Installation Instructions

Blow-molding Module

(catalog number 1746-BLM)

Before you begin

Use this document as a guide to installing and powering-up your Blow-molding Module. We assume that you are already familiar with the SLC 500™ family of Small Logic Controllers and associated I/O modules.

Tools that you need

- 1/8” slotted screwdriver

Handling the Module

Take these precautions to guard against ESD damage:

ATTENTION

Electrostatic discharge can damage the module. Follow these guidelines:

- touch a grounded object to discharge potential static
- wear an approved grounding wriststrap
- do not touch circuit components inside the module
- if available, use a static-safe work station
- when not in use, store the module in its anti-static bag.

WARNING

Do not insert or remove this module while backplane power is on. An electrical arc may occur that can cause an explosion in a hazardous environment and/or cause damage to the module or degrade its performance.

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 a hazard
- recognize the consequences

IMPORTANT

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

Recommendation for using associated software

To program the SLC processor to interface the module with molding machine operation, your PC should be equipped with programming software RSLogix 500™ from Rockwell Software. For instructions on using the software, refer to the documentation that accompanied it.

What you need to do to set up and operate the module?

This document covers a description of the module and its operation, wiring and configuring the module, writing ladder logic and using associated data files, calibrating, tuning, troubleshooting, and specifications.

Step: 1 Module description

We cover these aspects of module description:

- features
- overview
- communication with SLC processor
- internal microprocessor
- internal PID control algorithm
- analog I/O
- digital I/O

Features

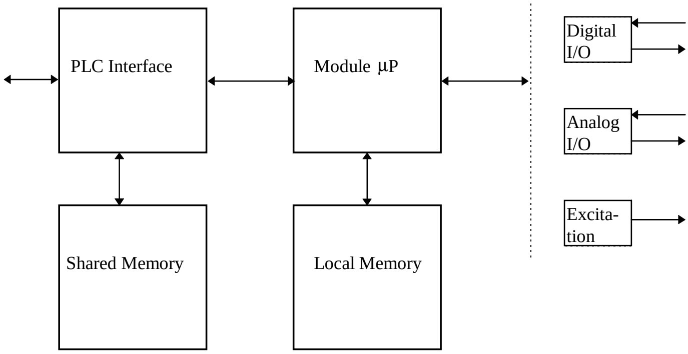
This 4-axis position-control module has these features:

- Open-loop or closed-loop control
- Independent and coordinated axis control
- Position- and time-based control
- Accumulator push-out control
- Zero-scale/full-scale (offset & span) calibration for position inputs
- PID with anti-windup, bumpless parameter changes, setpoint weighting, and limited high-frequency derivative gain.
- Profile interpolation (linear or cubic spline) between setpoints
- Converging/diverging tooling (direct/reverse acting control)
- Three hold values per axis: manual position, purge, or die gap
- Independent profile scale and offset adjustments
- Automatic parison weight adjustment
- Setpoint marking

Overview

The module performs its servo control task independently, but is dependent on the SLC processor for all of its configuration and run-time information. The processor may be also be used to supply process data or timing information over the backplane in certain situations (e.g. parison drop synchronization on continuous extrusion machines, or accumulator position in reciprocating screw machines).

The module uses a digital signal processor running a Proportional-Integral-Derivative (PID) algorithm to control four axes of motion. Four analog inputs and four analog outputs are used for process variables and signals, while four digital inputs and four digital outputs are used for start-of-drop synchronization and profile step synchronization signals, respectively. An excitation voltage is provided for use with linear potentiometers.



Communication with the SLC Processor

- shared memory
- control bit/status bit handshake
- micro processor
- PID control algorithm
- digital I/O
- analog I/O

Shared memory

From the ladder programmer's perspective, communication with the module is via five data files located in shared memory on the module:

Config(G) File contains information regarding the operational mode and feature settings of the module. You specify the contents of this file with the ladder logic programming utility (RSLogix500). Entries in the file are static and read-only from the module's perspective (e.g. time vs. position based operation). This file is automatically downloaded to the module when you switch the SLC processor to Run mode.

Output File contains 32 16-bit entries used by ladder program to command module operation. The Output File may also be used to supply process data to the module in certain situations. Entries in this file are updated automatically, at the end of each scan, by the SLC processor from the user data file but may be written at any time by immediate I/O instructions in the ladder program.

Input File contains 32 16-bit entries used by ladder program to extract status information from the module. The Input File contains acknowledge bits corresponding to control bits in the Output File, as well as information pertaining to the profile executing on each analog I/O channel (step number, setpoint, analog input, process variable, control output, etc.) and a parameter error flag. The entries in this file are read automatically, once per scan, by the SLC processor into the user data file, but may be read at any time by immediate I/O instructions in ladder program.

M0 File contains four axis control structures and five setpoint profiles. Each axis has a variety of PID and profiling options, controlled by its axis control structure. Each axis also has a unique 256-point setpoint profile. A single master setpoint profile is used with an “interpolate” command to ease the task of generating setpoint profiles.

Entries in the M0 File are written by move or copy instructions in ladder program. Unlike changes made to the Output File, which are automatically detected by the module, the module must be explicitly instructed to download axis-control structures and setpoint profiles from shared memory (done by setting bits in the Output File).

M1 File contains four axis-status structures, four process-variable profiles, and a single interpolated profile. Axis-status structures are copies of respective axis-control structures, except that status information has been inserted by the module. Each process-variable profile provides a record of the actual position response to a setpoint profile. The interpolated profile is the result of either a linear or natural cubic-spline interpolation performed between the setpoints specified in the master setpoint profile.

Unlike the Input File, which is automatically updated, the module must be explicitly instructed to upload axis-status structures, process variable profiles, and the interpolated profile to shared memory (done by setting bits in the Output File). Entries in this file are then read by move or copy instructions in ladder program.

Handshake with control and status bits

To ease the task of synchronizing module operations with your ladder program, all control bits in the Output File have a corresponding status bit in the Input File. Upon detecting a change in a control bit from zero to one, the module performs any associated processing and then acknowledges completion by setting the corresponding status bit to one. The status bit will remain set as long as the control bit remains set. When the control bit is cleared, the status bit will be cleared immediately in acknowledgment.

Exceptions to this protocol are the profile enable control/status bits and the control/status bits for the digital inputs and digital outputs. See step 9 for complete descriptions of these and other bits.

Module's microprocessor

The module processor is a 16-bit fixed-point digital signal processor (DSP). It communicates with the analog I/O channels over a high speed (2MHz) full-duplex synchronous serial link. Serial connection between the processor and analog I/O hardware facilitates electrical isolation. Digital I/O is performed in a similar fashion.

The module processor manages all communications between the module and the SLC processor. It performs such functions as interpolation between profile setpoints, loop tuning, and calculation of calibration coefficients in addition to executing the control algorithm.

Module's PID control algorithm

For servo control, the module uses a Proportional + Integral + Derivative algorithm with anti-windup, high-frequency derivative gain limiting and setpoint weighting. Anti-windup is achieved by modeling the actuator (normally a valve amplifier) as a nonlinear device that operates linearly over a limited range, beyond which it saturates.

An additional error signal is formed by taking the difference of raw controller output, v(n), and control output, u(n), which is clamped at the actuator saturation limits. This signal is multiplied by gain 1/Tt, where Tt is called the integrator tracking time and summed into the integral term. High-frequency derivative gain limiting lets you compensate for derivative term susceptibility to high frequency noise. Setpoint weighting provides a mechanism for independent tuning of setpoint and load response.

Digital I/O

There are four fully isolated digital inputs on the module. They are of the current-sinking type. Their primary use is for start-of-parison-drop synchronization on continuous extrusion machines. The digital inputs may be used as general purpose inputs if the start of drop synchronization feature is not needed.

There are four isolated digital outputs on the module. They are of the open-collector (current-sinking) type and share a common 24VDC (nominal) external power supply. Their primary use is as profile step-synchronization indicators. The digital outputs may be used as general purpose outputs if the step synchronization feature is not needed. See page 41 for complete specifications.

Analog I/O

There are four analog I/O channels on the module. Each channel consists of a 14-bit analog-to-digital converter and a 14-bit digital to analog converter. As a group, the four I/O channels and excitation output are optically isolated from the remainder of the module. The high common mode input range of the input amplifiers and the isolated nature of LVDTs and linear potentiometers make it unnecessary to isolate the channels from one another. See page 41 for complete specifications.

