



*Allen-Bradley*

*Synchronized Axes  
Control Module*

*(Cat. No. 1746-QS)*

# User Manual

Allen-Bradley PLCs

## 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.

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

**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.

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## System Overview

### Chapter Objectives

This chapter presents a conceptual overview of how you use the 1746-QS module in an application.

### What Is the 1746-QS Module?

The 1746-QS Synchronized Axes Module provides four axes of closed-loop synchronized servo positioning control, and lets you change motion parameters while the axis is moving. The module has four optically isolated inputs for signals from linear displacement transducers (LDTs) and four optically isolated  $\pm 10$  volt outputs that interface with proportional or servo valve amplifiers.

The module's microprocessor provides closed-loop control. The module reads the axis position and updates the drive output every two milliseconds, for precise positioning even at high speeds.

### What Is the Hydraulic Configurator

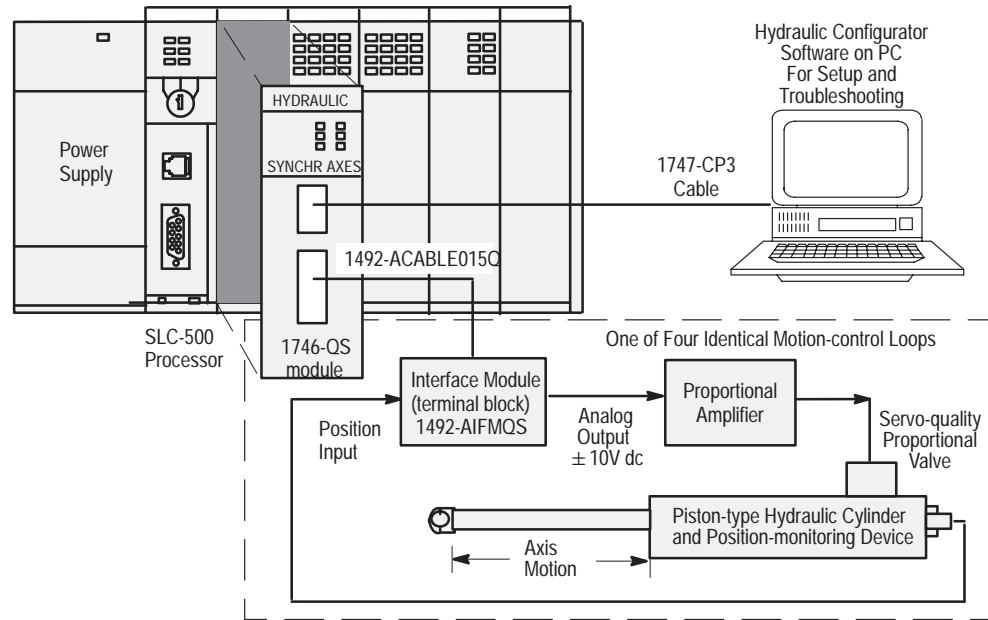
The module is designed for use with the Hydraulic Configurator, a software product that you can obtain from the Allen-Bradley website on the Internet. The Hydraulic Configurator is an interactive executable that lets you configure the module and tune its axes. With it, you can:

- configure axes and store configuration parameters
- tune each axis independent of the ladder program
- store multiple commands to initiate repetitive axis motion
- display a log of the last 64 motion commands sent to the module
- observe and/or store plots of each axis
- access help screens that explain and/or describe module features

**Important:** The Hydraulic Configurator saves considerable time when tuning axes and troubleshooting faults. Thereafter, your ladder logic sequences module operation with the machine.

### What Is an SLC-500 System?

The Allen-Bradley Small Logic Controller (SLC) system is a programmable control system with an SLC processor, I/O chassis containing analog, digital, and/or special-purpose modules, and a power supply. The 1746-QS module occupies one slot of the I/O chassis and communicates with the SLC processor over the backplane using 32 words in the SLC processor's output image table and 32 words in the input image table. The processor loads or reads the module's configuration parameters using M0 or M1 files, respectively. Your ladder logic sequences synchronized axes movement with machine operation. The system can be illustrated as follows:



## Why Use This System?

Because you can interact quickly and easily with the module's control of axis motion via the Hydraulic Configurator, this control system has these benefits:

- *faster setup and tuning of axes* – the Hydraulic Configurator lets you quickly set up and tune each axis independent of your ladder program.
- *reduced cycle time* – you can increase axis speed for faster operation
- *smoother operation for longer machine life* – you can profile accelerations and decelerations of the hydraulic actuator to limit pressure spikes
- *faster change-over to new parts* – you can store setups (configuration parameters) for quick and accurate change-over between parts

## How Does It Work?

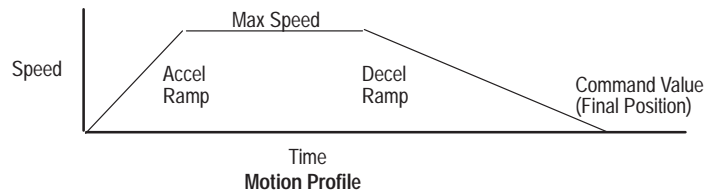
### Monitoring Axis Position

The module has four LDT inputs. You configure each axis for an LDT with a Pulse Width Modulated output (DPM) or a Start/Stop output (RPM) by changing axis configuration parameters.

### Controlling Axis Output

The module is a targeting controller: every two milliseconds its micro-processor updates TARGET POSITION and target SPEED values. For point-to-point moves, TARGET POSITIONS are generated so that resulting speed, accelerations, and decelerations follow either a trapezoidal or s-curve profile.

The MODE, ACCELERATION, DECELERATION, SPEED, and COMMAND VALUE (requested position) are used to generate the profile. You send these command words to the module through the processor's output image table. You may change them "on-the-fly" while the axis is moving.



The module compares ACTUAL POSITION with TARGET POSITION to determine position error. Every update, it uses the position error to adjust drive output. PID gains are adjustable and can be applied selectively.

The module also provides two different feedforward algorithms; EXTEND/RETRACT FEEDFORWARD, and EXTEND/RETRACT ACCELERATION FEEDFORWARD. These feedforward terms provide additional drive output to help the axis follow the target, freeing the PID loop to correct for system nonlinearity and changes in load.

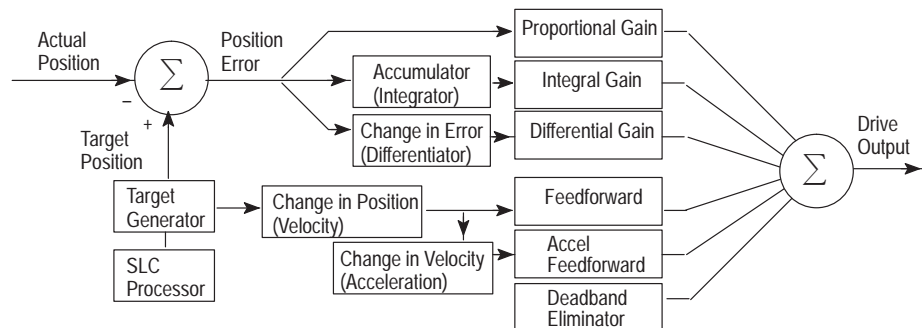


Diagram of the Control Loop

## Programming

A sample ladder program for the module is available from Allen-Bradley's website on the Internet. You can download it as an executable file to your PC's disk drive and transfer it to your SLC processor. But, you must modify it for your application.

Ladder logic transfers motion commands to the module and axis status from the module thru the I/O image table. Ladder logic also copies configuration parameters to the module's M0 file at power up. It also copies configuration parameters (that you enter/change with the Hydraulic Configurator) from the module's M1 file to processor files. Thus, you can establish a library of configurations (recipes) in processor files that you can select and download to the module at power up or each time you want to change the setup of your axes. We explain the functions of the ladder logic later in this manual.

## What Are Typical Applications?

Use the module in an SLC-based system for control of hydraulic applications where two or more axes must reach their final position at the same time, such as:

- plywood presses
- roll positioning
- palletizers and stackers
- forging machines
- hydraulic tailgate loaders

In addition, the module is designed to support independent axes using either servo or proportional amplifiers, and retrofit into existing hydraulic systems requiring a positive voltage irrespective of direction.

## System Requirements

Hardware/software requirements of this SLC processor system include:

Component:	Requirement:
SLC Processor	SLC 5/03 or later
Comm. Interface Card (alternate COM port)	1784-KTx
Personal Computer	3.9 MByte of disk space
PC Operating System	Windows 95™
PC/QS Interface Cable	1747-CP3
Synchronized Axes Module	1746-QS
Interface Module (terminal block)	1492-AIFMOS
Interface Module Cable	1492-ACABLExxxQ
Programming Software	RSLogix500
LDT (RPM or DPM)	Temposonics, Baluff, Santest, Gemco, etc



## Setting Up the Hardware

### Chapter Objectives

This chapter helps you install the hardware with these tasks:

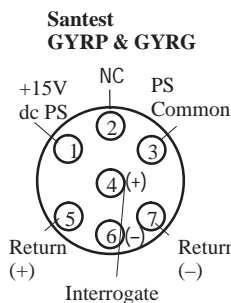
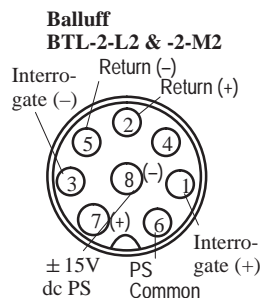
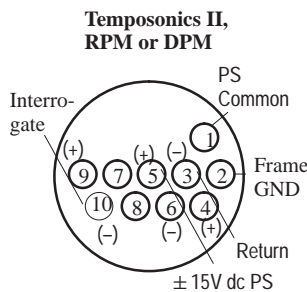
- connecting LDTs to the Interface Module (IFM) terminal block
- minimizing interference from radiated electrical noise
- connecting outputs to output devices
- checking out the wiring and grounding
- setting up the hydraulics
- regarding the Interface Module (IFM) terminal block and cable

### Connections to LDTs and 4-axis Terminal Block

We assume that you will use one of the following types of LDT:

- Temposonics II: RPM TTSRxxxxxxR, or DPM TTSRxxxxxxDExxx
- Balluff: BTL-2-L2, or BTL-2-M2
- Santest: GYRP, or GYRG
- Gemco Quick-Stick II: 951VP, or 951RS

We illustrate connections for these types of LDTs. (There are other suppliers with compatible LDTs.)



#### Gemco Quick-Stick II 951VP w/PWM Output

B-BLK PS Common  
 C-RED +15V dc PS  
 K-GRY + Interrogate  
 E-BRN -Return\*  
 F-BLU +Return\*  
 A-WHT -Interrogate  
 G, D, H RS232RXD  
 J-PUR 2nd PS COM  
 \*951RS has pulse trigger

The views are looking at the connector on the LDT head.

### LDT Connections (for fabricating your own LDT cable)

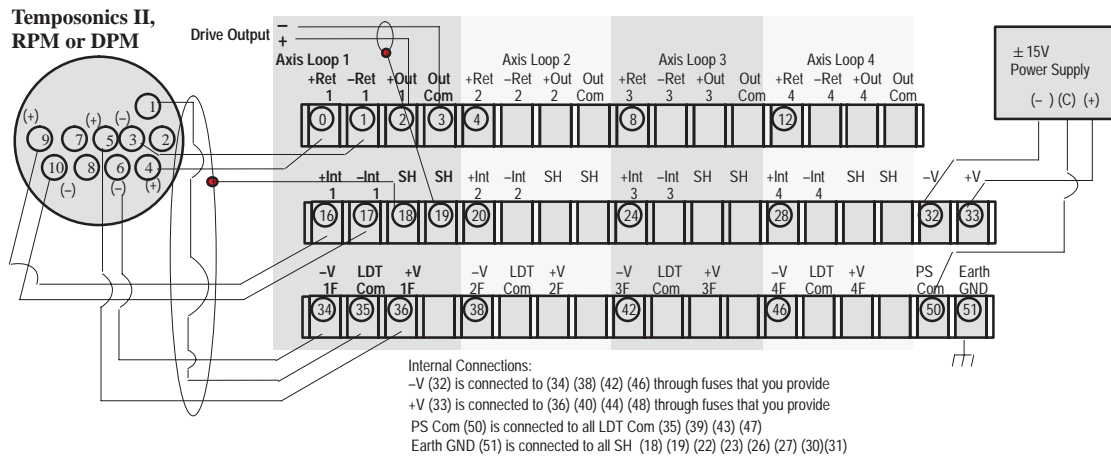
Function	Temposonics II RPM or DPM	Balluff BTL-2-L2 & -M2	Santest GYRP/GYRG	Gemco Quick-Stick 951VP/RS
(+) Return (note 1)	4 - Pink	2 - Gray	pin 5	F - Blue
(-) Return (note 1)	3 - Gray	5 - Green	pin 7	E - Brown
(-) Interrogate	10 - Green	3 - Pink	pin 6	A - White
(+) Interrogate	9 - Yellow	1 - Yellow	pin 4	K - Gray
-15V dc PS	6 - Blue	8 - White	n/a	n/a
PS Common	1 - White	6 - Blue	pin 3	B - Black
+15V dc PS	5 - Red	7 - Brown	pin 1	C - Red

(+) and (-) wires of the same function should be a twisted pair within the cable.

