HSL-4XMO

High Speed Link
4-Axis Motion Control Module
User's Manual

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Recycled Paper

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Table of Contents

Table of Contents i

List of Tables iv

List of Figures v

1 Introduction 1
- 1.1 Features 2
- 1.2 Specifications 3
- 1.3 Supported Software 5
  - Programming Library 5
  - Motion Creator on LinkMaster Utility 5

2 Installation 7
- 2.1 Package Contents 7
- 2.2 HSL-4XMO-CG-N/P Mechanical Drawing 8
- 2.3 HSL-4XMO-CD-N/P Mechanical Drawing 9
- 2.4 CN1 Pin Assignments: External Power Input 10
- 2.5 CN2 Pin Assignment: Emergency Input and General Input Common 10
- 2.6 HS1,2 Pin Assignments: HSL Communication Signal (RJ-45). 11
- 2.7 HS3 Pin Assignments: HSL Communication Signal (WAGO Type) 11
- 2.8 CM1-CM4 Pin Assignments: For HSL-4XMO-CG-N/P 11
- 2.9 CM1-CM4 Pin Assignments: For HSL-4XMO-CD-N/P 13
- 2.10 IOIF1-4 Pin Assignments: Mechanical I/O and GPIO Signal Connector 13
- 2.11 S1: Switch Setting for HSL Slave ID 14
- 2.12 JP1: Jumper Setting for HSL Communication Speed Selection 14
- 2.13 JP2 - 3: Jumper Setting for HSL Transmission Mode 15
- 2.14 JP4: Jumper Setting for HSL Termination Resistor 15
- 2.15 JP5-8, JP10-13: Enable/Disable DO to reset servo driver. 16
- 2.16 JP9: NPN/PNP setting of EMG signal 16

3 Signal Connections 17
- 3.1 Pulse Output Signals OUT and DIR 18

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3.2 Encoder Feedback Signals EA, EB and EZ 20
3.3 Origin Signal ORG 22
3.4 End-Limit Signals PEL and MEL 23
3.5 Ramping-down & Position Latch 23
3.6 In-position Signal INP 24
3.7 Alarm Signal ALM 25
3.8 Deviation Counter Clear Signal (ERC) 25
3.9 General-purpose Signal SVON 26
3.10 General-purpose Signal RDY 26
3.11 Position Compare Output CMP 27
3.12 Emergency Stop Input EMG 27
3.13 General-purpose Input 28
3.14 General-purpose Output 28

4 Operation Theory 31
4.1 Communication Block Diagram 31
4.2 Host Command 31
4.3 Command Delivering Time 32
4.4 Command Dispatching in DSP 34
4.5 The role of DSP and motion ASIC 35
4.6 Motion Control Modes 35
Pulse Command Output 35
Velocity Mode Motion 37
Trapezoidal Motion 38
S-curve Profile Motion 41
Linear interpolation for 2-4 axes 44
Circular interpolation for 2 axes 48
Circular Interpolation with Acc/dec Time 49
Relationship between Velocity and Acceleration Time . 50
Home Return Mode 53
4.7 The Motor Driver Interface 63
INP 63
ALM 64
ERC 64
SVON and RDY 65
4.8 The Limit Switch Interface and I/O Status 66
SD/LTC 66
EL 67
ORG 67
4.9 The Counters 68

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Command Position Counter 68
Feedback Position Counter 69
Position Error Counter 71
General Purpose Counter 71
Target Position Recorder 72
4.10 Multiple HSL-4XMO Operations 73
4.11 Change Position Or Speed On The Fly 74
Change Speed on the Fly 74
Change Position on the Fly 80
4.12 Position Compare 82
Comparators of the HSL-4XMO 82
Position Compare 83
4.13 Backlash Compensator and Vibration Suppression 86
4.14 Software Limit Function 87
4.15 Point Table Management 87
4.16 Motion Script Download 88

5 Motion Creator in LinkMaster 89
5.1 Execute Motion Creator in LinkMaster 89
5.2 About Motion Creator in LinkMaster 89
5.3 Motion Creator Form Introducing 91
Main Menu 91
Interface I/O Configuration Menu 92
Pulse IO Configuration Menu 93
Operation Menu 95

6 Appendix 103
6.1 HSL-4XMO Commmand Executuion Time 103

Warranty Policy 105

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List of Tables

Table 2-1: CN1 Pin Assignments: External Power Input 10
Table 2-2: CN2 Pin Assignments: Emergency Input and General Input Common 10
Table 2-3: HS1-HS2 Pin Assignments: HSL Communication Signal (RJ-45) 11
Table 2-4: HS3 Pin Assignments: HSL Communication Signal (WAGO type) 11
Table 2-5: CM1-CM4 Pin Assignments: Servo Interface 11
Table 2-6: CM1-CM4 Pin Assignments: For HSL-4XMO-CD-N/P 13
Table 2-7: IOIF1-4 Pin Assignments: Mechanical I/O and GPIO Signal Connector 13
Table 3-1: Encoder Power / External Resistor 21
Table 4-1: Base Scan Times 33
Table 4-2: Pulse Command Output 35
Table 4-3: Single Axis Motion Functions 44
Table 4-4: Counter Summary 72
Table 4-5: Multiple HSL-4XMO Operations 73
Table 4-6: HSL_M_v_change() Example 77
Table 4-7: HSL_M_p_change() Constraints 82
Table 4-8: HSL-4XMO Comparators 82
Table 6-1: Commmand Executuion Classifications 103
Table 6-2: HSL-4XMO Commmand Executuion Times 103

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List of Figures

Figure 2-1: HSL-4XMO-CG-N/P Mechanical Drawing 8
Figure 2-2: HSL-4XMO-CD-N/P Mechanical Drawing 9
Figure 2-3: S1: Switch Setting for HSL Slave ID..... 14
Figure 2-4: JP1: HSL Communication Speed Selection Jumper Setting..... 14
Figure 2-5: JP2 - 3: Jumper Setting for HSL Transmission Mode 15
Figure 2-6: JP4: HSL Termination Resistor Jumper Setting 15
Figure 2-7: JP5-8, JP10-13: Enable/Disable DO to reset servo driver 16
Figure 2-8: JP9: NPN/PNP setting of EMG signal 16
Figure 3-1: OUT and DIR Signals on the 4 Axes 18
Figure 3-2: Non-differential Type Wiring Example 19
Figure 3-3: EA, EB, and EZ signals 20
Figure 3-4: Connection to Line Driver Output 21
Figure 3-5: Connection to Open Collector Output..... 22
Figure 3-6: Origin Signal ORG..... 22
Figure 3-7: End-Limit Signals PEL and MEL 23
Figure 3-8: Ramping-down & Position Latch 24
Figure 3-9: In-position Signal INP 24
Figure 3-10: Alarm Signal ALM..... 25
Figure 3-11: Deviation Counter Clear Signal (ERC) 26
Figure 3-12: General-purpose Signal SVON 26
Figure 3-13: General-purpose Signal RDY 27
Figure 3-14: Position Compare Output CMP 27
Figure 3-15: Emergency Stop Input EMG..... 28
Figure 3-16: General-purpose Input..... 28
Figure 3-17: NPN Type General Purpose Output 29
Figure 3-18: PNP Type General Purpose Output 29
Figure 4-1: Communication Block Diagram 31
Figure 4-2: Single Command Timing 33
Figure 4-3: DSP Multi-Tasks..... 34
Figure 4-4: Single Pulse Output Mode (OUT/DIR Mode)..... 36
Figure 4-5: Dual Pulse Output Mode (CW/CCW Mode) 37
Figure 4-6: Velocity Mode Motion 38
Figure 4-7: Trapezoidal Motion 39
Figure 4-8: Encoder Diagram..... 41
Figure 4-9: S-curve Profile Motion 42
Figure 4-10: Automatic Velocity Decrease..... 43