Step: 2 Machine applications of the module

Each module can control up to four axes of closed-loop position control on most types of blow-molding machines. Configurations include:

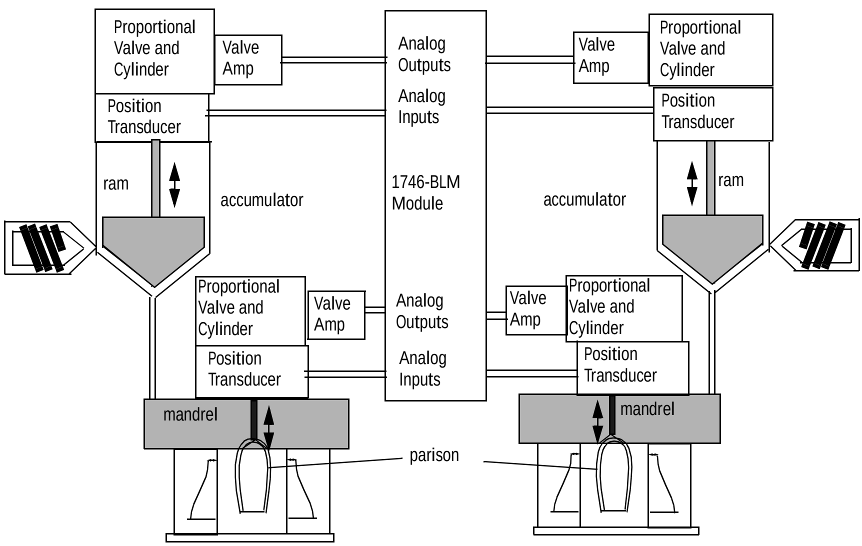
- accumulator push-out control and three parison axes
- two accumulator push-outs and two parison axes

You can use multiple modules on machines with more than four heads.

Control of Accumulator Head Machines

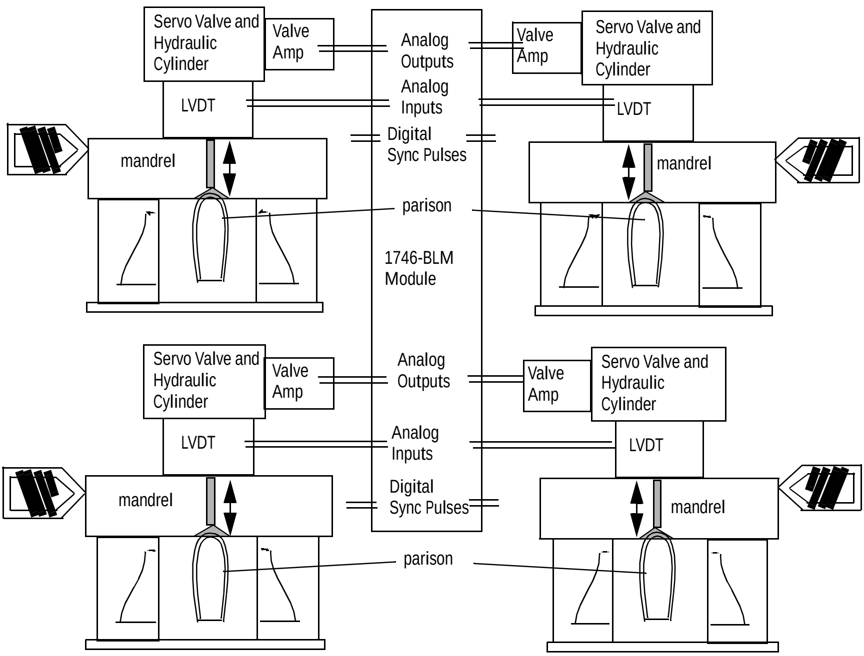
The module controls parison wall thickness on accumulator machines by following a setpoint profile of wall thickness vs. accumulator ram position. In this configuration, the module is capable of controlling up to three blow molding heads. One analog I/O channel is used for accumulator ram velocity control while the others are used for mandrel position control.

Optionally the module may simply monitor ram position. Mandrel position and accumulator ram velocity are normally both specified as a function of accumulator ram position. Since the module supports a mixture of time- and position-based modes, you may also specify accumulator position as a function of time.



Control of Continuous Extrusion Machines

The module controls parison wall thickness on continuous extrusion machines by following a setpoint profile of wall thickness vs. time. The module is capable of controlling up to four blow molding heads in this mode. Each of the module's four analog I/O channels is used for mandrel position control. Mandrel position is a function of the elapsed time since the last synchronization signal, indicating start of parison drop.

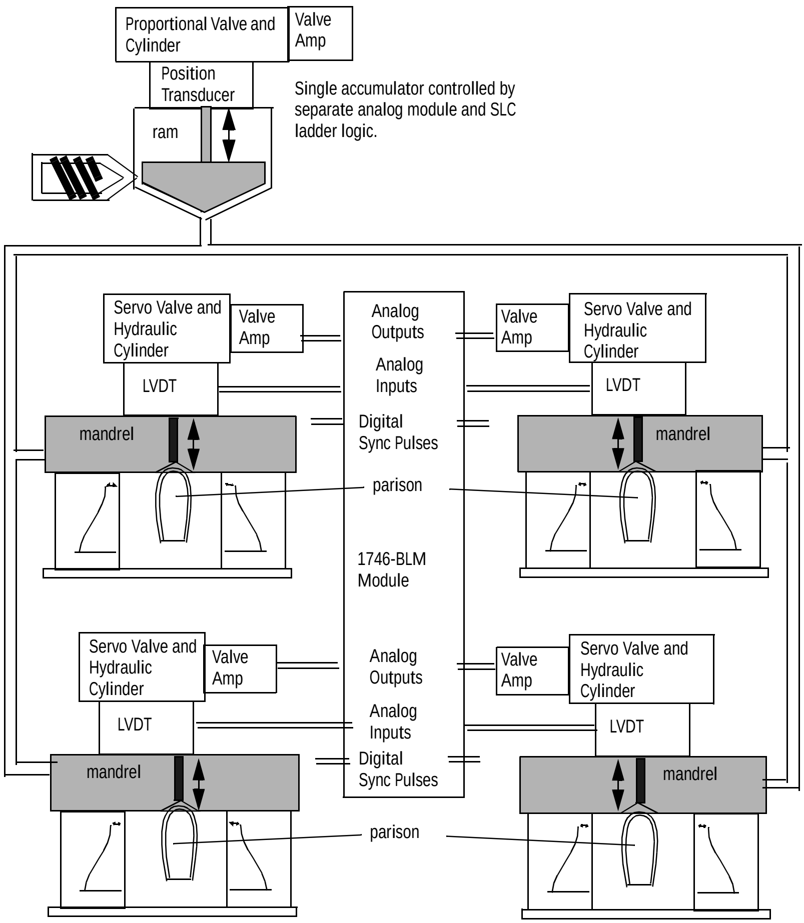


Control of Reciprocating Screw Machines

Reciprocating screw machines have multiple heads and a single accumulator. Control of accumulator position is performed by the SLC processor. The module may be used to monitor the accumulator (screw) position in either of two ways on this type of machine:

- **with an analog input to the module:** Each module configured in this manner can control three heads. This method offers optimal performance. However, hardware utilization may not be as high as the following method depending on the number of extrusion heads.

- **with a separate high speed analog module:** The SLC processor must read position information from an analog module and update the 1746-BLM. A selectable timed interrupt (STI) instruction can be used with a 4ms period and variability << 1ms (tested on a SLC5/04 CPU with no other interrupt sources). This is adequate for 256- setpoint profiles with drop times > 1 second (~4ms/setpoint). Drop times of less than one second necessitate monitoring accumulator position with the 1746-BLM. Avoid using other STI instructions with higher priority.


Proportional Valve and Cylinder
Valve Amp
Position Transducer
Single accumulator controlled by separate analog module and SLC ladder logic.
ram
Servo Valve and Hydraulic Cylinder
Valve Amp
LVDT
mandrel
Analog Outputs
Analog Inputs
Digital Sync Pulses
parison
1746-BLM Module
Servo Valve and Hydraulic Cylinder
Valve Amp
LVDT
mandrel
Analog Outputs
Analog Inputs
Digital Sync Pulses
parison

Step: 3 Module operation with an accumulator machine

Position-based Operation

In position-based mode, setpoint profiles are specified as a function of the position of a second, independent axis position. Here the independent axis corresponds to the accumulator ram position, while the dependent axis corresponds to mandrel position (or ram velocity).