(note 1) We use the term "Return" for gate out, pulse trigger, or square wave (Gemco) and start/stop (Balluff -M2) LDT signals.

## Typical Connections to the Interface Module (IFM) Terminal Block

Pin assignments of the IFM terminal block for I/O, power, shield, and ground connections are as follows: (For example, we show connections for one axis with a Temposonics LDT and power supply.)



Connect the  $\pm 15V$  dc power supply to pin 50 (Com), pin 33 (+V), and pin 32 (-V). Connect pin 51 (GND) to earth ground with 3/8" wire braid (as short as possible).

## Typical Fusing of the Interface Module (IFM) Terminal Block

The Interface Module (IFM) Terminal Block is wired for fusing of ( $\pm V$ ) to each LDT. Provide proper fusing (T500L 250V, typical) for each axis using fuse clips on the IFM terminal block.

## Example Connections for Temposonics II Differential Inputs

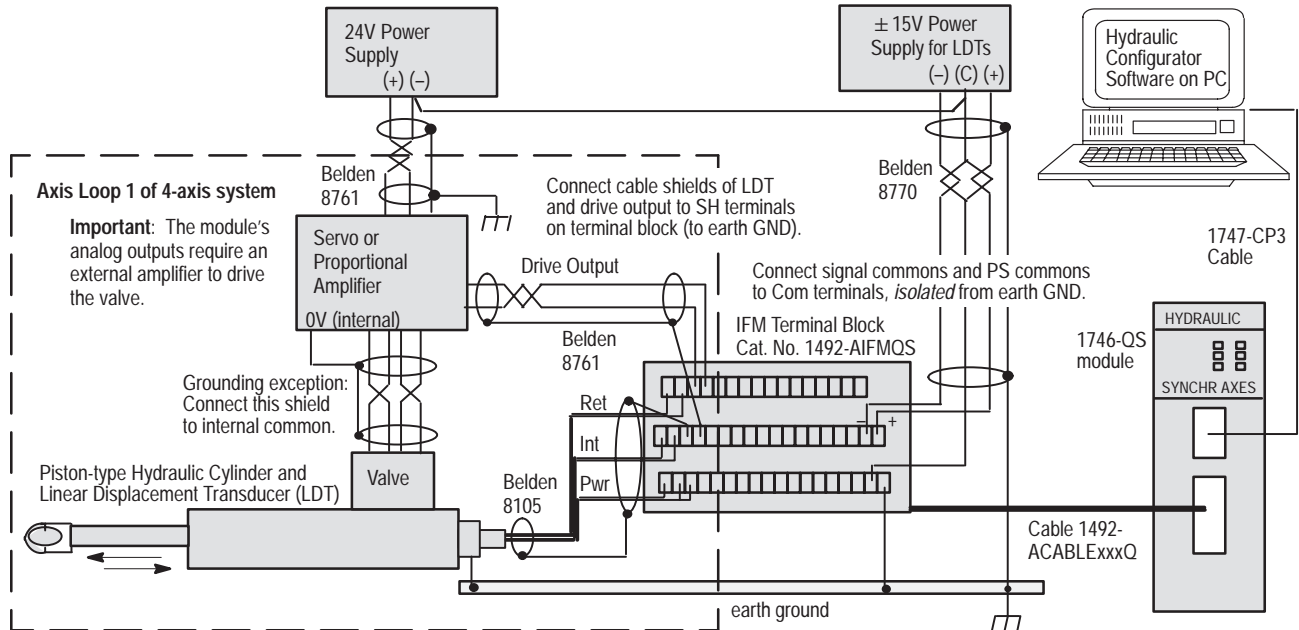
Use differential inputs when connecting LDTs to the IFM terminal block.

Temposonics II		IFM Terminal Block	
Function	Pin #	Function (Axis 1)	Term. #
(+) Interrogate	9	+ Int	16
(-) Interrogate	10	- Int	17
(+) Return	4	+ Ret	0
(-) Return	3	- Ret	1
+ 15V	5	+V 1F	36
-15V	6	-V 1F	34
Comm	1	LDT Com	35

If fabricating your own LDT cable, see connections on previous page.

## Wiring Example

We present a 1-axis loop with a differential LDT input.  
(You must provide power supplies and servo amplifiers.)



## Minimizing Interference from Radiated Electrical Noise

**Important:** Signals in this type of control system are very susceptible to radiated electrical noise. The module is designed to detect loss-of-sensor and sensor noise conditions for any of the four axes when position values are lost or corrupted. The Hydraulic Configurator displays these conditions in the Status word window. The resulting hard or soft stop depends on how you configured autostop conditions. (See Hydraulic Configurator, Config word, and click on autostop “Help”).

To minimize interference from radiated electrical noise with correct shielding and grounding:

- Connect LDT cable shields and drive output cable shields (all shields at one end, only) to IFM terminal block SH terminals, and connect the IFM terminal block GND terminal (51) to earth ground.
- Keep LDT signal cables far from motors or proportional amplifiers.
- Connect all of the following to earth ground:
  - power supply cable shields (one end, only)
  - LDT flange, frame, and machine
  - I/O chassis
  - AC ground
- Use shielded twisted pairs for all connections to inputs and outputs.
- Run shielded cables only in low-voltage conduit.
- Place the SLC-500 processor and I/O chassis in a suitable enclosure.

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**Important:** To minimize the adverse effects of ground loops, you must *isolate* power supply and signal *commons* from earth ground as follows:

1. Connect power supply commons to IFM Com terminal (50), and LDT commons to LDT Com terminals of the IFM terminal block. Be sure that they are *isolated* from earth ground.
2. Connect the cable shield of the servo or proportional amplifier output cable to a zero potential terminal inside the amplifier.
3. Use bond wires that are equal in size to signal wires.
4. When practical, use one power supply to power only your LDTs.

## Connecting Outputs to Output Devices

**Note:** Follow manufacturer recommendations for shielding the output cables of the proportional amplifier. Typically, pulse-width modulated outputs radiate electrical noise originating from the +24V dc power supply, so isolate the shields of the amplifier output cable to a 0V dc connection inside the proportional amplifier.

You have a choice of three configurations to match your hydraulics:

- proportional amplifier integrated with a proportional valve
- servo amplifier and variable-volume pump or servo valve
- Allen-Bradley 1305 Drive and hydraulic pump

You may use either of the following output voltage ranges:

- 0-10V dc for an Allen-Bradley 1305 Drive or variable-volume pump
- -10 to +10V dc for a proportional or servo amplifier

If using servo valves, you must convert the module's output from voltage to current.

## Output Polarity

In most hydraulic systems, the actuator extends (with increasing LDT counts) when a positive voltage is sent to the output. The extend direction is defined as the direction that causes the LDT to return increasing counts moving *away from* the head.

You can make these selections in the Config word that affect output:

- To generate a positive drive output (0-10V dc) regardless of move direction, you can select Absolute Mode.
- To extend the actuator by sending a negative voltage to the output, you can select Reverse Drive Mode.

For additional information on the Configuration word, select that subject in Help Topics.

## Checking Out the Wiring and Grounding

Repeat this procedure to check out each of the four axis loops connected to the IFM terminal block.

**ATTENTION:** Be sure to remove all power to the SLC processor, LDT, valve and pump beforehand.

1. Disconnect the LDT connector at the head end.
2. Disconnect the connector to the IFM terminal block.
3. Turn ON the power supplies for the LDT and SLC processor, and check the LDT connector and IFM terminal block for:
  - +15V dc
  - PS common
  - -15V dc
4. Observe that the module's fault LED indicates Green.
5. Verify continuity between IFM COM terminal (50) and each of:
  - shield of the amplifier output cable to the valve
  - output common on  $\pm 15V$  dc PS that powers the LDT
  - (-) terminal on +24V dc PS that powers the proportional amplifier
6. Verify NO continuity between drive output commons connected to IFM terminals 3, 7, 11, 15 and earth ground.
7. To minimize ground loops, verify that all cable shields are grounded (at one end, only) to SH terminals of the IFM terminal block, and that GND terminal (51) of the IFM is connected to earth ground.

## Setting Up the Hydraulics

1. **Design for adequate pressure and volume.** Hydraulic systems must have enough pressure and fluid volume (accumulator) to move the desired load the commanded distance and speed. Inadequate pressure or volume will cause the axis to lag the target position as the controller attempts to move the axis faster than the system can move. Consider monitoring system pressure or providing a low-limit (approx. 80%) pressure switch.
2. **Avoid flexible hose.** Use no flexible hose between the valve and the cylinder being controlled. Flexible hose will swell and contract as the valve opens and closes, causing oscillation and loss of control.
3. **Mount valve and cylinder in correct orientation.** To avoid problems from entrapped air, mount the valve directly to the cylinder and positioned above it. Mount pressure sensors beneath the cylinder.
4. **Use linear valves with minimal overlap.** If using proportional valves, they should have less than 3% overlap and a linear (not curvilinear) response. Nonlinear valves or valves with excessive (20%) overlap may cause oscillation or hunting. We recommend using servo valves or servo-quality proportional valves.

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**5. Avoid valves with a slow response (less than 60 Hz).** Valves with slow response cause the module to overcompensate for disturbances in the motion of the system. Since the system does not respond immediately to the control signal, the module continues to increase the drive signal. By the time the system begins to respond to the error, the control signal has become too large and the system overshoots. The module then attempts to control in the opposite direction, but again overshoots. These valves can cause the system to oscillate around the set point as the module overshoots first in one direction, then the other.

### Regarding the Interface Module Terminal Block (Cat. No. 1492-AIFMQS) and Cable

We recommend that you use the Interface Module (IFM) terminal block (Cat. No. 1492-AIFMQS) to connect module I/O and power. It facilitates power supply, shield, and fuse connections.

It is required for CE certification.

The pre-wired cable that connects the IFM terminal block to the module is available in standard sizes as indicated by its part number, 1492-ACABLExxxQ, where xxx indicates the length in meters:

length:	xxx:
0.5 m	005
1.0 m	010
2.5 m	025

**Important:** Because the system was certified with a shorter cable, you must re-certify the system if using the 2.5 m cable.

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

## Setting Up Your PC for the Hydraulic Configurator

### Chapter Objectives

This chapter helps you do the following:

- Obtain the Hydraulic Configurator from the Internet
- Set up communication between your PC and the module

### Obtaining the Hydraulic Configurator from the Internet

You can download the Hydraulic Configurator from our website to your PC. (You can also download ladder logic and transfer it to your SLC processor, but we cover that in chapter 6.)

System requirements for the Hydraulic Configurator are: Windows '95 series A or B and 4M available disk space.

#### To Access Our Website:

Access the Allen-Bradley website (and 1746-QS software) at:  
<http://www.ab.com/mem/appsys/prodinfo/applac/appla/QSsw/index.html>

The Hydraulic Configurator is stored there as a self-extracting Winzip™ executable.

#### To Load the Hydraulic Configurator:

1. Download the Hydraulic Configurator (1746-QS.EXE) onto your hard drive.
2. Run 1746-QS.EXE. The Winzip self-extractor will ask you where you want to store the Hydraulic Configurator.
3. Launch it using the file, QsCfg.exe.
4. Set up a shortcut (optional).

## Setting Up Communication Between PC and Module

You must establish communication between Hydraulic Configurator software on your PC and the module.

1. Connect your PC to the module with Allen-Bradley cable (cat. no. 1747-CP3): one end to a serial port on your PC such as COM1, the other end to the 9-pin D-shell connector on the module.

Windows '95 provides a virtual connection to the serial port without any intervention unless that port is already used by another application.

**Important:** You may run RSLogix500 and Hydraulic Configurator concurrently on your PC if you have both COM1 and COM2 available. If only one serial port is available, you may use the Communication Interface Card (1784-KTx) for the connection between PC and SLC processor.

2. Open the Hydraulic Configurator by running QsCfg.exe.  
The main screen appears.

If you also get the message “No Motion Controller Detected,” then:

- check the 1747-CP3 cable connection between PC and module
- match the software/hardware COM ports (step 3.)

Otherwise, go to step 4.

