axis feedback is immediately disabled, the servo amplifier output is zeroed, and the appropriate drive enable output is deactivated. `KILL DRIVE` is the most severe reaction to a fault and it is usually used for faults which could endanger the machine or the operator if power is not removed as quickly as possible.

If a fault action is set to `STATUS ONLY`, motion faults must be handled by the application program. In general, this setting should *only* be used in applications where neither the standard `STOP MOTION` nor `KILL DRIVE` actions are appropriate.

The recommended setting of the fault action configuration parameters–suitable for most applications–is shown below:

```
Hard Overtravel Action? KILL DRIVE
Soft Overtravel Action? STOP MOTION
Pos Error Fault Action? KILL DRIVE
Drive Fault Action? KILL DRIVE
Encoder Noise Fault Action? STATUS ONLY
Encoder Loss Fault Action? KILL DRIVE
```

Editing the Direct Command Mode Configuration

After completing the axis fault action configuration, the IMC-S/23x asks

```
Another Axis? NO
 Edit Direct Command Mode Config? NO
```

Toggle to `YES` and press **ENTER** to configure direct command mode for your application.

Direct Command Mode is a mode of operation where iCODE (the native language of the IMC-S/23x) commands can be sent directly to the IMC-S/23x via serial port A. It is used by the Online Manager in GML for communicating with the motion controller during application program development and debugging.

The recommended setting of the direct command mode configuration parameters for use with GML is shown below:

```
Linefeed Insertion? YES
Carriage Return Insertion? YES
Duplex? FULL
Multidrop? NO
```

TIP: If the direct command mode display is double-spaced, turn off Linefeed Insertion.

If you are using a dumb terminal or other terminal emulation software on a computer which automatically inserts Line Feed characters whenever a Carriage Return character is received, answer `NO` to the `Linefeed Insertion?` question to turn off the extra line feed normally generated by the IMC-S/23x. You can tell that your terminal is generating its own linefeeds if the direct command mode display is double spaced.

Normally, the IMC-S/23x appends a Carriage Return character to the response string generated by all commands sent to it in direct command mode which request data. If you are using direct command mode to communicate to a host computer, answer `NO` to the `Carriage Return Insertion?` question to turn off the sending of this Carriage Return character after all response strings.

Normally, the IMC-S/23x echoes all commands sent to it in direct command mode so that they are displayed on the screen. This is known as *full duplex* operation. If you are using direct command mode to communicate to a host computer or another IMC-S/23x in a multidrop configuration, answer `HALF` to the `Duplex?` question to set the IMC-S/23x direct command mode to half duplex and eliminate the extra echoed characters.

ATTENTION: It is not possible to use multidrop with RS-232 communications. See the Installation and Hookup section of this manual to configure serial port A for RS-422 operation if you are using multidrop.

Multidrop is a communications scheme which allows multiple IMC-S/23x controllers to communicate with a master controller or host computer over a single RS-422 serial link. Answer `NO` to the `Multidrop?` question for initial setup and commissioning of the IMC-S/23x. Also answer `NO` to the `Multidrop?` question if this IMC-S/23x is to be the master on the multidrop link.

If this IMC-S/23x is to be a slave on the multidrop link in your application, answer `YES` to the `Multidrop?` question to enable multidrop for serial port A only *after* you have completed setting it up. Use the recommended settings of the direct command mode configuration parameters for GML (shown earlier) with multidrop. After enabling multidrop, be sure to set the desired controller address using the front-panel selector switch.

Editing the Operator Interface Configuration

After completing the direct command mode configuration, the IMC-S/23x asks

```
Multidrop?
 Edit Operator Interface Config? NO
```

Toggle to `YES` and press **ENTER** to configure the operator interface for your application.

If you are *not* using DH-485 (see Configuring the IMC-S/23x in the Installation and Hookup section of this manual), the recommended setting of the operator interface configuration parameters for use with most serial devices is shown below:

```
Operator Interface Serial Port? B
Linefeed Insertion? YES
Carriage Return Insertion? YES
```

ATTENTION: Always configure the operator interface for serial port A if you are using DH-485 communications.

The operator interface can be configured to operate off either serial port. If you are using DH-485 or your application uses serial port B for another function (such as the master controller in multidrop), answer A to the `Operator Interface Serial Port?` question to place the operator interface on serial port A. Since direct command mode always appears on serial port A, if you configure the operator interface for use on serial port A also, use the ESC (Escape) key to toggle between these two modes.

► **TIP:** If the Operator Interface display is double-spaced, turn off Linefeed Insertion.

If you are using a dumb terminal or terminal emulation software on a computer which automatically inserts Line Feed characters whenever a Carriage Return character is received as an operator interface, answer `NO` to the `Linefeed Insertion?` question to turn off the extra line feed normally generated by the IMC-S/23x. You can tell that your terminal is generating its own linefeeds if the operator interface display is double spaced.

Do not answer `NO` to the `Carriage Return Insertion?` question otherwise erratic behavior of the operator interface may result.

The setup and application passwords may be changed from their default values by entering the desired three character string in response to the appropriate question. The passwords are not case-sensitive, so either upper or lower case characters may be used for the passwords. If you change the passwords, do not forget them or you will be prevented from re-entering the setup menus!

Editing the Runtime Display Configuration

After completing the operator interface configuration, the IMC-S/23x asks

```
  Setup Pasword?
 Edit Runtime Display Configuration? NO
```

Toggle to `YES` and press **ENTER** to configure the runtime display for your application.

If you are *not* using DH-485 (see Configuring the IMC-S/23x in the Installation and Hookup section of this manual), the recommended setting of the runtime display configuration parameters for use with most serial devices is shown below:

```
 Runtime Display? YES
  Runtime Display Serial Port? B
  Display Refresh Time (SEC) = 0.50
```

If your application does not use or require a runtime display while operating, answer `NO` to the `Runtime Display?` question.

ATTENTION: Always disable the runtime display if you are using DH-485 communications.

Like the operator interface, the runtime display can also be configured to operate off either serial port. If you are using DH-485 and select port B, the runtime display is automatically disabled and the message

```
Runtime Display Serial Port? B
 DH-485 Communications Uses Port B:
 Runtime Display Disabled!
```

is displayed. If your application uses serial port B for another function (such as the master controller in Multidrop), answer A to the `Runtime Display Serial Port?` question to place the runtime display on serial port A. Since direct command mode always uses serial port A, if you configure the runtime display for use on serial port A also, use the **ESC** (Escape) key to toggle between the two modes.

The runtime display (if enabled) is continuously updated as part of the Standard Operator Interface as well as during execution of the application program. The rate at which the display is updated is determined by the Display Refresh parameter. For most reasonably fast display devices, the recommended value of 0.5 seconds should be used.

If your display device cannot respond to updates every half second, the screen may become garbled or the data may noticeably lag behind reality. In this case, increase the display refresh time to allow time for the display to catch up. Due to the response time of the human eye, display refresh times less than 0.2 seconds are rarely effective and generally result in an unreadable display–especially with quickly changing values.

Editing the Serial Port Configuration

After completing the runtime display configuration, the IMC-S/23x asks

```
 Display Refresh Time (Sec) =
Edit Serial Port Configuration? NO
```

Toggle to YES and press **ENTER** to configure the serial ports for your application.

If you are *not* using DH-485, the recommended setting of the serial port configuration parameters for use with GML and most serial devices is shown below:

```
Channel A Baudrate? 9600
Channel B Baudrate? 9600
```

Either serial port may be set to any one of the following baud rates by toggling the appropriate parameter:

IMC S Class Serial Port Baud Rates

Baud Rate	*Recommended Use*
300	Minimum Baud Rate
1200	
2400	
4800	
9600	
19200	
38400	
57600	
115200	Maximum RS-232C Baud Rate
128000	RS-422 only

If you are using a device which cannot communicate at 9600 baud, set the baud rate for the appropriate serial port to a suitably lower value. If you are using DH-485, parameters for serial port B are not requested since DH-485 uses serial port B.

ATTENTION: For reliable communications, do not use baud rates higher than 9600 with RS-232C.

If you are using a serial device that can communicate faster than 9600 baud, the baud rate for the appropriate serial port may be set higher. It is recommended, however, not to use rates higher than 9600 with serial ports configured for RS-232 operation. See the Installation and Hookup section of this manual for more information on configuring the serial ports.

After entering a new baud rate, the IMC-S/23x displays

```
Channel # Baudrate? 1200
 Changing Baudrate...
```

and the new baud rate takes effect immediately! You must then also immediately change the baud rate of your terminal or host computer to be able to continue with the setup menus.

1. From GML, select **File** from the menu bar. the File menu appears.
2. Select **Preferences**. The Preferences dialog box appears.
3. In the Serial Interface area, select the new baud rate.
4. Select **Save**. The new rate is set.

Editing the RIO Configuration

For IMC-S/23x-R and IMC-S/23x-RL models only, after configuring the serial ports, the IMC-S/210 asksRemote I/O

```
Edit RIO Config? NO
```

Toggle to `YES` and press **ENTER** to configure the optional RIO Adapter for your application.

Next the IMC-S/23x asks

```
Edit RIO Config?  YES
 RIO?  NO
```

Toggle to `ADAPTER` and press **ENTER** if you plan to use the optional RIO Adapter in your application. If you do not need to use the RIO Adapter, toggle to `NO` and press **ENTER**.

RIO Adapter Channel

The IMC-S/23x can use either of the two channels (A or B) on the Remote I/O Adapter for RIO communications. Toggle to the channel to which you have connected the RIO cable and press **ENTER**. See Connecting the Remote I/O in the Installation and Hookup section of this manual for more information about RIO connections.

RIO Baud Rate

Remote I/O links with Allen-Bradley PLCs operate at one of three data rates (expressed in kilobits per second). These are 57.6KB, 115.2KB, and 230.4KB. Toggle to the rate which matches the RIO link to which you are connecting and press **ENTER**.

RIO Rack Size

The IMC-S/23x can be configured to occupy 1/4, 1/2, 3/4, or a full rack on the RIO link. Toggle to the desired rack size and press **ENTER**.

The Rack Size parameter–along with the Rack Address and Starting Group–determine where in I/O space the IMC-S/23x "appears" to the RIO scanner, as shown in the table below.

IMC-S/23x Remote I/O Adapter Addressing

Type of Transfer	*I/O Group*			
Block	0 2 4 6	0 2 4	0 2	0
Discrete	1 3 5 7	1 3 5	1 3	1
Discrete		2 4 6	2 4	2
Discrete		3 5 7	3 5	3
Discrete			4 6	4
Discrete			5 7	5
Discrete				6
Discrete				7
Starting Group	0 2 4 6	0 2 4	0 2	0
Rack Size	1/4	1/2	3/4	Full

The rack size also determines the number of user-defined discrete bits, as shown in the table below.

IMC-S/23x Remote I/O Adapter
Number of User-Defined Discrete I/O Bits

Rack Width	*Inputs*	*Outputs*
1/4	4	4
1/2	36	36
3/4	68	68
Full	100	100

In general, set the rack size to the smallest value which provides enough user-defined discrete I/O for your application.

RIO Rack Address

ATTENTION: Do not enter 0 for the rack address if you are using RIO to communicate with a PLC.

The Rack Address parameter–along with the Rack Size and Starting Group–determine where in I/O space the IMC-S/23x "appears" to the RIO scanner. Enter the desired rack address for the IMC-S/23x in your system and press **ENTER**. If your are communicating with a PLC using RIO, do not enter 0 for the rack address. Rack 0 is reserved for use by the PLC for local I/O.

RIO Starting Group

The Starting Group parameter–along with the Rack Size and Rack Address–determine where in I/O space the IMC-S/23x "appears" to the RIO scanner. Toggle to the desired starting group for your application and press **ENTER**. The selectable starting group values are determined by the previously selected rack width as shown in the table above to prevent the selection of illegal addresses.

Running the Application Program on Power-Up

After completing the serial port or RIO configuration, the IMC-S/23x asks

```
Run App Program on Power-up? No
```

Toggle to `YES` and press **ENTER** to configure the IMC-S/23x to automatically load its application program whenever power is applied to the unit.

While developing and de-bugging an application program, the usual setting of this parameter is `NO`. This causes the Standard Operator Interface to appear on the selected operator interface serial port (usually B) and/or direct command mode to appear on serial port A whenever power is applied. When the application program is completed and de-bugged, this parameter should normally be set to `YES` to cause automatic execution of the application program whenever power is applied.

Machine Setup Menu

The Machine Setup Menu allows values for machine-specific parameters for each axis to be entered and edited. A list of all the machine setup menu parameters is included at the end of this section for reference.

After completing the Application setup menu, the IMC-S/23x asks

```
 Run App Program on Power-up?
Machine Setup Menu? NO
```

Toggle to YES, press **ENTER**, and select the desired axis as explained earlier in this section to set up the axis parameters for your application.

If the axis you have selected is not enabled for your application in the application setup menu, the message

```
Select: AXIS #
 This Axis is NOT CONFIGURED!
```

is displayed and you must select another axis.

If enabled, each physical axis on the IMC-S/23x may be independently configured in the application setup menu to be either a full closed-loop SERVO axis or a MASTER ONLY axis (virtual axes are always MASTER ONLY). When an axis (physical or virtual) is configured as MASTER ONLY, the encoder input for that axis is used as a master for electronic gearing and cams. In this case, the IMC-S/23x displays

```
Select: AXIS
 Axis is Configured as MASTER ONLY
```

and questions relating to closed-loop operation are not asked in the machine setup menu.

If the axis you have selected is configured for full closed-loop SERVO operation in the application setup menu, the message

```
Select: AXIS #
 Axis is Configured as SERVO
```

is displayed and all questions are asked. If the imaginary axis is selected, the message

```
Select: IMAGINARY
 Axis is IMAGINARY
```

is displayed and only the conversion constant and unwind value (if the imaginary axis is configured as a rotary axis in the application setup menu) need be entered.

Editing the Feedback Configuration

After selecting the axis, the IMC-S/23x asks

```
Edit Feedback Configuration? NO
```

Toggle to YES and press **ENTER** to set up the conversion constant and feedback loss detection for this axis.

Conversion Constant (K)

To allow axis position to be displayed and motion to be programmed in the position units specified in the application setup menu, a *conversion constant* must be entered for each axis. The conversion constant (K) allows the IMC-S/23x to convert your position units into encoder (feedback) counts and vice versa. For physical and virtual axes, enter a value for K which is the number of encoder (feedback) counts per position unit (as specified in the application setup menu) using up to 15 digits, and press **ENTER**.

The IMC-S/23x uses 4X encoder decoding (both edges of channel A and B are counted). The count direction is determined from both the direction of the edge and the state of the opposite channel. Channel A leads channel B for increasing count. This is the most commonly used decode mode with incremental encoders, since it provides the highest resolution.

For example, suppose this axis utilizes a 1000 line encoder in a motor coupled directly to a 5 pitch lead screw (5 turns per inch). With position units of Inches, the conversion constant is calculated as shown below:

$$K = 1000\frac{\text{Lines}}{\text{Rev}} \times 4\frac{\text{Counts}}{\text{Line}} \times 5\frac{\text{Revs}}{\text{Inch}} = 20,000\ \frac{\text{Counts}}{\text{Inch}}$$

For the imaginary axis, the conversion constant is essentially arbitrary, but does affect the smoothness of gearing and position-lock cams which use the imaginary axis as their master. In general, a value between 4000 and 10,000 counts per position unit should provide adequate resolution.

Unwind

If the axis is configured as a rotary Axis in the application setup menu, a value for the Unwind constant is requested. This is the value used to perform electronic unwind of rotary axes. Electronic unwind allows infinite position range for rotary axes by subtracting the unwind value from both the actual and command position every time the axis makes a complete revolution. To avoid accumulated error due to roundoff with irrational conversion constants, the unwind value is requested in units of encoder or feedback counts per axis revolution. Enter the appropriate value using up to 9 digits and press **ENTER**.

For example, suppose this axis is configured as a rotary axis using position units of Degrees and 10 feedback counts per degree. It is desired to unwind the axis position after every revolution. In this case, the IMC-S/23x might display:

```
Unwind (Counts/Rev) = 4000.000000000
```

Enter 3600 since there are 3600 feedback counts ($10 \frac{\text{Counts}}{\text{Degree}} \times 360 \frac{\text{Degrees}}{\text{Rev}}$) per revolution of the axis and press **ENTER**.

► **TIP:** The unwind constant must be an integer. Because the number is in encoder counts, you cannot have a fraction of a count.

Unwind Reference Point

If the axis is configured as a rotary axis in the Application Setup menu, a value for the Unwind Reference Point is requested. This value is used when an unwind is performed on a rotary axis. The Unwind Reference Point is the position to which the axis rolls during an unwind. The position to which an axis rotates to before it unwinds to the Unwind Reference Point is equal to the Unwind Reference Point plus the Unwind. The total distance traveled before the axis unwinds remains constant and is not affected by the Unwind Reference Point.

For example, if the Unwind is 4 position units and the Unwind Reference Point is -1 position units, the axis rotates up to 3 position units and unwinds back to -1 position units.

The Unwind Reference value is entered in position units and can be a positive or negative number up to 9 digits.

```
Unwind Reference Point
(Position Units) = +0
```

Enter the Unwind Reference Point and press **ENTER**.

Encoder Loss Detection

Each physical axis of the IMC-S/23x can be configured to detect loss of the encoder feedback signal. The IMC-S/23x asks:

```
Use Encoder Loss Detection? NO
```

Toggle to `YES` and press **ENTER** to use encoder loss detection for this axis. If encoder loss detection is enabled, an encoder loss fault occurs under either of the following conditions:

5. Both of the differential signals for any encoder channel (A+ and A-, B+ and B-, or Z+ and Z-) are at the same level (both high or both low). Under normal operation, the differential signals are always at *opposite* levels. The most common cause of this situation is a broken wire between the encoder and the motion controller.
6. Loss of encoder power or encoder common to the motion controller or the encoder.