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Figure 4-11: 2 Axes Linear Interpolation 45
Figure 4-12: 3-Axis Linear Interpolation 46
Figure 4-13: Circular interpolation for 2 axes 48
Figure 4-14: Circular Interpolation with Acc/dec Time 50
Figure 4-15: Velocity and Acceleration Time A 51
Figure 4-16: Velocity and Acceleration Time B 52
Figure 4-17: home_mode=0 54
Figure 4-18: home_mode=1 55
Figure 4-19: home_mode=3 55
Figure 4-20: home_mode=4 56
Figure 4-21: home_mode=5 57
Figure 4-22: home_mode=6 57
Figure 4-23: home_mode=7 57
Figure 4-24: home_mode=8 58
Figure 4-25: home_mode=9 58
Figure 4-26: home_mode=10 59
Figure 4-27: home_mode=11 60
Figure 4-28: home_mode=12 60
Figure 4-29: Home Search Example 61
Figure 4-30: 90° Phase Difference Signals 70
Figure 4-31: Change Speed on the Fly 74
Figure 4-32: HSL_M_v_change() Theory 76
Figure 4-33: Velocity Suggestions A 77
Figure 4-34: Velocity Suggestions B 78
Figure 4-35: Velocity Example 78
Figure 4-36: Velocity Profile Example 79
Figure 4-37: Change Position on the Fly 80
Figure 4-38: Theory of HSL_M_p_change() 81
Figure 4-39: Continuously Comparison with Trigger Output 84
Figure 4-40: Vibration Suppression 86
Figure 5-1: HSL Master Utility 90
Figure 5-2: Main Menu 91
Figure 5-3: Interface I/O Configuration Menu 92
Figure 5-4: Pulse IO Configuration Menu 94
Figure 5-5: Operation Menu 96
Figure 5-6: Show Velocity Curve 97
Figure 5-7: Home Mode Configuration 98

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1 Introduction

The HSL-4XMO is a 4-axis motion controller module for HSL system. It can generate high frequency pulses (6.55MHz) to drive stepper or servomotors. As a motion controller, it can provide 2-axis circular interpolation, 4-axis linear interpolation, or continuous interpolation for continual velocity. Also, changing position/speed on the fly is available with a single axis operation.

Multiple HSL-4XMO modules can be used in one HSL system. Incremental encoder interface on all four axes provide the ability to correct positioning errors generated by inaccurate mechanical transmissions. With the aid of on board DSP, the HSL-4XMO can also perform many real-time applications without compromising CPU resources. In addition, a mechanical sensor interface, servo motor interface, and general-purposed I/O signals are provided for easy system integration.

The HSL-4XMO uses one ASIC (PCL6045) to perform all 4 axes motion controls and one DSP to communicate with Host PC and HSL protocol. The motion control functions include linear and S-curve acceleration/deceleration, circular interpolation between two axes, linear interpolation between 2~4 axes, continuous motion positioning, and 13 home return modes. All these functions and complex computations are performed internally by the ASIC, thus limiting the impact on the PC's CPU usage. The DSP can perform as a motion path-loading manager without consuming Host PC's resource. It is more powerful than traditional ASIC-based motion control card.

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1.1 Features

- High Speed Link (HSL) protocol compatible
- 3M/6M/12M data transfer rate selectable
- Support dual and half duplex modes
- On board DSP (TMS320C6711)
- 4-axis stepper or servo motor control by pulse signal command
- Maximum pulse output frequency: 6.55 MPPS
- Pulse output types: OUT/DIR (single pulse), CW/CCW (dual pulse)
- Support up to 63 axes in one HSL network
- Motion point table management
- Motion script download for precision timing motion control
- Any 2 of 4 axes circular interpolation in one module
- Any 2-4 of 4 axes linear interpolation in one module
- Continuous interpolation for contour following motion
- 3 Command buffers for special speed profile motion
- Change position and speed on the fly
- Change speed by condition comparing
- 13 home return modes with auto searching
- 2 ways software end-limits of each axis
- 28-bit up/down incremental encoder interface of each axis
- Dedicated motion I/O : home (DOG), index signal (EZ), end limit, servo on, INP, ERC, ALM, motion interface of each axis
- 4 general-purpose DI/DO channels
- One Emergency input with hardware motion stop function
- High-speed position counter latch input for each axis
- Continuous position compare with trigger pulse output of each axis
- All digital input and output signals are 2500Vrms isolated
- Includes Motion Creator, a Microsoft Windows-based application development software built in LinkMaster Utility

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- User-friendly function libraries and utilities for DOS and Windows 9x/NT/2000/XP. Also supported under Linux

1.2 Specifications

Command Response Time

- Half Duplex: 240us for one module under 6Mhz data transfer rate
- Full Duplex: 240us for two modules under 6Mhz data transfer rate

Motion Control

- Maximum controllable axes in one module: 4
- Internal reference clock: 19.66MHz
- Position counter range: –134,217,728 to +134,217,727 (28-bit)
- Command counter setting range: -134,217,728 to +134,217,728 (28-bit)
- Pulse rate setting range: 1~ 65,535 (16-bit)
- Pulse rate multiplier setting range: 0.1~100

Pulse Output

- Line driver output
- Max. Speed: 6.55 Mhz
- Output Voltage:
  - Logic H: 2.5V min.
  - Logic L: 0.5V max.
- Isolated voltage: 500Vrms

Encoder Input

- Incremental Encoder Input
- Max. Speed: 5 Mhz
- Input Voltage:
  - Logic H: 3~5V
  - Logic L: 0~2.4V
- Input resistor: 220Ω @ 0.125W
- Isolated voltage: 500Vrms

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Digital Input

- Sink or source type can be selected via ICOM
- Switching capability: 10K Hz
- Input voltage range:
  - Logic H: 14.4~24V
  - Logic L: 0~5V
- Input resistor: 4.7KΩ @ 0.5W
- Isolated voltage: 500Vrms

Digital Output

- Output type: Open-collector (PC3H7C)
- Sink Current: 4mA max.
- Switching capability: 10KHz @ 24V, load = 4.7KΩ
- Isolated voltage: 500Vrms

General Purpose Output

- Output type: NPN sinking type for –N module; PNP sourcing type for –P module
- Sink Current: 90 mA max.
- Switching capability: 2 KHz @ 24V, load = 300Ω
- Isolated voltage: 500 Vrms

General Specifications

- Operating Temperature: 0°C – 60°C
- Storage Temperature: -20°C – 80°C
- Humidity: 0% – 90%, non-condensing

Power Consumption

- 5 Watts max. @ 24Vin

Dimensions

- 163.5mm (W) × 74.9mm (D) × 52.7mm (H)

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1.3 Supported Software

Programming Library

The Library supports Borland C/C++ (Version: 3.1) and Windows 95/98/NT/2000/XP. These function libraries are shipped with the module. Users can check ADLINK website for latest update.

This module supports DOS/Windows 98/NT/2000/XP. For other OS, please contact the local vendors.

Motion Creator on LinkMaster Utility

This Windows-based utility is used to setup cards, motors, and systems. It can also aid in debugging hardware and software problems. It allows users to set I/O logic parameters to be loaded in their own program. This product is also bundled with the card.

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2 Installation

This chapter describes how to install the HSL-4XMO series. Please follow these steps below:

- Check what you have (section 2.1)
- Check the PCB (section 2.2)
- Install the hardware (section 2.3)
- Install the software driver (section 2.4)
- Understanding the I/O signal connections (chapter 3) and their operation (chapter 4)
- Understanding the connector pin assignments (the remaining sections) and wiring the connections

2.1 Package Contents

In addition to this User's Guide, the package also includes the following items:

- HSL-4XMO: Advanced 4-Axis Servo / Stepper Motion Control Card (HSL-4XMO-CG-N/P, HSL-4XMO-CD-N/P)
- ADLINK All-in-one Compact Disc

If any of these items are missing or damaged, contact the dealer from whom you purchased the product. Save the shipping materials and carton to ship or store the product in the future.