Conceptually, the shot size of the independent axis is divided into 256 segments. When the accumulator ram position falls within the range of a particular segment, the number of that segment is used as an index into the setpoint profile to determine the current setpoint for the mandrel position (or ram velocity).

IMPORTANT Although you may specify profile sizes less than 256 in the config file, the module expands these to 256-point profiles after downloading from shared memory. Internally to the module, all profiles are 256 points in length. Similarly, process variable profiles are compressed from the module's 256-point internal representation to your desired profile size prior to uploading.

Controlling Mandrel Position

Static control: Mandrel position may be controlled statically by means of the three axis-hold values and corresponding hold-value control bits accessible via the module output file. The hold values are prioritized with hold value #0 being highest priority and hold value #2 being lowest.

In absence of an active profile, the highest priority enabled hold value becomes the position setpoint. By convention, the fully-closed mandrel position is the zero-scale calibration point, while the fully-open mandrel position is the full-scale calibration point.

Dynamic control: Mandrel position may be controlled dynamically by downloading a setpoint profile to the module's M0 file and setting the profile enable bit. Then, upon detecting the independent axis position at shot size, the module will automatically update the mandrel position once per millisecond through the last profile setpoint.

The last setpoint is maintained until *all* of the following are complete:

- profile enable bit is cleared
- independent axis is again at shot size
- profile enable bit is set again, which starts the next profile

Monitoring Mandrel Position

Instantaneous mandrel position may be monitored by reading the current process variable from the module's input file. Several other values of interest are also available for each axis (e.g. control output, profile step, etc.). Process variable profiles may be read from the module's M1 file.

Controlling Ram Velocity

Accumulator ram velocity is controlled in position-based mode by specifying ram velocity as a function of ram position. As with mandrels, rams are calibrated for zero-scale and full-scale positions. Velocity is then expressed as velocity = change of position/millisecond. By convention, the fully-forward ram position is the zero-scale calibration point, while the fully-retracted ram position is the full-scale calibration point. This implies that negative velocities result in moving the ram forward.

Velocity can be controlled in either open loop or closed loop. You select closed-loop velocity control by setting the appropriate axis' velocity-control bit in the module output file. Since hydraulic valves generally provide a constant hydraulic flow with a constant command input, setpoints in open-loop mode inherently specify velocity. Once closed-loop velocity control is enabled, hold value #2 is interpreted as shotsize, and the axis' step synchronization output is enabled as an at-shotsize indicator.

Operation by Controlling Ram Velocity

Normally, ram velocity is controlled in closed loop using a single module analog I/O pair. A velocity profile (as opposed to a position profile) is necessary since the independent axis is the ram position. The remaining three analog I/O pairs are available for controlling machine heads.

Operation by Monitoring Ram Velocity

This mode of operation is identical to operation with ram velocity control, except ram position is monitored only (a velocity profile for the ram is not used). You can control up to three machine heads per 1746-BLM. The resulting unused analog output is available for general (open-loop) use.

Operation with an Auxiliary Position Input

This mode of operation lets you control four machine heads per 1746-BLM. Your ladder program is responsible for calibration and scaling of process variable data sent to the module via the output file. A value of -32768 corresponds to the fully-forward ram position and +32767 corresponds to the at-shotsize ram position. See page 12 for additional information on controlling with a separate, high-speed analog module.

Step: 4 Module operation with a continuous extrusion machine

Time-based Operation

In time-based mode, setpoint profiles are specified as a function of the elapsed time starting with the leading edge of the start-of-drop synchronization signal. Profile duration may be held constant or derived from the time between previous sync pulses. In either case, profile duration is divided into 256 segments.

When the elapsed time since the start of drop falls within the range of a particular segment, the number of that segment is used as an index into the setpoint profile to determine the current setpoint for the mandrel position. Should a new start-of-drop synchronization pulse occur prior to completion of a profile in progress, a new profile will be started. If the profile duration expires without receiving a synchronization pulse, the last profile setpoint will be maintained indefinitely.

TIP

Although you may specify profile sizes less than 256 in the config file, the module expands these to 256-point profiles after a download. Internally to the module, all profiles are 256 points in length. Similarly, process variable profiles are compressed from the module's 256-point internal representation to your desired profile size prior to an upload.

Controlling Mandrel Position

Static Control: Mandrel position may be controlled statically with three axis-hold values and corresponding hold-value control bits accessible via the module output file. Hold values are prioritized with hold value #0 being highest, and hold value #2 being lowest. In *time-based* mode the hold values have no special interpretation. In absence of an active profile, the highest priority enabled hold value becomes the position setpoint.

Dynamic control: Mandrel position may be controlled dynamically by downloading a setpoint profile to the module’s M0 file and setting the profile enable bit. Then, upon receipt of an axis sync input signal, the module will automatically update the mandrel position setpoint every millisecond until the profile duration has expired or a new synchronization pulse is received.

Monitoring Mandrel Position

Instantaneous mandrel position may be monitored by reading the current process variable from the module’s input file. Several other values are also available for each axis (e.g. control output, profile step, etc.). Process variable profiles may be read from the module’s M1 file.

Generating a Synchronization Signal

The module examines its digital inputs once every millisecond, so the minimum pulse width (high or low) for external synchronization inputs is also one millisecond. The module may also be configured via the G file to accept synchronization inputs via its input file.

Modes of time-based operation

Fixed profile timing: For fixed profile times, the profile-time filter constant should be set to zero. This way, the default profile time is used as the profile duration for every profile, regardless of sync input pulse period.

Variable profile timing: The module may also be programmed to adapt to the machine cycle time by setting the profile-time filter constant to values other than zero. The programmed value enables a digital lowpass filter on the profile time sequence. This has an effect similar to averaging previous profile times. Larger filter time constants result in more filtering.

Step: 5 Determining an axis setpoint

All position setpoints and process variables are represented in the SLC500 16-bit signed integer format, where the minimum value of -32768 corresponds to zero-scale (fully-closed or fully-forward) and the maximum value of +32767 corresponds to full-scale (fully-open or fully-retracted).

The setpoint for a machine axis comes from one of four prioritized sources: an active profile or one of three hold values. When enabled, the profile setpoint is highest priority. In absence of an active profile, hold values 0, 1 and 2 are applied in order of decreasing priority, with value 0 having the highest priority.

The tooling position for hold values is a function of the user setpoint and calibration data. Profile setpoints may be affected by three other factors:

- offset adjustment from the axis control structure
- scale factor from the axis control structure
- offset resulting from a comparison of the current profiles mean value with that of a previous profile

The offset and scale adjustments are provided to let you manipulate the weight of a profile without individually changing each setpoint in the original profile and re-downloading. The mean value comparison is done as part of an “automatic weight control” feature.

When the weight control bit in the output file is set, the current profile mean value is calculated. Subsequent profiles are then offset to achieve this same mean value. This maintains a constant part weight. Note that all such modifications to profile setpoints are performed immediately after a profile is downloaded. To modify a profile iteratively, you must repeatedly set the control bit that downloads the setpoint profile.

Step: 6 Wiring the module

WARNING

When you insert or remove the module while the backplane power is on, or you connect or disconnect the RTB with field side power applied, an electrical arc can occur. This could cause an explosion in hazardous location installations.

Be sure that power is removed or the area is nonhazardous before proceeding. Repeated electrical arcing causes wear to contacts on both the module and its mating connector. Worn contacts may create electrical resistance that can affect module operation.

ATTENTION

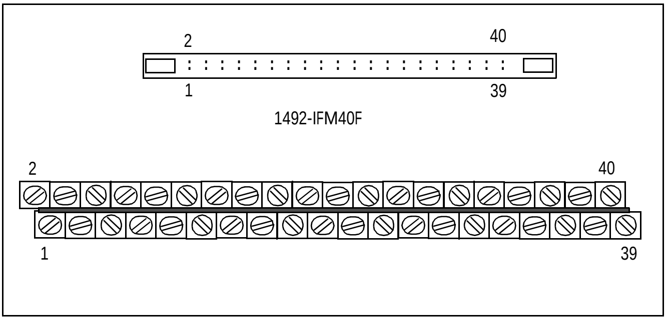
Disconnect all power to the SLC system before wiring.