If encoder loss detection is not desired for this axis, toggle to `NO` and press **ENTER** to disable encoder loss detection.

Editing the Overtravel Configuration

For physical `SERVO` axes, after editing the conversion constant, the IMC-S/23x asks

```
Edit Overtravel Configuration? NO
```

Toggle to `YES` and press **ENTER** to set up the overtravel configuration for this axis.

ATTENTION: Even though the IMC-S/23x provides overtravel protection while it is operating, for utmost safety, the overtravel limit switches and/or the CPU watchdog contacts should also be hardwired into the drive amplifiers so that drive power is interrupted if a fault occurs.

The IMC-S/23x can be configured to perform both overtravel limit switch checking and software travel limit checking to prevent a physical axis from traveling outside pre-defined limits and possibly causing damage. If overtravel limit switches are used, they may be specified as having either `NORMALLY OPEN` or `NORMALLY CLOSED` contacts. Toggle to the contact type which matches your switches and press **ENTER**.

ATTENTION: Hardware overtravel switches should be wired normally closed to provide failsafe operation.

Overtravel Limit Switches

If overtravel limit switches are used, they are active whenever the IMC-S/23x is operating. Activating either the positive or negative overtravel limit switch at any time causes a hardware overtravel fault on the axis (`HRD LIM` displayed in the status field of the Standard Operator Interface) and causes the fault action specified by the hard overtravel action parameter in the application setup menu to occur.

Software Travel Limits

The IMC-S/23x also provides programmable software travel limits. Exceeding these position limits results in a software overtravel fault (`SFT LIM` displayed in the status field of the Standard Operator Interface).

► **TIP:** Use both overtravel limit switches and software travel limits for utmost protection.

If software travel limits are used, enter appropriate values for the maximum travel in both the positive and negative directions. Both of these values are entered in the position units of the axis. If you enter a maximum positive travel value less than the maximum negative travel, the IMC-S/23x displays

```
Max Neg Travel (Position Units) =
***   Neg Limit Must Be < Pos Limit!
```

since the maximum negative travel must always be *less than* the maximum positive travel.

The software travel limits–unlike the overtravel limit switches–are not enabled until the selected homing sequence is completed.

Editing the Homing Configuration

A total of six different types of homing are available in the IMC-S/23x to enable each physical or virtual axis to find a known absolute position at power-up. After editing the overtravel configuration, the IMC-S/23x asks

```
Edit Homing Configuration? NO
```

Toggle to `YES` and press **ENTER** to set up the homing configuration for this axis.

Home Position

The Home Position is the desired absolute position for the axis after the homing sequence has been completed. In most cases, enter a home position of zero, although any value (within the software travel limits discussed earlier in this section) may also be used. If you enter a home position value outside the travel limits entered above, the IMC-S/23x displays

```
Home Position (Position Units) =
***   Home Position Outside Travel Limits!
```

since the home position must always be *between* the travel limits when software travel limits are used. When the homing sequence has completed, the axes will be at their specified home positions.

For physical axes, the IMC-S/23x next asks

```
Homing Procedure? ACTIVE
```

Toggle to the desired type of homing procedure and press **ENTER**. The three available active homing procedures are described below. For AxisLink virtual axes, passive homing is selected automatically and the following message

```
Select: VIRTUAL AXIS 0
Homing for Virtual Axis is PASSIVE !
```

is displayed. The imaginary axis cannot be homed.

Active Homing

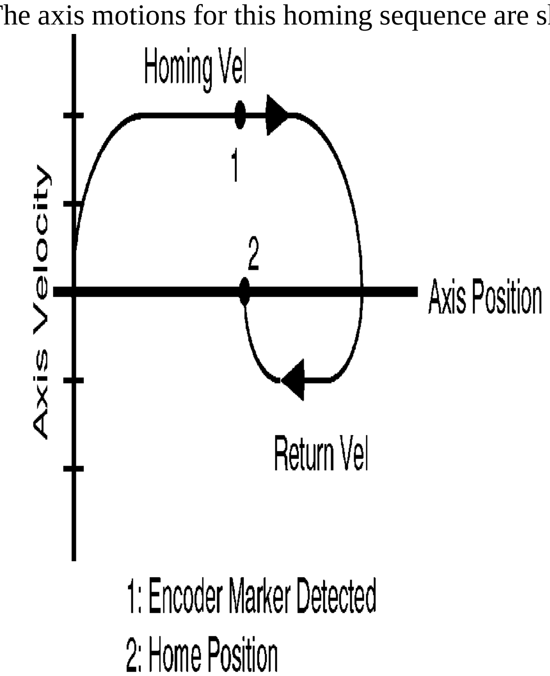
Active homing is the most common homing procedure for physical SERVO axes. When ACTIVE is chosen as the homing procedure, the desired homing sequence is selected by specifying whether or not a home limit switch and/or the encoder marker is used for this axis. Active homing sequences always use the trapezoidal velocity profile. The available active homing sequences are described below.

Homing Without a Limit Switch or Marker

This is the simplest active homing sequence. When this sequence is performed, the IMC-S/23x immediately assigns the home position to the current axis position. This homing sequence produces no axis motion.

Homing to an Encoder Marker

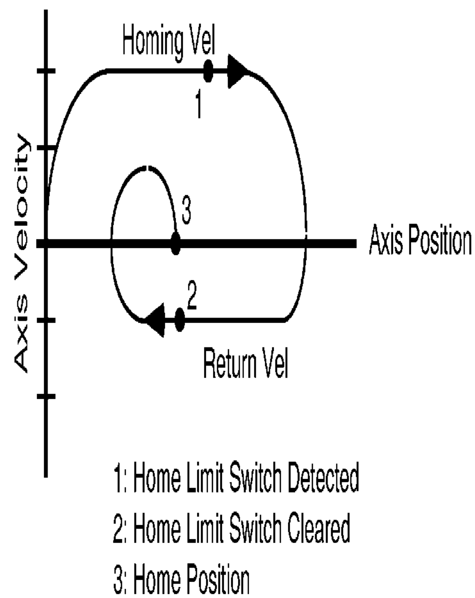
This active homing sequence is useful for single turn rotary and linear encoder applications since these have only one encoder marker for full axis travel. When this sequence is performed, the axis moves in the specified home direction at the specified homing velocity until the marker is detected. The home position is assigned to the axis position corresponding to the marker location, and the axis decelerates to a stop. The axis then moves back to the home position at the specified return velocity. The axis motions for this homing sequence are shown below.



Homing to a Limit Switch

This active homing sequence is useful for multi-turn rotary and linear applications where there are multiple encoder markers over full axis travel or when an encoder marker is not available.

When this sequence is performed, the axis moves in the specified home direction at the specified homing velocity until the home limit switch is detected. The axis decelerates to a stop and then moves in the opposite direction at the specified return velocity until the home limit switch is cleared. The home position is assigned to the axis position at the moment the limit switch is cleared, and the axis decelerates to a stop. The axis then moves back to the home position at the return velocity. The motions for this active homing sequence are shown below.



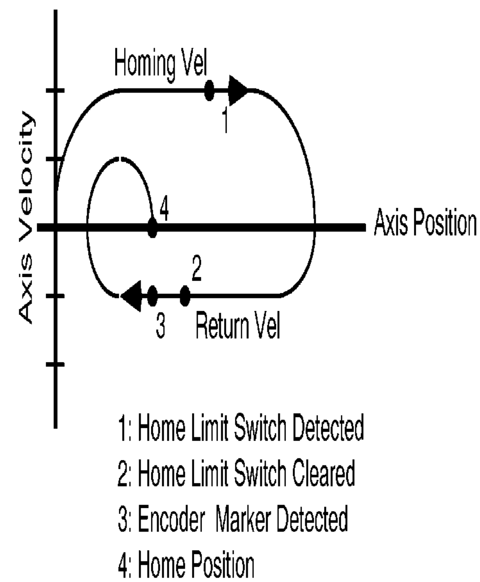
Neglecting the mechanical uncertainty of the home limit switch, the accuracy of this homing sequence depends on the time uncertainty in detecting the home limit switch transitions. The position uncertainty of the home position is the product of the maximum time for the control to detect the home limit switch (8 milliseconds) and the specified return velocity.

For example, if a return velocity of 0.1 inches per second (6 IPM) is specified, the uncertainty of the home position is calculated as shown below:

$$0.1\frac{\text{Inch}}{\text{Second}} \times 0.008\text{ Seconds} = 0.0008\text{Inch}$$

Homing to a Limit Switch and Marker

This is the most precise active homing sequence available. When this sequence is performed, the axis moves in the specified home direction at the specified homing velocity until the home limit switch is detected. The axis then decelerates to a stop and moves in the opposite direction at the specified return velocity until the home limit switch is cleared. After clearing the home limit switch, the axis continues in the same direction at the return velocity until the first encoder marker is detected. The home position is assigned to the axis position at the moment the marker is detected, and the axis then decelerates to a stop. The axis then moves back to the home position at the return velocity. Axis motions for this homing sequence are shown below.



Limit Switch Contacts

In home sequences that utilize a home limit switch, the limit switch contact configuration can be specified as being `NORMAL OPEN` or `NORMAL CLOSED`. Toggle to the contact type that matches your switch and press **ENTER**.

```
Home Direction:  Positive
```

1. Toggle to the desired homing direction (negative or positive)
2. Select Enter.

```
Home Direction: Positive
Homing VEL (user units/sec) = xxx
```

Homing velocity sets the speed in user units/second. Refer to *Homing to a Limit Switch and a Marker* for more information.

```
Homing VEL (user units/sec) = xxx
Return VEL (user units/sec) = xx
```

Return velocity sets the speed in user units/second. Refer to *Homing to a Limit Switch and a Marker* for more information.

Absolute Homing

If you are interfacing with the IMC-S/23x through an absolute transducer and are using a single resolver, parallel encoder or a magnetorestrictive transducer as an absolute feedback device:

1. Select ABSOLUTE as the homing procedure. The following message appears:

```
Select: converter card?
(converter card name)
```

ATTENTION: Be sure to purchase the appropriate converter card for your absolute transduce device.

2. Toggle through the list to select the absolute transducer and press **ENTER**.

Absolute Transducer Type	Converter Card Name
Parallel Encoder	AEC
Single Resolver Package (12 Bits of Resolution)	REC
*Single Resolver Package (10 Bits of Resolution)	REC-4096 10 Bits
*Single Resolver Package (12 Bits of Resolution)	REC-4096 12 Bits
*Single Resolver Package (14 Bits of Resolution)	REC-4096 14 Bits
*Single Resolver Package (16 Bits of Resolution)	REC-4096 16 Bits
Magnetostrictive	TEC

Note: Use the absolute homing procedure only on axes configured for absolute feedback.

You can use the REC-4096 with Allen-Bradley dual resolver packages under an ABSOLUTE homing procedure. You need to home each of the two resolvers in the package separately using two axis inputs from the IMC-S/23x. The application program must calculate the absolute position of the transducer based on the two positions.

If ABSOLUTE is selected when you execute a homing command, the controller will request the absolute position of the feedback transducer to initialize the axis position.

Note: There is a two-second delay (approximately) with absolute homing to allow the absolute transducer converter to read the absolute position.

In operation, the absolute homing procedure:

A. Disables feedback

B. Activates the absolute position strobe output to read the current absolute position of the axis from the absolute transducer converter

C. Sets the actual position of the axis to the current absolute position of the feedback device plus the home position

D. Re-enables feedback

Using absolute homing, the home position parameter acts as an *offset* to the absolute position read from the absolute transducer converter. For example, assume that an axis is using a resolver for feedback with position units of degrees, the current absolute position of the resolver is 146.0°, and the Home Position parameter is 34.0°. In this case, absolute homing sets the current actual position of the axis to 146.0 + 34.0 = 180°.

Absolute_MV

Absolute_MV is an absolute homing procedure. You can only use the Absolute_MV homing procedure when you are using both of the following:

- Allen-Bradley Bulletin 1326 dual resolver packages (operating in master/vernier fashion)
- REC transducer card (not REC-4096)

The IMC-S/23x uses these two products to determine the transducer's absolute position by way of a single home command. During homing, the two resolver positions are multiplexed into the IMC-S/23x through a single feedback input. The IMC-S/23x performs calculations to derive the absolute position. To use Absolute_MV:

1. Select Absolute_MV and press **ENTER**. The following message appears:

```
1326AB-MOD-VD: Package number?
(256/255 or CUSTOM)
```

2.

If you Select:	This happens:
256/255 and press **ENTER**.	The 1326-MOD-VD: catalog number is appended to include the full Allen-Bradley 256 turn dual resolver package part number. When 256/255 is selected, an internal variable called Turns Range inside the IMC-S/23x is set to 256.
CUSTOM and press **ENTER**.	The IMC-S/23x selects the following: `Custom turns range = (turns range)` 1. Enter a value between 1 and 256 for the Turns Range of the master vernier device. The custom option is solely intended for future supported dual resolver packages. 2. Press **ENTER**.

Absolute_Serial

Absolute_Serial is a specific absolute homing procedure. You can only select Absolute_Serial when you use both of the following:

- Serial output absolute encoders.
- Allen-Bradley AEC converter card

With this system configuration, the IMC S Class determines the transducer's absolute position using a single home command.

Passive Homing

Passive homing re-defines the current absolute position of the axis on the next occurrence of the encoder marker. Passive homing is most commonly used to calibrate `MASTER ONLY` axes to their markers, although it can be used on `SERVO` axes as well. Passive homing is identical to active homing to an encoder marker as described above except that no motion is commanded–the IMC-S/23x just *waits* for the marker to occur.

If you are setting up a physical axis configured as `MASTER ONLY` in the application setup menu, select `PASSIVE` as the homing procedure. If you are setting up an AxisLink virtual axis, passive homing is selected automatically and the following message appears:

```
Select: VIRTUAL AXIS 0
Homing for Virtual Axis is PASSIVE !
```

Editing the Servo Configuration

Each physical axis of the IMC-S/23x can be configured to interface with standard servo amplifiers operating in either the velocity (tach) or torque (current) modes. Next, the following message appears on the IMC-S/23x:

```
Edit Servo Configuration? NO
```

1. To set up the servo configuration for this axis, toggle to `YES` and press **ENTER**.

2. Select the servo drive type that matches the type of servo system you are using. If a `VELOCITY LOOP` servo drive type is specified, the software velocity loop (see Technical Overview earlier in this manual) is disabled.

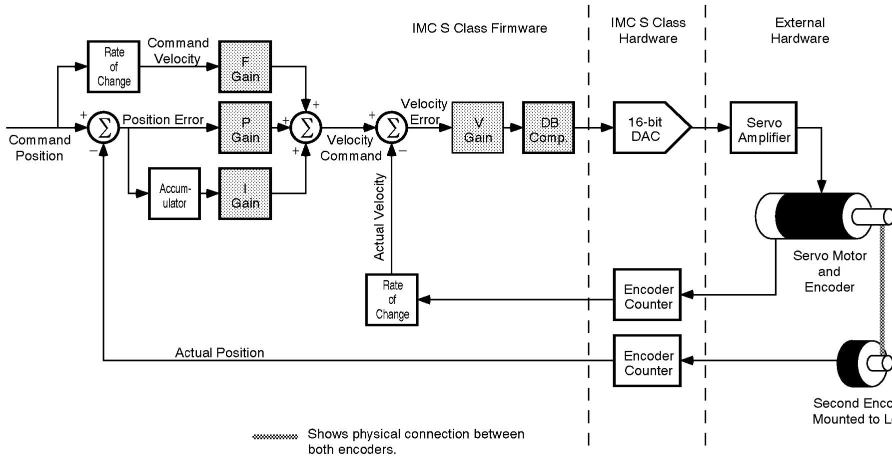
Dual Loop Control

Dual Loop Control is a special mode of operation–available only if you have selected `TORQUE LOOP` as the servo drive type–which uses a separate feedback device to close the digital velocity loop. It is sometimes useful in applications where accurate positioning must be achieved despite severe mechanical non-linearities (backlash, slip, gear ratio variations, etc.) between the motor and the load.

Dual loop control requires two encoders (or other feedback devices) for each axis, one coupled to the motor and the other to the load. The encoder on the motor is used to close the velocity loop since tight coupling is essential for maximum gain and performance of the velocity loop. The encoder on the load is used to close the position loop, putting the mechanical non-linearities of the system inside the position loop, which provides better positioning accuracy.

Note: The second encoder used for closing the position loop is wired into another axis. Using dual loop actually consumes two physical axes on the IMC S/23x.

The usual answer to the `Dual Loop Control?` question is `NO`, which disables the special dual loop mode. To enable dual loop control for this axis, toggle to `YES`, and press **ENTER**. The servo control loop with dual loop control enabled is shown below.



ATTENTION: There must always be a physical connection between the two feedback devices used with a dual loop controlled axis or unpredictable motion may occur!

Once dual loop control is enabled for an axis (the dual loop axis), a corresponding dual loop velocity axis must be selected. The encoder input of the selected dual loop velocity axis is then used to close the software velocity loop as shown in the figure above. Toggle to the desired axis and press **ENTER**.

The axis selected as the dual loop velocity axis must not be the same as the dual loop axis (the axis you are setting up) and must also be a physical axis configured as `MASTER ONLY` in the application setup menu. If you select an axis which is not configured, the message

```
***   This Axis is NOT CONFIGURED!
```

is displayed and you must select another axis.