3. Set the Hydraulic Configurator COM port to match your PC.  
To do this, click Tools on the toolbar, then Monitor Options from the menu. Enter the COM port number you used for your PC cable connection to the module in step 1.
4. To verify communication with the module, observe that the Com: window (screen bottom left) displays “Online“.

**Important:** You can run the Hydraulic Configurator offline to view plots, stored data files, and access Help screens.



## Tuning an Axis with the Hydraulic Configurator

### Chapter Objectives

We cover these topics:

- Before You Begin
- Finding the Value of the Null Drive
- Moving the Axis to Set Offset, Scale, Extend and Retract Limits
- Getting Ready to Tune the Axes
- Tuning Each Axis
- Finding the Value of the Dead Band Eliminator
- Saving Parameters

### Before You Begin

**ATTENTION:** Great care must be taken to avoid accidents when starting the module for the first time. The most common accident is a runaway, where the module tries to move the axis to a position beyond the physical limits, or in the wrong direction while in closed-loop control.

When the module is first turned on, parameters are set to default values. You must change these parameters (with the Hydraulic Configurator) to operate the module in your application.

**ATTENTION:** Do not attempt to operate the module in closed-loop mode until EXTEND and RETRACT limits have been determined and initialized in the module using the Hydraulic Configurator.

Before starting, be sure that:

1. Hydraulic Configurator is communicating with the module
2. **Important:** You have identified the type of LDT output. To Do this:
  - Double-click the Config word in the screen's PARAMETER section.
  - Click the transducer type that matches your LDT.
  - Disable simulate mode.  
Do this by removing the  from its check box in the Config word.
  - Leave the other selections at default.
3. LDTs are connected and powered up

### Finding the Value of the Null Drive

The Null Drive compensates for axis drift.

This procedure requires operating the module in open-loop mode *with drive outputs connected to the amplifier*. In this procedure, you will increase the drive output until the axis stops drifting. Then you will initialize that value in the module with an "N" command.

1. Turn off the power to the module.
2. Connect the axis drive output to the amplifier.
3. Turn the power back on.
4. Turn on the hydraulics.  
If the axis drifts, go to step 5.  
If not, you are done. Go to the next procedure, Moving the Axis.
5. Find the Null Drive value to stop axis drift:
  - a) Estimate a drive output (mV) required to hold zero motion.
  - b) Command the module to output that value with the “O” command:
    - Select axis and enter value into COMMAND VALUE number field.
    - From Command in the CommandBar, click the “O” command.
  - c) Repeat until the value produces no drift. This is the Null Drive
6. Zero the open-loop output with the “K” (Kill) command. To do this:
  - Click [ K ] in the ToolBar.

**Important:** The axis will resume its initial drift until you do step 7.
7. Command the module to output the Null Drive with “N” command.
  - Enter Null Drive into COMMAND VALUE number field.
  - From Command in the CommandBar, click the “N” command.
8. If drift persists, adjust Null Drive with “N” commands (as in step 7).

## Moving the Axis to Set Scale, Offset, Extend, and Retract Limits

By moving the axis, you will calibrate these configuration parameters with the Hydraulic Configurator:

- Scale
- Offset
- Extend and Retract Limits

We give you a preferred and an alternate procedure based on whether the drive output is disconnected from or connected to the module:

If:	Then:
You have a diddle box* to move the axis	Use the preferred procedure with the drive output <i>disconnected</i>
You do Not have a diddle box	Use the alternate open-loop procedure with the drive output <i>connected</i>

\* a control box that can electrically drive the valve amplifier

### Procedure to Set Scale and Offset with Drive Output Disconnected

With the axis drive output *disconnected* and the LDT on, you will move the axis with a diddle box (or manually) to two known machine positions (typically the extend and retract limits). There you will use the Hydraulic Configurator “Scale/Offset Calibration” feature to enter ACTUAL POSITION and COUNTS values.

**Important:** When moving to axis limits, be sure to leave space for safety. Remember that extend is the direction that returns increasing LDT COUNTS.

1. Turn off the power to the module.
2. Disconnect the axis drive output to the amplifier.
3. Turn the power back on.
4. Turn on the hydraulics.
5. Move the axis to the first position with the diddle box.  
It doesn't matter whether the first position is an extend or retract.
6. In the Scale/Offset Calibration window (from Tools in command bar):
  - a) Enter the desired position value into the Actual Position field for the First Position. (For example, -4000)
  - b) In corresponding First Position Counts field, click "Use Current".
7. Move the axis from the first position to the second.
8. In the Scale/Offset Calibration window (from Tools in CommandBar):
  - a) Enter the desired position value in the Actual Position field for the Second Position . (For example, 40,000)
  - b) In corresponding Second Position Counts field, click "Use Current".  
The New Parameters area of the window will show the calculated values for the Config word, Scale, and offset. (Set extend/retract limits later.)
9. Confirm that the displayed New Parameters (step 8) are valid. Then,
  - a) Click "Apply" to enter the values into configuration parameter words.
  - b) Click "Done" to close the editor window.

**Important:** You must set the EXTEND and RETRACT LIMITS *after* setting the scale and offset. The Scale/Offset Calibration tool will re-calculate any existing EXTEND and RETRACT LIMITS automatically when you use it to set a scale and offset.

10. For each axis, enter the desired end-point values for the EXTEND and RETRACT LIMITS in the screen's PARAMETER section.  
Enter them in the same engineering units as used in steps 6 and 8.
11. Transfer the parameters to the module using the "P" Command.
12. Repeat this procedure for each axis in use.

### Alternate Open-loop Procedure to Set Scale and Offset

You will move the axis with the module in open-loop mode to two known machine positions (typically the extend and retract limits). There you will use the Hydraulic Configurator "Scale/Offset Calibration" feature to enter ACTUAL POSITION and COUNTS values.

#### ATTENTION:


- A. Drive outputs will be connected to the amplifier.
- B. Open-loop operation will ignore all limits.  
Be prepared to instantly remove drive power.
- C. To avoid surprises, read the entire procedure before starting.

1. Turn off the power to the module.
2. Connect the axis drive output to the amplifier.

3. Turn the power back on.
  4. Turn on the hydraulics.  
If the axis drifts, go back to the Null Drive procedure.  
If not, go to step 5.
  5. To move the axis to the first position (either extend or retract).
    - a) Estimate drive output (mV) that would generate a slow safe speed.  
Enter it into the COMMAND VALUE number field.  
Note: In open-loop mode, this field sets the module output.  
In closed-loop mode, this field sets the commanded position.
    - b) Command the module to output that value with the “O” command.  
The axis should start to move.
  6. To stop axis motion:
    - a) Zero the COMMAND VALUE number field.
    - b) Command the module to zero its output with an “O” command.
  7. In Scale/Offset Calibration window (from Tools in CommandBar):
    - a) Enter the desired position value in the Actual Position field for the First Position . (For example, 40,000)
    - b) In corresponding Counts field, click “Use Current”.
  8. To move the axis to the second position:
    - a) Command the module to output a negative value (such as -200) with the “O” command (as with step 5b).  
The axis should start to retract. If not, verify that the value is (-).
  9. To stop axis motion:
    - a) Zero the COMMAND VALUE number field.
    - b) Command the module to zero its output with an “O” command.
  10. In the Scale/Offset Calibration window (from Tools in command bar):
    - a) Enter the desired position value in the Actual Position field for the Second Position . (For example, -4000)
    - b) In corresponding Counts field, click “Use Current”.  
The New Parameters area of the window will show the calculated values for the Config word, Scale, and offset. (Set extend/retract limits later.)
  11. Confirm that the displayed New Parameters (step 10) are valid. Then,
    - a) Click “Apply” to enter the values into configuration parameter words.
    - b) Click “Done” to close the editor window.
- Important:** You must set the EXTEND and RETRACT LIMITS *after* setting the scale and offset. The Scale/Offset Calibration tool will re-calculate any existing EXTEND and RETRACT LIMITS automatically when you use it to set a scale and offset.
12. For each axis, enter the desired end-point values for the EXTEND and RETRACT LIMITS in the screen’s PARAMETER section.  
Enter them in the same engineering units as used in steps 7 and 10.
  13. Initialize (activate) axis parameters with the “P” Command.
  14. Repeat this procedure for each axis in use.

## Getting Ready to Tune the Axes

Once you have set scale, offset, and extend/retract limits in open-loop mode, you can now use the Hydraulic Configurator to tune the axis using closed-loop move commands and axis plots. We suggest that you:

1. Leave un-entered configurations parameters at default, except for:
  - Auto Stop to 000E0 (hard stop, only for LDT faults)
2. If not done already, initialize the axes with the “P” command.
3. Store two 6-word motion commands in the S Stored Command Editor:
  - Mode word = 00000  
(This sets integrator to Always Active and accel/decel to slow ramp.)
  - SPEED, ACCEL, and DECEL values at 20% of typical machine move  
(For safety, start slow and increase SPEED gradually.)
  - COMMAND VALUEs to desired end positions for the axis to tune
  - Zero all six command words of the axes not to be tuned
4. Set the plot clock (in even-numbered seconds, 20 max) to longer than you expect for the axis to run “tuning” moves.
5. **ATTENTION:** Highlight the axis you want to move before moving the axis back and forth using stored commands [ 1 ] and [ 2 ]. Unexpected motion could occur if the wrong axis is highlighted.
6. Open the status bits window (Ctrl-B), and check the STATUS word for errors while the axis is moving.
7. View captured axis plots (click [  ] in the ToolBar). Observe the Sum-Error<sup>2</sup> value displayed in the window.

## Tuning Each Axis

‘There is no substitute for experience when tuning an axis. This section offers some guidelines, tips, and suggestions for tuning your system. While helpful for many systems, they may not be the best for a particular system. We help you with:

- General Procedure for Tuning an Axis
- Adjusting Command-word Speed and Acceleration values
- Adjusting Feedforward Parameters
- Using Acceleration Feedforwards
- Adjusting PID Gains

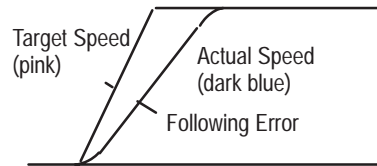
### General Procedure for Tuning an Axis

Use this generalized procedure with the Hydraulic Configurator.

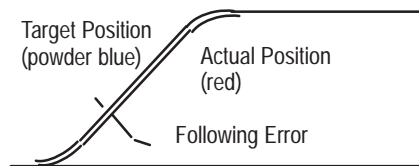
- Move the axis using stored commands [ 1 ] and [ 2 ].
  - Observe the axis plot for each move.
  - Adjust one configuration parameter at a time in the order given.
1. Observe plots of axis moves between the two positions that you set up with stored commands in the previous section, Getting Ready. Observe following error, overshoots, and oscillations.

For adjusting command values *and* configuration parameters, refer to Adjusting Command-word Speed and Acceleration Values, page 4-7.

2. The Following Error will probably vary as indicated by diverging plots of target and actual speeds during acceleration or deceleration.



3. To achieve a nearly constant steady-state Following Error, increase the PROPORTIONAL GAIN until the plots of target and actual *speeds* become *parallel* during acceleration or deceleration.
4. To minimize the Following Error, use the auto Adjust Feedforward “F” command. With each “F” command, the module boosts (prescales) the drive output by increasing the FEEDFORWARD term. This brings the plots of target and actual *positions* to coincide.



For additional information, refer to Feedforward Parameters, below.

5. For critical tuning, adjust the ACCELERATION FEEDFORWARD term. To do this, observe the Sum-Error<sup>2</sup> value found in the window on the plot screen. Repeat axis moves with adjustments until Sum-Error<sup>2</sup> value reaches a minimum. Too much ACCELERATION FEEDFORWARD will increase the Sum-Error<sup>2</sup> value.

**Important:** Critical tuning may increase pressure spikes. If the axis load is too large, consider lowering your expectations of machine performance and use smaller accel/decel values in the motion command. Using the S-curve feature (Command Mode) is another alternative.

For additional information on Acceleration Feedforward, refer to Using Acceleration Feedforward, below.

6. For end-point stability, adjust the PROPORTIONAL GAIN (and INTEGRAL GAIN) to minimize the end-point position error by either of two ways. Adjust P and/or I until the:
- end position oscillates. Then back down to 75% of P.
  - Sum-Error<sup>2</sup> value no longer decreases with each adjustment.
- Remember to enter an IN POSITION value in the Config word to monitor end-position stability.

7. If moving a relatively large mass with a relatively small hydraulic cylinder, first investigate the affect of:
  - a) Integrator Mode selection in the Command-mode word:  
active always, for accel/decels, in position, or never.
  - b) Integrator Limit selection in the Config word:  
20% for a typical hydraulic system, 80% for a difficult system.Also, see step 6 for using INTEGRAL GAIN to help minimize the end-point position error.