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2.2 HSL-4XMO-CG-N/P Mechanical Drawing

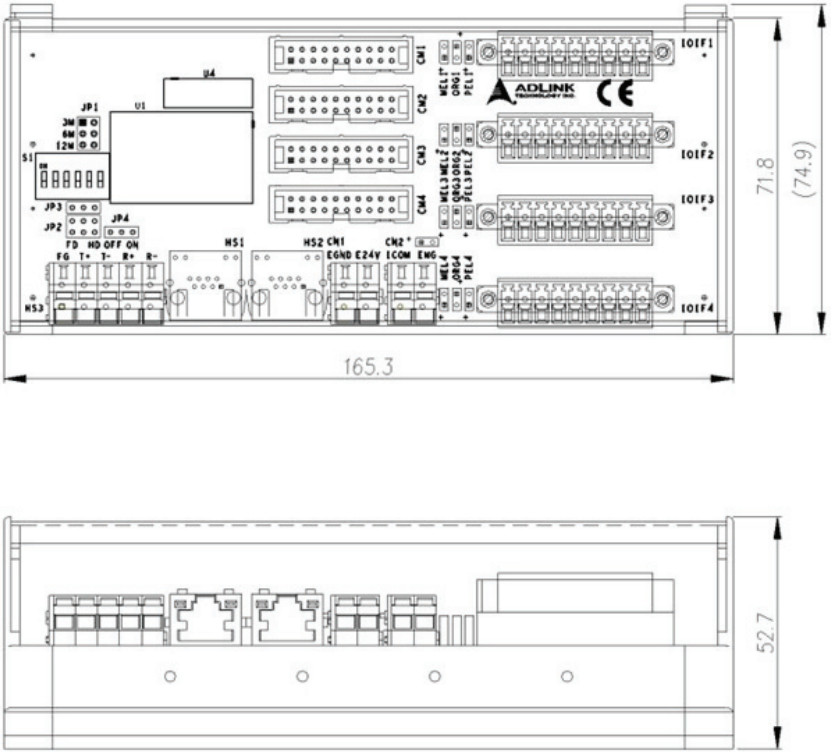


Figure 2-1: HSL-4XMO-CG-N/P Mechanical Drawing

CN1:	External Power Input Connector (+24V)
CN2:	Digital Input Common and Emergency Input Pin
HS1-2:	HSL Communication Signal Connector (RJ45)
HS3:	HSL Communication Signal Connector (WAGO)
CM1-4:	Servo Interface Signal Connector
IOIF1-4:	Mechanical I/O and GPIO Signal Connector
S1:	Slave ID Switch
JP1:	Communication Speed Selection Jumper
JP2-3:	Full Duplex / Half Duplex Selection Jumper
JP4:	HSL Termination Resistor Jumper

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2.3 HSL-4XMO-CD-N/P Mechanical Drawing

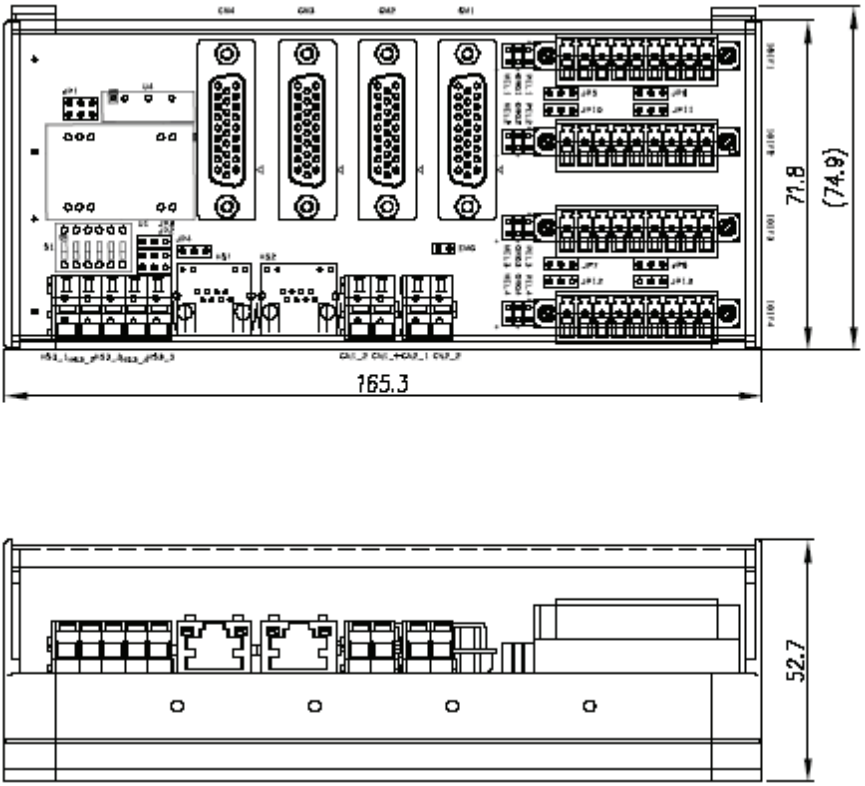


Figure 2-2: HSL-4XMO-CD-N/P Mechanical Drawing

CN1:	External Power Input Connector (+24V)
CN2:	Digital Input Common and Emergency Input Pin
HS1-2:	HSL Communication Signal Connector (RJ45)
HS3:	HSL Communication Signal Connector (WAGO)
CM1-4:	Servo Interface Signal Connector
IOIF1-4:	Mechanical I/O and GPIO Signal Connector

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S1:	Slave ID Switch
JP1:	Communication Speed Selection Jumper
JP2-3:	Full Duplex/Half Duplex Jumper
JP4:	Termination Resistor Jumper
JP5-8:	Enable/Disable DO to reset servo driver
JP9:	NPN/PNP setting of EMG signal
JP10-13:	NPN/PNP setting of DO signal

2.4 CN1 Pin Assignments: External Power Input

CN1 Pin Name	Description
EGND	External power ground
E24V	+24VDC ±5% External power supply

Table 2-1: CN1 Pin Assignments: External Power Input

2.5 CN2 Pin Assignment: Emergency Input and General Input Common

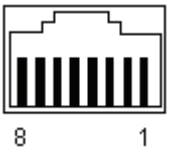
CN2 Pin Name	Description
ICOM	Mechanical Input and General Input Common
EMG	Emergency Stop Input

Table 2-2: CN2 Pin Assignments: Emergency Input and General Input Common

Note: ICOM should be connected to either EGND or E24V

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2.6 HS1,2 Pin Assignments: HSL Communication Signal (RJ-45).