If you select the axis you are setting up or another SERVO axis, the message

```
***   This Axis is a SERVO AXIS!
```

is displayed and you must select another axis. If you select an AxisLink virtual axis , the message

```
***   This Axis is a VIRTUAL AXIS!
```

is displayed and you must select another axis.

Both the hookup diagnostics and the self tuning procedures work properly for dual loop axes. It is important, however, that *both* encoders be functioning properly before attempting to close the servo loop.

There must always be a physical connection between the dual loop axis (position loop) encoder and the dual loop velocity axis encoder or it will not be possible to move the axis correctly. Since the dual loop axis (position loop) encoder is not normally connected directly to the motor, this has implications when, for instance, this encoder is driven by the material fed by a feeder: when there is no longer material driving the position encoder, the axis will "run away" at a controlled speed until the position error tolerance is exceeded since it has no position feedback!

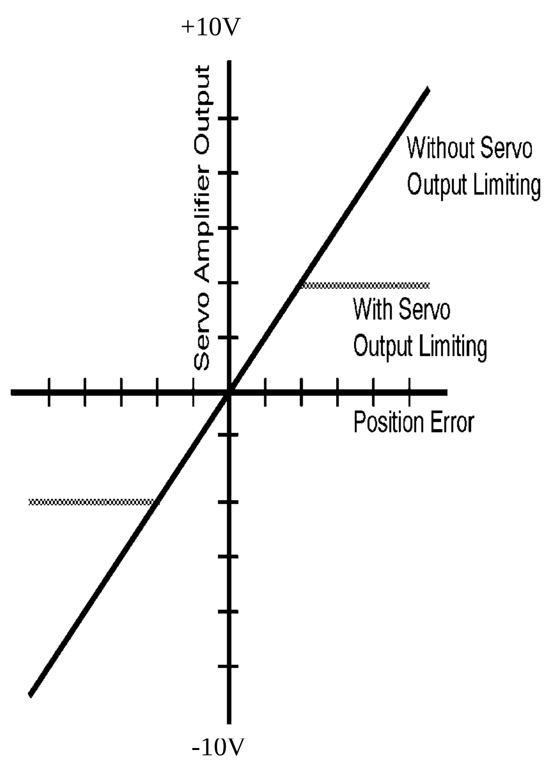
ATTENTION: When disabling dual loop control on an axis, be sure to run the hookup diagnostics and the servo setup routines again to ensure proper operation.

To disable dual loop control for an axis, answer `NO` to the `Dual Loop Control?` question. You may also need to rewire the encoders since the encoder mounted directly to the motor (the dual loop velocity axis) will most likely be the one used for position feedback when dual loop control is no longer required. In this case, be sure to run the hookup diagnostics for this axis again to ensure proper feedback polarity and then run the servo setup routines to establish proper gain values for the axis after re-wiring the encoders.

Servo Output Limiting

Servo Output Limiting allows limiting the maximum servo output voltage (if configured for voltage output) or current (if configured for current output) of a physical axis to a specified level. See Configuring the IMC-S/23x in the Installation and Hookup section of this manual for information on setting the servo output format for each axis.

The servo output as a function of loop error both with and without servo output limiting is shown below.



The servo output limit may be used as a software current or torque limit if you are using a servo amplifier in torque (current) mode. The percentage of the amplifier's maximum current that the IMC-S/23x will ever command is equal to the specified servo output limit. For example, if your amplifier is capable of 30 Amps of current for a 10 Volt input, setting the servo output limit to 5V limits the maximum amplifier current to 15 Amps.

The servo output limit may also be used if your servo amplifier cannot accept the full ±10 Volt or ±150 mA range of the servo output. In this case, the servo output limit value effectively limits the maximum command sent to the amplifier. For example, if your servo amplifier can only accept command signals up to ±7.5 Volts, set the servo output limit value to 7.5 volts.

While the servo output limit is specified in volts (assuming use of voltage format servo output), it functions equally well with current format servo output. If this axis is configured for current format servo output, the actual servo output limit can be calculated as shown below.

$$\text{Actual Servo Output Limit (mA)} = \text{Servo Output} \quad \frac{150\text{Ma}}{10\text{Volts}}$$

For example, if the servo output limit is specified as 8.2 volts but the axis is configured for current format servo output, the actual servo output limit is 123 mA, as shown below.

$$\text{Actual Servo Output Limit (mA)} = 8.2\text{V x} \frac{150\text{Ma}}{10\text{Volts}} = 123\text{ mA}$$

Drive Fault Input

The IMC-S/23x provides a dedicated drive fault input for each physical axis. These inputs may be connected to fault outputs on the servo amplifiers (if provided) to notify the IMC-S/23x of a fault in the amplifier itself.

If you are using the drive fault input, the "contact configuration" of the amplifier's drive fault output must be specified. Select `NORMAL OPEN` drive fault contacts if your amplifier *activates* the drive fault input when a fault occurs. Select `NORMAL CLOSED` drive fault contacts if your amplifier *deactivates* the drive fault input when a fault occurs.

Editing the Positioning Configuration

After editing the servo configuration, the IMC-S/23x asks

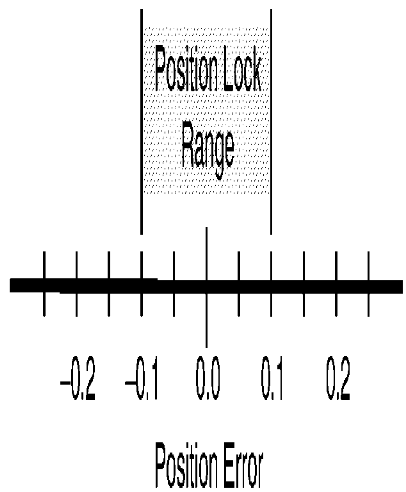
```
Edit Positioning Configuration? NO
```

Toggle to `YES` and press **ENTER** to set up the positioning configuration for this axis.

Position Lock Tolerance

The Position Lock Tolerance value specifies how much position error the IMC-S/23x tolerates when giving an axis locked indication (`LOCKED` displayed in the status field of the Standard Operator Interface). As such, it is one of the factors which determines positioning accuracy. Enter a value in position units for this axis equal to the desired positioning accuracy of the axis and press **ENTER**.

Note that the position lock tolerance value is interpreted as a ± quantity. For example, if your position units are Inches, specifying a position lock tolerance of 0.01 provides a minimum positioning accuracy of ±0.01 inches as shown below.



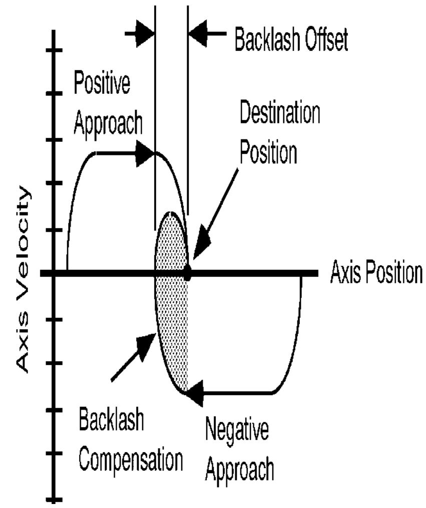
Backlash Offset

When either `UNIDIR APPROACH` or `LOAD REVERSAL` backlash compensation is selected in the application setup menu, a value for the backlash offset must be entered. Enter a value equal to the desired distance in axis position units that the axis should overshoot when approaching the destination position from the opposite direction (`UNIDIR APPROACH`) or add/subtract from the axis' absolute position whenever the axis changes direction (`LOAD REVERSAL`).

Approach Direction

When `UNIDIR APPROACH` backlash compensation is selected in the Application setup menu, a value for the approach direction must be selected. Toggle to the desired direction (`POSITIVE` or `NEGATIVE`) from which all moves will approach the destination position.

For example, if the approach direction is `POSITIVE`, the axis approaches the destination position from the *positive* direction. In other words, moves approaching the destination position in the positive direction operate normally. Moves approaching the destination position from the *negative* direction "overshoot" the destination position by an amount equal to the backlash offset, and then move back to the destination position in the positive direction as shown below.



Hookup Diagnostics Menu

The IMC-S/23x provides a complete set of diagnostic routines to determine and verify correct hookup of feedback transducers, servo amplifiers, limit switches, and discrete I/O devices. Before running any of these diagnostics, however, the appropriate external components should be connected to the control as explained in the Installation and Hookup section of this manual.

After completing the positioning configuration, the IMC-S/23x asks

```
Another Axis? NO
Hookup Diagnostic Menu? NO
```

Toggle to `YES`, press **ENTER**, and select the desired physical axis on which to run the hookup diagnostics. If the axis you have selected is not configured, the message

```
Select: AXIS #
***   This Axis is NOT CONFIGURED!
```

is displayed and you must select another axis.

If the axis you have selected is a virtual axis, the message

```
Select: VIRTUAL AXIS #
You must test on the Physical Axis!
```

is displayed and you must select another axis. Virtual axes cannot be tested using the hookup diagnostics–check the associated physical axis at the appropriate motion controller.

If you select the imaginary axis, the message

```
Select: IMAGINARY
No Diagnostics for IMAGINARY AXIS!
```

is displayed and you must select another axis. Since the imaginary axis has no physical connections, the hookup diagnostics are not available for it.

Checking Motors and Encoders

The Motor/Encoder Test is used with physical `SERVO` axes to check for proper electrical connection of the servo drive and encoder or other feedback device and also to establish the correct rotational direction of the servo drive and encoder. Establishing these motor and encoder polarities ensures that the axis will not run away when the feedback loop is closed.

ATTENTION: Press **ESC** (Escape) to immediately abort the motor/encoder test.

Enter a value for the test increment in the position units of this axis. The test increment is the maximum distance that the axis will move during the motor/encoder test assuming that the encoder is functioning properly. Usually, this value can be quite small, but it must be large enough so that the motor and encoder produce some measurable motion.

First, for velocity loop servo amplifiers, any offset in the amplifier is compensated. The message

```
Test Increment (Position Units) =
Compensating for Drive Offset...
```

is displayed while the IMC-S/23x attempts to make the motor stand still. For torque loop servo amplifiers, both the offset and the deadband are compensated and the message

```
Test Increment (Position Units) =
Compensating for Offset & Deadband...
```

is displayed. If the offset or deadband cannot be compensated, the message

```
***   Motor Does NOT Respond!
***   Check Motor Hookup and Retest
```

is displayed. Check the connections between the IMC-S/23x and the servo amplifier and between the servo amplifier and the motor and make sure that the drive system is working properly. Then re-run the motor/encoder test.

After the offset (and deadband for current loop servo amplifiers) has been successfully compensated, the message

```
Offset Compensation Complete...
Press Any Key and Watch for Motion
```

is displayed. After pressing any key, the motor/encoder test slowly ramps up the servo output voltage until the axis has moved a distance equal to the test increment. The IMC-S/23x then determines the direction of axis motion and the message

```
Press Any Key and Watch for Motion
Observed Motion Direction? POSITIVE
```

is displayed. Toggle to the appropriate motion direction (`POSITIVE` or `NEGATIVE`) depending on whether the observed motion direction was in the desired positive or negative direction for your application.

ATTENTION: Press **ESC** (Escape) to immediately abort the motor/encoder test.

If the maximum servo output is reached before the axis has moved a distance equal to the test increment, the message

```
***   No Motion Detected!
Run Encoder Test? YES
```

is displayed. If this occurs, run the encoder test to check the encoder separately from the drive. See Testing Encoders below for information on the encoder test.

ATTENTION: Turn off all power before disconnecting or re-connecting cables.

Once proper encoder operation of the drive, motor, and encoder or other feedback transducer has been verified, the message

```
Hookup OK
Motor/Encoder Polarity Set
```

is displayed, indicating satisfactory completion of the motor/encoder test.

Testing Encoders

The encoder test is used with physical `MASTER ONLY` axes or `SERVO` axes which fail the motor/encoder test to check for proper electrical connection of an encoder or other feedback device and also to define the relationship between the mechanical and electrical rotation direction of the encoder.

The encoder test asks that you manually move the encoder in whichever direction is positive for your application and then press a key. If at least 16 valid encoder counts are received, the encoder counters are setup such that motion in this direction always produces an increasing encoder count.

If you run the encoder test and no motion is detected, the message

```
***   No Motion Detected!
***   Check Encoder Hookup and Retest
```

is displayed. If this happens, check that the encoder is connected to the IMC-S/23x properly (see the Installation and Hookup section of this manual), has power of the proper voltage, and that both channels A and B are generating signals. This check is most easily done with an oscilloscope. Be sure to turn off the IMC-S/23x and the appropriate axis amplifier before changing any connections. After fixing the problem, re-run the encoder test.

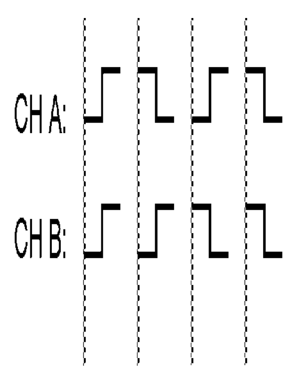
ATTENTION: Turn off all power before disconnecting or re-connecting cables.

If encoder noise (a simultaneous transition on both encoder channels) is detected during the encoder test, the message

```
***   Encoder Noise Detected!
***   Check Encoder Hookup and Retest
```

is displayed.

Encoder noise (shown below) is most often caused by loss of quadrature in the encoder itself or radiated noise signals being picked up by the encoder wiring, both of which may be able to be seen on an oscilloscope.



Loss of quadrature can be caused by physical mis-alignment of the encoder components, or excessive capacitance (or other delays) on the encoder signals. Radiated noise problems can usually be cured by proper grounding and shielding techniques. See the Installation and Hookup section of this manual for cabling recommendations. After fixing the problem, re-run the encoder or motor/encoder test.

If the encoder loss detection circuitry noise is activated during the encoder test, the message

```
***   Encoder Loss Detected!
***   Check Encoder Hookup and Retest
```

is displayed. An encoder loss condition indicates that one of the following occurred:

1. Both of the differential signals for any encoder channel (A+ and A-, B+ and B-, or Z+ and Z-) are at the same level (both high or both low). Under normal operation, the differential signals are always at *opposite* levels. The most common cause of this situation is a broken wire between the encoder and the motion controller.
2. Loss of encoder power or encoder common to the motion controller or the encoder.

Correct the problem with the encoder wiring and re-run the encoder test.

Once proper operation of the encoder or other feedback transducer has been verified, the message

```
Hookup OK
Motor/Encoder Polarity Set
```

is displayed, indicating satisfactory completion of the encoder test.

If you are running the encoder test because this axis failed the motor/encoder test, when proper operation of encoder or other feedback transducer has been verified, the message

```
***   Encoder Hookup OK!
***   Check Motor Hookup and Retest
```

is displayed, indicating that the encoder or other feedback transducer is operating properly and that the problem is in the servo amplifier.

Editing the Motor/Encoder Polarity

After completing the motor/encoder test, the IMC-S/23x asks

```
 Motor/Encoder Polarity Set
Edit Motor/Encoder Polarity? NO
```

It is recommended that you *do not* edit the motor/encoder polarity since changing either of these parameters after successfully completing the motor/encoder test will cause axis runaway when the feedback loop is later applied around the axis. Press **ENTER** to confirm that you do not wish to edit the motor/encoder polarity.

If you must review or set the motor/encoder polarities manually, toggle to YES and press **ENTER**. The IMC-S/23x displays the following warning:

```
Edit Motor/Encoder Polarities? YES
***   Changing Polarities Can Cause RUNAWAY!
```

You may then review or edit the encoder and servo output polarities.

ATTENTION:
Changing the motor/encoder polarities can cause axis runaway!

Tuning Velocity Loop Servo Drives

When a SERVO axis is configured for VELOCITY LOOP operation, an extra set of tests is available to allow you to easily set up the drive. The IMC-S/23x asksServo Amplifiers

```
Tune Drive Offset, Speed, Response? NO
```

Toggle to YES and press **ENTER** test and set up a velocity loop servo amplifier. While these tests are most often used when the IMC-S/23x servo output is set for voltage, they may also be used when it is set for current. In this case, servo output "volts" must be converted to mA by multiplying by 15. Thus 0.5 "volts" is equivalent to 7.5 mA, 5 volts is equivalent to 75 mA, etc.

Adjusting Offset

To adjust the offset in the servo amplifier, the IMC-S/23x displays the current offset compensation voltage (determined during the motor/encoder test) necessary to make the motor stand still. Next, the servo output voltage is set to zero volts and the message

```
Drive Offset is ______
Adjust Drive Offset Pot
Press Any Key to Continue
```

is displayed. Adjust the Offset or Balance pot on the servo amplifier until the motor is not moving. This adjustment is not critical–a new servo offset compensation value is calculated again at the conclusion of the tuning procedure–but should be used only to get the drift near zero. After adjusting the offset, press any key to continue.

Digital Battery Box

To help in adjusting the response and gain pots on most velocity loop servo amplifiers, the IMC-S/23x provides a digital (programmable) battery box which allows you to send test signals directly to the servo amplifier. Connect an oscilloscope to the tach (or velocity output) of the motor to display the resulting velocity profiles and evaluate the adjustments. Refer to the manual for your servo amplifier for specific recommendations for setting the pots on your amplifier.