For additional information on PID Gains, refer to that topic, below.

### **Adjusting Command-word Speed and Acceleration Values**

Increase the SPEED and ACCELERATION command words gradually while making long moves. Use Hydraulic Configurator to plot the moves and look for following errors, overshoot, or oscillations. Eventually, when the SPEED and ACCELERATIONS are too high, the moves will cause an error on the axis.

If an overdrive error occurs, there is not enough drive capacity to drive the axis at the requested SPEED. Should this occur, reduce the SPEED.

If excess Following Error occurs, the appropriate FEEDFORWARD configuration parameter must be adjusted for extend and retract moves.

If excess Following Error persists, ACCEL and DECEL ramps may be too steep for your system response. You can reduce their values, or increase the ACCEL FEEDFORWARD term.

Also remember that you can specify either the time or the distance in which the ACCELERATION or DECELERATION must occur.

After correcting the problem of excess Following Error, keep moving the axis back and forth with increasing SPEED values until you reach desired speed. Should the system seem a little sloppy, try increasing the PROPORTIONAL GAIN until the axis moves with a steady state FOLLOWING ERROR (as observed by axis plot) and stops at the end point with minimum in-position error. Remember: the parameters are not updated in the module until you issue the "P" command.

### **Adjusting Feedforward Parameters**

In many hydraulic systems the feedforward parameters (EXTEND FEEDFORWARD and RETRACT FEEDFORWARD) are the most important parameters for position tracking during a move.

Use the auto Feedforward Adjust command "F" to minimize the FOLLOWING ERROR. Refer to General Tuning Procedure, step 2. For move information, refer to these parameters in the Help Topics.



**Important:** When tuning the Feedforward term with command “F”, plot sequential axis moves and compare plots of target position and actual position until the two plots coincide.

Another way to adjust these parameters is to set the DIFFERENTIAL GAIN and INTEGRAL GAIN to zero and the PROPORTIONAL GAIN to a small value (between 1 and 5), then make long slow moves in both directions.

Adjust the EXT FEEDFORWARD and RET FEEDFORWARD until the axis tracks within 10% in both directions. In hydraulic systems, the EXTEND and RETRACT FEEDFORWARD terms typically differ by the ratio of the extend and retract piston areas.

Alternately, you can find the appropriate value for the FEEDFORWARD terms by making moves with the axis at a SPEED of 1,000. The amount of output drive required to maintain this SPEED is the correct value for the FEEDFORWARD parameter.

### Using Acceleration Feedforwards

The ACCELERATION FEEDFORWARD terms are particularly useful for axes which move large masses with relatively small cylinders. This combination delays the start of movement, and the ACCELERATION FEEDFORWARD terms can help compensate for this delay.

ACCELERATION FEEDFORWARDS are easiest to adjust with the PID gains set low. After commanding a move, plot it using Hydraulic Configurator and look for a following error during the acceleration.

Increase the ACCELERATION FEEDFORWARD until the error is minimized. For large masses the ACCELERATION FEEDFORWARD can be in the tens of thousands.

**Important:** When tuning acceleration feedforward terms, you can plot multiple axis moves and observe the Sum-Error<sup>2</sup> value found in the window on the plot screen. Repeat axis moves and adjust this term until the Sum-Error<sup>2</sup> value reaches a minimum.

### Adjusting P-I-D Gains

PROPORTIONAL GAIN affects the responsiveness of the system. Low gains make the system sluggish and unresponsive. Gains that are too high make the axis oscillate or vibrate. You can adjust the PROPORTIONAL GAIN by slowly increasing it and moving the axis. When you see a tendency to oscillate as the axis moves or stops, reduce the gain by 10 to 30 percent.



It is usually desirable to have some INTEGRAL GAIN (5 to 50 counts) to help compensate for valve null drift or changes in system dynamics. Some systems may require larger INTEGRAL GAIN, in particular if they are moving a large mass or are nonlinear. Too much INTEGRAL GAIN will cause oscillations. On the other hand, some hydraulic systems do not require INTEGRAL GAIN.

DIFFERENTIAL GAIN is used mainly on systems which have a tendency to oscillate. This happens when heavy loads are moved with relatively small cylinders. DIFFERENTIAL GAIN will tend to dampen out oscillations and help the axis track during acceleration and deceleration. If you use DIFFERENTIAL GAIN, you may be able to increase the PROPORTIONAL GAIN somewhat without causing the system to oscillate.

A disadvantage to DIFFERENTIAL GAIN is that it amplifies position measurement noise which can cause the system to chatter or oscillate if the gain is too high or there is too much noise.

## Finding the Value of the Dead Band Eliminator

The DEAD BAND ELIMINATOR compensates for valve overlap. Typically it is required if the valve has relatively:

- large overlap (up to 20%)
- slow speed (less than 40 Hz)
- large capacity for its application

(For a description of how Dead Band Eliminator affects the system, refer that subject under Hydraulic Configurator Help Topics.)

**Important:** Use this procedure only if your valve needs the DEAD BAND ELIMINATOR. If not, go to the next section, Saving Parameters.

This procedure requires operating the module in open-loop mode *with drive outputs connected to the amplifier*. In this procedure, you will increase the drive output until the axis just moves in one direction, then in the other.

1. Select the axis and enter a small positive value (such as 200 mV) in the COMMAND VALUE number field.
2. Issue the open-loop output command “O”.
3. Look for axis motion.
4. **Important:** If necessary, be prepared to stop axis motion. To stop:
  - Enter zero in the COMMAND VALUE number field.
  - Issue the open-loop output command “O”.
5. Slowly increase the value that you entered in the COMMAND VALUE number field, and repeat steps 2 and 3 until the axis just starts to move.

**Important:** Observe if the axis moved in the intended direction. If in the wrong direction, check drive wiring polarity and hydraulic plumbing before reversing the drive mode in the Config word.

6. Back down the valve below no motion. Write down this value.
7. Repeat steps 1-6 with negative values for opposite direction.
8. Determine DEAD BAND ELIMINATOR value. It is the larger of the values from step 6, regardless of sign ( $\pm$ ).
9. Enter the value of the DEAD BAND ELIMINATOR in the number field in the Parameter section of the main screen.
10. Transfer the parameter to the module using the “P” Command.

## Saving Parameters

At any time during tuning, you can save configuration parameters:

- For PC backup, save the file of configuration parameters from the Hydraulic Configurator with the “Save-as” function.
- Store them in integer (N) files of the SLC processor to insure that the ladder program matches the configuration parameters, issue a ladder logic command to copy the M1 file of configuration parameters from the module into SLC processor integer (N) files.

For ladder logic examples, refer to chapter 5.

## Using Ladder Logic

### Chapter Objectives

This chapter covers:

- Obtaining sample ladder program from the Internet
- Configuring your SLC processor, off-line
- Using the sample ladder program, RSExempl.RSS, to:
  - copy configuration parameters to the SLC processor
  - copy configuration parameters to the module
  - operate axis movement automatically
  - jog the axis
  - respond to loss or restoration of hydraulic power
  - run multiple synchronized axes

### Obtaining Sample Ladder Program from the Internet

You can obtain sample ladder logic from the Allen-Bradley website on the Internet and download it to your PC as an executable file.

#### To Access the Internet:

1. Access the Allen-Bradley website (and module software logic) at:  
<http://www.ab.com/mem/appsys/prodinfo/applac/appla/qssw/index.html>
2. The sample ladder program (130 Kbyte) is in the same file as the Hydraulic Configurator (2.9Mbyte).
3. Download the Hydraulic Configurator and ladder program to your PC.
4. Move the sample program into the subdirectory on your hard drive where your programming software looks for files.  
For example, with RSLogix500: C:\RSI\Logix500\QSEXAMPL.RSS.

### Configuring Your SLC Processor, Off-line

This procedure uses RSLogix500 version 2.0 or later. For other types of programming software, the procedure and/or prompts may vary.

You must modify the I/O configuration to match your system layout and change associated addresses, offline.

1. Open file QSEXAMPL.RSS from the file pull-down window.
2. Select the I/O Configuration icon and launch it. Then select:
  - A. Processor type (ladder sample is SLC 5/04).
  - B. Module slot number (ladder sample is slot 2 in 4-slot chassis).
  - C. Module ID is 13627 entered under “Other”.
3. The sample ladder logic creates M0/M1 files at 64 words each. If you move the module to another slot, be sure to retain the files.
4. Search and replace all addresses that must be changed.
5. Save the file as a new file to preserve the original file for backup.

## Using the Sample Ladder Program

Consider creating a bit and data address table for your own application. Data and bit addresses associated with the sample program are:

Address:	Description:
N7:0	current state of axis 1, programmed automatic motion
N7:1	current state of axis 2, programmed automatic motion
N7:4	next state of axis 1, programmed automatic motion
N7:5	next state of axis 2, programmed automatic motion
N11	M-file initialization parameters
N12:0-5	axis 1 advance profile, programmed automatic motion
N12:6-11	axis 2 advance profile, programmed automatic motion
N12:12-17	axis 1 retract profile, programmed automatic motion
N12:18-23	axis 2 retract profile, programmed automatic motion
N12:24-29	axis 1 advance profile for jog
N121:30-35	axis 1 retract profile for jog
B3:0/0	copy M file from N11 into module and initialize axis 1 and 2
B3:0/1	copy M file from module into N11
B3:0/3	jog advance
B3:0/4	jog retract
B3:0/7	enter programming for automatic motion

Load the ladder file into the SLC processor.

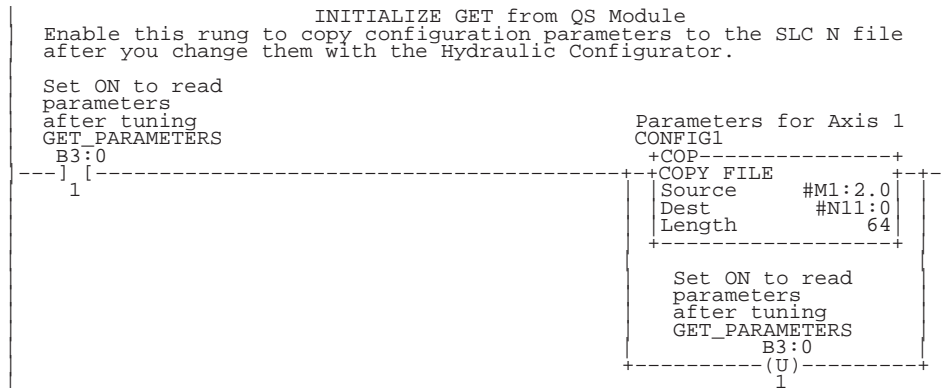
**Important:** You can run the sample ladder program from the desktop using pre-programmed configuration parameters in file N11 *without LDT or drive output connections to the module* because the Simulate bit is set by default in each axis Config word in the sample program.

**ATTENTION:** To guard against equipment damage or personal injury, do NOT attempt to operate the module outside of simulate mode without first initializing valid configuration parameters in the module.

If you have *already initialized* the module with valid configuration parameters that suit your machine, you should copy them from the module into the N11 file. (Refer to Copy Configuration Parameters to the SLC Processor, next.)

If you have *NOT initialized* the module with valid configuration parameters, copy the N file of the sample program to the module to initialize axis 1 and 2 with pre-programmed configuration parameters (Refer to Copy Configuration Parameters to the Module, next.)