We recommend making connections to the module with:

- Interface Module (cat. no. 1492-IFM40F)
- Interface Cable (cat. no. 1492-CABLE010H)

The Interface Module is a 40-pin miniature terminal block. The Interface Cable is one meter long.

For additional information on these items, Refer to Wiring Digital I/O on page 23. The pin-out for the terminal block is as follows:

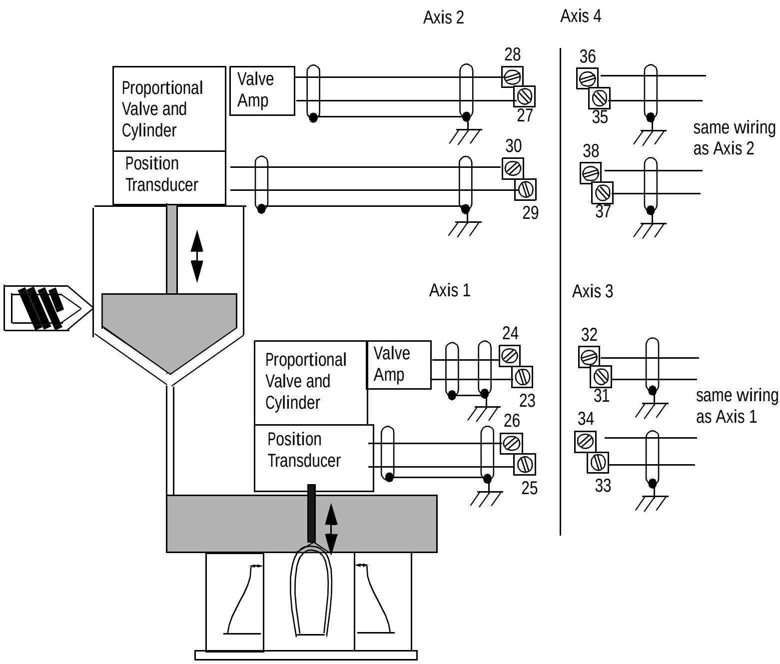


Description	Axis 1	Axis 2	Axis 3	Axis 4	System
Reserved					4, 3, 2, 1
Digital OUT-	17	13	9	5	
Digital OUT+ (+24EXT)	18	14	10	6	
Digital IN-	19	15	11	7	
Digital IN+	20	16	12	8	
-24V dc RET					21
+24V dc EXT					22
Analog OUT- (GND)	23	27	31	35	
Analog OUT+	24	28	32	36	
Analog IN-	25	29	33	37	
Analog IN+	26	30	34	38	
Excitation- (-10V)					39
Excitation+ (+10V)					40

Wiring a Two-head Dual-actuator Machine

This setup has two identical injection units. Wire axis 1 and 2 identical to axis 3 and 4 with these I/O devices:

- analog output to the valve amplifier for the accumulator
- LVDT position input from the accumulator
- analog output to the valve amplifier for the parison die head
- LVDT position input from the parison die head

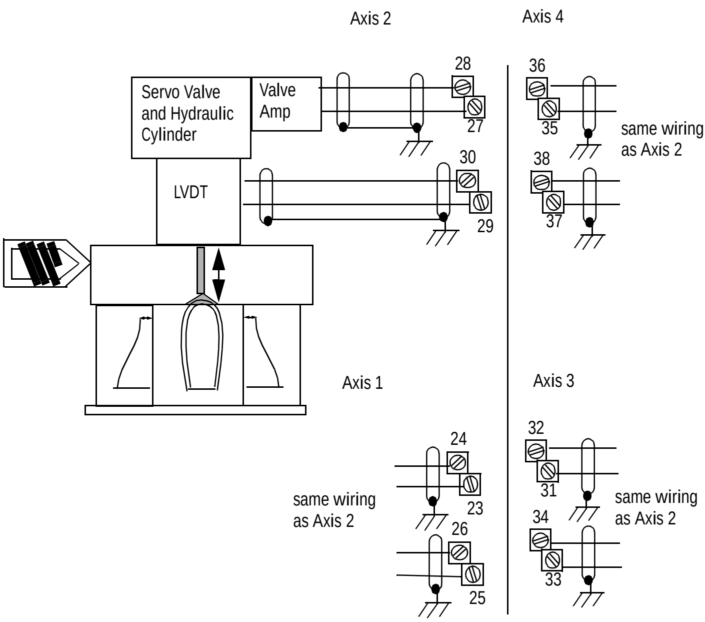


IMPORTANT If multiple power sources can be used, do not exceed the specified isolation voltage.

Wiring a Continuous-extrusion Machine

This setup has four identical injection units. Wire all four channels the same with these I/O devices:

- analog output to the valve amplifier for the parison die head
- LVDT position input from the parison die head



IMPORTANT If multiple power sources can be used, do not exceed the specified isolation voltage.

Wiring a Reciprocating Screw Machine with Single Accumulator

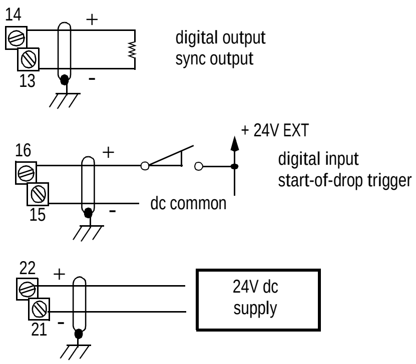
This setup has a single accumulator driving four identical injection units. Wire all four channels the same (see continuous extrusion, above) with these I/O devices:

- analog output to the valve amplifier for the parison die head
- LVDT position input from the parison die head

Wire the actuator for analog I/O signals from a fast-analog I/O module such as 1746-FIO4V (for voltage-level signals) in the SLC I/O chassis.

Wiring Digital I/O

To use module hardware inputs (DIN) for start-of-drop synchronization, reset bit 05 = 0 of the G-file axis-configuration word, and wire as follows: (Channel 1 shown. See page 27 for G-file configuration.)



IMPORTANT	If multiple power sources can be used, do not exceed the specified isolation voltage.

Polarity of I/O devices

Transducers must be wired so that the voltage corresponding to the open or retracted position is greater than the voltage corresponding to the closed or forward position.

Actuators may be either direct or reverse acting. Applying a positive voltage to the direct-acting type results in an increase in the corresponding process variable voltage. Applying a positive voltage to the reverse-acting type results in a decrease in the corresponding process variable voltage. Both types are accommodated by the module.

Minimizing interference from radiated electrical noise:

- Isolate signal wiring (such as LVDT input cables) from power lines and sources of electrical noise (such as motors and proportional amplifiers).
- Use shielded twisted pairs for all input and output connections.
- Make cables and unshielded leads as short as possible.
- Connect the shields of LVDT input cables and drive-output cables to earth ground at the I/O chassis at the nearest chassis mounting bolt.
- Ground cable shields at one end only.
- Connect all of the following to earth ground:
  - power supply cable shields
  - LDT flange, frame, and machine
  - I/O chassis
  - a/c ground
- Place the SLC processor and I/O chassis in a suitable enclosure.
- About the Interface Module Terminal Block (cat. no. 1492-IFM40F)

We recommend that you use this device for connections to the module.
The associated cable connects the device to the module. Cables are available in standard sizes as indicated by part number 1492-CABLExxxH where xxx indicates cable length in meters:

length:	**xxx**:
0.5 M	005
1.0 m	010
1.5m	015
2.5m	025
5.0	050

Publication 1492-5.1 describes the IFM terminal block and cables. For information on the entire line of Interface Modules and associated cables for wiring analog systems, see publication 1492-2.15.

Step: 7 Configuring the SLC processor (including I/O, M0/M1, and G file)

This procedure is based on RSLogix500 programming software, version 2.0 or later. For other software, the procedure may vary.

Configure the SLC processor, I/O, size of M0/M1 files, and G file offline to match your system layout.

1. With the File pull-down window, open the ladder file associated with this project, or create a project (ladder file) for it.

2. If you have not already done so, select the Controller Properties icon and launch it. Then select/enter the type of SLC processor.

3. Select the I/O Configuration icon and launch it. Then select/enter:

a. Slot number in the I/O chassis for this module
If using this module in a Pro-Set 200 Injection Control System, assign this module to slot 7.