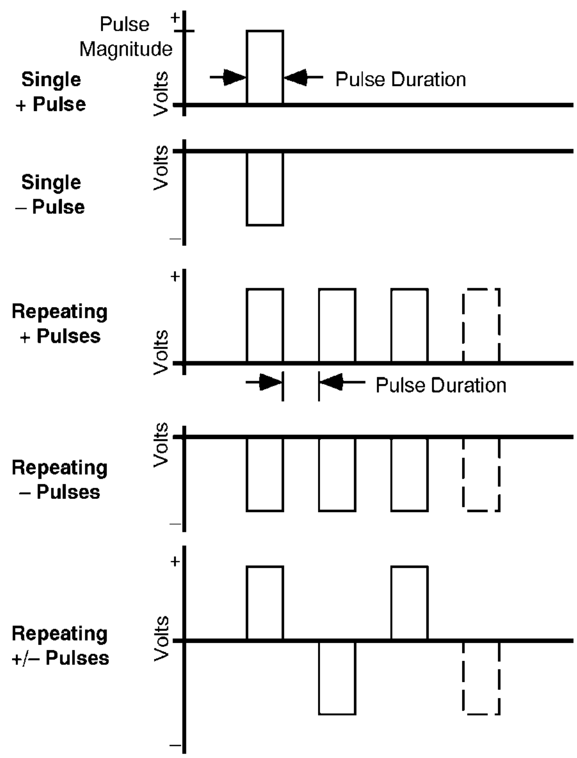
The IMC-S/23x asks

```
Press Any Key to Continue
Run Digital Battery Box? NO
```

Toggle to `YES` and press **ENTER** test and use the digital battery box to set up your servo system.

ATTENTION: Press **ESC** (Escape) to immediately abort the digital battery box.

Enter the desired Magnitude in Volts, Duration in Seconds, and Type for the test pulse. A single pulse of either polarity or a repeating string of pulses of either polarity or of alternating polarity may be selected. The pulse magnitude should always be a positive number–select the direction via pulse type. The five types are shown below.



A small magnitude (1 - 2 volt) pulse is recommended for evaluating the small-signal response of the system and setting the Gain or Response pots, while a large value (5 - 10 volts) works best for adjusting the speed scaling of the drive. Note that for the repeating pulse types, the delay between pulses is equal to the pulse duration (50% duty cycle).

Remember that the speed of the motor is proportional to the pulse magnitude and that the distance traveled is proportional to both the magnitude and duration of the pulse(s). Be very careful in using `Repeating + Pulses` or `Repeating - Pulses` if the axis has mechanical travel limits.

ATTENTION: The distance traveled by the axis during the digital battery box tests is proportional to both the magnitude and duration of the pulses!

After defining the desired pulse(s), the IMC-S/23x asks:

```
Pulse Type?
Ready? NO
```

Toggle to YES and press **ENTER** to initiate the test. While the digital battery box is running, a continuously updated display of the current velocity and overshoot is displayed. Use the velocity reading with long pulses for drive scaling and the overshoot value to adjust the response of the amplifier for the minimum (or specified) velocity overshoot.

ATTENTION: Press **ESC** (Escape) to immediately abort the digital battery box.

At the conclusion of the digital battery box test, you may specify a new pulse or finish the test. Before finishing the test, the drive offset is once again automatically compensated to reflect any changes as a result of the tuning.

Checking Encoder Markers

If you have configured the IMC-S/23x to use the encoder marker for homing (see Editing the Homing Configuration earlier in this section), use the marker input test to verify that the marker is being properly received. The marker input test requests that you generate a marker pulse (usually by physically moving the feedback transducer) and verifies that at least one transition on the marker or Z channel was received.

If a marker pulse is not detected, the message

```
Press Any Key
***   Marker NOT Detected!
```

is displayed. If this occurs, check the connection of the encoder marker channel to the IMC-S/23x (see the Installation and Hookup section of this manual) and verify that the marker signal is being generated properly by the encoder. This is most easily done with an oscilloscope or logic probe. When the problem is corrected, re-run the marker test.

When the encoder marker is properly detected, the message

```
Press Any Key
Marker OK
```

is displayed, indicating satisfactory completion of the marker test.

Align Absolute Transducers

If you have configured the IMC-S/23x to use an absolute transducer, you need to align the absolute position of the transducer to correspond with the position of the axis. This can be extremely difficult due to the resolution of the transducers and their location. Using the Align Absolute transducer procedure, you can randomly affix the transducer to the physical axis. There is no need to match the actual position of the transducer to the actual position of the axis. The Alignment routine reads the position and then compensates for the position of the transducer relative to the actual position of the axis. To Align Absolute Transducers:

1. Select the Align Absolute Transducer procedure. The following message appears:

```
Align Absolute Transducer?
```

2. Press **ENTER**.

If the message below appears on the IMC-S/23x:

```
No Alignment Required!
Check Homing Procedure
```

You did not select one of the following during Machine Setup:

- ABSOLUTE
- ABSOLUTE_MV
- ABSOLUTE_SERIAL

The routine ends and no IMC-S/23x parameters are modified. Make sure you have selected the proper homing procedure for the feedback transducer.

If this message appears:

```
Alignment for transducer type
Homing Procedure
Move axis to minimum travel position
Press any Key
```

1. Verify that it is the right one for the absolute transducer and accompanying converter card.

2.

If:	Then:
It is not	The alignment procedure may be incorrect. 1. Select the appropriate Homing Procedure. 2. Go back to the Align Absolute Transducer Procedure section. 3. Repeat the procedure.
It is	Move the axis to its minimum travel position and press **ENTER** to align the transducer to the zero position of the axis. This position is defined as zero by the alignment procedure. The following message appears. (It takes abouttwo seconds to align a transducer). `Please Wait`

The alignment procedure reads the absolute position of the transducer. If no encoder noise or loss faults have occurred during this time, the routine completes successfully. The read position is negated and placed into the Home Position variable in the IMC-S/23x working memory. For absolute devices, use Home Position as a home offset, which is added to the actual position of the transducer during a homing command.

For example, assume the actual position of the absolute transducer is 1. After alignment, the home offset (Home Position) variable will be equal to -1 and the axis position is 1 + (-1) = 0. Assume the axis is moved one unit and the position of the absolute transducer is now 2. If a home command is issued at this point, the axis position will be 2 + (-1) = 1.

If the alignment routine is successful, the following message appears on the IMC-S/23x:

```
Alignment Completed OK
```

The alignment procedure is complete and the home offset (Home Position) has been updated in the IMC-S/23x working memory. If an encoder loss or encoder noise fault has occurred during the alignment procedure, the following message appears:

```
***   Encoder Loss or Noise Detected
***   Check Transducer Hookup
```

If this is the case, the IMC-S/23x has detected an encoder type fault. This can be caused by:

- Electro-magnetic noise
- Loss of encoder input to the IMC-S/23x
- A transducer error reported by the converter card (not all converter cards report errors by triggering Encoder Loss Fault)

Encoder loss detection is forced on for the alignment procedure even if it was not selected in the Edit Feedback Configuration. If any of the faults listed above occurred, the alignment routine aborts and the home offset (Home Position) remains unchanged. If those faults occur:

1. Verify the integrity of the system wiring and installation.

2. Correct any problems.

3. Perform the alignment procedure again.

Checking The Discrete I/O

Six I/O tests are provided to verify correct hookup and operation of the axis-specific (dedicated) discrete inputs and outputs of the IMC-S/23x and the Flex I/O. Since each application uses the discrete I/O differently, refer to a wiring or schematic diagram of how the I/O is connected on your machine before running the discrete I/O test.

The six discrete I/O tests are as follows:

- Dedicated Input Test
- Dedicated Output Test
- Discrete Input Test
- Discrete Output Test
- Analog Input Test
- Analog Output Test

Each of these tests is explained following.

Checking the Dedicated Discrete Inputs

The five dedicated discrete inputs (home, positive overtravel, negative overtravel, drive fault, and position registration) for each axis are checked using the dedicated input test. When this test is run, the current state (`ON` or `OFF`) of the five dedicated inputs for the selected axis is continuously displayed as shown below.

```
   HOME   +OTRV   -OTRV   FAULT   REG
    OFF   OFF   OFF   OFF   OFF
```

Manually activate the devices connected to the dedicated inputs and verify that the state (`ON` or `OFF`) displayed beneath each input label changes properly.

Note that the contact configuration (`NORMALLY OPEN` or `NORMALLY CLOSED`) selected for the home limit switch, overtravel limit switches, and the drive fault input in the machine setup menu *does not* affect the state reported by the dedicated input test. A normally-closed overtravel limit switch, for instance, will test `ON` in its inactive condition, and `OFF` when activated.

Press **ENTER** to terminate the dedicated input test.

Checking the Dedicated Discrete Outputs

The dedicated discrete outputs (drive enable and absolute position strobe) for each axis are tested using the dedicated output test. When this test is run, the IMC-S/23x displays

```
DRIVE=1  STROBE=2
 OFF       OFF
```

and the state of the drive enable and absolute position strobe outputs may be toggled between `ON` and `OFF` using the indicated key.

Verify correct operation of the drive enable output with your servo amplifier. If you are using an absolute position transducer for feedback on this axis, also verify correct operation of the strobe output with the REC, REC-4096, TEC-242, or AEC-216.

ATTENTION: The dedicated output test activates the drive enable outputs directly. Ensure that this is safe before running this test.

Press **ENTER** to terminate the dedicated output test.

Checking Flex I/O Discrete Inputs

Discrete inputs on Flex I/O 1794-IB16 or 1794-IA8 modules are tested in groups of four using the discrete input test. The IMC-S/23x displays

```
Run Discrete Input Test? YES
 Test Module 0
```

Toggle to the desired Flex I/O module to test and press **ENTER**. If the selected module is not an IB16 or IA8 discrete input module, an appropriate warning message is displayed and you may select another block.

If the selected block has not been configured in the GML Definitions menu, the message

```
Test Module
 This Module is NOT CONFIGURED!
```

is displayed. The Flex I/O connected to the IMC-S/23x must be configured before it can be tested. See The Definitions Menu in the GML Programming Manual for IMC S Class Motion Controllers (999-104) for information on configuring Flex I/O modules.

When this test is run, the current state (on or off) of the first four inputs is continuously displayed as shown below.

```
INPUT0   INPUT1   INPUT2   INPUT3
 OFF   OFF   OFF   OFF
```

Manually activate the devices connected to the displayed inputs and verify that the state (`ON` or `OFF`) displayed beneath each input label changes properly. Press **ENTER** to test the next group of discrete inputs or to terminate the discrete input test.

Checking Flex I/O Discrete Outputs

Discrete outputs on Flex I/O 1794-OB16 or 1794-OA8 modules are tested in groups of four using the discrete output test. The IMC-S/23x displays

```
Run Discrete Output Test? YES
 Test Module 0
```

Toggle to the desired Flex I/O module to test and press **ENTER**. If the selected module is not an OB16 or OA8 discrete output module, an appropriate warning message is displayed and you may select another block.

If the selected block has not been configured in the GML Definitions menu, the message

```
Test Module
 This Module is NOT CONFIGURED!
```

is displayed. The Flex I/O connected to the IMC-S/23x must be configured before it can be tested. See The Definitions Menu in the GML Programming Manual for IMC S Class Motion Controllers (999-104) for information on configuring Flex I/O modules.

ATTENTION: The discrete output test activates the selected output **directly**-no interlocks are used. Ensure that it is safe to activate the outputs before running this test.

When this test is run, the IMC-S/23x displays

```
OUT0=1   OUT1=2   OUT2=3   OUT3=4
 OFF   OFF   OFF   OFF
```

and the state of the displayed Flex I/O outputs may be toggled between `ON` and `OFF` using the indicated key.

Verify correct operation of the device connected to each output and then press **ENTER** to test a different group of outputs or to terminate the discrete output test.

Checking Flex I/O Analog Inputs

Analog inputs on Flex I/O 1794-IE8 or Flex I/O 1794-IE4XOE2 modules are tested in groups of two using the analog input test. The IMC-S/23x displays

```
Run Analog Input Test? YES
 Test Module 0
```

Toggle to the desired Flex I/O module to test and press **ENTER**. If the selected module is not an IE8 or IE4XOE2 analog module, an appropriate warning message is displayed and you may select another block.

If the selected block has not been configured in the GML Definitions menu, the message

```
Test Module
 This Module is NOT CONFIGURED!
```

is displayed. The Flex I/O connected to the IMC-S/23x must be configured before it can be tested. See The Definitions Menu in the GML Programming Manual for IMC S Class Motion Controllers (999-104) for information on configuring Flex I/O modules.

When this test is run, the current input value of the first two inputs is continuously displayed. If the input is configured for 4 - 20 mA operation, the value is displayed in milliamps; if the input is configured for 0 - 10 or ±10V operation, the value is displayed in Volts. For example, if input 0 is configured for 4 - 20 mA and input 1 for ±10V, the following is displayed.

```
INPUT0 INPUT1
xx.xxx(mA)+xx.xxx(V)
```

Verify that the analog value displayed beneath each input label changes properly as the input level is changed. Press **ENTER** to test the next group of analog inputs or to terminate the analog input test.

Checking Flex I/O Analog Outputs

Analog outputs on Flex I/O 1794-OE4 or 1794-IE4XOE2 modules are tested individually using the analog output test. The IMC-S/23x displays

```
Run Analog Output Test? YES
 Test Module 0
```

Toggle to the desired Flex I/O module to test and press **ENTER**. If the selected module is not an OE4 or IE4XOE2 analog output module, an appropriate warning message is displayed and you may select another block.

If the selected block has not been configured in the GML Definitions menu, the message

```
Test Module
 This Module is NOT CONFIGURED!
```

is displayed. The Flex I/O connected to the IMC-S/23x must be configured before it can be tested. See The Definitions Menu in the GML Programming Manual for IMC S Class Motion Controllers (999-104) for information on configuring Flex I/O modules.

When this test is run, the IMC-S/23x displays the current value of the analog output in the configured units. For example, if input 0 is configured for ±10V output and is currently putting out -4.563 Volts, the following is displayed.

```
Test Output 0
 Output # value (+/-10V):  -4.563
```

ATTENTION: The analog output test activates the selected output **directly**. Ensure that it is safe to activate the outputs before running this test.

To change the analog output value, enter the desired new value and press **ENTER**. Verify that the specified output is producing the specified output level.

Servo Setup Menu

The IMC-S/23x provides a sophisticated automatic tuning routine which allow it to determine proper settings for the servo loop parameters for each SERVO axis. These include not only the P, I, V, and F gains, but also the maximum acceleration, deceleration, and velocity. The values determined using the automatic tuning routine may also be reviewed and edited (changed) if desired.

Usually, the servo loop parameters need only be tuned once when the motion controller is first integrated onto the machine or when the machine is being commissioned at start-up. However, if the load on any axis changes significantly or if the motor or servo amplifier are replaced for any reason, it may be necessary to re-tune the servo loop parameters.

The Servo Loop Gains

The IMC-S/23x uses a Nested Digital Servo Control Loop consisting of a position loop with proportional, integral and feedforward gains around a digitally synthesized inner velocity loop using velocity gain for each physical axis. These gains provide software control over the servo dynamics, and allow the servo system to be completely stabilized.

Unlike analog servo controllers, these digitally set gains do not drift. Furthermore, once these gains are set for a particular system, additional IMC-S/23x controllers programmed with these gain values will operate identically to the original one. A detailed explanation of the servo loop operation can be found in Technical Overview earlier in this manual. The units for the servo loop gain terms are shown following.

IMC-S/23x Servo Gain Units

Gain	*Description*	*Units*		
P	Proportional Gain	$\frac{\text{Counts per Millisecond}}{\text{Count of Error}}$	or	$\frac{1}{\text{Millisecond}}$
I	Integral Gain	$\frac{\text{Counts per Millisecond}^2}{\text{Count of Error}}$	or	$\frac{1}{\text{Millisecond}^2}$
V	Velocity Gain	$\frac{\text{Millivolts}}{\text{Count per Millisecond}}$	or	$\frac{\text{Millivolts}}{\text{kCPS}}$
F	Feedforward Gain	$\frac{\text{Counts per Millisecond}}{\text{Count per Millisecond}}$		
	Deadband Compensation	Volts		
	Offset Compensation	Volts		

Velocity Gain

When using a torque (current) loop servo amplifier, the synthesized velocity loop provides damping without the requirement for an analog tachometer. Increasing the velocity gain (V gain) results in smoother motion, enhanced acceleration, reduced overshoot, and greater system stability. The velocity loop also allows higher effective proportional gain values to be used, however, too much V gain leads to high frequency instability. The velocity loop in the motion controller is not used with velocity loop servo amplifiers, but the V gain must still be set properly. Note that millivolts per count per millisecond is equivalent to millivolts per 1000 (**k**) **c**ounts **p**er **s**econd.

Proportional Gain

Increasing the proportional gain (P gain) decreases response time and increases the "stiffness" of the servo system. Under pure proportional control, the drive system applies a restoring torque in proportion to the position error of the axis. Too high a proportional gain results in instability, while too low a proportional gain results in "loose" or "sloppy" system dynamics.

Integral Gain

Integral gain (I gain) improves the steady-state positioning performance of the system. By using integral gain, it is possible to achieve accurate axis positioning despite the presence of such disturbances as static friction or gravity. Increasing the integral gain generally increases the ultimate positioning accuracy of the system. Excessive integral gain, however, results in system instability.

Feedforward Gain

Feedforward gain (F gain) allows the following error (position error while the axis is moving) of the system due to velocity to be reduced nearly to zero. This is important in applications such as electronic gearing and synchronization applications where it is necessary that the actual axis position not lag behind the commanded position at any time.