## Copy Configuration Parameters to the SLC Processor



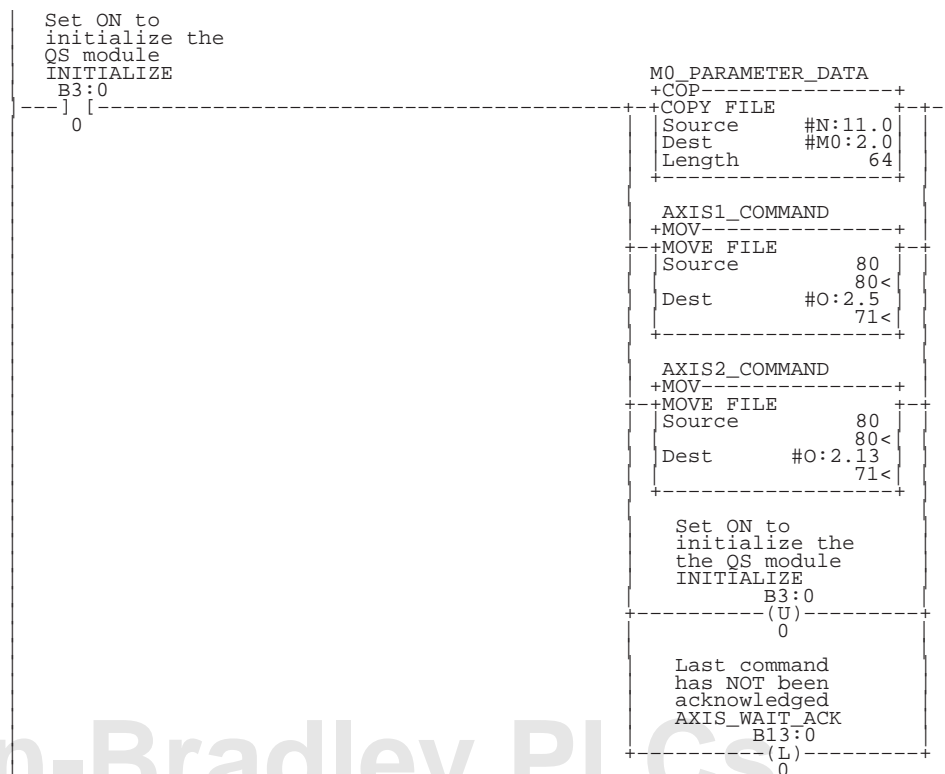
## Copy Configuration Parameters to the Module

This rung copies configuration parameters from SLC N11 file to the module's M0 file and issues the "P" command for axis 1 and 2.

The "P" command is the decimal value "80" that is moved to output image Command words O:2.5 (axis 1) and O:2.13 (axis 2).

**Important:** Configuration parameters copied to the module's M0 file are not initialized (activated) until the "P" command is issued.

**Important:** This rung will overwrite configuration parameters currently stored in the module. If you want to retain configuration parameters stored in the module, be sure that you have copied them to the N11 file (previous section) before activating this rung.



## Back and Forth Motion with State-machine Logic (Programming for Automatic Operation)

This ladder logic example moves axes 1 and 2 back and forth with Go “G” commands. Each move has its own set of motion profile words (mode, accel, decel, speed, and position).

The example is a state machine with four automatic states:

State:	Description:
0	No motion. Used when automatic mode is not enabled
1	Moves axis 1 and 2 independently Uses profile command words N12:0-5 (axis 1) and N12:12-17 (axis 2)
2	Synchronizes axis 1 and 2 to reach the end point at the same time Uses profile command words N12:6-11 (axis 1) and N12:18-23 (axis 2)
3	Pauses five seconds, then returns to state 1.

Error detection and recovery logic is application dependent, and should include (for each axis) recovery from module-detected errors and axis timeouts.

The mode words in these profile commands put the module into simulate mode, which means it is *isolated* from LDT inputs and output drive. It allows for axis-position update and axis plotting.

You cannot be jogging when you attempt to enter automatic mode, and you cannot be in automatic mode when attempting a jog.

**Important:** If you intend to use this sample program on a live machine (module NOT in simulate mode), be sure that you have:

- stored valid motion profiles in N12 files
- initialized the module with valid configuration parameters such as axis limits, scale, offset, and feedforwards

Assuming that axes are initialized, the setting of bit B3:0/7 simulates an auto operation switch that starts the state machine in state 1.

```

To run this example, set HYDRAULICS OK bit in the data table.
Then set the AUTO_SS bit.

      Valve drive power
      and pumps are ON,
      Operator          electronic servo
      Auto Mode        valve is enabled,
      select SW        blocking valves open
      AUTO_SS          HYDRAULICS_OK
      B3:0              B3:0
      ] [-----] [-----]
      7                 2

      Axis has received
      valid "P" command
      AXIS1_INITIALIZED
      I:2
      ] [-----]
      70

      Axis is jogging
      AXIS JOGGING
      B13:3
      ] [-----]
      0

      Run state
      machine
      example
      AUTO_MODE        AUTO_MODE
      B3:0              B3:0
      ] [-----]
      14

Set the state machine to state 1 for all axes when entering auto mode.
This fill command initializes all four axes.

Run state
machine
example
      One Shot
      AUTO_MODE_OS
      B3:0              B3:0
      ] [-----] [OSR]
      14                 15

      AXIS1_NEXT_STATE
      +FLL-----+
      FILE FILL
      Source          1
      Dest             #N7:4
      Length           4
  
```

Reset the state machine for all axes if not in auto mode.  
 In state 0, the auto mode state machine does not write to the module's I/O.

Run state machine  
 example  
 AUTO\_MODE  
 B3:0  
 ]/[  
 14

```

+-----+
| AXIS1_NEXT_STATE |
+-----+
| +FLL-----+
| FILE FILL        |
| Source           |
| Dest             | #N7:4
| Length           | 4
+-----+
    
```

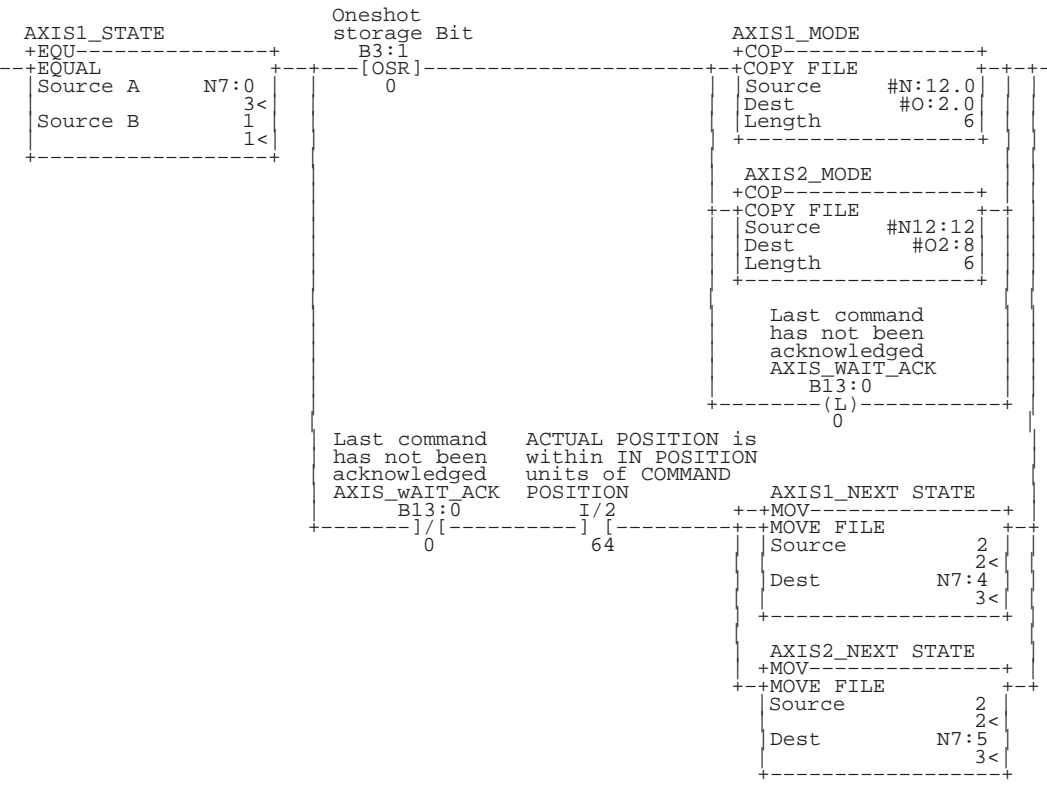
Copy next state to state machine.  
 This technique avoids race conditions.

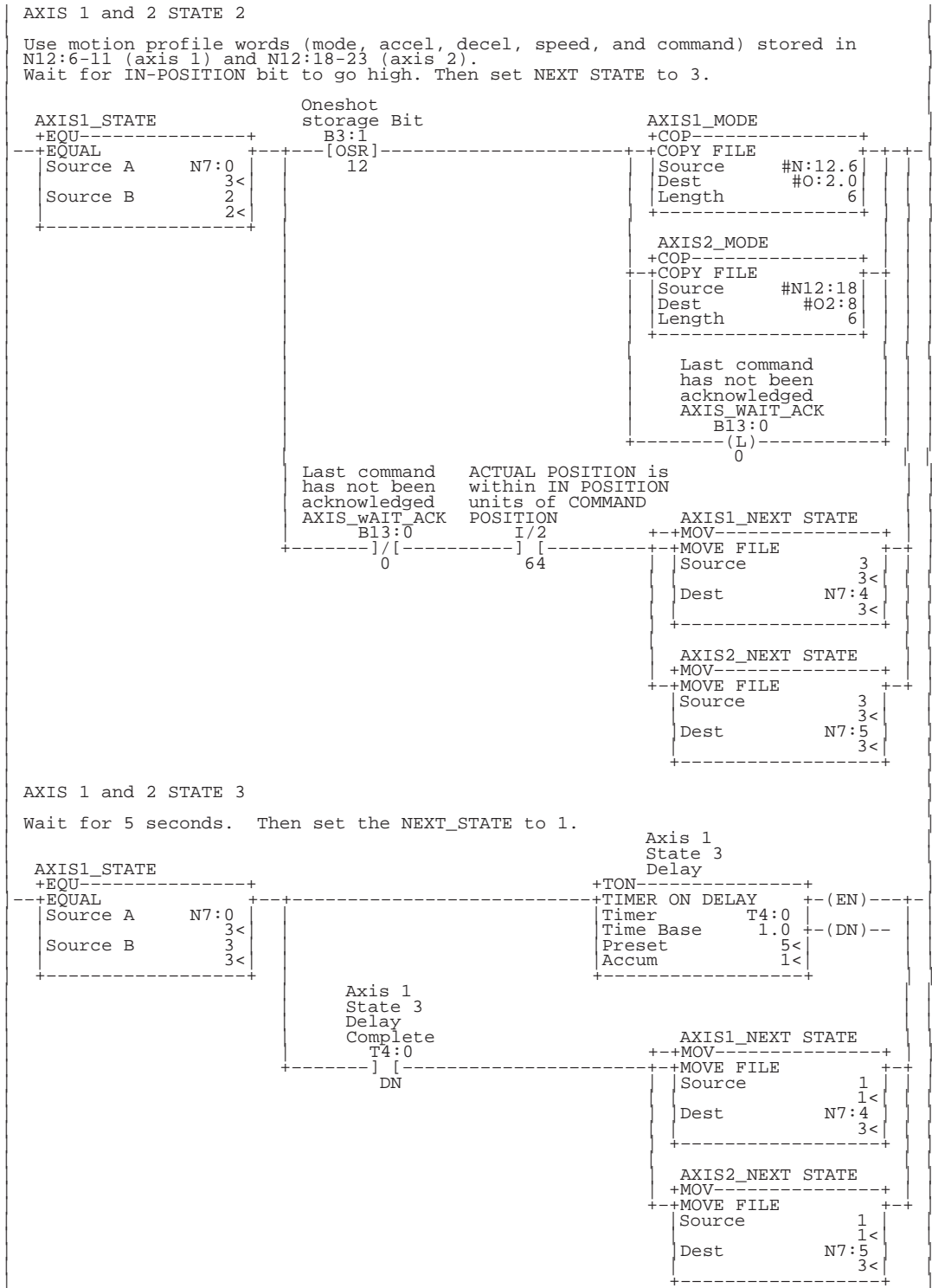
```

+-----+
| AXIS1_NEXT_STATE |
+-----+
| +COP-----+
| COPY FILE        |
| Source           | #N7:4
| Dest             | #N7:0
| Length           | 4
+-----+
    
```

AXIS 1 and 2 STATE 1

Use motion profile words (mode, accel, decel, speed, and command) stored in  
 N12:0-5 (axis 1) and N12:12-17 (axis 2).  
 Wait for IN-POSITION bit to go high. Then set NEXT STATE to 2.







## Jogging the Axes

In the sample program:

- Commands for jogging axis 1 are stored in N12:24-29 (to advance) and N12: 30-35 (to retract).
- Jog “pushbutton” addresses are B3:0/3 (advance) and B3:0/4 (retract).