RJ45 Female Connector

PIN NO.	PIN OUT
PIN 1	NC
PIN 2	NC
PIN 3	TXD+
PIN 4	RXD-
PIN 5	RXD+
PIN 6	TXD-
PIN 7	NC
PIN 8	NC

Table 2-3: HS1-HS2 Pin Assignments: HSL Communication Signal (RJ-45)

2.7 HS3 Pin Assignments: HSL Communication Signal (WAGO Type)

HS3 Pin Name	Description
FG	Shielding ground
T+	TXD+
T-	TXD-
R+	RXD+
R-	RXD-

Table 2-4: HS3 Pin Assignments: HSL Communication Signal (WAGO type)

2.8 CM1-CM4 Pin Assignments: For HSL-4XMO-CG-N/P

No.	Name	Function	No.	Name	Function
1	EA+	Encoder A-phase (+)	2	EA-	Encoder A-phase (-)
3	EB+	Encoder B-phase (+)	4	EB-	Encoder B-phase (-)
5	EZ+	Encoder Z-phase (+)	6	EZ-	Encoder Z-phase (-)
7	PGND	Ground of pulse I/O signals	8	PGND	Ground of pulse I/O signals

Table 2-5: CM1-CM4 Pin Assignments: Servo Interface

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No.	Name	Function	No.	Name	Function
9	OUT+	Pulse signal (+)	10	OUT-	Pulse signal (-)
11	DIR+	Direction signal (+)	12	DIR-	Direction signal (-)
13	EGND	Ext. power ground	14	SVON	Servo on output signal
15	INP	In-position input signal	16	ERC	Deviation counter clear output signal
17	EGND	External power ground	18	E24V	External power supply, +24V
19	RDY	Ready input signal	20	ALM	Alarm input signal

Table 2-5: CM1-CM4 Pin Assignments: Servo Interface

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2.9 CM1-CM4 Pin Assignments: For HSL-4XMO-CD-N/P

No.	Name	Function	No.	Name	Function
1	SVON	Servo on output signal	2	INP	In-position input signal
3	ERC	Deviation counter clear output signal	4	RDY	Ready input signal
5	OUT-	Pulse signal (-)	6	OUT+	Pulse signal (+)
7	EA-	Encoder A-phase (-)	8	EA+	Encoder A-phase (+)
9	N.C.	Not Connected	10	RST	Alarm reset output signal
11	ALM	Alarm input signal	12	E24V	External power supply, +24V
13	EGND	Ext. power ground	14	N.C.	Not Connected
15	PGND	Ground of pulse I/O signals	16	EB-	Encoder B-phase (-)
17	EB+	Encoder B-phase (+)	18	PGND	Ground of pulse I/O signals
19	EMG	Emergency stop output signal	20	EGND	External power ground
21	EGND	External power ground	22	EGND	External power ground
23	DIR-	Direction signal (-)	24	DIR+	Direction signal (+)
25	EZ-	Encoder Z-phase (-)	26	EZ+	Direction signal (+)

Table 2-6: CM1-CM4 Pin Assignments: For HSL-4XMO-CD-N/P

2.10 IOIF1-4 Pin Assignments: Mechanical I/O and GPIO Signal Connector

Pin No.	Pin Name	Description
1	E24V	External power supply, +24V
2	MEL	End limit input signal (-)
3	ORG	Origin input signal
4	PEL	End limit input signal (+)
5	LTC/SD	Ramp-down/position latch input signal (default for LTC)
6	DI/EZ	General purposed input/Index Input
7	DO	General purposed output
8	CMP	Position compare output
9	EGND	External power ground

Table 2-7: IOIF1-4 Pin Assignments: Mechanical I/O and GPIO Signal Connector

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2.11 S1: Switch Setting for HSL Slave ID

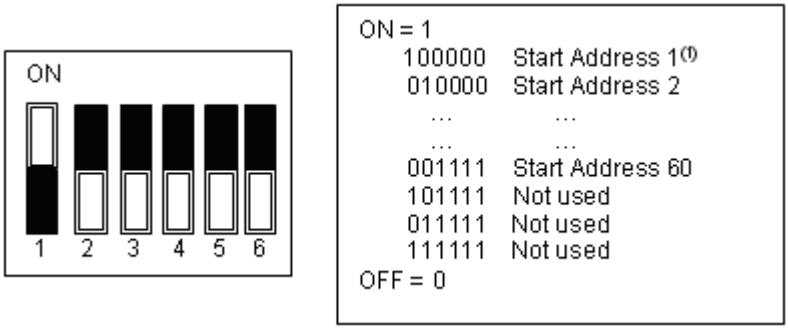


Figure 2-3: S1: Switch Setting for HSL Slave ID

Note: Each HSL-4XMO occupies 4 HSL IDs. If using half duplex mode, the occupied ID will be continuously from this setting. For example, if you set the ID=1 then the occupied IDs will be 1, 2, 3, 4. If using full duplex mode, the occupied ID will be two ID steps in order. For example, if you set the ID=1 then the occupied IDs will be 1, 3, 5, 7.

2.12 JP1: Jumper Setting for HSL Communication Speed Selection

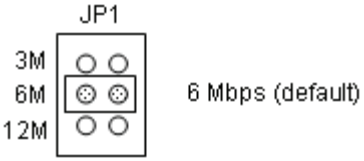


Figure 2-4: JP1: HSL Communication Speed Selection Jumper Setting

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2.13 JP2 - 3: Jumper Setting for HSL Transmission Mode

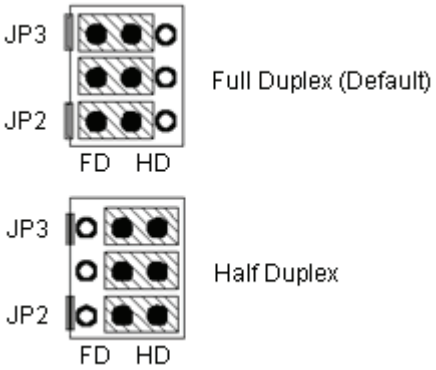


Figure 2-5: JP2 - 3: Jumper Setting for HSL Transmission Mode

2.14 JP4: Jumper Setting for HSL Termination Resistor

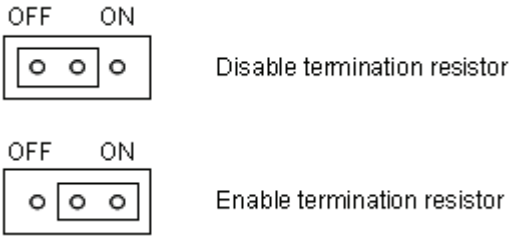


Figure 2-6: JP4: HSL Termination Resistor Jumper Setting

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2.15 JP5-8, JP10-13: Enable/Disable DO to reset servo driver

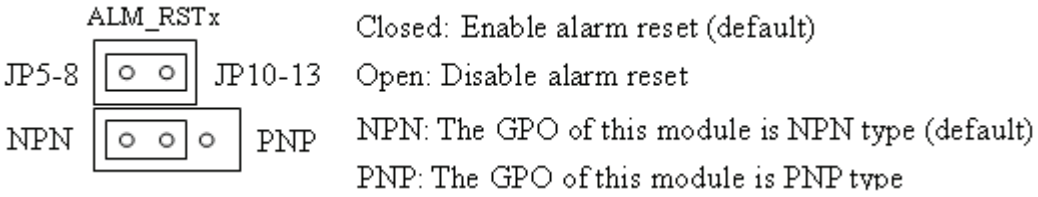


Figure 2-7: JP5-8, JP10-13: Enable/Disable DO to reset servo driver

2.16 JP9: NPN/PNP setting of EMG signal

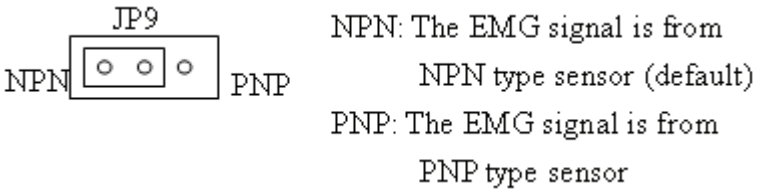


Figure 2-8: JP9: NPN/PNP setting of EMG signal

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3 Signal Connections

Signal connections of all I/O's are described in this chapter. Refer to the contents of this chapter before wiring any cables between the HSL-4XMO and any motor drivers.