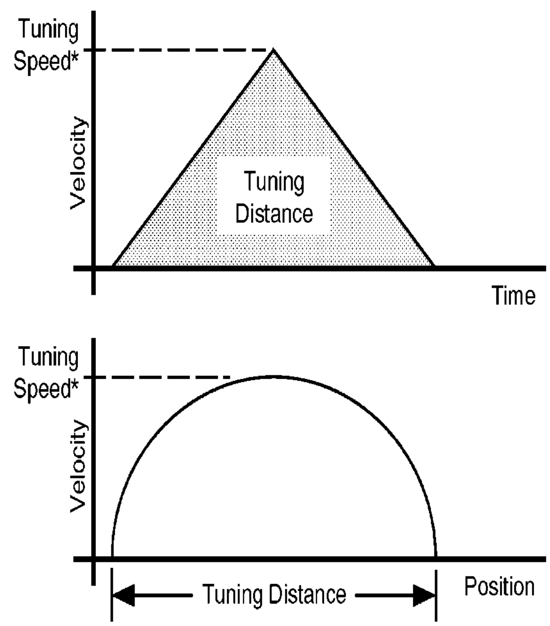
Self-Tuning the Servo Gains

After entering the servo setup menu and selecting a physical SERVO axis, the IMC-S/23x asks

```
Select: AXIS #
Tune Servo Parameters? NO
```

Toggle to YES to have the IMC S Class automatically tune the servo gains and determine the maximum acceleration, deceleration, and velocity of this axis.

To determine the loop response, the self tuning routine moves the axis in the specified tuning direction as shown below.



*For Torque Loop servo amplifiers, the Tuning Speed is specified directly before executing the self tuning routine. For Velocity Loop amplifiers, the Tuning Speed is 85% of the product of the specified Tuning Output Limit, the Servo Output Limit, and the speed scaling of the servo drive.

During this motion, the total inertia of the system as well as the maximum speed, acceleration, and deceleration capabilities of the system are measured. These measured values are then used to calculate and set the servo parameters.

Before tuning the servo gains, a number of parameters must be entered. These parameters constrain the motion produced by the tuning routine so that no damage to the machine occurs. The IMC-S/23x next displays

```
Tune Servo Parameters? YES
 Tuning Direction? POSITIVE
```

prompting you to enter the direction for the self tuning motion. Toggle to the desired direction for this axis and press **ENTER**. All motion during the self tuning routine occurs in the specified direction, making it easy to tune axes or machines which are mechanically constrained to move in only one direction. If your axis can move in either direction, choose the direction which provides the longest distance for tuning.

The IMC-S/23x next displays

```
Tuning Direction? POSITIVE
Max Tuning Travel (Position Units) =
```

prompting you to enter the maximum distance available for tuning in the chosen direction. Enter the maximum distance in the specified direction which the axis should be allowed to move during the self tuning and press **ENTER**. The value should be entered in the position units of the axis.

If this axis is using a torque loop servo amplifier, the IMC-S/23x next displays

```
Max Tuning Travel (Position Units) =
Tuning Speed (Position Units/Sec) =
```

prompting you to enter the maximum speed which the axis should be allowed to reach during the self tuning in the position units of the axis per second. For best self tuning results, enter the maximum speed at which the axis is expected to operate. Do not enter a speed which is above the capabilities of the axis! If the drive system is capable of moving the axis faster than this speed, the maximum velocity will be limited to the specified value during the tuning procedure.

ATTENTION: Do not enter a Tuning Speed greater than the maximum possible speed of the axis.

The IMC-S/23x next displays

```
Tuning Output Limit (% of Max) =
```

prompting you to enter the maximum percentage of the servo output limit entered in the machine setup menu to use for tuning. If this axis is using a velocity loop amplifier, the tuning output limit is an additional maximum *speed* limit. If this axis is using a torque loop amplifier, the tuning output limit is an additional *torque* limit. The self tuning routine actually uses 85% of the entered value to provide some headroom. Enter 100 for the tuning output limit to limit the servo output to the value specified in the machine setup menu.

Enter a lower value to further limit the servo output for the self tuning procedure. For example if the servo output is configured for voltage output and the servo output limit entered in the machine setup menu for this axis is 9V, entering a tuning output limit of 90% limits the actual servo output during self tuning to 6.885V (85% of 90% of 9V). If this axis is using a velocity loop amplifier, this limits axis speed to 68.85% of the motor's speed with a 10V command. If this axis is using a torque loop amplifier, this limits motor torque to 68.85% of the torque produced by a 10V command.

When the IMC-S/23x prompts

```
Tuning Output Limit (% of Max) =
Ready? NO
```

it is ready to execute the self tuning routine. Ensure that the machine is also ready, toggle to `YES`, and press **ENTER** to tune the axis.

The message

```
Ready? YES
Tuning...
```

is displayed while the axis is being tuned.

If at any time during the automatic tuning, axis motion becomes alarming or there is danger of damage or injury, press the escape key (**ESC**)on the terminal. This immediately stops all motion and aborts the tuning routine displaying

```
*** Aborted by Escape!
*** Gains Not Tuned!
 Review Servo Parameters? NO
```

ATTENTION: Press **ESC** (Escape) to immediately abort the self tuning routine.

If the specified maximum tuning travel distance is too short to adequately tune the axis, the message

```
*** Safe Travel Limit Exceeded:
*** Travel Limit Too Small!
```

is displayed. Specify a larger maximum tuning travel distance (the axis may need to be re-positioned manually) and run the self tuning procedure again.

If this axis is using a torque loop servo amplifier and the specified tuning speed could not be reached within the specified maximum tuning travel using the specified tuning output limit, the message

```
*** Did Not Reach Tuning Speed:
*** Try Again with Lower Tuning Speed
*** or Higher Max Travel/Torque Limit!
*** Gains Not Tuned!
```

is displayed. In this case, run the self tuning procedure again specifying a lower tuning speed, a higher maximum tuning travel, or a higher tuning output limit. If possible, it is best to increase the maximum tuning travel to give the self tuning more "room" to operate. If this is not possible due to physical travel constraints on the axis, either the tuning output limit must be increased or the tuning speed must be decreased.

For a torque loop servo amplifier, the distance traveled during the self tuning procedure is proportional to the square of the specified tuning speed and inversely proportional to the specified tuning output limit, as shown by the formula below.

$$\mathrm{TuningTravel}\ \alpha\ \frac{\mathrm{TuningSpeed}^2}{\mathrm{TuningOutputLimit}}$$

This means that if the tuning output limit is doubled, the distance required to self tune the axis is cut in half. However, if the tuning speed is cut in half the axis can be self tuned in one-quarter of the distance.

If this axis is using a velocity loop servo amplifier and the speed implied by the specified tuning output limit could not be reached in the specified tuning distance, the message

```
*** Insufficient Travel for Tuning:
*** Try Again with Lower Max Output
*** or Higher Max Travel Limit!
*** Gains Not Tuned!
```

is displayed. In this case, run the self tuning procedure again specifying a higher maximum tuning travel or a lower tuning output limit. If possible, it is best to increase the maximum tuning travel to give the self tuning more "room" to operate. If this is not possible due to physical travel constraints on the axis, the tuning output limit must be decreased.

For a velocity loop servo amplifier, the distance traveled during the self tuning procedure is proportional to the square of the specified tuning output limit, as shown by the formula below.

$$\text{Tuning Travel} \propto \text{Tuning Output Limit}^2$$

This means that if the tuning output limit is cut in half, the axis can be self tuned in one-quarter of the distance.

After successful completion of the tuning routine, the IMC-S/23x displays

```
Tuning Complete!
Damping Factor: 0.8
```

The total system inertia, measured at a 1V servo output during the test, is shown in units of milliseconds per count per millisecond (thousand feedback counts per second, or KCPS).

The damping factor which will be used to compute the loop gains is also displayed. Initially, the damping factor defaults to 0.8, which provides good gain values for most systems. Press **ENTER** to use the displayed damping factor to calculate the servo gains.

If necessary, the damping factor may be increased to provide additional damping if required in your application. Raising the damping factor reduces the amount of overshoot at the end of moves but slows down the response of the axis. Usually, a damping factor between 0.707 and 2 is sufficient. Damping factors greater than 2 are rarely effective since the resulting loop gains cause the servo loop to be very sluggish.

ATTENTION: Do not use a damping factor less than 0.5 or greater than 2 for most systems.

While the damping factor may also be reduced to decrease the damping, this is also rarely effective–the servo loop response is made faster and the amount of overshoot at the end of moves is increased. Usually, damping factors less than 0.5 should not be used since the resulting loop gains may cause the axis to become unstable.

The measured bandwidth of the velocity loop amplifier (if this axis is using a velocity loop servo amplifier) and the calculated maximum possible positioning bandwidth of the axis in Hertz based on the specified damping factor and the measured response is displayed next.

```
Velocity Bandwidth (Hz) =
Position Bandwidth (Hz) =
```

Unless different values are entered, these are the bandwidths which will be used to calculate the servo gains. Initially, press **ENTER** to use the displayed bandwidths to calculate servo gains which provide maximum system bandwidth.

The measured velocity bandwidth may be overridden by entering a different value. However, this should only be done if the self-tuning routine fails to provide adequate performance and you know the actual bandwidth of your velocity loop.

If necessary, the position bandwidth may be decreased if required in your application. Decreasing the position bandwidth slows down the response of the axis by making it less responsive to rapid command changes. Never increase the position bandwidth by entering a value greater than that calculated by the self tuning routine–the resulting system could be highly unstable!

ATTENTION: Do not enter a position bandwidth greater than that calculated by the self-tuning routine.

Using the Position Error Integrator

After displaying the measured servo performance, the IMC-S/23x displays

```
Position Bandwidth (Hz) =
Use Position Error Integrator? NO
```

prompting you to decide whether or not to use integral gain in the position loop. In general, you *should* use the position error integrator with torque loop amplifiers and you should *not* use the position error integrator with analog velocity loop amplifiers. If you are using a digital velocity loop amplifier, the velocity integrator in the amplifier must be disabled to use the position integrator in the motion controller. To use integral gain in the position loop, toggle to YES and press **ENTER**.

Using Velocity Feedforward

After deciding whether or not to use integral gain in the position loop, the IMC-S/23x displays

```
Use Position Error Integrator? NO
Use Velocity Feedforward? NO
```

prompting you to decide whether or not to use velocity feedforward in the position loop. If near-zero position error over the entire speed range of the axis is necessary for your application, toggle to YES and press **ENTER**. This sets the feedforward gain to the value that produces the smallest position error during constant velocity motion.

Even though feedforward gain operates on the axis command position (see Technical Overview earlier in this manual) and therefore has no effect on system stability, it does affect the appearance of motion profiles. Higher F gain values produce greater velocity overshoot at the end of acceleration ramps and position overshoot at the end of moves. If position overshoot cannot be tolerated in your application, toggle to NO and press **ENTER**. This sets the F gain to zero.

After determining whether or not to use the position loop integrator and velocity feedforward, the servo loop gains are calculated and feedback turned ON. The computed loop gains, maximum acceleration and deceleration, maximum velocity, and position error tolerance values may then be reviewed and edited, if desired. Feedback is disabled while the gains are being edited to prevent an undesired or unexpected machine motion should an erroneous gain value be entered.

Regardless of whether velocity feedforward is used for this axis, the position error tolerance of the axis is set to twice the position loop following error at maximum velocity *without* feedforward.

Tuning Faults

During the self tuning procedure, a fault on the axis may occur which prevents the procedure from completing properly. If this happens, the message

```
*** Fault Message
*** Gains Not Tuned!
```

is displayed. The fault message indicates what caused the fault, as explained below.

Aborted by Escape!

This message is displayed when the **ESC** (Escape) key is pressed to immediately abort the self tuning routine. Re-run the self tuning with a different maximum tuning travel, tuning speed, and/or tuning output limit such that it is not necessary to abort the procedure.

Encoder Fault!

This message indicates that either *noise* was detected on the axis' encoder input or that one of the encoder connections is broken. See Checking Motors/Encoders earlier in this section for more information on encoder noise and loss.

Hit Hardware Overtravel Limit!

This message indicates that one of the overtravel limit switches was activated during the self tuning procedure. See Editing the Overtravel Configuration earlier in this section for more information on configuring the overtravel limit switches.

Position Error Tolerance Exceeded!

This message indicates that the position error of the axis exceeded the position error tolerance during the self tuning procedure. See Setting the Position Error Tolerance later in this section for information on setting the position error tolerance.

Drive Fault Detected!

This message indicates that the axis' drive fault input was activated during the self tuning procedure. See Editing the Servo Configuration earlier in this section for more information on configuring the drive fault input.

Manually Tuning the Loop Gains

Even though the self tuning procedure works satisfactorily with most systems, it is possible that they will fail to yield satisfactory results in your particular application. If this is the case, the servo loop gains, maximum acceleration and deceleration, maximum velocity, and position error tolerance values can be tuned manually using the following procedures. For the imaginary axis, these values *must* be entered manually.

It is recommended that the loop gain parameters be adjusted in the following order:

Drive Offset and deadband compensation
Velocity gain
Proportional gain
Integral gain (optional)
Feedforward gain (optional)

In general, each parameter is adjusted (tuned) by starting initially with a low value, evaluating the response of the system, and increasing the value until the desired response is achieved.

To begin the gain tuning procedure, answer `YES` to the `Review Servo Parameters?` question in the servo setup menu. Next, set all the gains to zero, the maximum acceleration, deceleration, and velocity to reasonable values, and the position error tolerance to an arbitrarily large value to avoid nuisance faults while tuning the gains. These values should reflect the actual performance limits of each axis. Do not enter values higher than what can be reasonably expected from your system!

Setting the Drive Offset and Deadband Compensation

Use the motor/encoder test in the hookup diagnostics menu to tune the drive offset and the deadband compensation. If this axis is using a velocity loop servo amplifier, also use the digital battery box in the hookup diagnostics menu to tune the servo amplifier *before* tuning the motion controller gains. See Hookup Diagnostics earlier in this section for more information on the motor/encoder test and the digital battery box.

Setting the Velocity Gain

If you are using a velocity loop servo amplifier, the software velocity loop (see Technical Overview earlier in this manual) is disabled. Set the velocity gain to the value calculated by the following formula.

$$\text{V gain} \quad \frac{10{,}000{,}000}{\text{Speed @ 10V}\left[\frac{\text{PositionUnits}}{\text{Second}}\right] \text{ x K } \left[\frac{\text{Counts}}{\text{PositionUnit}}\right]}$$

For example, if this axis is using position units of motor revolutions (revs), a 1000 line encoder mounted on the motor, and the servo drive is scaled such that with an input of 10V the motor goes 5,000 RPM, the V gain would be calculated as shown below.

$$\text{V gain} \quad \frac{10{,}000{,}000}{\left(5000 \text{ RPM x } \frac{1\text{Minute}}{60\text{Seconds}}\right)\left(\frac{1{,}000\text{x}4\text{Counts}}{\text{Rev}}\right)} = 30$$

If you are using a torque (current) loop servo amplifier, increase the velocity gain, starting at 1, to provide damping. As the velocity gain is increased, notice that the motor (or axis) resists changes in speed as you move it by hand. Increase the velocity gain until you notice a grainy or cogging feeling as you move the axis. Set the V gain to about 50% of this value.

If this axis uses a torque loop servo amplifier and you are converting it from a basic (IMC-S/20x) or integrated (IMC-S/21x) IMC S Class motion controller, use the same V gain in the IMC S Class Compact (IMC-S/23x) as was used in the basic or integrated controller.

Setting the Proportional Gain

With the velocity gain tuned or set as outlined above, increase the proportional gain from 0.01 to provide position control. In general, the optimal setting for proportional gain is the largest value that does not cause excessive overshoot or oscillation when stopping.

A well-tuned system will move and stop quickly or "smartly" and exhibit little or no "ringing" during constant velocity or when the axis stops. If the response time is poor, or the motion "sloppy" or slow, the proportional gain may need to be increased. If excessive ringing or overshoot is observed when the motor stops, the proportional gain may need to be decreased.

The P gain may also be set based on the desired loop gain of the final system. If you know the desired loop gain in inches per minute per mil or millimeters per minute per mil, use the following formula to calculate the corresponding P gain.

$$\text{P gain} = \frac{\text{Desired Loop Gain}\left[\frac{\text{InchesperMinute}}{\text{Mil}}\right]}{60}$$

A loop gain of 1 inch per minute per mil (P gain = 0.0167) provides stable positioning of virtually any axis.

If this axis uses a velocity loop servo amplifier and you are converting it from a basic (IMC-S/20x) or integrated (IMC-S/21x) IMC S Class motion controller, calculate the equivalent P gain for the IMC S Class Compact (IMC-S/23x) using the formula below.

$$\text{Compact P gain} = \frac{\text{Basic/Integrated P gain}}{\text{Compact V gain}}$$

Continuing our example above, if a basic or integrated IMC S Class had previously been used successfully on this axis with a P gain of 0.586, the equivalent P gain for the IMC S Class Compact is calculated as shown below.

$$\text{Compact P gain} = \frac{0.586}{30} = 0.0195$$

If this axis uses a torque loop servo amplifier and you are converting it from a basic (IMC-S/20x) or integrated (IMC-S/21x) IMC S Class motion controller, use the same P gain in the IMC S Class Compact (IMC-S/23x) as was used in the basic or integrated controller.

Setting the Integral Gain

Once the proportional and velocity gains have been tuned or set as explained above, small amounts of integral gain may be added to improve static positioning accuracy. If you are using an analog velocity loop servo amplifier, set the integral gain to zero–most analog velocity loop servo amplifiers will not tolerate *any* amount of integral gain without producing severe oscillations. With a digital velocity loop servo amplifier, the velocity integrator in the amplifier must be disabled to use I gain in the motion controller.