When either jog “pushbutton” is pressed:

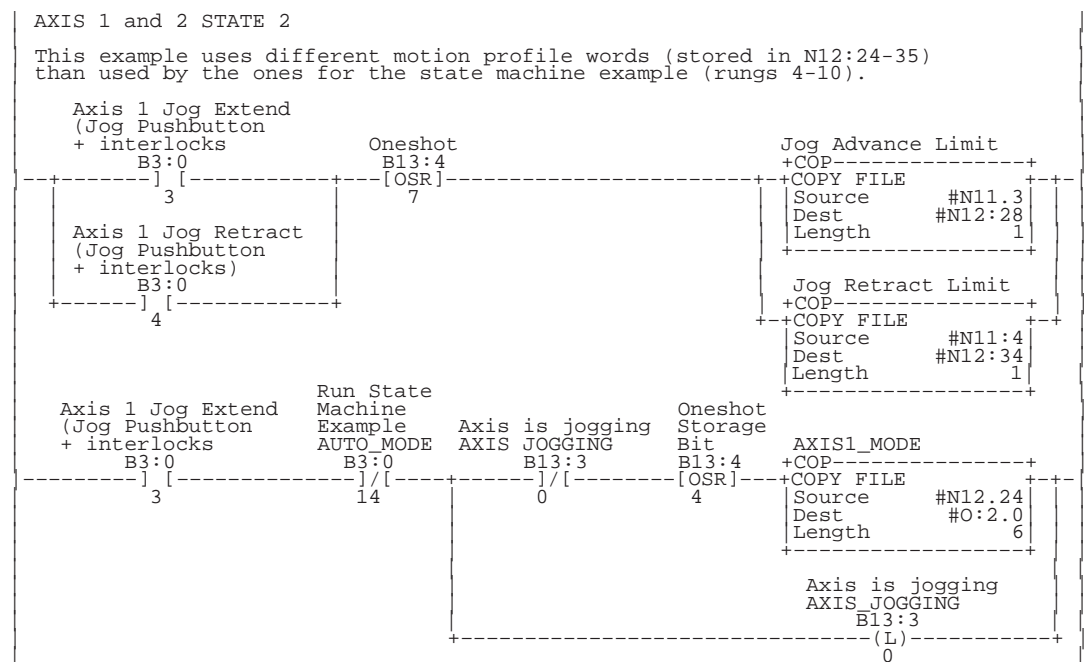
- extend and retract limits are copied into the jog command position words in the N files
  - the corresponding N file is copied to the output word to the module
- This provides a target position at the end of travel in each direction.

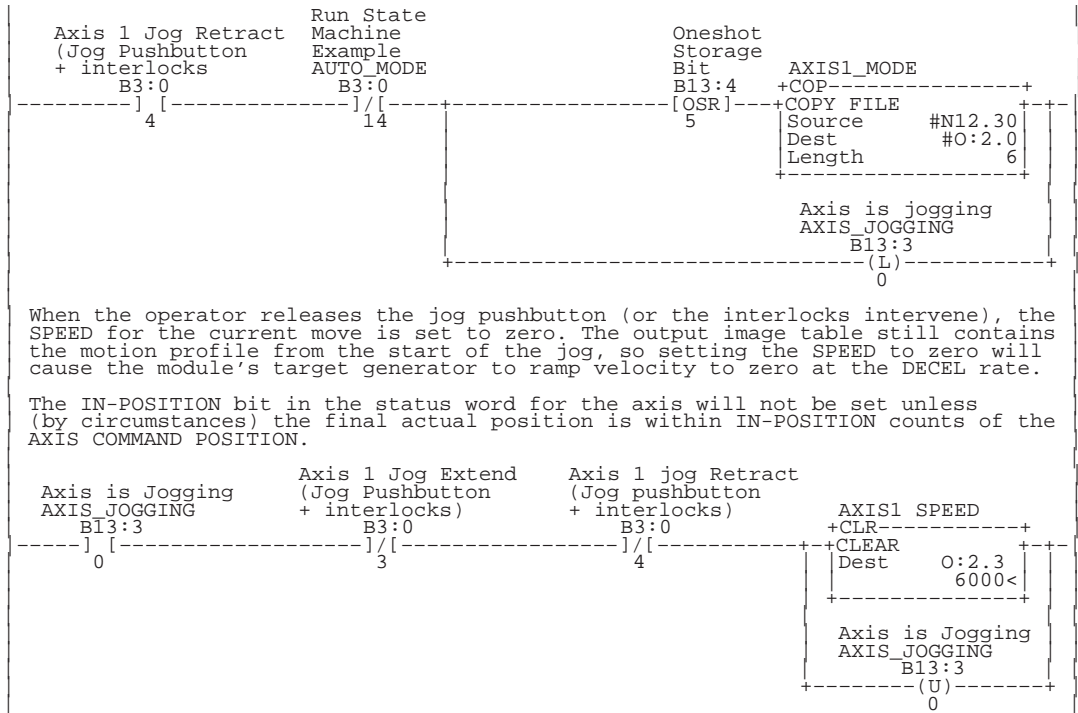
When the jog “pushbutton” is released, zero is copied into the jog command speed word, allowing the axis to decelerate to a stop and unlatch the jog command.

You cannot be in automatic mode when attempting a jog, and you cannot be jogging when you attempt to enter automatic mode.

**Important:** If you intend to use this sample program on a live machine (module NOT in simulate mode), be sure that you have:

- stored valid motion profiles in N12 files
- initialized the module with valid configuration parameters such as axis limits, scale, offset, and feedforwards





### Responds to Hydraulics On/Off

The purpose of this sample is to help you consider how to handle typical events that may occur when hydraulic system power is cycled.

When hydraulic power is lost and the module remains powered, the axis may be allowed to drift or to be moved manually. The module interprets this axis motion as following error, so when hydraulic power is restored, the module attempts to return the axis to the In-Position band which may cause significant unexpected motion.

**ATTENTION:** To guard against unexpected motion when hydraulic power is restored, the moment that hydraulic pumps are turned Off your ladder logic should take precautions to help prevent valve null and integrator windup from accumulating. Precautions include:

- detect that hydraulic power is Off
- issue a halt ("K") command to stop axis motion and disable valve null and integrator update
- lock out any movement commands such as Go or Jog

When the hydraulic pumps are turned On, your ladder logic should:

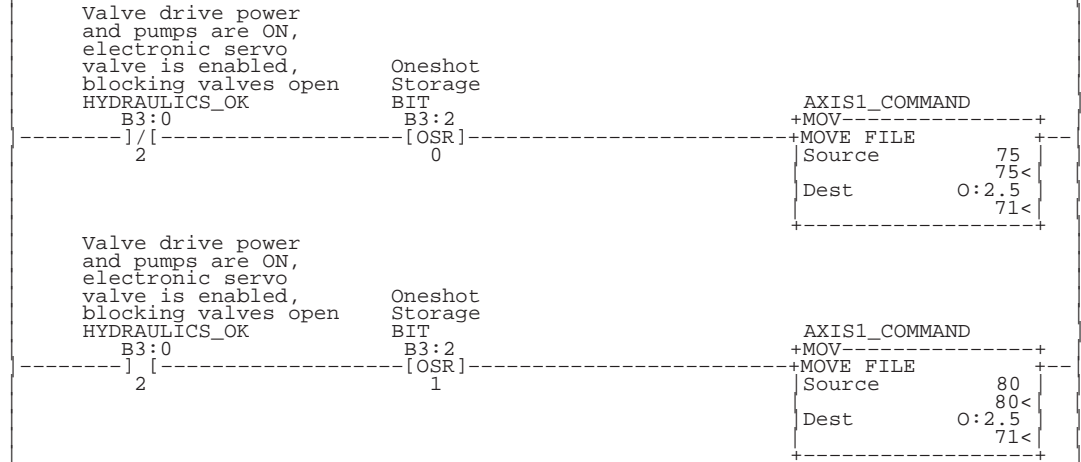
- issue a Go ("G") command to its current position (This restores Null Drive and Integrator Drive from before the halt command was issued.)

**ATTENTION:** When hydraulic system power is lost, your ladder logic is responsible for ensuring that valve null and integrator sum do not wind up if the axis is out of position. If wind up is allowed, the axis will move unexpectedly when hydraulic system is restored. Typically, the preferred method is to:

- issue a Kill ("K") command when the pump goes off to disable valve null and integrator wind up
- issue a Go ("G") command to current position or known target when the pump goes on to re-enable the integrator and null with values from before the Halt was issued

This should minimize unexpected motion when hydraulic power is restored.

Also, your ladder logic must lock out any movement commands such as Go or Jog when the axis is stopped due to loss of hydraulic power.



## Running Synchronized Axes

In Command-mode word (O:e.0, 8, 16, or 24 for axes 1, 2, 3, or 4):

- select "Always Active" for the Integrator Mode (Bits 2 and 3 must both be reset to zero.)
- assign the same Synch A or B to all axes that are synchronized (Bits 4, 5: Each of the synchronized axes must have the same bit set.)

The axis that moves the farthest is the master for module computations. Speed values that you entered for shorter-run axes may not be achieved, because all synchronized axes must reach the final position at the same time. If one of the synchronized axis faults (stops), the others stop, also. The module uses the *master axis* to compute axis decels so all stop at the same point.

You may apply the above considerations to the previous ladder logic example, Back and Forth Motion with State-machine Logic (Programming for Automatic Operation).

**Notes:**

## Troubleshooting

### Objectives

This chapter:

- Describes the module's LED indicators
- Suggests corrective action for typical operating problems

### Using LED Indicators

Use this table to interpret the module's LED-indicated status.

<div style="border: 1px solid black; padding: 5px; width: fit-content; margin: auto;"> <p style="text-align: center; margin: 0;"><b>HYDRAULIC</b></p> <div style="display: flex; justify-content: space-around; align-items: center;"> <div style="text-align: center;"> <p>RUN/FLT <input type="checkbox"/></p> <p>AXES 1 <input type="checkbox"/></p> <p>3 <input type="checkbox"/></p> </div> <div style="text-align: center;"> <p><input type="checkbox"/></p> <p><input type="checkbox"/></p> <p><input type="checkbox"/></p> </div> <div style="text-align: center;"> <p>2</p> <p>4</p> </div> </div> <p style="text-align: center; margin: 0;"><b>SYNCHR AXES</b></p> </div>	<p><b>Module "Run" status:</b>          Green: Module OK          Off: SLC not communicating          Flash Grn: Updating FLASH memory</p> <p><b>Module "Fault" status:</b>          Red: Fault or Power-up reset          Green: Module power OK</p> <p><b>Axis status (one LED per axis):</b>          Red: LDT error (loss of input, noise)          Green: Axis OK          Flash Red: Axis motion error          Off: Axis not initialized</p>
-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------	-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------

### Correcting Typical Problems

Use this table to look up corrective action for typical problems.

Problem Condition:	Possible Cause:	Corrective Action – Check the Following:
Ladder program cannot: – access parameters – operate the module	You made errors configuring the module or addressing your ladder logic.	1) module is not configured properly 2) module's I/O slot number and ladder address do not match
Red Axis LEDs are on	The transducer is not responding to the module.	1) Status word to determine which transducer fault has occurred 2) Transducer power supply and wires to the transducer
During a move, the Actual Position is erratic	Incorrect shielding or a defective transducer is causing electrical noise.	Monitor bits 13, 14, and 15 of the axis' STATUS word to determine if the module is detecting a transducer error. To reduce electrical noise: 1) Make sure the transducer wiring is separated from all other wiring. 2) Add a termination resistor (220 ohm for Temposonics I) as close to the transducer as possible. 3) Connect the shield at the module end, transducer end, or both.
During a move, the drive halts for no apparent reason	When the module detects a "transducer not responding" error it stops automatically.	See "...Actual Position is erratic" above for more information. If any of the following conditions are enabled, the axis will also halt: – Following Error – Position Overflow – Integrator Windup – Overdrive – Parameter Error
Transducer counts field is not indicating transducer location	See "Red Axis LEDs are on" above.	
Transducer counts field changes but output drive does not work	See "...drive halts for no apparent reason" above.	
The System is unresponsive and hard to tune	This problem could have several causes.	1) Is a hose rather than rigid pipe installed between the hydraulic valve and the cylinder? The fluid expands the hose rather than moving the cylinder. 2) Does the valve have overlap? Overlap in hydraulic valves causes a significant dead band and slows the system response. Some proportional valve amplifiers have dead band eliminator circuits which make tuning easier.
The axis oscillates	This problem could have several causes.	1) The DEAD BAND ELIMINATOR value may be too high. 2) Reduce PROPORTIONAL, INTEGRAL, or DIFFERENTIAL gains.
The axis does not finish moves or moves differently than expected	The SLC processor is issuing unintended commands.	Use the Hydraulics Configurator command queue to monitor commands sent by the SLC processor to the module. Confirm that only the expected commands are being sent.