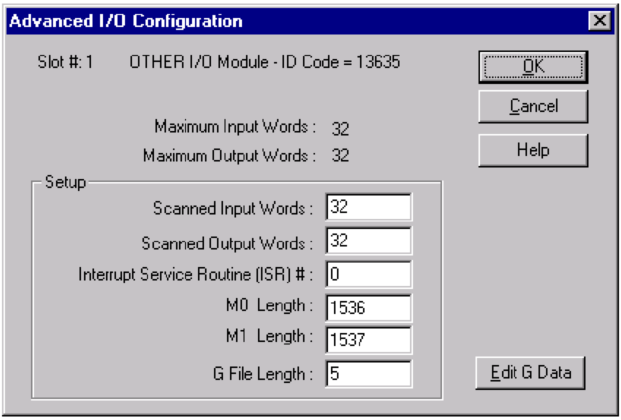
b. Module ID (13635), entered under *Other* in the I/O Module window.

IMPORTANT	When you enter the module ID, the processor automatically reserves the required number of I/O image table words. The location of those words in the I/O image table is determined by the module's slot location in the I/O chassis. Slot location is a required addressing unit. For example, I:e.6 locates the 6th word in the block of input image table words assigned to the module in slot e that you entered in A, above.

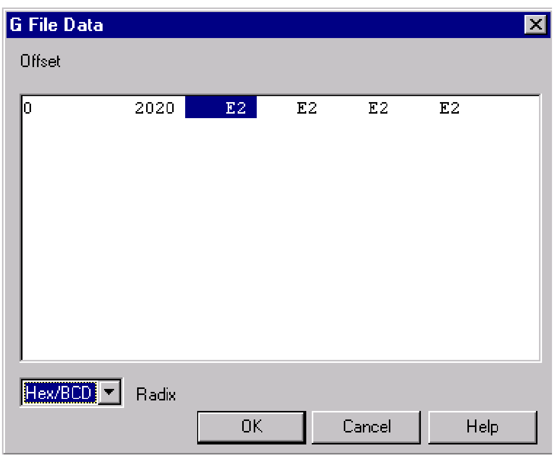
c. If you have not already done so, enter the size of I/O chassis and the type of power supply.

4. Select the Adv Configuration icon and launch it. Then select/enter:

a. Length of M0 file at 1536 words, M1 file at 1537 (listed in section 7).



b. Length of G file at 5 words.



5. Select and launch the Enter G Data icon.

a. Change the display radix to hex. You see:

0	2020	0	0	0	0

b. Select word one (as shown) and enter the bit-selected data word that corresponds to axis 1. You determine the equivalent hex value of this word in next section. Repeat for G-file words 2-4 (for axes 2-4).

G-file Configuration

The module requires software-configured selections in G file words 1-4 for axes 1-4, respectively. All four axes have identical structures:

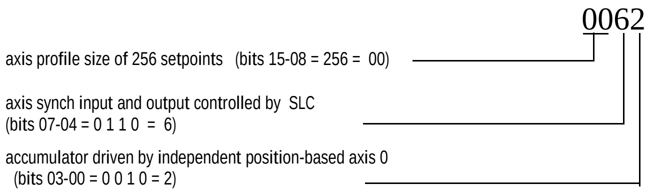
Bit	Purpose	Selection
00	axis operation is time based (1) (2)	0 = disabled, 1 = enabled
01	axis operation is position based (if set, see (3))	0 = disabled, 1 = enabled
02-04	mandrel will follow: - accumulator axis number: - SLC profile via output image file:	enter bit code, such as 000 for axis 1, 001 for axis 2, 010 for axis 3, 011 for axis 4 100
05	axis synch input source (see note 3)	0 = from module DIN input 1 = from SLC output image
06	axis synch output source (see note 3)	0 = from module DOUT 1 = from SLC output image
07	SP and PV range	0=-32k to +32k 1= 0 to +10k
08-15	axis profile size (modulo 256) range of 0-255 (see note 3)	bit code for number of setpts

(1) Bits 00 and 01 must be set to opposite states, else a fault occurs.

(2) When setting up a continuous extrusion machine, consider this:
Select time-based operation for each axis to be used.
Specify zero for the independent axis.
Select an SLC-generated or externally-generated start-of-drop synchronization input, depending on your machine requirements.
Select SLC-generated or module-generated synchronization output, depending on your machine requirements.
Specify a user profile size of 256 points (unless SLC memory space requires fewer points)

(3) When setting up an accumulator machine, consider this:
Select position-based operation for each axis to be used.
Specify a number between 0 and 3 for each independent axis.
Select an SLC-generated start-of-drop synchronization input, since this feature is unused in position-based mode (This lets the SLC processor use the input for other purposes).
Select SLC-generated or module-generated synchronization output, depending on your application's requirements.
Specify a profile size of 256 points (unless SLC memory space requires fewer points)

You may set bits by entering an equivalent bit-set word in hex. For example, a hex value of 0062 represents:



IMPORTANT

Before operating the module for the first time, you must download the G file to the module. Do this by downloading your ladder file, even if it contains no rungs. The SLC processor must be in Program mode for a download.

Using M0/M1 Files

The module's M0 file receives axis-control structures and axis profiles from your designated N files. The module returns to designated N files:

- axis-control structures for verification
- process-variable profiles to indicate how setpoint profiles were executed

Your ladder logic must move this data between N files and M0/M1 files.

M0 file - write blocks to the BLM module

Words	Description
0-63	Control structure for axis 1 (see next page for listing)
64-127	Control structure for axis 2
128-191	Control structure for axis 3
192-255	Control structure for axis 4
256-511	Setpoint profile for axis 1
512-767	Setpoint profile for axis 2
768-1023	Setpoint profile for axis 3
1024-1279	Setpoint profile for axis 4
1280-1535	Master Setpoint profile

M1 file - read blocks from the BLM module

Words	Description
0-63	Control structure for axis 1 (see next page for listing)
64-127	Control structure for axis 2
128-191	Control structure for axis 3
192-255	Control structure for axis 4
256-511	Process-variable profile for axis 1
512-767	Process-variable profile for axis 2
768-1023	Process-variable profile for axis 3
1024-1279	Process-variable profile for axis 4
1280-1535	Interpolated setpoint profile
1536	Module's firmware revision (in BCD)
Note: M1 control structure files are returned in engineering units.	

Step: 8 Axis Control Structures in M0/M1 Files

Addresses for Axes1, 2, 3 and 4(1)

1	2	3	4	Description	Range
0/0	64/0	128/0	192/0	enable PID Proportional term	
0/1	64/1	128/1	192/1	enable PID Integral term	
0/2	64/2	128/2	192/2	enable PID Derivative term	
0/3	64/3	128/3	192/3	enable reverse-acting output	
0/4	64/4	128/4	192/4	enable reverse sensing input	
:	:	:	:	reserved	
1	65	129	193	KC (proportional gain x 100) for 0 ≤ gain ≤ 256	1 ≤ KC ≤ 25600
2	66	130	194	KCB (proportional gain x setpoint weight x 100)	1 ≤ KCB ≤ 25600
3	67	131	195	TI (integral time in ms)	1 ≤ TI ≤ 32767
4	68	132	196	TT (integral tracking time in ms)	1 ≤ TT ≤ 32767
5	69	133	197	TD (derivative time in 1/10 ms)	1 ≤ TD ≤ 32767
6	70	134	198	N (hi freq derivative gain x 100) for 1 ≤ gain ≤16)	1 ≤ N ≤ 1600
7	71	135	199	Umin (neg bound on control output, mV, > -10V	–10K ≤ Umin < Umax
8	72	136	200	Umax (pos bound on control output, mV, ≤ +10V	Umin < Umx ≤ 10K
9	73	137	201	FK (exponential input-filter constant)	0 ≤ FK ≤ 8
:	:	:	:	reserved	
32	96	160	224	YZS (PV @ zero-scale cal point)	-32K ≤ YZS ≤ +32K
33	97	161	225	YFS (PV @ full-scale cal point)	-32K ≤ YFS ≤ +32K
34	98	162	226	POFF (profile offset adjust value)	-32K ≤ Poff ≤ +32K
35	99	163	227	SBEG (step to assert sync output)	0 ≤ Sbeg ≤ Send
36	100	164	228	SEND (step to negate sync output)	Sbeg ≤ Send < 255
37	101	165	229	MVAL (mark value)	-32K ≤ Mval ≤ +32K
38	102	166	230	MBEG (step to begin parison mark))	0 ≤ Mbeg ≤ Mend
39	103	167	231	MEND (step to end parison mark)	Mbeg ≤ Mend < 255
40	104	168	232	interpolation type	0 = lin, 1 = cu spline
41	105	169	233	max profile time, ms	0 < time ≤ 32767
42	106	170	234	default profile time, ms	0 < time ≤ 32767
43	107	171	235	current profile time, ms	n/a
44	108	172	236	profile-time filter constant	0 ≤ filter const ≤ 8
45	109	173	237	profile delay, ms	0 ≤ delay ≤ 32767
46	110	174	238	profile size (number of points in PV profile)	(status, only)
47	111	175	239	profile mean (mean value of setpoint profile)	(status, only)
48	112	176	240	profile scale adjust (scale factor/32767)	0 < Pscale ≤ 32767
:	:	:	:	reserved	
63	127	191	255	reserved	

(1) To save space, 1K = 1000, -32K = -32768, +32K = +32767 when needed. Refer to Descriptions of module parameters on page 43 . M1 control structure files are returned in engineering units.