If you are using a torque (current) loop servo amplifier, set the I gain using the formula below.

$$\text{I Gain} = 250 \times (\text{P Gain})^2$$

Alternately, increase the integral gain starting at 0 until the motor sustains oscillation for a few seconds or more. The optimal I gain value is about 50% of this value. Notice that as the I gain is increased, the system becomes "tighter" at standstill, but also tends to become more unstable or "jittery". In general, the smallest integral gain value that gives a reasonably tight system without excessive jittering at standstill is best. Too much integral gain causes severe instability!

If you are converting the integral gain from a basic (IMC-S/20x) or integrated (IMC-S/21x) IMC S Class motion controller, calculate the equivalent I gain for the IMC S Class Compact (IMC-S/23x) using the formula below.

$$\text{Compact I gain} = 1{,}000 \times (\text{Basic/Integrated I gain})$$

For example, if a basic or integrated IMC S Class had previously been used successfully on this axis with an I gain of 0.003, the equivalent I gain for the IMC S Class Compact is 3.

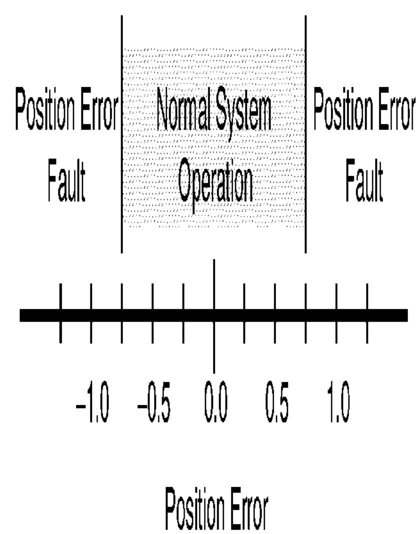
Setting the Feedforward Gain

If near-zero position error over the entire speed range of the axis is desired, set the feedforward gain at 1.00 to achieve this. If necessary, the F gain may be "tweaked" using the Watch Window in the Online Manager in GML to monitor the position error of the axis during a move. Increase the feedforward gain until the following error at constant speed is as small as possible, but still positive. If the following error at constant speed is negative, the actual position of the axis is *ahead* of the command position (see Technical Overview earlier in this manual). If this occurs, decrease the F gain such that the following error is again positive. Note that reasonable maximum velocity, acceleration, and deceleration values must be entered to move the axis.

Setting the Position Error Tolerance

The self tuning routine sets the position error tolerance to twice the following error at maximum speed based on the measured response of the axis. In most applications, this value provides reasonable protection in case of an axis fault or stall condition without nuisance faults during normal operation.

The Position Error Tolerance parameter specifies how much position error the IMC-S/23x tolerates before giving a position error fault (`ERR FLT` displayed in the status field of the Standard Operator Interface). Like the position lock tolerance, the position error tolerance is interpreted as a ± quantity. For example, specifying a position error tolerance of 0.75 position units means that a position error fault will be generated whenever the position error of the axis is greater than 0.75 or less than -0.75 position units, as shown below:



If you need to change the calculated position error tolerance value, the recommended setting is 150% to 200% of the position error while the axis is running at its maximum speed.

Saving Setup Values

At the conclusion of the servo setup menu, the IMC-S/23x asks

```
Another Axis? NO
Save Setups to App Module? NO
```

Toggle to `YES` and press **ENTER** to save the configurations and setup values just entered using the setup menus for use as the power-up values. Until changed (by going through the setup menus again), the power-up values saved in the application module are used whenever the IMC-S/23x is turned on.

If memory is locked, the message

```
Save Setups to App Module? YES
Save Aborted: App Module Locked!
```

is displayed. Unlock the memory using the keyswitch on the front panel and save the setups again.

Answer `NO` to this question if you do not wish to save the configurations and setup values just entered using setup menus.

Setup Menu Reference

IMC-S/23x Application Setup Menu Reference

Prompt	*Data*
Application Password? Incorrect Password! Inhibit Program Upload? **NO/YES**	 B26
Edit AxisLink Config??**NO/YES** AxisLink??**NO/YES**	B48
Edit DH-485 Config??**NO/YES** DH-485??**NO/YES** Maximum Node Address? ___________ Network Node Address? ___________ Address Must be < than Max. Address! DH-485 Baud Rate?? **9600/19200**	 B53 D107 D106 D109
Edit Axis Setup Parameters??**NO/YES** Select: **AXIS #/IMAGINARY/VIRTUAL AXIS #** Axis Configuration?? **NOT CONFIGURED/MASTER ONLY/SERVO** A Virtual Axis is MASTER ONLY Imaginary Axis is COMMAND ONLY Controller Address?? **0/1/2/3/4/5/6/7** ***Cannot Select This Controller! Axis on Controller #?? **AXIS #/IMAGINARY** Axis Type is COMMAND Axis Type?? **ACTUAL/COMMAND** Relative Direction?? **SAME/OPPOSITE** Rotary Axis?? **NO/YES** Position Units = ___________ Position Unit = ___________ Position Display Field Length = ___________ Number of Decimal Digits = ___________ Velocity Display Field Length = ___________ Number of Decimal Digits = ___________ Accel Display Field Length = ___________ Number of Decimal Digits = ___________ Avg Vel Timebase (Sec) = ___________ Move Profile?? **TRAPEZOIDAL/S-CURVE/PARABOLIC** Jog Profile?? **TRAPEZOIDAL/S-CURVE/PARABOLIC** Backlash Comp?? **NO/UNIDIR APPROACH/LOAD REVERSAL** Another Axis?? **NO/YES**	 D31 D61 D62 B50 B10 B9 D29 D30 D48 D49 D50 D51 D35 D23 D24 D46
Edit Axis Fault Action Configs?? **NO/YES** Select: **AXIS #/VIRTUAL AXIS #** ***This Axis is NOT CONFIGURED! ***This Axis is MASTER ONLY! This Axis is IMAGINARY ONLY Hard Overtravel Action?? **KILL DRIVE/STOP MOTION/STATUS ONLY** ***Runaway may Occur if not KILL DRIVE! Soft Overtravel Action?? **KILL DRIVE/STOP MOTION/STATUS ONLY** Pos Error Fault Action?? **KILL DRIVE/STOP MOTION/STATUS ONLY** ***Runaway may Occur if not KILL DRIVE! Drive Fault Action?? **KILL DRIVE/STOP MOTION/STATUS ONLY** ***Runaway may Occur if not KILL DRIVE! Encoder Noise Fault Action?? **KILL DRIVE/STOP MOTION/STATUS ONLY** Encoder Loss Fault Action?? **KILL DRIVE/STATUS ONLY** ***Runaway may Occur if not KILL DRIVE! Another Axis?? **NO/YES**	 D41 D40 D42 D44 D45 D43

IMC-S/23x Application Setup Menu Reference (continued)	
Prompt	*Data*
Edit Direct Command Mode Config?? **NO/YES** Linefeed Insertion?? **NO/YES** Carriage Return Insertion?? **NO/YES** Duplex?? **FULL/HALF** Multidrop?? **NO/YES**	 B19 B20 B31 B33
Edit Operator Interface Config?? **NO/YES** Operator Interface Serial Port?? **A/B** DH-485 Communications Uses Port B: Operator Interface Set to Port A! Linefeed Insertion?? **NO/YES** Carriage Return Insertion?? **NO/YES** Application Password? ____________ Setup Password? ____________	 D38 B21 B22
Edit Runtime Display Config?? **NO/YES** Runtime Display?? **NO/YES** Runtime Display Serial Port?? **A/B** DH-485 Communications Uses Port B: Runtime Display Disabled! Display Refresh Time (Sec) = ____________	 B23 D37 D39
Edit Serial Port Config?? **NO/YES** Port A Baudrate? **300/1200/2400/4800/9600/** **19200/38400/57600/115200/128000** Changing Baudrate . . . Port B Baudrate? **300/1200/2400/4800/9600/** **19200/38400/57600/115200/128000** Changing Baudrate . . .	 D32 D33
Edit RIO Config?? **NO/YES** RIO?? **NO/ADAPTER** RIO Adapter Channel?? **A/B** RIO Baud Rate?? **57.6KB/115.2KB/230.4KB** RIO Rack Size?? **1/4 / 1/2 / 3/4 / FULL** RIO Rack Address (0 - 31) = ____________ RIO Starting Group?? **0/2/4/6**	 B44-46 D57 D58 D56 D55 D59
Run App Program on Power-up?? **NO/YES**	B29

IMC-S/23x Machine Setup Menu Reference	
Prompt	*Data*
Select: **AXIS #/IMAGINARY/VIRTUAL AXIS #** This Axis is NOT CONFIGURED! Axis is Configured as MASTER ONLY Axis is Configured as SERVO Axis is IMAGINARY	
Edit Feedback Configuration?? **NO/YES** K (Counts/Position Unit) = ___________ Unwind (Counts/Rev) = ___________ Unwind Reference Point (Position Units) ___________ Use Encoder Loss Detection?? **NO/YES**	 D9 D13 D110 B25
Edit Overtravel Configuration?? **NO/YES** Use Overtravel Limit Switches?? **NO/YES** Switch Contacts?? **NORMAL OPEN/NORMAL CLOSED** Use Soft Travel Limits?? **NO/YES** Max Pos Travel (Position Units) = ___________ Max Neg Travel (Position Units) = ___________ ***Neg Limit Must Be < Pos Limit!	 B4 B5 B6 D11 D12
Edit Homing Configuration?? **NO/YES** Home Position (Position Units) = ___________ ***Home Position Outside Travel Limits! Homing for Virtual Axis is PASSIVE ! Homing Procedure?? **PASSIVE/ABSOLUTE/ACTIVE/** **ABSOLUTE_MV/ABSOLUTE_SERIAL** ___________ Use Marker?? **NO/YES** Select converter card? **AEC/TEC/REC/REC-4096 10 BITS/** **REC-4096 12 BITS/REC-4096 14 BITS/** **REC-4096 16 BITS** 1326AB-MOD-VD: Package number? **256/255/CUSTOM** Custom turns range = ___________ Use Home Limit Switch?? **NO/YES** Switch Contacts?? **NORMAL OPEN/NORMAL CLOSED** Home Direction?? **POSITIVE/NEGATIVE** Homing Vel (Position Units/Sec) = Return Vel (Position Units/Sec) = ___________	 D10 D36 D14,?D15 B0 D114 D115 B1 B2 B3 D17 D18
Edit Servo Configuration?? **NO/YES** Servo Drive Type?? **TORQUE LOOP/VELOCITY LOOP** Dual Loop Control?? **NO/YES** Select Velocity Axis: **AXIS #** *** This Axis is NOT CONFIGURED! *** This Axis is a SERVO AXIS! *** This Axis is a VIRTUAL AXIS! Servo Output Limit (Volts) = ___________ Use Drive Fault Input?? **NO/YES** Input Contacts?? **NORMAL OPEN/NORMAL CLOSED**	 B8 B14 D22 D6 B17 B18
Edit Positioning Configuration?? **NO/YES** Pos Lock Tol (Position Units) = ___________ Backlash Offset (Position Units) = ___________ Approach Direction?? **NEGATIVE/POSITIVE**	 D16 D14 B13
Another Axis?? **NO/YES**	

IMC-S/23x Hookup Diagnostics Reference

Prompt	*Data*
Select: **AXIS #/IMAGINARY/VIRTUAL AXIS #** This Axis is NOT CONFIGURED! You must test on the Physical Axis! No Diagnostics for IMAGINARY AXIS! Run Motor/Encoder Test?? **NO/YES** To Stop Test, Press ESC Key Test Increment (Position Units) = ___________ Compensating for Drive Offset... Compensating for Offset & Deadband... ***Aborted by Escape! ***Motor Does NOT Respond! ***Check Motor Hookup and Retest Offset Compensation Complete... Press Any Key and Watch for Motion ***Aborted by Escape! ***No Motion Detected! Run Encoder Test?? **NO/YES** Move Axis in Positive Direction Press Any Key ***Encoder Hookup OK! ***Check Motor Hookup and Retest ***No Motion Detected! ***Check Encoder Hookup and Retest Observed Motion Direction?? **POSITIVE/NEGATIVE** Hookup OK Motor/Encoder Polarity Set	 D34 D4, D7 B10/11
Run Encoder Test?? **NO/YES** Move Axis in Positive Direction Press Any Key Hookup OK Encoder Polarity Set ***No Motion Detected! ***Encoder Noise Detected! ***Encoder Loss Detected! ***Check Encoder Hookup and Retest	 B10
Edit Motor/Encoder Polarity?? **NO/YES** ***Changing Polarity Can Cause RUNAWAY! Encoder Polarity?? **POSITIVE/NEGATIVE** Servo Output Polarity?? **POSITIVE/NEGATIVE**	 B10 B11

IMC-S/23x Hookup Diagnostics Reference (continued)

Prompt	*Data*
Tune Drive Offset, Speed, Response?? **NO/YES** Drive Offset is __________ Adjust Drive Offset Pot Press Any Key to Continue Run Digital Battery Box?? **NO/YES** To Stop Pulses, Press ESC Key Pulse Magnitude (Volts) = Pulse Duration (Secs) = Pulse Type? **SINGLE + PULSE/SINGLE - PULSE/** **REPEATING + PULSES/REPEATING - PULSES/** **REPEATING +/- PULSES** Ready?? **NO/YES** Velocity Overshoot ±xxx.xxx ±xxx% ***Aborted by Escape! Try Again?? **NO/YES** Retuning Drive Offset Comp... Offset Compensation Complete...	D7
Run Marker Input Test?? **NO/YES** Generate a Marker Pulse Press Any Key ***Marker NOT Detected! Marker OK	
Align Absolute Transducer? **NO/YES** ***No Alignment Required! Check Homing Procedure Alignment for transducer type *Homing Procedure* Move axis to minimum travel position Press any key Please wait ... ***Encoder Loss or Noise Detected! ***Check Transducer Hookup Alignment Completed OK Run Dedicated Input Test? **NO/YES** HOME +OTRV -OTRV FAULT REG OFF OFF OFF OFF OFF	
Run Dedicated Input Test?? **NO/YES** HOME +OTRV -OTRV FAULT REG OFF OFF OFF OFF OFF	
Run Dedicated Output Test?? **NO/YES** DRIVE=1 STROBE=2 OFF OFF	
Another Axis?? **NO/YES**	
Run Discrete Input Test?? **NO/YES** Test Module **0/1/2/3/4/5/6/7** This Module is NOT CONFIGURED! This is an OUTPUT Module! This is an ANALOG INPUT Module! This Module type is UNSUPPORTED! INPUT0 INPUT1 INPUT2 INPUT3 OFF OFF OFF OFF INPUT4 INPUT5 INPUT6 INPUT7 OFF OFF OFF OFF INPUT8 INPUT9 INPUT10 INPUT11 OFF OFF OFF OFF INPUT12 INPUT13 INPUT14 INPUT15 OFF OFF OFF OFF Test Another Module?? **NO/YES**	

IMC-S/23x Hookup Diagnostics Reference (continued)	
Prompt	*Data*

`Run Discrete Output Test??` **`NO/YES`**
`Test Module` **`0/1/2/3/4/5/6/7`**
`This Module is NOT CONFIGURED!`
`This is an INPUT Module!`
`This is an ANALOG OUTPUT Module!`
`This Module type is UNSUPPORTED!`
OUT0=1 OUT1=2 OUT2=3 OUT3=4
OFF OFF OFF OFF
OUT4=1 OUT5=2 OUT6=3 OUT7=4
OFF OFF OFF OFF
OUT8=1 OUT9=2 OUT10=3 OUT11=4
OFF OFF OFF OFF
OUT12=1 OUT13=2 OUT14=3 OUT15=4
OFF OFF OFF OFF	

`Run Analog Input Test??` **`NO/YES`**
`Test Module` **`0/1/2/3/4/5/6/7`**
`This Module is NOT CONFIGURED!`
`This is an OUTPUT Module!`
`This is a DISCRETE INPUT Module!`
`This Module type is UNSUPPORTED!`
INPUT0 INPUT1
xx.xxx (mA) ±xx.xxx (V)
INPUT2 INPUT3
xx.xxx (mA) ±xx.xxx (V)
INPUT4 INPUT5
xx.xxx (mA) ±xx.xxx (V)
INPUT6 INPUT7
xx.xxx (mA) ±xx.xxx (V)
`Test Another Module??` **`NO/YES`**	

`Run Analog Output Test??` **`NO/YES`**
`Test Module` **`0/1/2/3/4/5/6/7`**
`This Module is NOT CONFIGURED!`
`This is an INPUT Module!`
`This is an DISCRETE OUTPUT Module!`
`This Module type is UNSUPPORTED!`
`Test Output 0/1/2/3`
`??Output # value (4-20mA):  xx.xxx`
`??Output # value (0-10V):   xx.xxx`
`??Output # value (+/-10V): ±xx.xxx`
`Test Another Output??` **`NO/YES`**
`Test Another Module??` **`NO/YES`**	

IMC-S/23x Servo Setup Menu Reference		
Prompt		*Data*
Select: **AXIS #/IMAGINARY/VIRTUAL AXIS #** This Axis Is NOT a SERVO Axis! This Axis is NOT CONFIGURED! Another Axis?? **NO/YES**		
Tune Servo Parameters?? **NO/YES**		
Tuning Direction?? **POSITIVE/NEGATIVE**		
Max Tuning Travel (Position Units) =	____________	D52
Tuning Speed (Position Units/Sec) =	____________	D86
Tuning Output Limit (% of Max) =	____________	D87
Ready?? **NO/YES** Tuning. . . . ***Aborted by Escape! ***Safe Travel Limit Exceeded: ***Travel Limit Too Small! ***Encoder Fault! ***Hit Hardware Overtravel Limit! ***Pos Error Tolerance Exceeded! ***Drive Fault Detected! ***Did Not Reach Tuning Speed: ***Try Again with Lower Tuning Speed ***or Higher Max Travel/Torque Limit! ***Insufficient Travel for Tuning: ***Try Again with Lower Max Output ***or Higher Max Travel Limit! ***Gains Not Tuned! Tuning Complete!		
Damping Factor: 0.8	____________	D84
Velocity Bandwidth (Hz) =		
Position Bandwidth (Hz) =	____________	D83
Use Position Error Integrator?? **NO/YES** Use Velocity Feedforward?? **NO/YES**		
Gains Computed! Feedback On!		D0-3, D15, D19-21
Review Servo Parameters?? **NO/YES** Feedback Off!		
P Gain (1/mSec) =	____________	D0
I Gain (1/mSec2) =	____________	D1
V Gain (mV/KCPS) =	____________	D3
F Gain =	____________	D2
Deadband Comp (Volts) =	____________	D4
Drive Offset Comp (Volts) =	____________	D7
Max Velocity (Position Units/Sec) =	____________	D19
Max Accel (Position Units/Sec2) =	____________	D20
Max Decel (Position Units/Sec2) =	____________	D21
Pos Error Tol (Position Units) =	____________	D15
Another Axis?? **NO/YES**		

Chapter 6

Setting Up Your IMC-S/23x Using GML

Chapter Objectives

This chapter provides you with the information to set up and tune the IMC-S/23x System. This chapter includes:

- General startup precautions
- Setup and tuning procedures for the IMC-S/23x

Before you begin the setup procedures, be sure to read and understand the information in the previous chapters of this manual.