**Notes:**

## Module Specifications

### Electrical

SLC Processor	For use with SLC 5/03 or SLC 5/04 processors
Backplane Power Requirements	1.0 A at 5V dc 200 mA at +24V dc
I/O Chassis Location	Any I/O-chassis slot except slot 0
I/O Image Table Usage	<b>Input:</b> 32 16-bit words <b>Output:</b> 32 16-bit words
Configuration Parameters	M0 and M1 64-word files (16 words per axis)
LDT Input	Differential interface to LDTs Pulse-width modulated (DPM) or start/stop pulse (RPM) with external interrogation
Analog Output	-10 to +10V dc @ 5 mA
Output Resolution	12-bit
Module Update Time	2 ms
Fail Safe Timers	<b>Drive Output Disable</b> -15 microseconds Retriggered by activity on the module's internal bus. If not retriggered within 15 microseconds, timer disables the drive outputs. When internal bus activity resumes, drive outputs are re-enabled. <b>Software Reset</b> - 30 milliseconds If the microprocessor fails to retrigger the onboard watchdog timer, the 30 millisecond reset timer expires and resets the CPU. This has the same effect on the module as powering up.

### Physical

LED Indicators	<b>Module "Run" status:</b> Grn: Module OK Off: SLC not communicating Flash Grn: Updating FLASH memory <b>Module "Fault" status:</b> Red: Fault or Power-up reset Grn: Module power OK <b>Axis status (one LED per axis):</b> Red: LDT error Grn: Axis OK Flash Red: Axis motion error Off: Axis not initialized
Compatible LDT Input Devices	Linear Displacement Transducer such as: Balluff BTL-2-L2 or -M2 Gemco Quick-Stick II Santest GYRP or GYRG Temposonics II with DPM or RPM
LDT Range and Resolution	230 inches @ 0.004 inch 120 inches @ 0.002 inch 60 inches @ 0.001 inch
LDT Cable Length	<b>RPM-type:</b> 150 ft. <b>DPM-type:</b> 200 ft.
Interface Module (IFM) Terminal Block and Cable	<b>IFM:</b> 1492-AIFMOS (required for CE certification) <b>Cable:</b> 1492-ACABLExxxQ (to DB-26 connector on module) where xxx = cable length in meters (for 2.5m cable, xxx = 025.)
Module Cable Connections	<b>I/O to IFM:</b> - DB-26 subminiature (1492-ACABLE) <b>Configuration/Diagnostics:</b> - DB-9 (1746-CP3)
Module ID Code	13627

## Environmental

Operating Temperature	0°C to 60°C (32°F to 140°F)
Storage Temperature	-40°C to +85°C (-40°F to +185°F)
Relative Humidity	5% to 93% (without condensation)

## Certification

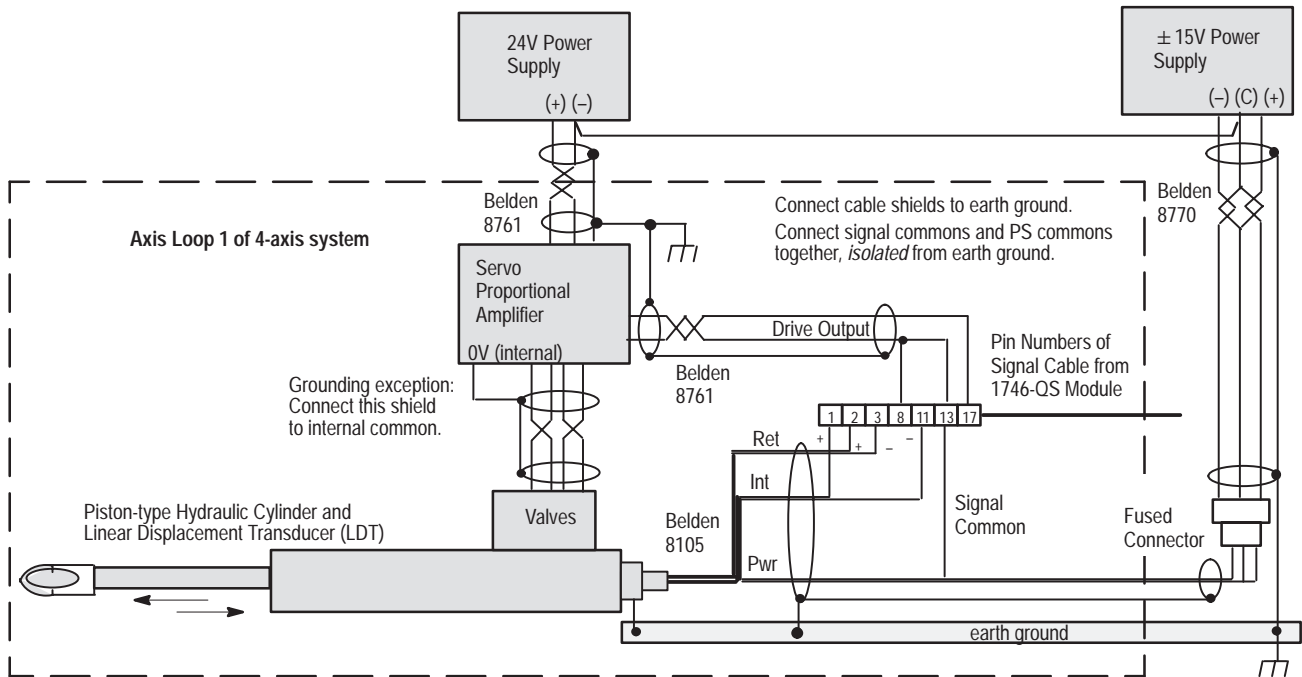
Agency Certification (when marked on product or package)	CE marked for all applicable directives
----------------------------------------------------------------	-----------------------------------------



## Wiring Without the Interface Module

### Wiring Example

We present a 1-axis loop with a differential LDT input.  
(You must provide power supplies and servo amplifiers.)



We present the DB-26 connector pin functions in two ways:  
LDT/loop number (1-4) and numerical order (1-26) in the connector:

by LDT/Loop					in Numerical Order					
I/O Function	Pins for Loop 1	Pins for Loop 2	Pins for Loop 3	Pins for Loop 4	Pin #	I/O Function	Pin #	I/O Function	Pin #	I/O Function
(+) Interrogate	1	10	4	22	1	(+) Interrogate 1	10	(+) Interrogate 2	19	(-) Interrogate 2
(-) Interrogate	11	19	5	14	2	(+) Return 1	11	(-) Interrogate 1	20	(+) Return 2
(+) Return	2	20	15	23	3	(-) Return 1	12	(-) Return 2	21	LDT Common
(-) Return	3	12	6	24	4	(+) Interrogate 3	13	LDT Common	22	(+) Interrogate 4
LDT Common	13, 21				5	(-) Interrogate 3	14	(-) Interrogate 4	23	(+) Return 4
n/c	7, 16				6	(-) Return 3	15	(+) Return 3	24	(-) Return 4
Drive Common	8, 26				7	n/c	16	n/c	25	Drive Output 2
Drive Output	17	25	9	18	8	Drive Common	17	Drive Output 1	26	Drive Common
					9	Drive Output 3	18	Drive Output 4		

## Minimizing Interference from Radiated Electrical Noise

**Important:** Signals in this type of control system are very susceptible to radiated electrical noise. Minimize interference from radiated electrical noise with correct shielding and grounding as follows:

Connect LDT cable shields and drive output cable shields (all shields at one end, only) to earth ground.

Keep LDT signal cables far from motors or proportional amplifiers.

Connect all of the following to earth ground:

- power supply cable shields (one end, only)
- LDT flange, frame, and machine
- I/O chassis
- AC ground

Use shielded twisted pairs for all connections to inputs and outputs.

Run shielded cables only in low-voltage conduit.

- Place the SLC-500 processor and I/O chassis in a suitable enclosure.

**Important:** To minimize the adverse effects of ground loops, you must *isolate* power supply and signal *commons* from earth ground as follows:

6. Connect power supply commons and LDT commons together. Be sure that they are *isolated* from earth ground.
7. Connect the cable shield of the servo or proportional amplifier output cable to a zero potential terminal inside the amplifier.
8. Use bond wires that are equal in size to signal wires.
9. When practical, use one power supply to power only your LDTs.

## Checking Out the Wiring and Grounding

Repeat this procedure to check out each of the four axis loops.

**ATTENTION:** Be sure to remove all power to the SLC processor, LDT, valve and pump beforehand.

1. Disconnect the LDT connector at the head end.
2. Turn ON the power supplies for the LDT and SLC processor, and check the LDT connector for +15V dc, PS common, and –15V dc.
3. Observe that the module's fault LED indicates Green.
4. Verify continuity between all of the following commons:
  - shield of the amplifier output cable to the valve
  - output common on  $\pm 15V$  dc PS that powers the LDT
  - (–) terminal on +24V dc PS that powers the proportional amplifier
  - all LDT commons
5. Verify NO continuity between drive output commons and earth ground.
6. To minimize ground loops, verify that all cable shields are grounded (at one end, only) to earth ground.

## Using Processor Files

This appendix covers these topics:

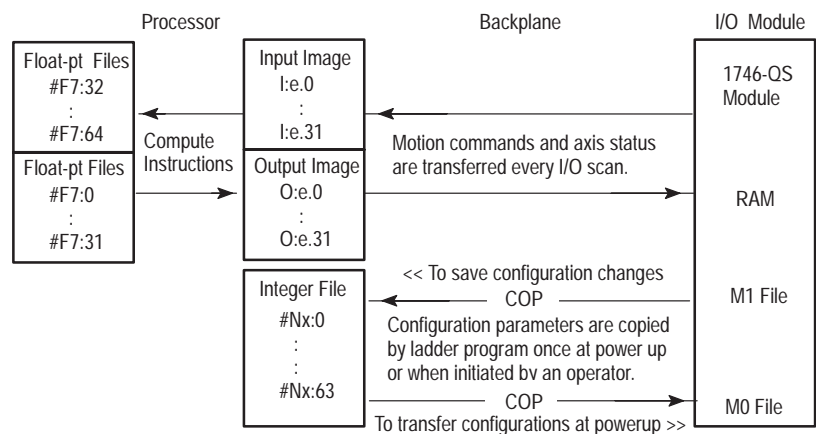
- Transferring Data
- M0 and M1 files – for initial configuration
- I/O image table – to write commands and read status while running

### Transferring Data

#### Overview

The module communicates with the SLC processor over the I/O backplane. Motion commands and axis status for all four axes are transferred across the backplane in groups of 32, 16-bit words in output image table O:e.0-31 for commands and input image table I:e.0-31 for status. Ladder logic copies the 8-word (per axis) motion commands from processor files, typically floating-point (F), into the output image table for automatic scan to the module. It also copies the 8-word (per axis) status blocks, scanned to the processor's input image table, into processor files.

Ladder logic also copies 16 words (per axis) of configuration parameters from integer (N) files to the module's 64-word M0 file at power up or when initiated by an operator. Ladder logic also copies the same configuration parameters (updated in the module by the Hydraulic Configurator) by copying them from the module's 64-word M1 file to integer (N) files in the SLC processor. This example shows motion commands and axis status as floating-point numbers.



If using multiple sets of configuration parameters, you can set up “library“ files for them in SLC processor memory or in the Hydraulic Configurator. Ladder program can read configuration parameters from the module (loaded with the Hydraulics Configurator), and download a set each time you want run a different multi-axis configuration (recipe).

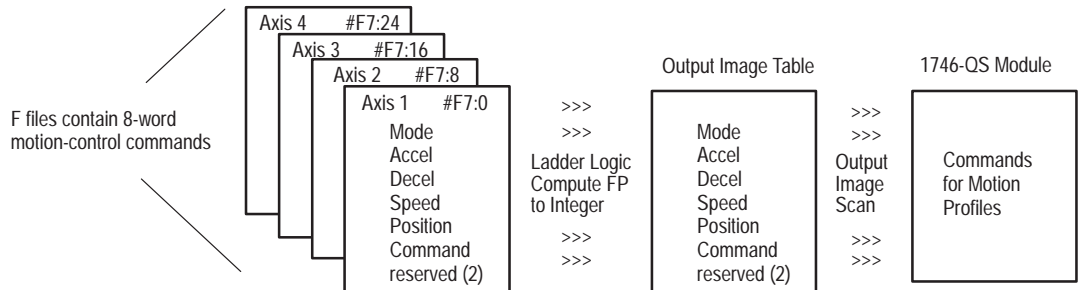
### Transferring Motion Commands and Axis Status

Motion commands and axis status can be integer or floating-point values.