This chapter contains the following sections:

- Section 3.1 Pulse Output Signals OUT and DIR
- Section 3.2 Encoder Feedback Signals EA, EB and EZ
- Section 3.3 Origin Signal ORG
- Section 3.4 End-Limit Signals PEL and MEL
- Section 3.5 Ramping-down & Position latch signals
- Section 3.6 In-position signals INP
- Section 3.7 Alarm signal ALM
- Section 3.8 Deviation counter clear signal ERC
- Section 3.9 General-purpose signals SVON
- Section 3.10 General-purpose signal RDY
- Section 3.11 Position compare output pin: CMP
- Section 3.12 General-purpose DI
- Section 3.13 General-purpose DO

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3.1 Pulse Output Signals OUT and DIR

There are 4 axis pulse output signals on the HSL-4XMO. For each axis, two pairs of OUT and DIR signals are used to transmit the pulse train and to indicate the direction. The OUT and DIR signals can also be programmed as CW and CCW signal pairs. In this section, the electrical characteristics of the OUT and DIR signals are detailed. Each signal consists of a pair of differential signals. For example, OUT2 consists of OUT2+ and OUT2- signals.

The following wiring diagram is for OUT and DIR signals on the 4 axes.

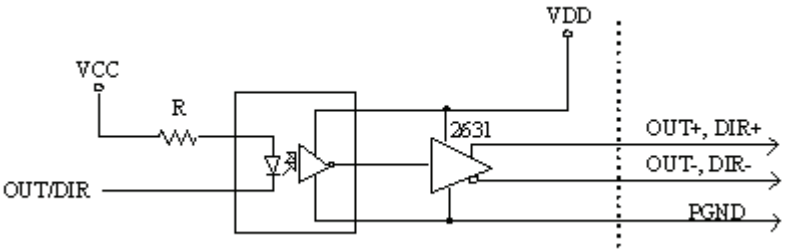


Figure 3-1: OUT and DIR Signals on the 4 Axes

Non-differential type wiring example:

Choose one of OUT/DIR+ and OUT/DIR- to connect to driver's OUT/DIR

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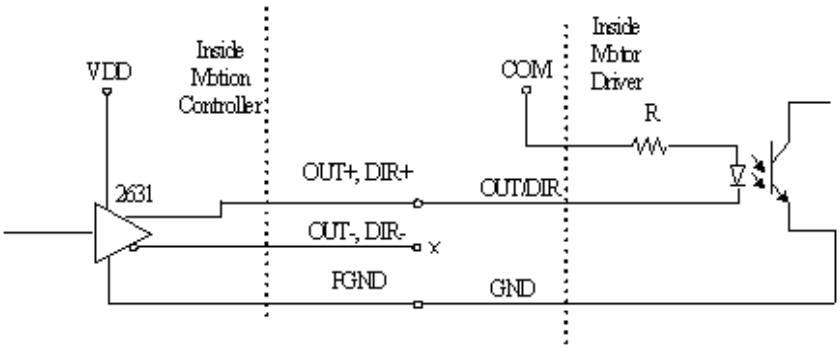


Figure 3-2: Non-differential Type Wiring Example

Warning: The sink current must not exceed 20mA or the 2631 will be damaged!

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3.2 Encoder Feedback Signals EA, EB and EZ

The encoder feedback signals include EA, EB, and EZ. Every axis has six pins for three differential pairs of phase-A (EA), phase-B (EB), and index (EZ) inputs. EA and EB are used for position counting, and EZ is used for zero position indexing.

The input circuit of the EA, EB, and EZ signals is shown as follows:

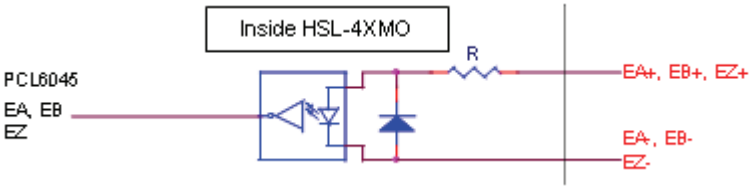


Figure 3-3: EA, EB, and EZ signals

Please note that the voltage across each differential pair of encoder input signals (EA+, EA-), (EB+, EB-), and (EZ+, EZ-) should be at least 3.5V. Therefore, the output current must be observed when connecting to the encoder feedback or motor driver feedback as not to over drive the source. The differential signal pairs are converted to digital signals EA, EB, and EZ; then feed to the PCL6045 ASIC (R=220ohm).

Below are examples of connecting the input signals with an external circuit. The input circuit can be connected to an encoder or motor driver if it is equipped with: (1) a differential line driver or (2) an open collector output.

Connection to Line Driver Output

To drive the HSL-4XMO encoder input, the driver output must provide at least 3.5V across the differential pairs with at least 6mA driving capacity. The grounds of both sides must be tied together. The maximum frequency will be 4Mhz or more depends on wiring distance and signal conditioning.

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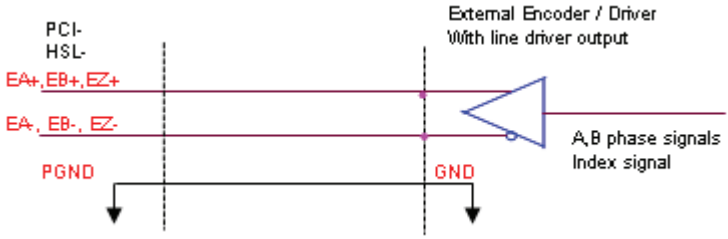


Figure 3-4: Connection to Line Driver Output

Connection to Open Collector Output

To connect with an open collector output, an external power supply is necessary. Some motor drivers can provide the power source. The connection between the HSL-4XMO, encoder, and the power supply is shown in the diagram below. Note that an external current limiting resistor R is necessary to protect the HSL-4XMO input circuit. The following table lists the suggested resistor values according to the encoder power supply.

Encoder Power (VDD)	External Resistor R
+5V	0Ω (None)
+12V	1.8kΩ
+24V	4.3kΩ

Table 3-1: Encoder Power / External Resistor

- I_f = 6mA max.

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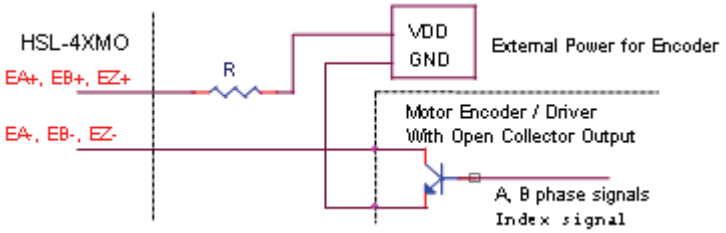


Figure 3-5: Connection to Open Collector Output

For more operation information on the encoder feedback signals, refer to section 4.9.

3.3 Origin Signal ORG

The origin signals (ORG1-ORG4) are used as input signals for the origin of the mechanism.

The input circuit of the ORG signals is shown below. Usually, a limit switch is used to indicate the origin on one axis. The specifications of the limit switch should have contact capacity of +24V @ 6mA minimum. An internal filter circuit is used to filter out any high frequency spikes, which may cause errors in the operation.

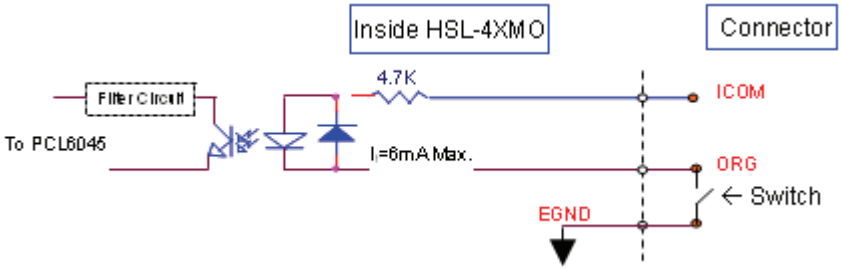


Figure 3-6: Origin Signal ORG

When the motion controller is operated in the home return mode, the ORG signal is used to inhibit the control output signals (OUT

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and DIR). For detailed operations of the ORG signal, refer to section 4.8.

3.4 End-Limit Signals PEL and MEL

There are two end-limit signals PEL and MEL for each axis. PEL indicates the end limit signal is in the plus direction and MEL indicates the end limit signal is in the minus direction.