Note: The procedures in this chapter do not include information regarding integration with other products.

General Startup Precautions

The following precautions pertain to all of the procedures in this chapter. Be sure to read and thoroughly understand them before proceeding.

ATTENTION: You need to apply power to the Compact to perform many of the adjustments specified in this chapter. Voltages on the connection can be 90-132 or 175-264V AC. Refer to *Connect the AC Power* for more information. To avoid injury to personnel and/or damage to equipment, you should only perform these startup procedures if you are a qualified service person. Thoroughly read and understand the procedure before beginning. If an expected event does not occur while performing this procedure, do not proceed. Remove power by opening the branch circuit disconnect device and correct the malfunction before continuing.

ATTENTION: This controller contains ESD (Electrostatic Discharge) sensitive parts and assemblies. You are required to follow static control precautions when you install, test, service, or repair this assembly. If you do not follow ESD control procedures, components can be damaged. If you are not familiar with static control procedures, refer to Allen-Bradley publication 8000-4.5.2, Guarding Against Electrostatic Damage or any other applicable ESD Protection Handbook.

Setting Up Your Compact

This section provides the following to help you set up and tune the Compact:

- What you need to have before you begin
- Setup procedures

Before You Begin

Before you begin the startup procedure be sure to have the following:

- A computer running windows and GML V3.7.0 or later
- A nine-pin serial cable to connect the computer to the Compact serial port A
- A GML V3.7.0 Programming Manual (P/N 999-104) or later (optional)
- A voltmeter
- A standard screwdriver

Preparing the System

Before you start your system, there are some switches you need to be aware of:

To:	Do this:
Be able to save setup menus	Set the *Memory* keyswitch to the unlock position.
Set the remote node if you are using AxisLink or multi-drop functions	Use the *Address* switch to set a unique address for each Compact connected. The addresses can be set in any order. Refer to Mechanical Specifications for location.
Reset critical controller parameters to their factory default value if the Compact does not communicate properly during power-up	Hold down the *Init* switch while you power up the system. Release after power-up sequence is complete. System OK light should be steady green.
Reset the system	Press the *Reset* switch.

Getting Started

You will use GML to start the Compact. Refer to the *GML Programming Manual* (Publication 999-104) for more detailed information on using GML.

To start GML for your system:

1. Connect the serial cable from the programming terminal to serial port A on the controller.
2. Start GML for Windows.
3. At the New Diagram window, select **File** from the menu bar. The File menu appears.
4. Select **Close**. The New Diagram window closes and the GML window appears.

Defining Preferences

To define preferences for your system:

1. Select **File** from the menu bar. The File menu appears.
2. Select **Preferences**. The Preferences window appears.
3. In the *Control Family* area, select **IMC S Control Family**.
4. In the *Serial Interface* area, set the correct baud rate and port.

   Note: GML and the IMC S Class have a default baud rate of 9600.

5. Review the other preferences and make changes, as needed, for the configuration you want.
6.

To save these preferences for:	Do this:
This and future sessions of GML	Click on **Save**.
This session of GML only	Click on **OK**.

7. Select **File** from the menu bar. The File menu appears.
8. Select **New Diagram**. a new diagram window appears.

Defining Your Controller and Its Options

To define your controller and the options that you will use with it:

1. Select **Definitions** from the menu bar. The Definitions menu appears.
2. Select **Control Options**. The IMC S/200 Options window appears.
3. In the *Control type* area, select **IMCS (2 or 4 axes)**. A dot appears in the radio button in front of the text.
4. In the *iCODE Version* box, select the iCODE firmware version and hardware configuration of your control.

   Note: You can find the ICODE firmware version using the Online Manager. Refer to *Establishing Communication* for more information.
5. Select any options (e.g., RIO, AxisLink, DH-485) that you will use.
6. Select **Axis/Drive Data Downloads**. An X appears in the box in front of the text. This allows the Axis Use setups to be downloaded with the diagram.
7. Click on **Save**. The information is saved and the Diagram window appears.
8. Select **File** from the menu bar. The **File** menu appears.
9. Select **Save As**. The GML:Save As windowSave As windowSave As window appears.
10. Type the name that you want to assign to this file and click on **OK**. The Diagram window appears with name you just assigned to this file as the title.

Defining Your Axes

To define your axes:

1. Select **Definitions** from the menu bar. The Definitions menu appears.
2. Select **Axis Use**. The Axis Configuration window appears.
3. Select an axis. A checkmark appears in front of the selected axis and the Edit button is enabled.
4. Select **Edit**. The AXIS*X* (where *X* is the number of the selected axis) window appears.
5. Set the appropriate parameters for the axis.

   For most applications, you need to enter information in the following fields:

- Axis name
- Axis use
- Transducer type

Note: The GML diagram will configure the control with two or four axes. If you are going to use fewer than the selection, disable the axes that you will not use using Axis use on the Definitions menu.

For most applications, you need to enter information in the following fields in the Configure area of the window:

For:	**Refer to the Following Sections in Chapter 5:**
Position Units	*Machine Setup Menu.*
Positioning	*Move and Jog Profiles.*
Servo	*Editing the Servo Configuration.*
Homing	*Editing the Homing Configuration.*
Overtravel	*Editing the Overtravel Configuration.*
Fault Action	*Editing the Axis Fault Action Configuration.*

6. Click on Save. The information is saved and the Axis Configuration window appears.
7.

If you:	**Do this:**
Have more axes to define	Go to step 3.
Have defined all of your axes	Click on **Done**. The Diagram window appears.

Note: Refer to *The Definitions Menu* chapter of the *GML Programming Manual* for the remaining definitions. The iCODE version must be defined before you can download a program.

Applying Power

This procedure assumes that you have wired your Compact, verified the wiring, and are ready to download your program.

1. Apply 120 or 230V AC input power and 24V DC control power to the Compact.

2.

If the System OK LED:	**Then:**
Is steady green	You have successfully applied power.
Does not illuminate	You may have a wiring problem. Go to the *Troubleshooting* chapter.

When you apply power to the motion controller, the hardware and software are initialized. Refer to the *GML Programming Manual* (publication 999-104) for a listing of the initialized values.

Establishing Communication

When the System OK LED is a steady green, you are ready to establish communication.

To establish communication:

1. Select **Diagram** from the menu bar. The Diagram menu appears.

2. Select **Online**. The GML Online Manager, which allows communication with the motion controller is loaded and the Online Manager window appears.

Note: The control's firmware revision number appears in the Online Manager window.

Note: If you click your mouse on the diagram, the Online Manager window disappears behind the diagram. To view the Online Manager window again, either re-size the diagram to view both, or select Online from the Diagram menu.

Downloading Your Diagram

Note: If you do not yet have a GML diagram, you can connect the start and end blocks to create a test diagram.

To download your diagram:

1. In the Online Manager window, select **Download Diagram**. The null diagram is downloaded.
2. In the Online Manager window, select the **Enter Setups**. The Do Setups window appears.

   Note: These setups are commonly referred to as Online Setups.
3. Select an axis.
4. Go to *Testing Motor Connections and Defining Direction*.

Testing Motor Connections and Defining Direction

To test motor connections and define direction of movement:

1. Select **Motor/Encoder Test**.
2. Select **Execute**. The GML Response window appears.
3. Type the maximum motor rotation that your application will use for this axis.

   Note: The motor moves according to the user units assigned when you defined your axis.
4. Click on **OK**. The GML Info window appears, which describes the control's actions. A second GML Info window appears with the following warning:

   Motion starts upon OK.
5. Select OK and observe the direction of the motion.

6.

If the motor rotates in a direction that you want to be perceived as:	Do this:
Positive	Click on **Yes**. The Do Setup window appears.
Negative	Click on **No**. The Do Setup window appears.

7. Go to *Testing the Encoder Marker.*

Testing the Encoder Marker

To test the encoder marker:

1. Select **Marker Input Test**.
2. Select **Execute**. The GML Info window appears.
3. Move your axis slightly more than one revolution.
4. Click on **OK**. A GML Info window appears with the message "Marker OK."

   Note: If the message is not Marker OK, check the feedback device and wiring and try again.
5. Click on **OK**. The Do Setups window appears.
6. Go to *Tuning a Velocity Loop*.

Tuning a Velocity Loop

If the servo is configured as velocity loop operation, an extra set of tests is available to allow easy setup of the drive. To tune a velocity loop:

1. Select **Drive Offset Tuning**.
2. Select **Execute**. The GML Info window appears.
3. Follow the instructions in the window.
4. Select **OK**. The GML Info window appears showing the status of offset compensation.
5. Select **OK**.
6. Select **Battery Box Test**.
7. Select **Execute**. The Digital Battery Box Test window appears.
8. Select **Pulse Magnitude**.
9. Select **Duration**.
10. Select **Type**.

11. Select **Start**. The GML Info window appears showing velocity and overshoot.

12. When drive adjustments are complete, select **Abort**.

13. Go to *Tuning Servo Parameters*.

Tuning Servo Parameters

To tune servo parameters:

1. Select **Tune Servo Params**.

2. Select **Execute**. The Motion Parameters window appears.

Note: In most cases, the default values in this window will work very well, however, you can modify the values, as needed, for your application.

ATTENTION: Selecting Start at this point causes motion to occur.

---

3. Select **Start**. The Diagram window appears briefly, followed by the GML Info window which contains a "Servo Parameter Tuning Successful!" message. The axis rotates according to the auto tuning setups to determine maximum velocity/acceleration/ deceleration and gains.

Note: If a message other than this appears, repeat these steps adjusting the parameters in the Motion Parameters window as needed.

4. Click **OK**. The Do Setups window appears.

Note: To see your setups before you save them, select Dynamic Gains Edit or Dynamic Vel/Acc/Dec Edit in the Do Setups window.

5.

If you have:	**Do this:**
More axes to define	Select another axis. Go to *Testing motor connections and Defining Direction*.
Defined all of your axes	Go to *Saving Your Parameters*.

Important: If you do not save your parameters, you will lose all of the information you just set up.

Saving Your Parameters

To save the parameters you have just tested:

1. Click on **Tuning Complete, Save Data/Update Diagram**.
2. Select **Execute**. The controller uploads these setups and saves them in the diagram. The Diagram window appears briefly, followed by the Online Manager window.

   Note: To see the setups you've defined, select Axis Use from the Definitions menu.

Troubleshooting

Chapter Objectives

This chapter contains information that you need to:

- Understand how to detect a problem
- Replace modules
- Understand what LEDs mean
- Understand what faults mean

Understanding How to Detect a Problem

There are several ways to detect a problem with the IMC-S/23x:

- LEDs on the front panel
- Using GML

ATTENTION: You should only attempt the procedures in this chapter if you are qualified to do so and familiar with solid-state control equipment and the safety procedures in publication NFPA 70E.

ATTENTION: If you use an oscilloscope (or chart recorder) for troubleshooting, you must properly ground it. The oscilloscope chassis can be at a potentially fatal voltage if you do not properly ground it. Always connect the oscilloscope chassis to an earth ground.

This material, along with the diagnostic/troubleshooting information included with the position controller, will help you identify most common system malfunctions and determine which module that problem pertains to.

Replacing Modules

Use these procedures to:

- Determine what you need to replace modules
- Remove the main CPU module
- Install a replacement CPU module
- Remove a power supply module
- Install a replacement system module

ATTENTION: The Compact contains ESD (Electrostatic Discharge) sensitive parts and assemblies. You are required to follow static control precautions when you install, test, service, or repair this assembly. If you do not follow ESD control procedures, components can be damaged. If you are not familiar with static control procedures, refer to Allen-Bradley publication 8000-4.5.2, Guarding Against Electrostatic Damage or any other applicable ESD Protection Handbook.

Before You Begin

Before you replace modules, be sure to have the following:

- A phillips screw driver

Removing a CPU Module

To remove a CPU module:

1. Remove 24V control power and AC input power from the system.

ATTENTION: This system may have multiple sources of power. More than one disconnect switch may be required to de-energize the system. To avoid shock hazard or personal injury, assure that all power has been removed before proceeding.

2. Loosen the top and bottom screws on the front cover.
3. Remove all cables from the front panel.
4. Open the front cover.
5. Remove two phillips screws that retain the faceplate on the CPU module.
6. Using the card ejectors, remove the CPU module.

Installing a Replacement CPU Module

To install a replacement CPU module:

1. Configure switches as required. Refer to *Configuring the IMC-S/23x* for more information.
2. Slide the new CPU module into the chassis.
3. Press firmly into place making sure the tabs on the cover plate are touching the tabs on the chassis.
4. Install and tighten the two phillips screws ensuring that the ground lugs are under the screw heads.
5. Close the cover and reconnect all cables.
6. Reconnect 24V DC and AC power.

Removing a Power Supply Module

To remove a power supply module:

1. Remove 24V control power and AC input power from the system module.

ATTENTION: This system may have multiple sources of power. More than one disconnect switch may be required to de-energize the system. To avoid shock hazard or personal injury, assure that all power has been removed before proceeding.

ATTENTION: This product contains stored energy devices. To avoid hazard of electrical shock, verify that all voltage on the capacitors has been discharged before attempting to service, repair, or remove this unit. You should only attempt the procedures in this chapter if you are qualified to do so and familiar with solid-state control equipment and the safety procedures in publication NFPA 70E.

2. Loosen the top and bottom screws on the front cover.
3. Remove all cables from the front panel.
4. Open the front cover.
5. Remove the top and bottom phillips screws.

   Important: Do not loosen the two center screws.
6. Using the card ejectors, remove the power supply module.

Installing a Replacement Power Supply Module

To install a replacement power supply module:

1. Configure switches SW3, 4, and 5 as required. Refer to *Configuring the IMC-S/23x* for more information.
2. Slide the new power supply module into the chassis.
3. Press firmly into place making sure the retaining bar is seated against the tabs on the chassis.
4. Close the cover and reconnect all cables.
5. Reconnect 24V DC and AC power.

Understanding Status LEDs

Three general purpose status LEDs are provided on the front panel of the IMC-S/23x. These LEDs (status 0, 1, and 2) indicate the results of power-up diagnostics.

Table 7.A Status LEDs

For this LED:					
0	**1**	**2**	**Status of the LED:**	**Description:**	**Possible resolution:**
Off	Off	Off	Solid	Controller okay. No faults.	None.
On	Off	Off	Solid	Memory fault. Setup or program checksum error.	Note: This condition is normal after you change firmware or perform a hardware re-init. Download the GML diagram and the setups again and reset the controller.
On	On	Off	Solid	AxisLink initialization failure	Reset the control. If the problem persists, return to the factory for repair.
Off	Off	On	Solid	RIO interface initialization failure	Reset the control. If the problem persists, return to the factory for repair.
On	Off	On	Solid	Flex I/O initialization failure	Reset the control. If the problem persists, return to the factory for repair.
Off	On	On	Solid	Interrupt initialization failure	Reset the control. If the problem persists, return to the factory for repair.
On	On	On	Solid	Initialization failure	Reset the control. If the problem persists, return to the factory for repair.
On	Off	Off	Flashing fast*	Dram test #1 failed	Return to the factory for repair.
Off	On	Off	Flashing fast*	Dram test #2 failed	Return to the factory for repair.
On	On	Off	Flashing fast*	Dram test #3 failed	Return to the factory for repair.
Off	Off	On	Flashing fast*	Applications memory functionality test failed	Return to the factory for repair.
On	Off	On	Flashing fast*	Setup memory functionality test failed	Return to the factory for repair.
On	Off	Off	Flashing slow*	Serial port test failed	Return to the factory for repair.
Off	On	Off	Flashing slow*	Timer test failed	Return to the factory for repair.
On	On	Off	Flashing slow*	Initialization test failed	Return to the factory for repair.
Off	Off	On	Flashing slow*	Auxiliary I/O test failed	Return to the factory for repair.
On	Off	On	Flashing slow*	CXIC failed	Return to the factory for repair.
Off	On	On	Flashing slow*	DRAM test failed	Return to the factory for repair.
On	On	On	Flashing slow*	Transfer system failed	Return to the factory for repair.

* Flashing slow is twice per second, flashing fast is ten times per second.