Step: 9 Using output and input image tables

I/O image tables are used as follows:

Output Image	
	bit commands to the module (for each axis)
	axis hold words
Input Image	
	bit status from the module
	error flag due to data-entry error in axis control structure
	return of current axis status (word values):
	- profile step
	- setpoint
	- process variable
	- control output
	- dac output
	- adc input

Output Image

Addresses for axes 1-4

axis 1	axis 2	axis 3	axis 4	Control-bit Description (1 = enable)
0/0	2/0	4/0	6/0	profile-enable
0/1	2/1	4/1	6/1	hold-value-0
0/2	2/2	4/2	6/2	hold-value-1
0/3	2/3	4/3	6/3	hold-value-2
0/4	2/4	4/4	6/4	download axis control structure (from SLC)
0/5	2/5	4/5	6/5	upload axis control structure (to SLC)
0/6	2/6	4/6	6/6	record current axis position as zero-scale calibration
0/7	2/7	4/7	6/7	record current axis position as full-scale calibration
0/8	2/8	4/8	6/8	download setpoint profile (from SLC)
0/9	2/9	4/9	6/9	upload process-variable profile (to SLC)
0/10	2/10	4/10	6/10	download master setpoint profile (from SLC)
0/11	2/11	4/11	6/11	upload interpolated setpoint profile (to SLC)
0/12	2/12	4/12	6/12	synch input
0/13	2/13	4/13	6/13	synch output
0/14	2/14	4/14	6/14	parison weight control
0/15	2/15	4/15	6/15	accumulator velocity control
1	3	5	7	reserved
8	11	14	17	hold-value “0”
9	12	15	18	hold-value “1”
10	13	16	19	hold-value “2”
20				high speed analog input word (see page 12)
21 – 31				reserved

Note: For description definitions, see page 43.

Input Image

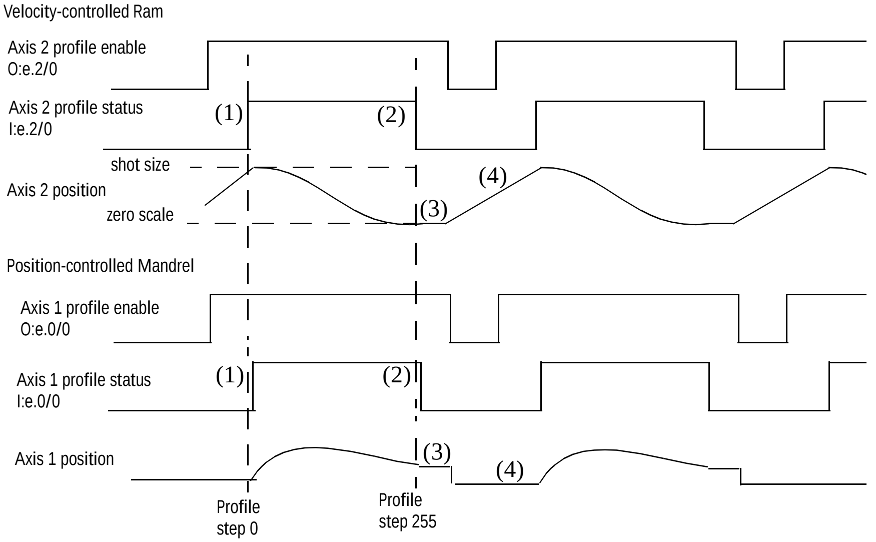
Addresses for axes 1-4				
axis 1	**axis 2**	**axis 3**	**axis 4**	**Status-bit Description (=1 for reported status)**
0/0	2/0	4/0	6/0	profile enable is set for duration of profile
0/1	2/1	4/1	6/1	follows state of hold-value-0 control bit
0/2	2/2	4/2	6/2	follows state of hold-value-1 control bit
0/3	2/3	4/3	6/3	follows state of hold-value-2 control bit
0/4	2/4	4/4	6/4	verifies completion of structure download
0/5	2/5	4/5	6/5	verifies completion of structure upload
0/6	2/6	4/6	6/6	verifies zero-scale calibration has been recorded
0/7	2/7	4/7	6/7	verifies full-scale calibration has been recorded
0/8	2/8	4/8	6/8	verifies completion of setpoint profile download
0/9	2/9	4/9	6/9	verifies completion of process-variable profile upload
0/10	2/10	4/10	6/10	verifies completion of master setpoint profile download
0/11	2/11	4/11	6/11	verifies completion of interpolated setpoint profile upload
0/12	2/12	4/12	6/12	indicates state of sync input logically ANDed with profile enable bit
0/13	2/13	4/13	6/13	indicates state of synch output
0/14	2/14	4/14	6/14	follows state of parison-weight control bit
0/15	2/15	4/15	6/15	follows state of parison-velocity control bit
1	3	5	7	error flag (see note)
8	9	10	11	current profile step
12	13	14	15	current setpoint
16	17	18	19	current process variable
20	21	22	23	current control variable
24	25	26	27	current dac output
28	29	30	31	current adc input

Notes: Error flag value (decimal) -1 = axis control structure address of parameter in error. For additional control structure information, see page 30.
For description definitions, see page 43.

Using Timing Diagrams

Study these timing diagrams for position-based and time-based modes of operation.

Figure 1 Example Diagrams for Position-based Model (see wiring on page 23)



Notes:

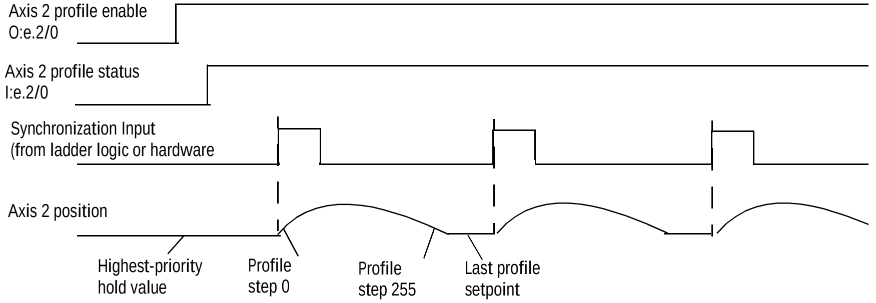
(1) Profile status bits are set when profile enable bits are set and the independent axis position reaches step 0.
shot size ≥ independent axis position ≥ (255/256)(shot size - zero scale)

(2) Profile status bits are cleared when the independent axis position reaches step 255.
independent axis position ≤ (shot size - zero scale)/256

(3) Axis position setpoint retains its previous value until the profile enable bit is disabled.

(4) The highest priority enabled hold value determines the axis setpoint when profiling is disabled:
the mandrel will hold constant position, the ram will hold constant velocity
(for additional information, see Step 5, page 26).