A circuit diagram is shown in the diagram below. The external limit switch should have a contact capacity of +24V @ 6mA minimum. Either 'A-type' (normal open) contact or 'B-type' (normal closed) contact switches can be used. The type of switch can be configured by software. For more details on EL operation, refer to section 4.8.

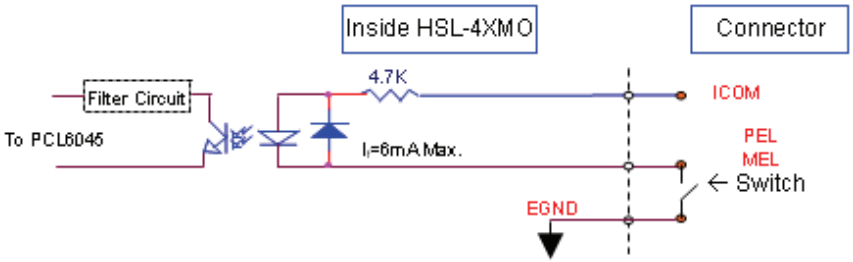


Figure 3-7: End-Limit Signals PEL and MEL

3.5 Ramping-down & Position Latch

There is a SD/LTC signal for each of the 4 axes. A circuit diagram is shown below. Typically, the limit switch is used to generate a slow-down signal to drive motors operating at slower speeds. While act as the LTC signal, it will trigger the counter-value-capturing functions, which provides a precise position determination. For more details on SD/LTC operation, refer to section 4.8.

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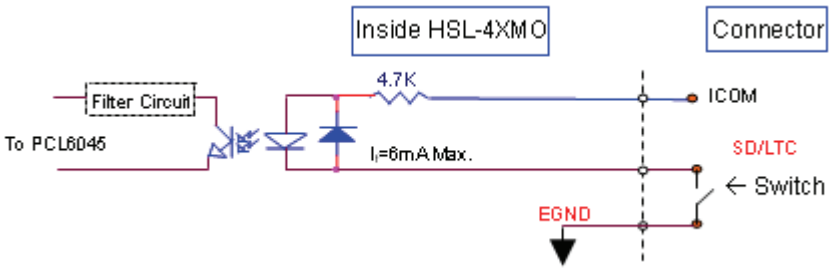


Figure 3-8: Ramping-down & Position Latch

3.6 In-position Signal INP

The in-position signal INP from a servo motor driver indicates its deviation error. If there is no deviation error then the servo's position indicates zero. The input circuit of the INP signals is shown in the diagram below:

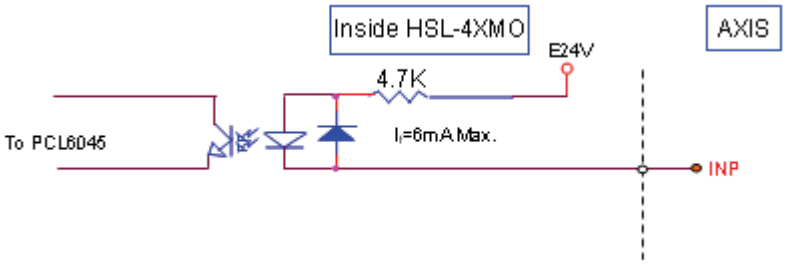


Figure 3-9: In-position Signal INP

The in-position signal is usually generated by the servomotor driver and is ordinarily an open collector output signal. An external circuit must provide at least 6mA current sink capabilities to drive the INP signal. For more details of INP signal operations, refer to section 4.7.

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3.7 Alarm Signal ALM

The alarm signal ALM is used to indicate the alarm status from the servo driver. The input alarm circuit is shown below. The ALM signal usually is generated by the servomotor driver and is ordinarily an open collector output signal. An external circuit must provide at least 6mA current sink capabilities to drive the ALM signal. For more details of ALM signal operations, refer to section 4.7.

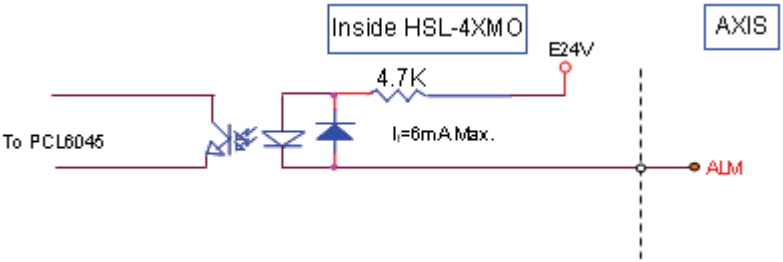


Figure 3-10: Alarm Signal ALM

3.8 Deviation Counter Clear Signal (ERC)

The deviation counter clear signal (ERC) is active in the following 4 situations:

1. Home return is complete
2. End-limit switch is active
3. An alarm signal stops OUT and DIR signals
4. An emergency stop command is issued by software (operator)

The ERC signal is used to clear the deviation counter of the servomotor driver. The ERC output circuit is an open collector with a maximum of 35V at 6mA driving capacity. For more details of ERC operation, refer to section 4.7.

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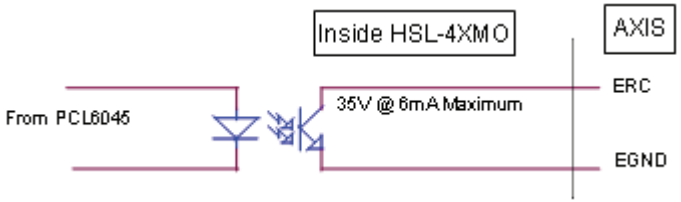


Figure 3-11: Deviation Counter Clear Signal (ERC)

3.9 General-purpose Signal SVON

The SVON signal can be used as a servomotor-on control or general- purposed output signal. The output circuit for the SVON signal is shown below:

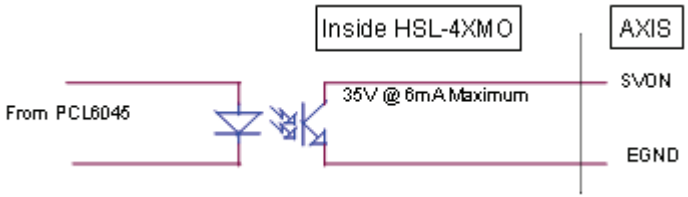


Figure 3-12: General-purpose Signal SVON

3.10 General-purpose Signal RDY

The RDY signals can be used as motor driver ready input or general purpose input signals. The input circuit of RDY signal is shown in the following diagram:

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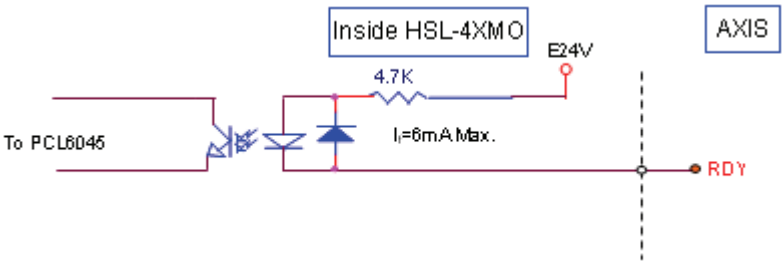


Figure 3-13: General-purpose Signal RDY

3.11 Position Compare Output CMP

The HSL-4XMO provides 4 comparison output channels. The comparison output channel will generate a pulse signal when the encoder counter reaches a pre-set value set by the user.

The following wiring diagram is of the CMP signals:

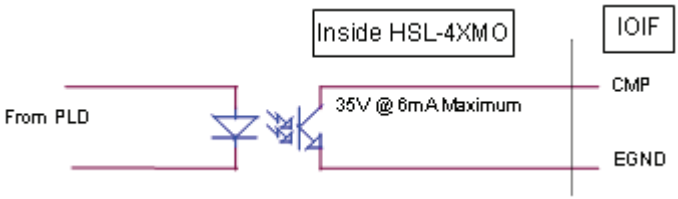


Figure 3-14: Position Compare Output CMP

Note: CMP trigger type can be set as normal low (rising edge) or normal high (falling edge). Default setting is normal high.