Understanding the System OK LED

If the system passes its power-up diagnostics, all three status lights are off and the System OK LED (CPU Watchdog) is illuminated.

Understanding System Faults

System faults appear in GML in the Online Manager or Watch windows. Refer to the GML Programming Manual V3.8 or greater for additional fault information.

Finding Faults

To examine the fault status of the system, you can:

- View instantaneous status
- View constant status

Viewing Instantaneous Status

You can look at the status of a particular variable within GML at a particular point in time. To look at a status:

1. Open GML. The GML window appears.
2. Select **Diagram** from the menu bar. The Diagram menu appears.
3. Select **Online**. The Online Manager window appears.
4. In the *Axis* area, select the axis you want to see status on.
5. In the area above the *Axis* area, select the variable for which you want to see status.

   Note: For example, select the *Global Fault* variable to determine which system fault has occurred.
6. Select **Examine**. Information about that variable appears in the box on the bottom of the Online Manager window.

Viewing Continuous Status

When you use the Watch feature, a window appears within the Online Manager window showing the variables you selected. GML constantly updates the status of those variables as they change.

To view continuous status:

1. Open GML. The GML window appears.
2. Select **Definitions** from the menu bar. The Definitions menu appears.
3. Select **Watch Items**. The Watch Items window appears.
4. Select any variables that you want to watch from the *Defined Items* area and click on **Add**. Those items appear in the *Items to Watch* area.
5. Click on **Save**. The GML window appears.
6. Select **Diagram** from the menu bar. The Diagram menu appears.
7. Select **Online**. The Online Manager window appears.
8. On the top right of the window, select the **Watch**. A message box appears. The variables that you selected and their status appear in this window.

Refer to the *Expression Builder* chapter of the *GML Programming Manual V3.7* (or above) for a list of fault and status variables.

Troubleshooting General System Problems

The tables that follow provide potential conditions that could occur with your system and recommends possible resolutions to those conditions.

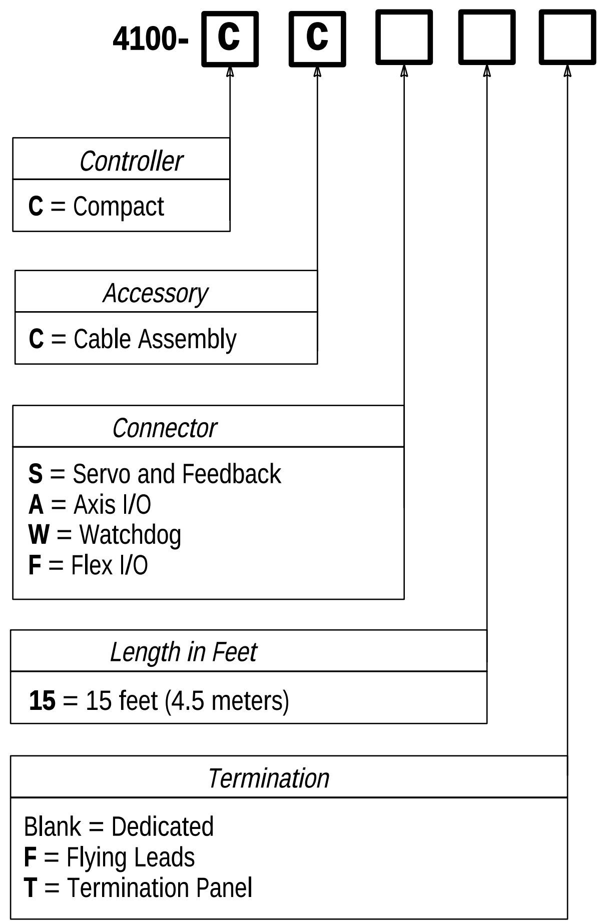
Table 7.B System Troubleshooting

Condition:	Potential cause:	Possible resolution:
Axis runs uncontrollably	The velocity feedback, position feedback device, or velocity command signal wiring is incorrect or open.	• Check wiring.
	Unintentionally in torque mode.	• Check to see what mode was programmed.
	An internal malfunction exists.	• Replace system or axis module.
Axis is unstable	[Prop Gain, Intg Gain, Feed Fwd Gain] are set too high.	• Run auto tune.
	Position loop gain or position controller accel/decel rate is improperly set.	• Run auto tune.
	Improper grounding or shielding techniques are causing noise to be transmitted into the position feedback or velocity command lines, causing erratic axis movement.	• Check wiring and ground.
You cannot obtain the motor acceleration/deceleration that you want	The system inertia is excessive.	• Check motor size vs. application need. • Review servo system sizing.
	The system friction torque is excessive.	• Check motor size vs. application need.
	Available current is insufficient to supply the correct accel/decel rate.	• Check motor size vs. application need. • Review servo system sizing.
Motor does not respond to a Velocity Command	Check for possible faults.	• Verify that the parameters are set correctly and correct them, as necessary.
	Enable signal has not been applied or the enable wiring is incorrect.	• Check the controller. • Check the wiring. • Check drive control.
	The motor wiring is open.	• Check the wiring.
	The motor thermal overload has tripped.	• Check for a fault. • Check the wiring.
	The motor has malfunctioned.	• Repair or replace the motor.
	The coupling between motor and machine has broken (i.e., the motor moves, but the load/machine doesnít).	• Check and correct the mechanics.
	[CW, CCW VEL Lim] parameters are set incorrectly.	• Check and properly set the parameter. • Retune.
	The drive has malfunctioned.	• Replace the drive.

Cable Information

Introduction

The IMC-S/23x uses pre-engineered cable assemblies for all connections to external devices. Cable assembly catalog numbers are constructed as shown below.



The currently available cable assemblies are shown in the table below.

IMC-S/23x Pre-Engineered Cable Assemblies

Catalog Number	*Used for...*	*Length*
4100-CCF1 or	Flex I/O	1 foot (0.3 m)
4100-CCF3	Flex I/O	3 feet (1 m)
4100-CCS15F	Servo and Feedback	15 feet (4.5 m)
4100-CCA15F	Axis I/O	15 feet (4.5 m)
4100-CCW15F	CPU Watchdog	15 feet (4.5 m)
4100-RCS3T	REC Interface	3 feet (1 m)
4100-CCAQB	Single Axis Connection to Allen-Bradley 1391	-

Each of these cable assemblies is fully described following.

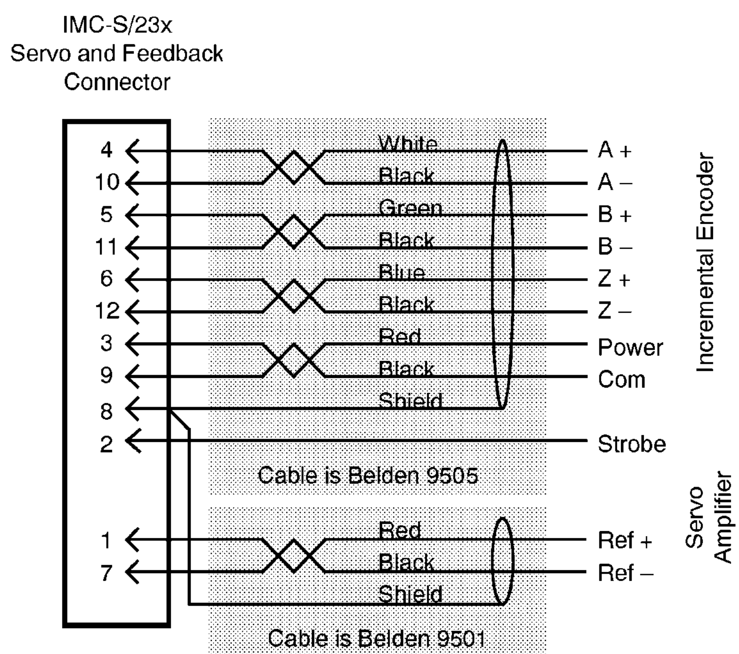
4100-CCF1 or 4100-CCF3

The 4100-CCF1 is a 1 foot (0.3 meter) long cable assembly for connecting the IMC S Class to Flex I/O. The 4100-CCF3 is a 3 foot (1 meter) long cable assembly for connecting the IMC S Class to Flex I/O. Both cables come pre-terminated at both ends with the appropriate connectors for the S Class Compact and Flex I/O. You only need one cable assembly (either a 4100-CCF1 or a 4100-CCF3) for each IMC S Class Compact that uses Flex I/O.

4100-CCS15F

The 4100-CCS15F is a 15 foot (4.5 meter) long cable assembly with flying leads which connects the IMC S Class Compact to a single axis of encoder feedback and servo drive command. Each 4100-CCS15F cable assembly provides connections for one axis-use multiple cable assemblies for multiple axes.

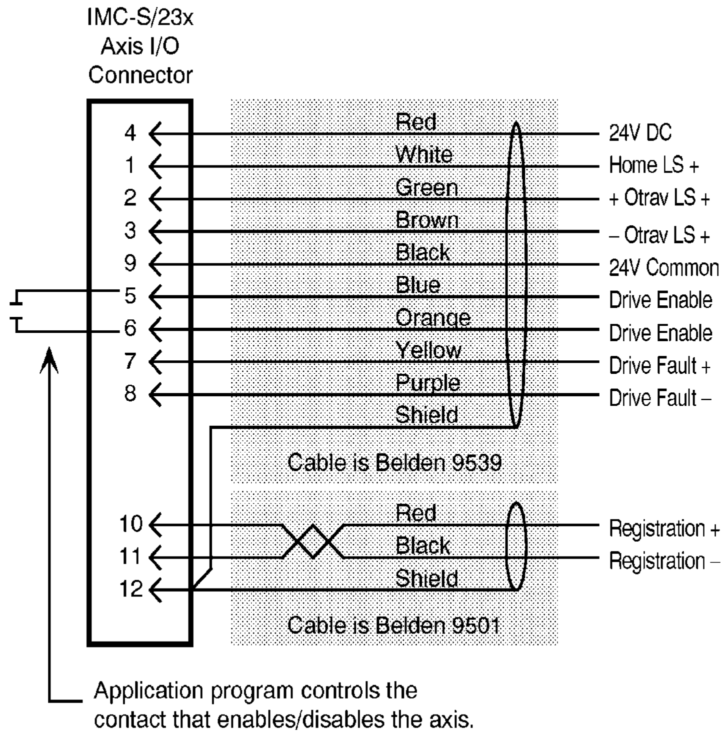
A schematic of the 4100-CCS15F cable assembly is shown below.



4100-CCA15F

The 4100-CCA15F is a 15 foot (4.5 meter) long cable assembly with flying leads which connects the IMC S Class Compact to a single axis of dedicated discrete I/O. Each 4100-CCA15F cable assembly provides connections for one axis-use multiple cable assemblies for multiple axes.

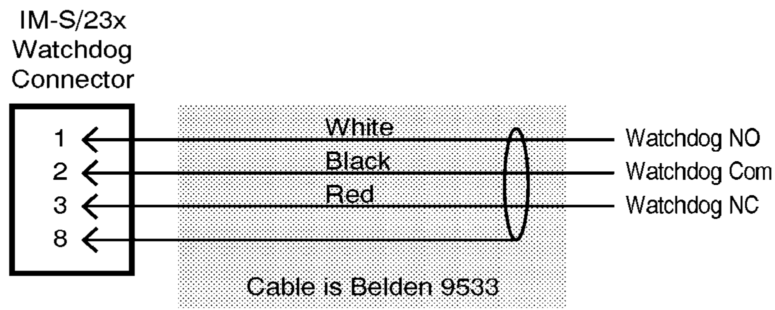
A schematic of the 4100-CCA15F cable assembly is shown below.



4100-CCW15F

The 4100-CCW15F is a 15 foot (4.5 meter) long cable assembly with flying leads which provides connections for the IMC S Class CPU Watchdog relay contacts. One 4100-CCW15F cable assembly is required for each IMC S Class Compact.

A schematic of the 4100-CCW15F cable assembly is shown below.



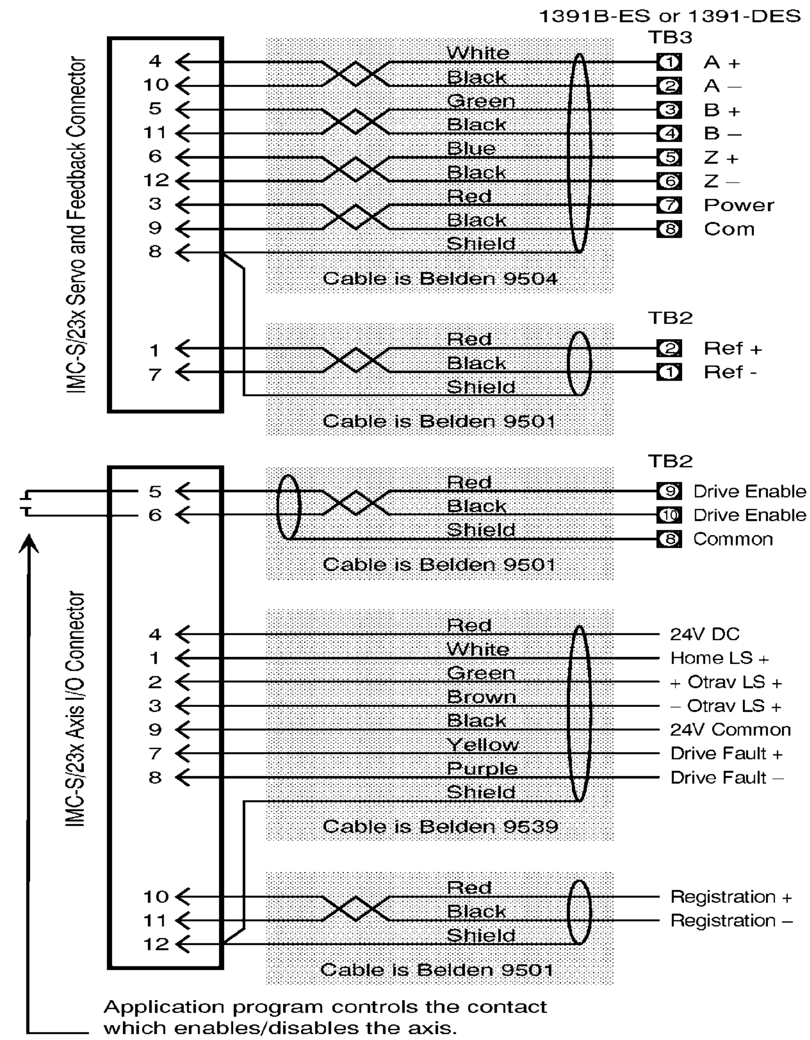
4100-RCS3T

The 4100-RCS3T is a 3 ft (0.9 m) cable assembly that connects the 4100-REC (resolver to encoder converter module) to a single axis of encoder feedback on the IMC S/23x. Refer to the 4100-REC *Installation and Setup Manual* (publication number 999-126) for more information.

4100-CCAQB

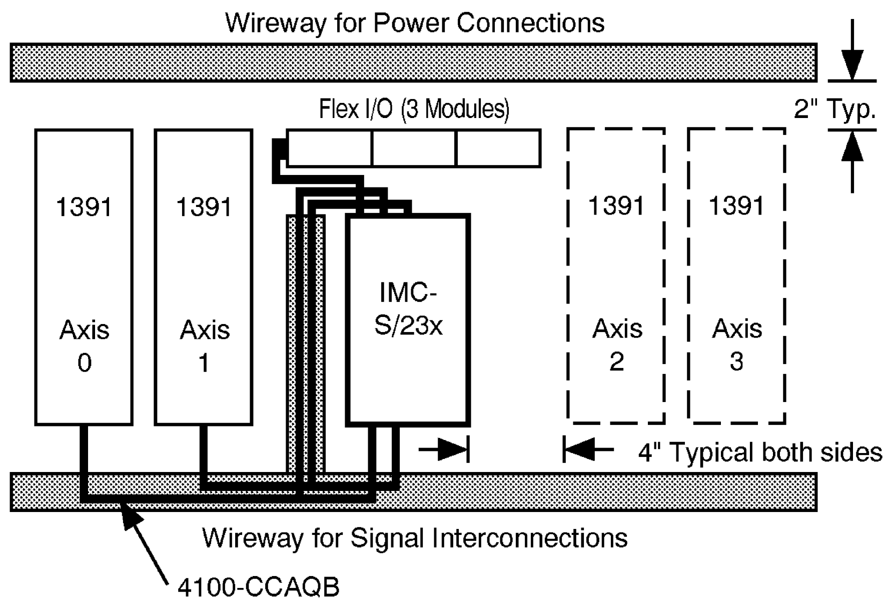
The 4100-CCAQB is a complete, ready-to-install cable assembly for connecting one IMC S Class compact axis to a single 1391B-ES or 1391-DES servo drive", "Servo Amplifiers">. Both ends of the cable assembly are terminated in the appropriate mating connectors for the motion controller and the servo drive.

A schematic of the 4100-CCAQB cable assembly is shown below.



Connections for home and overtravel limit switches, drive fault contacts, and the registration sensor are flying leads for connection to a user-supplied terminal block. 15 feet (4.5 m) of cable is provided for these connections.

The 4100-CCAQB cable assembly is designed to be used with the panel layout shown below. Be sure to keep the power and signal wires segregated in separate wireways for maximum noise immunity.



The length of the 4100-CCAQB cable assembly is sufficient for all axes when this panel layout is used. See Installation and Hookup earlier in this manual for more information.

If your servo drives are *not* mounted according to the recommended panel layout, use the 4100-CCSxxF and 4100-CCAxxF cable assemblies discussed previously to connect the drives.

Symbols

A

B

C

D

E

F

G

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Publication 999-122 – January 1997

Supersedes Publication 999-122 - August 1995