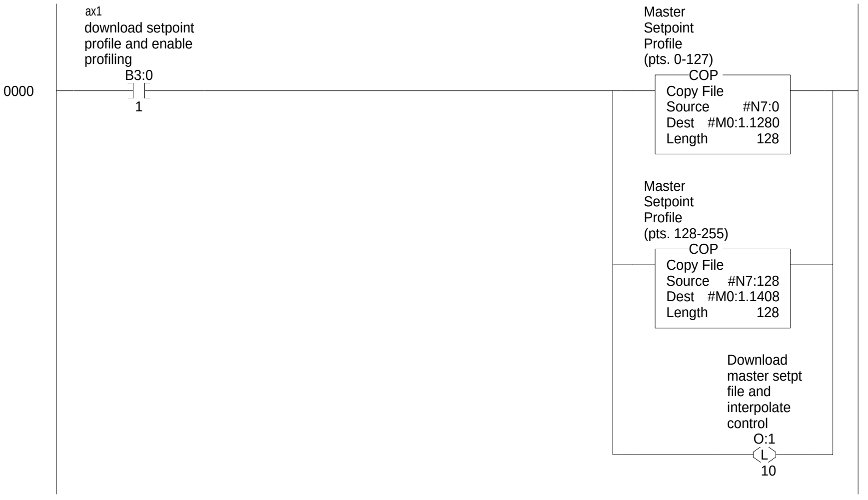
Figure 2 Example Diagrams for Time-based Mode (see wiring on page 23)



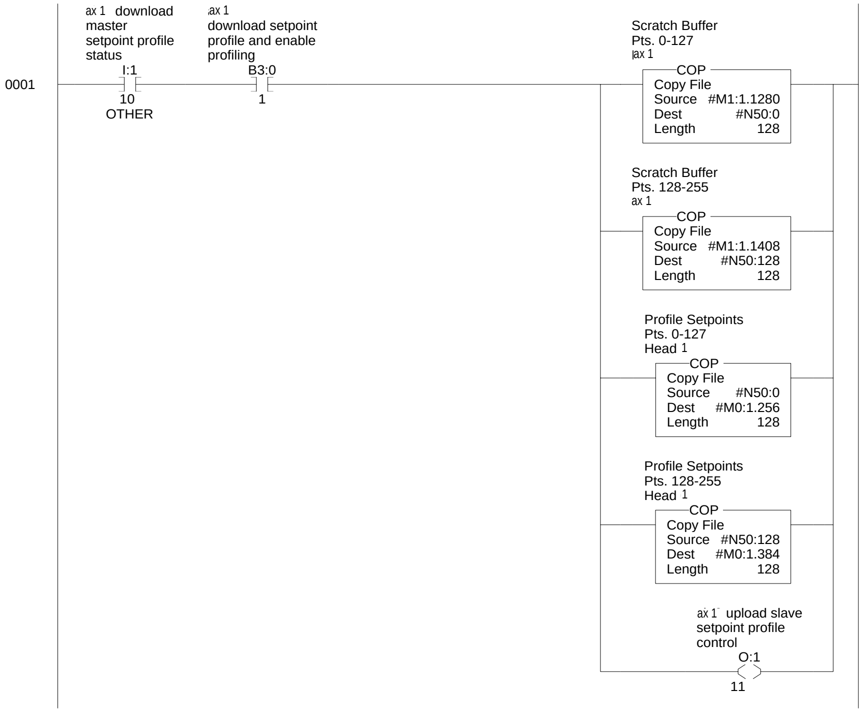
Step: 10 Writing Ladder Logic

We give you two sample ladder rungs to illustrate using handshake bits.

- **Rung 0**
  - copies your profile setpoints to the module
  - instructs the module to interpolate between setpoints



- **Rung 1**
  - waits for the module to confirm completion of interpolation
  - copies the interpolated profile into a buffer file
  - copies the interpolated profile to the module's axis-1 profile area
  - instructs the module to read the interpolated profile (from its M1 file)



Step: 11 Calibrating the module

To achieve precise closed-loop position control, you must calibrate the module's analog inputs. The module uses calibration data to transform setpoints/process variables to/from 16-bit signed integer format to the corresponding voltages present at the analog inputs.

You may calibrate the module in either of two ways:

- open loop
- closed loop

Closed Loop Calibration

You may calibrate the module's analog output by moving the mandrel (ram) to its limits of travel. To do this in closed loop mode, first download an axis control structure to the module with -32768 and +32767 for the zero- and full-scale calibration data, respectively. This insures that the module is able to move the mandrel (ram) over its full range of travel.

Then proceed with the open-loop procedure.

Open Loop Calibration (or continuation of closed-loop procedure):

1. Move mandrel (ram) to its fully-open position.
2. Set the full-scale calibration control bit in the output file. The module acknowledges by setting the full-scale status bit in the input file.
3. Move mandrel (ram) to the fully-closed position.
4. Set the zero-scale calibration control bit in the output file.
   The module again acknowledges by setting the corresponding bit in the input file. At this point the full- and zero-scale calibration data may be read from M1 file in shared memory after issuing an upload- axis-status-structure command via the output file.
5. Copy the new calibration data to the M0 file in shared memory.
   Issue the download-axis-control-structure command.
   The new calibration data will take effect.

Step: 12 Tuning a PID Loop

Use the following standard PID tuning method to tune the module's PID control loops:

Introduction

In the module's feedback control system, steady-state error using the proportional term is 100% x 1/(1+K), where K = proportional gain.

EXAMPLE

If the proportional gain is 9, the steady state error is an unacceptably high 10%. At the maximum proportional gain of 256, the error is better at 0.4%, but such a high gain may cause instability. Using the integral term forces the steady-state error to zero without adverse effects on system stability. This is especially important in position-based operation, where the position of the independent axis (ram) must reach the first and last steps as follows:

- step 0 (within 1/256th of shot size) before a profile may begin
- step 255 (within 1/256th of zero-scale) before a profile may complete

Procedure

IMPORTANT

Monitor the response to a setpoint change after performing each of the subsequent steps.

1. Start with a proportional gain of one; with integral and derivative terms disabled.
2. Double the proportional gain until oscillation just begins to occur.
3. Halve the proportional gain.
4. Enable the integral term using a large integral time (e.g. 1 sec.)
5. Halve the integral time until oscillation just begins to occur.
6. Double the integral time.
7. Fine tune the proportional gain, integral time, and derivative time to achieve optimum results.

Step: 13 Troubleshooting

The module and SLC provide three aids for troubleshooting:

- one status LED on the module
- axis error flags returned from the module in the input image table
- SLC processor's fault indication in the status file

When the module or SLC processor detects these types of errors or faults, it responds accordingly, and you must clear the error or fault as follows:

When indicated by:	This type of error or fault:	may be cleared by
module status LED	major fault in configuration or module hardware/firmware	correcting the fault condition and cycling power to the module
axis error-code words in the SLC input image table	your data-entry error in the axis-control structure (parameter out of range)	re-downloading valid parameters
error code in the SLC status file	processor fault	correcting the fault condition and cycling power to the processor

Module status LED

When this indicator turns ON, if cycling power does not reset the module, return it the factory for repair or replacement.

Axis error flags

The SLC operating system makes no response to out-of-range errors that you may make when entering parameters in axis-control structures (M0 file). But when the module detects that you downloaded an out-of-range parameter, it returns a status code to indicate the word number in the axis- control structure containing the error. The status code is returned in input image table words 1, 3, 5, and 7, the error flag words for axes 1, 2, 3, and 4.

Error-flag words return a non-zero status code that points to the invalid entry in the M0 file. The code is the Control Structure Word + 1. For example, if input image word 5 (for axis 2) contains the value 130, your entry for KC (proportional gain) in word 1 of the control structure (M0 word 129) is out of range.

SLC processor's error codes in the status file

The SLC processor's operating system responds to a major fault by immediately halting all processing. The source of the fault is recorded in the SLC processor's status file. The fault may be cleared only by cycling power after correcting the fault condition.