3.12 Emergency Stop Input EMG

There is emergency stop input pin for this module. When EMG is active, all the motion pulse output command will be rejected until the EMG is deactive.

A circuit diagram is shown in the diagram below. The emergency stop switch should have a contact capacity of +24V @ 6mA minimum. Either ‘A-type’ (normal open) contact or ‘B-type’ (normal

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closed) contact switches can be used. The type of switch can be configured by software.

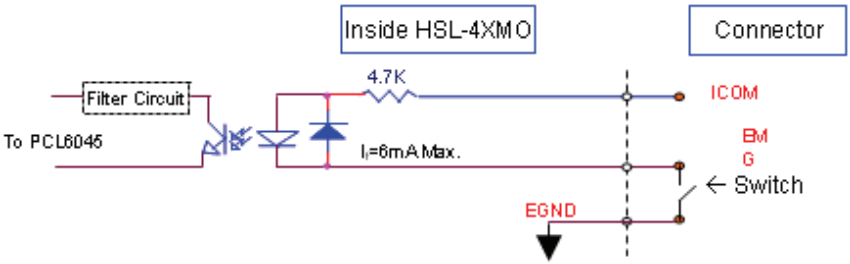


Figure 3-15: Emergency Stop Input EMG

3.13 General-purpose Input

HSL-4XMO has 4 opto-isolated digital inputs for general-purposed use. The following wiring diagrams are of these signals

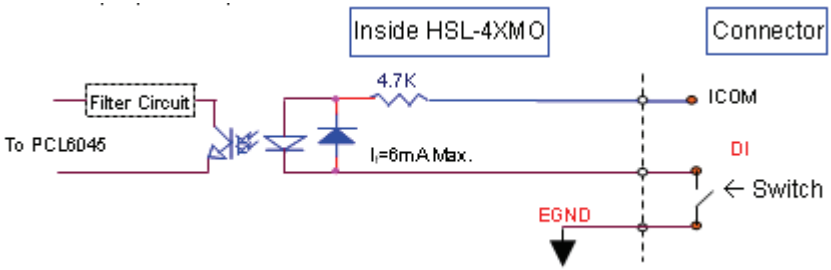


Figure 3-16: General-purpose Input

3.14 General-purpose Output

HSL-4XMO has 4 opto-isolated digital outputs for general-purposed use. The following wiring diagrams are of these signals

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NPN type general purpose Output (available in –N modules):

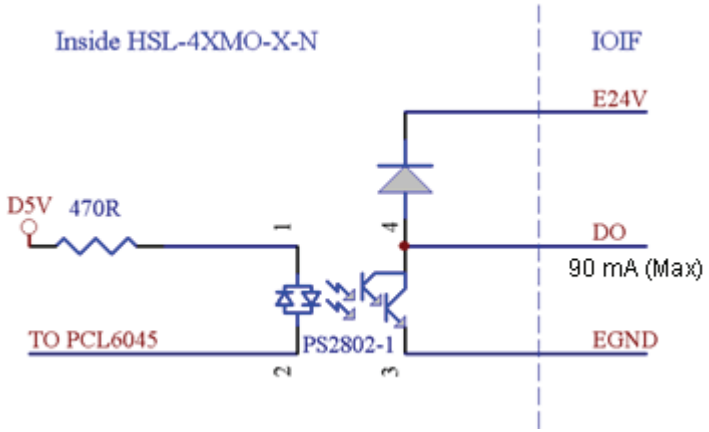


Figure 3-17: NPN Type General Purpose Output

PNP type general purpose Output (available in –P modules):

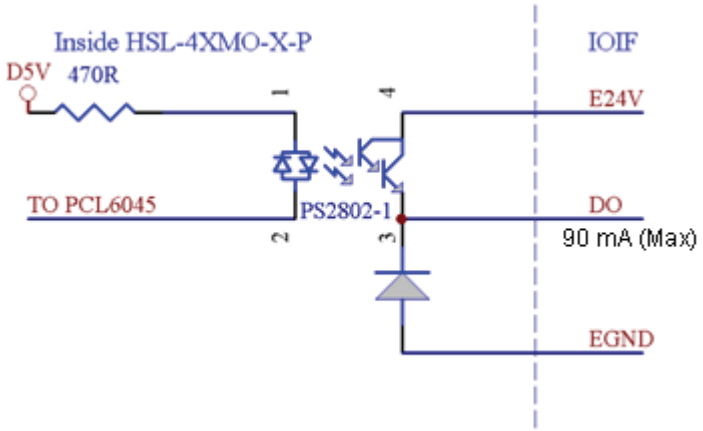


Figure 3-18: PNP Type General Purpose Output

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4 Operation Theory

4.1 Communication Block Diagram

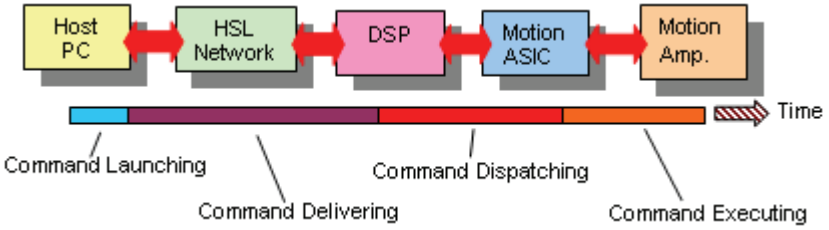


Figure 4-1: Communication Block Diagram

4.2 Host Command

Inside the HSL system, those remote modules communicate with each other with HSL network packets. Actually, users do not have to understand what the content of the packet is. Instead, we provide many kinds of API functions for controlling this module. They are very easy to understand and to use.

Those APIs can analyze the parameters from user's command and pack them as HSL network packets. Next, the packets are passed to the remote modules. Then, the remote modules will interpret those packets and execute the commands correctly.

Before launching the packet, all the commands issued by users are written into the dual port RAM and transferred on HSL network. Consequently, the dual port RAM is the bridge between HSL master controller and host PC. The accessing time of dual port RAM for one packet is about 600ns. It is quiet fast on host PC.

Furthermore, the delivering time of one command on network depends on the number of modules and operating clock rate. A complete command delivering time depends on the number of HSL packets. Some APIs, which have much more parameters, would need more packets and time for delivering. One packet command could be delivered in one HSL scan (cycle) time.

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4.3 Command Delivering Time

HSL-4XMO supports both full duplex and half duplex mode. In full duplex mode, one module occupies 4 HSL slave IDs by two ID number steps. For example, if the module start ID=1, then it occupies ID 1, 3, 5, 7. If having two slave modules, we suggest that the second ID can be set at 2. Then, the second module would occupy ID 2, 4, 6, 8.

In half duplex mode, the module occupies 4 HSL slave IDs by one ID number step. For example, if the module start ID=1, then it occupies ID 1, 2, 3, 4. If having two slave modules, we suggest that the second ID can be set at 5. Then, the seoncd module occupies ID 5, 6, 7, 8.

Host command on PC is transferring via HSL protocol. The base time for one ID at 6Mbps data transder rate is 30us. The more IDs exist in HSL system, the more scan time is needed. For example, one HSL-4XMO module occupies 4 IDs at full duplex mode. The total scan (cycle) time would be 7 times base time (30.4us × 8). Because it occupies ID1, 3, 5, and 7, it need time to scan from ID1 to ID7. Consequently, it would take 243.2 us.

The following figures show the timing of single command.