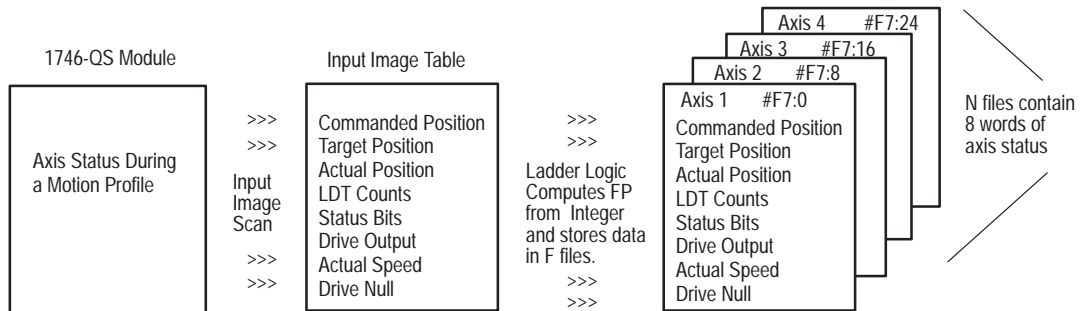
**Important:** If your application requires position values > 32,767, you must use floating-point values and your ladder logic instructions must: compute floating-point numbers from integer

- store values in floating-point (F) files

Each of four files contains the 8-word motion command for an axis. The eight words define the axis' motion profile. When directed by a ladder logic command, ladder logic moves the files into the output image table for transfer to the module. The example shows floating point files with compute instructions.



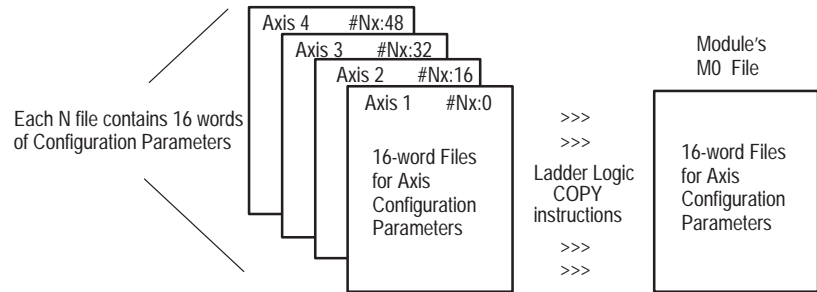
When directed by a ladder logic command, ladder logic moves eight words of axis status from the input image table to processor files. The example shows floating-point with compute instructions and floating-point files.



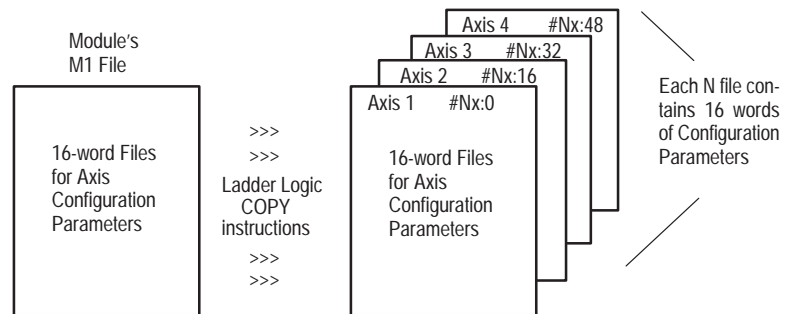
### Transferring Configuration Parameters

Configuration parameters are defined as integer (N) values.

Each of four N files contains the 16-word configuration parameters for an axis. The 16 words define the axis' static characteristics. At power up or when directed by a ladder logic command, ladder logic copies N files into the M0 file for transfer to the module.



When commanded, ladder logic copies 16 words of axis configuration parameters from the module's M1 file to processor N files.



## Using Floating-point for Values Above 32,767

If your data, such as a position value in a motion command, is in the range of  $-32,767$  to  $+32,768$ , ladder logic can operate on it directly as integer (N) values. If using values above 32,767, then your ladder logic must substitute floating-point files (F) for integer files (N) and use compute instructions to change from integer to floating-point. As a result, ladder logic:

wraps the value from  $+32,767$  to  $-32,768$  (signed integer)  
 increments the value (less negative, smaller in absolute value)  
 with each increasing count

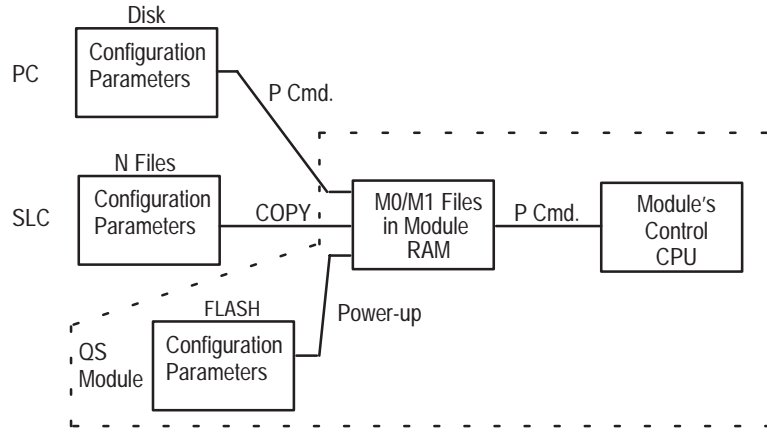
For example, we show how ladder logic handles these numbers:  
 $32,767-32,770$ ,  $40,000$ , and  $65,535$  max:

You Want	Signed Integer	You Want	Signed Integer
32,767	32,767	32,770	-32,766
32,768	-32,768	40,000	-25,536
32,769	-32,767	65,535	-1

The number you want (above 32,767) = signed integer + 65,536.

## Using M0 and M1 Files for Initial Configuration

Configuration parameters for M0 and M1 files can be stored in three locations: on PC disk, in SLC-processor N files, and in module FLASH memory. The “P” command activates the parameters (moves them from RAM to control CPU in the module).



### M0 and M1 Memory Map for Ladder Logic

M0 and M1 files both have the same 16-word memory map. They are addressed in ladder logic as M0e:n or M1e:n (e = rack #, n = word #).

Copy these parameters:	To/From these file addresses:			
	Axis 1	Axis 2	Axis 3	Axis 4
Configuration	e.0	e.16	e.32	e.48
Scale	e.1	e.17	e.33	e.49
Offset	e.2	e.18	e.34	e.50
Extend Limit	e.3	e.19	e.35	e.51
Retract Limit	e.4	e.20	e.36	e.52
Proportional Gain	e.5	e.21	e.37	e.53
Integral Gain	e.6	e.22	e.38	e.54
Differential Gain	e.7	e.23	e.39	e.55
Extend Feedforward	e.8	e.24	e.40	e.56
Retract Feedforward	e.9	e.25	e.41	e.57
Extend Accel Feedforward	e.10	e.26	e.42	e.58
Retract Accel Feedforward	e.11	e.27	e.43	e.59
Dead Band Eliminator	e.12	e.28	e.44	e.60
In Position	e.13	e.29	e.45	e.61
Following Error	e.14	e.30	e.46	e.62
Auto Stop	e.15	e.31	e.47	e.63

### Bit Map of Configuration Word (e:0, e:16, e:32, e:48)

Word	Bit	Description												
Configuration (bit map)	15-12	Number of LDT recirculations = bit combination. bit 15 = 8 recirculations bit 14 = 4 recirculations bit 13 = 2 recirculations bit 12 = 1 recirculation												
	11-04	Reserved												
	03	Simulate mode, used for debugging. = 1 Drive output is set to null, LDT inputs are ignored. Internally, the target position is used as the actual position. (LDT error bits and LEDs are cleared.) = 0 Simulate mode ignored.												
	02-01	Divide LDT counts = bit combination; used to reduce LDT count resolution for long strokes or high speeds <table border="1" style="margin-left: 20px;"> <thead> <tr> <th>Bit 02</th> <th>Bit 01</th> <th>Divide counts by</th> </tr> </thead> <tbody> <tr> <td>0</td> <td>1</td> <td>2</td> </tr> <tr> <td>1</td> <td>0</td> <td>4</td> </tr> <tr> <td>1</td> <td>1</td> <td>8</td> </tr> </tbody> </table>	Bit 02	Bit 01	Divide counts by	0	1	2	1	0	4	1	1	8
	Bit 02	Bit 01	Divide counts by											
0	1	2												
1	0	4												
1	1	8												
0	Integrator limit, to help prevent drive output saturation. If integrator = limit, integrator windup bit in status word is set, and integrator value is held to the limit. =1 limit is 80% of full drive =0 limit is 20% of full drive													

### Using I/O Image Tables for Commands and Status

Motion-control command words for all four axes are sent to the module through the output image table, and axis status words of all four axes are returned from the module through the input image table. The ladder program may write 32 command words (for all four axes) from an integer file to the output image table (by a COPY instruction), and may read 32 status words (for all four axes) from the input image table (by a COPY instruction) into another integer file.

Eight output image words per axis (for commands) and eight input words per axis (for status) are addressed as follows:

Your Ladder Logic Must Write These Parameters	To These Output Image Addresses:			
	Axis 1	Axis 2	Axis 3	Axis 4
Mode	O:e.0	O:e.8	O:e.16	O:e.24
Acceleration	O:e.1	O:e.9	O:e.17	O:e.25
Deceleration	O:e.2	O:e.10	O:e.18	O:e.26
Speed	O:e.3	O:e.11	O:e.19	O:e.27
Position/Command Value	O:e.4	O:e.12	O:e.20	O:e.28
Command	O:e.5	O:e.13	O:e.21	O:e.29
Reserved	O:e.6	O:e.14	O:e.22	O:e.30
Reserved	O:e.7	O:e.15	O:e.23	O:e.31

Your Ladder Logic Must Read These Parameters	At These Input Image Addresses:			
	Axis 1	Axis 2	Axis 3	Axis 4
Commanded Position	I:e.0	I:e.8	I:e.16	I:e.24
Target Position	I:e.1	I:e.9	I:e.17	I:e.25
Actual Position	I:e.2	I:e.10	I:e.18	I:e.26
LDT Counts	I:e.3	I:e.11	I:e.19	I:e.27
Status Bits	I:e.4	I:e.12	I:e.20	I:e.28
Drive Output	I:e.5	I:e.13	I:e.21	I:e.29
Actual Speed	I:e.6	I:e.14	I:e.22	I:e.30
Drive Null	I:e.7	I:e.15	I:e.23	I:e.31

Allen-Bradley PLCs

### Bit Map of Command Mode Word

Word	Bit	Description	
Command Mode (Command word 0)	15	0 = plots each move of the axis, overwriting previous plot 1 = disables axis plot to preserve the last plot	
	14-08	reserved	
	07	0 = disables S Curve 1 = module computes an S-curve target for smoother motion	
	06	0 = disables Quick Mode 1 = module ramps up to (max) drive output in open loop, maintains it, then ramps down in closed loop axis limit	
	05-04	Synch A/B: Axes with same bit set are synchronized	
	03-02	Integrator Mode = bit combination Bit 03 Bit 02 Integrator is Active	
		0	0
0		1	during DECEL and IN POSITION
1		0	during IN POSITION
1	1	never	
01-00	Accel/Decel Mode = bit combination Bit 01 Bit 00 Accel/Decel values define:		
	0	0	ramp rate in position units/sec/sec
	0	1	ramp rate in 1000 position units/sec/sec
	1	0	distance to SPEED
1	1	time to SPEED	

### Bit Map of Axis Status Word

Word	Bit	Description		
Axis Status (Status word 4)	15	0 = LDT input OK 1 = LDT input lost		
	14	0 = LDT input OK 1 = LDT input noisy For hard/soft stop, see config auto-stop, bit 06		
	13	0 = LDT input OK 1 = LDT input overflow For hard/soft stop, see config auto-stop, bit 05		
	12	0 = output drive power OK 1 = output drive exceeds D/A range (insufficient drive power) For hard/soft stop, see config auto-stop, bits 12 and 04		
	11	0 = no parameter error detected 1 = initialization or control parameter is out of bounds For hard/soft stop, see config auto-stop, bits 11 and 03		
	10	0 = no position overflow detected 1 = actual position exceeded range of 16-bit number display		
	09	0 = integrator windup OK 1 = integrator value exceeded 20% or 80% (see config bit 00) For hard/soft stop, see config auto-stop, bits 09 and 01		
	08	0 = following error OK 1 = difference between target and actual positions > max error For hard/soft stop, see config auto-stop, bits 08 and 00		
	07	0/1 = toggles to acknowledge valid command or status request received by the module		
	06	0 = module not initialized (module is reset) 1 = initialized with P command (axis ready for Go command)		
	05-04	State of target generator = bit combination Bit 05 Bit 04 Target Generator is		
		0	0	stopped
		0	1	accelerating
		1	0	at constant speed
1	1	decelerating		
03	0 = axis in closed loop 1 = axis in open loop, caused by O command or hard stop			
02	0 = axis movement 1 = axis is halted, caused by H command, hard or soft stop			
01	0 = axis movement 1 = axis speed < 500 transducer counts (cleared @ 1000 cts)			
00	0 = axis outside in-position window 1 = difference between actual and command positions is less than the in-position value			



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