The following error codes are defined for major faults:

0x70	System configuration fault
0x71	Module firmware fault
0x80	Module unspecified hardware fault
0x81	Module flash-memory fault
0x82	Module program-memory fault
0x83	Module data-memory fault
0x84	Module shared-ram fault
0x85	Module watchdog-timeout fault

Specifications

Analog Inputs	Conversion Rate	10KHz
	Resolution	14 bits
	Differential Input Range	+/-10Vdc
	Common Mode Input Range	+/-200Vdc
	Differential Impedance	800KΩ
	Common Mode Impedance	400KΩ
	Isolation from PLC backplane	Tested to 500Vdc for 60 sec or equivalent
	Overvoltage Protection	+/-500V
	Input Conductors: Wire size	Belden 8761 or equivalent 22-14 AWG stranded copper wire 3/64 inch insulation maximum Wire Category 2[(2)]
Analog Outputs	Conversion Rate	10KHz
	Resolution	14 bits
	Output Voltage Range	+/-10Vdc
	Maximum Continuous Current	1mA
	Short Circuit Current	<20mA
	Short Circuit Duration (single output)	indefinite
	Isolation from PLC backplane	Tested to 500Vdc for 60 sec or equivalent
	Output Conductors: Wire size	Belden 8761 or equivalent 22-14 AWG stranded copper wire 3/64 inch insulation maximum Wire Category 2[(2)]
Exicitation Output	Output Voltage	+/-10 Vdc
	Source	axis 0 A/D reference
	Maximum Continuous Current	2mA (10KΩ linear pot)
	Short Circuit Current	<20mA
	Short Circuit Duration (single output)	indefinite
	Isolation from PLC backplane	Tested to 500Vdc for 60 sec or equivalent
	Output Conductors: Wire size	Belden 8761 or equivalent 22-14 AWG stranded copper wire 3/64 inch insulation maximum Wire Category 2[(2)]
Digital Input	Type	Optocoupler
	Input Voltage Range	0 to 30 Vdc
	Minimum ON State Voltage	22 Vdc
	Maximum OFF State Voltage	2 Vdc
	Maximum Input Current (@30VDC)	7mA
	Isolation from PLC backplane	Tested to 500Vdc for 60 sec or equivalent
	Protection	polarity reversal
	Input Conductors: Wire size	Belden 8761 or equivalent 22-14 AWG stranded copper wire 3/64 inch insulation maximum Wire Category 2[(2)]

Digital Output	Type	Open Collector
	Maximum OFF State Voltage	30Vdc
	Isolation from PLC backplane	Tested to 500Vdc for 60 sec or equivalent
	Output Conductors: Wire size	Belden 8761 or equivalent 22-14 AWG stranded maximum 3/64 inch insulation maximum Wire Category 2(2)
Environmental (1)	Power requirement	5 Watts (1A @ +5Vdc)
	Operating (ambient) temperature	0 to 60°C
	Storage temperature	-40 to +85°C
	Relative humidity	5 to 95% (non-condensation)
Agency Certifications When product is marked:	Listed Industrial Control Equipment Certified Process Control Equipment Certified for use in Class I, Division 2, Groups A, B, C, D or nonhazardous locations Marked for all applicable directives Marked for all applicable acts N223	

(1) This product must be mounted within a suitable system enclosure to prevent personal injury resulting from accessibility to live parts. The interior of this enclosure must be accessible only by the use of a tool. This industrial control equipment is intended to operate in a Pollution Degree 2 environment, in overvoltage category II applications, (as defined in IEC publication 664A) at altitudes up to 2000 meters without derating.

(2) See Industrial Automation Wiring and Grounding Guidelines, publication 1770-4.1.

Descriptions of module parameters

Module Parameter	Description
axis control structure	64 axis-configuration words that you enter in the M0 file
axis current adc input	raw 14-bit value read from adc (for LVDT position counts)
axis current control output	16-bit integer
axis current dac output	raw 14-bit value written to dac
axis current process variable	16-bit integer representing the position input
axis current profile step	indicates which step of a profile is currently executing
axis current setpoint	indicates axis target position (can be unrelated to the profile)
axis full-scale point	calibrated maximum travel limit of LVDT
axis zero-scale point	calibrated minimum travel limit of LVDT
axis process-variable profile	256 words in M1 file to indicate actual setpoint execution
axis setpoint profile	256 words in M0 file to control parison head or accumulator
axis synchronization input	command trigger to start drop of the parison
axis synchronization output	signal used to synchronize external hardware with a profile step
interpolated setpoint profile	returned master profile filled with module-computed setpoints.
master setpoint profile	selected critical profile setpoints in M0 file. Other setpoints = 0
operation: position-based mode	profile steps triggered by position inputs from LVDT
operation: time-based mode	profile steps triggered by module-computed time intervals
parison weight adjustment	capability to offset entire profile to adjust weight of parison-
profile scale adjustment	capability to change profile scale without changing part weight
setpoint marking	capability to relate a setpoint in the profile to a ridge in the part
shotsize	length of screw backup to inject a full shot of melt
signed-integer format	minimum value of -32768 corresponds to zero-scale (fully-closed or fully-forward) and the maximum value of +32767 corresponds to full-scale (fully-open or fully-retracted).

European Communities (EC) Directive Compliance

If this product has the CE mark it is approved for installation within the European Union and EEA regions. It has been designed and tested to meet the following directives.

EMC Directive

This product is tested to meet the Council Directive 89/336/EC Electromagnetic Compatibility (EMC) by applying the following standards, in whole or in part, documented in a technical construction file:

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

This product is intended for use in an industrial environment.

Low Voltage Directive

This product is tested to meet Council Directive 73/23/EEC Low Voltage, by applying the safety requirements of EN 61131-2 Programmable Controllers, Part 2 - Equipment Requirements and Tests. For specific information required by EN 61131-2, see the appropriate sections in this publication, as well as the Allen-Bradley publication Industrial Automation Wiring and Grounding Guidelines, publication 1770-4.1.

Open-style devices must be provided with environmental and safety protection by proper mounting in enclosures designed for specific application conditions. See NEMA Standards Publication 250 and IEC Publication 529 as applicable, for explanations of the degree of protection provided by different types of enclosures.

Rockwell Automation Support

Rockwell Automation offers support services worldwide, with over 75 sales/support offices, over 500 authorized distributors, and 260 authorized systems integrators located throughout the United States alone, plus Rockwell Automation representatives in every major country around the world. Contact your local Rockwell Automation representative for:

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

Obtain Pre-Sales Product Support

If you need to contact Rockwell Automation for pre-sales product support, call your local Rockwell Automation representative.

Obtain Technical Product Support

If you need to contact Rockwell Automation for technical assistance, try one of the following methods:

Type of technical support:	Access at:
Personalized Service	Call your local Rockwell Automation representative
Post-sales Technical Support	1.440.646.5800
Email your questions to	racleasktheexpert@ra.rockwell.com
Internet site	www.ab.com
Publications	www.theautomationbookstore.com

Hazardous Location Approval

The following information applies when operating this equipment in hazardous locations:

Products marked “CL I, DIV 2, GP A, B, C, D” are suitable for use in Class I Division 2 Groups A, B, C, D, Hazardous Locations and nonhazardous locations only. Each product is supplied with markings on the rating nameplate indicating the hazardous location temperature code. When combining products within a system, the most adverse temperature code (lowest “T” number) may be used to help determine the overall temperature code of the system. Combinations of equipment in your system are subject to investigation by the local authority that has jurisdiction at the time of installation.

WARNING

EXPLOSION HAZARD –

- Do not disconnect equipment unless power has been removed or the area is known to be nonhazardous.
- Do not disconnect connections to this equipment unless power has been removed or the area is known to be nonhazardous. Secure any external connections that mate to this equipment by using screws, sliding latches, threaded connectors, or other means provided with this product.
- Substitution of components may impair suitability for Class I, Division 2.
- If this product contains batteries, they must only be changed in an area known to be nonhazardous.

Informations sur l’utilisation de cet équipement en environnements dangereux:

Les produits marqués « CL I, DIV 2, GP A, B, C, D » ne conviennent qu’à une utilisation en environnements de Classe I Division 2 Groupes A, B, C, D dangereux et non dangereux. Chaque produit est livré avec des marquages sur sa plaque d’identification qui indiquent le code de température pour les environnements dangereux. Lorsque plusieurs produits sont combinés dans un système, le code de température le plus défavorable (code de température le plus faible) peut être utilisé pour déterminer le code de température global du système. Les combinaisons d’équipements dans le système sont sujettes à inspection par les autorités locales qualifiées au moment de l’installation.

AVERTISSEMENT

RISQUE D’EXPLOSION –

- Couper le courant ou s’assurer que l’environnement est classé non dangereux avant de débrancher l'équipement.
- Couper le courant ou s'assurer que l’environnement est classé non dangereux avant de débrancher les connecteurs. Fixer tous les connecteurs externes reliés à cet équipement à l'aide de vis, loquets coulissants, connecteurs filetés ou autres moyens fournis avec ce produit.
- La substitution de composants peut rendre cet équipement inadapté à une utilisation en environnement de Classe 1, Division 2.
- S’assurer que l’environnement est classé non dangereux avant de changer les piles.

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Publication 1746-IN014B-EN-P - January 2001 PN 957464-71

Supersedes Publication 1746-5.14 - November 1999