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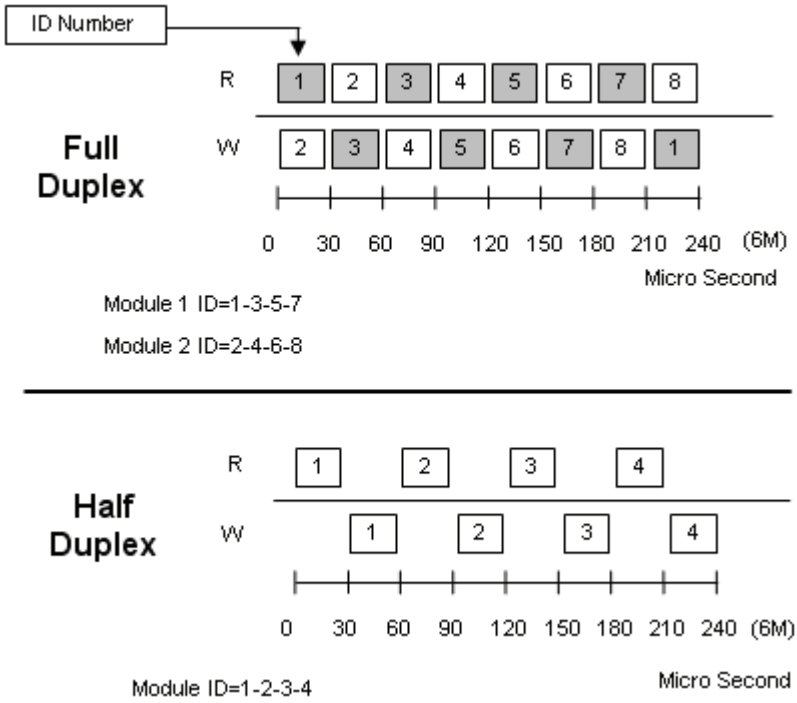


Figure 4-2: Single Command Timing

The base scan time table is as follows, N is the range of total IDs.

	Half Duplex	Full Duplex	Maximum Length
3M	118 us x N	60.7 us x N	400 meters
6M	59 us x N	30.4 us x N	200 meters
12M	29.5 us x N	15.2 us x N	100 meters

Table 4-1: Base Scan Times

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4.4 Command Dispatching in DSP

Command-dispatching task is executed by the DSP on the module. Once the DSP receives a new command, it will process this command within the time less than the HSL scan time. The dispatching task includes the motion ASIC command, data downloading command, point table command and script program downloading command.

The command-dispatching task is executed every HSL scan cycle. It is real-time. While the DSP in idling, the other tasks, such as position compare, point table motion, script motion, special speed profile control and data monitoring are running at lower priority than command dispatching.

The timing block diagram as follows shows the multi-tasks working in DSP.

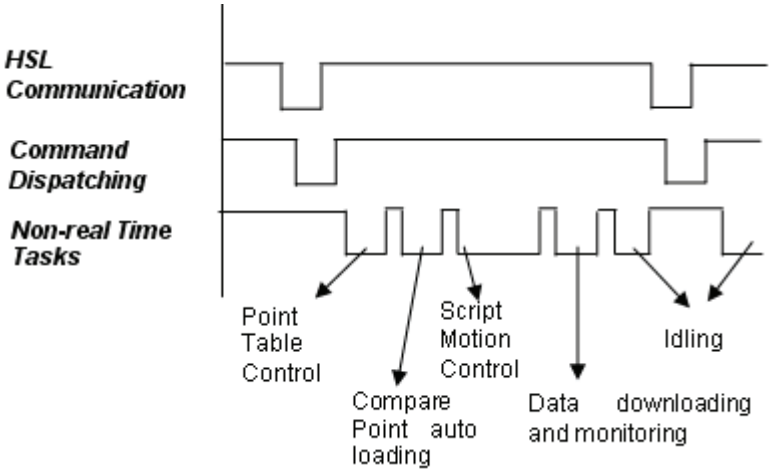


Figure 4-3: DSP Multi-Tasks

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4.5 The role of DSP and motion ASIC

Motion control is executed by motion ASIC. DSP acts as a role to execute the command dispatching, data management and motion command sequecing. Motion ASIC is used for generating pulse trains, position control, dedicated motion I/O control and so on. There is no motion I/O scan time problem because the ASIC will take care all of them.

4.6 Motion Control Modes

In this section, the pulse output signal configuration and the following motion control modes are described.

Pulse Command Output

The HSL-4XMO uses pulse commands to control servo/stepper motors via the drivers. A pulse command consists of two signals: OUT and DIR. There are two command types: (1) single pulse output mode (OUT/DIR), and (2) dual pulse output mode (CW/CCW type pulse output). The software function, HSL_M_set_pls_outmode(), is used to program the pulse command mode. The modes vs. signal type of OUT and DIR pins are listed in the table below:

Mode	Output of OUT pin	Output of DIR pin
Dual pulse output (CW/CCW)	Pulse signal in plus (or CW) direction	Pulse signal in minus (or CCW) direction
Single pulse output (OUT/DIR)	Pulse signal	Direction signal (level)

Table 4-2: Pulse Command Output

The interface characteristics of these signals can be differential line driver or open collector output. Please refer to section 3.1 for the jumper setting for different signal types.

Single Pulse Output Mode (OUT/DIR Mode)

In this mode, the OUT signal is for the command pulse (position or velocity) chain. The numbers of OUT pulse represent the relative “distance” or “position.” The frequency of the OUT pulse represents the command for “speed” or “velocity.” The DIR signal repre-

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sents direction command of positive (+) or negative (-). This mode is most commonly used. The diagrams below show the output waveform. It is possible to set the polarity of the pulse chain.

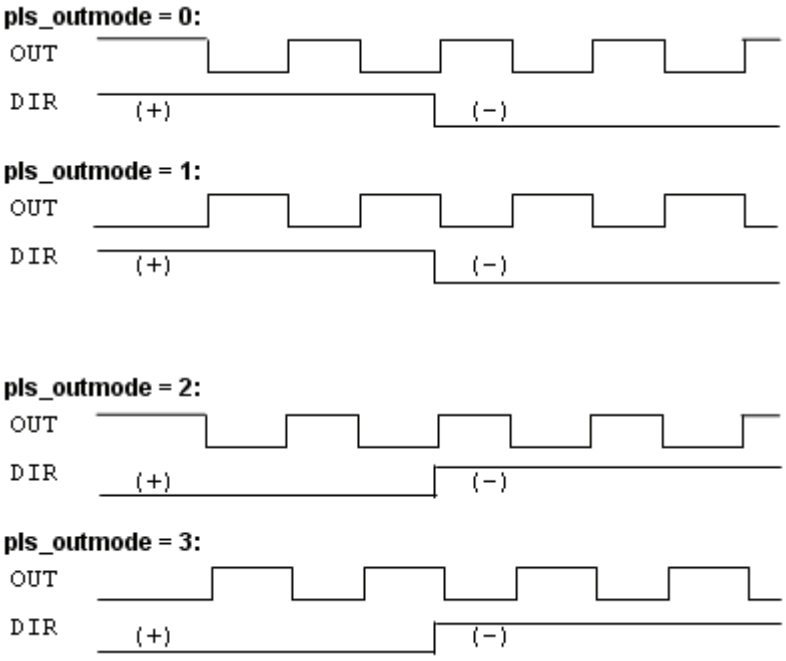


Figure 4-4: Single Pulse Output Mode (OUT/DIR Mode)

Dual Pulse Output Mode (CW/CCW Mode)

In this mode, the waveform of the OUT and DIR pins represent CW (clockwise) and CCW (counter clockwise) pulse output respectively. Pulses output from the CW pin makes the motor move in positive direction, whereas pulse output from the CCW pin makes the motor move in negative direction. The following diagram shows the output waveform of positive (+) commands and negative (-) commands.

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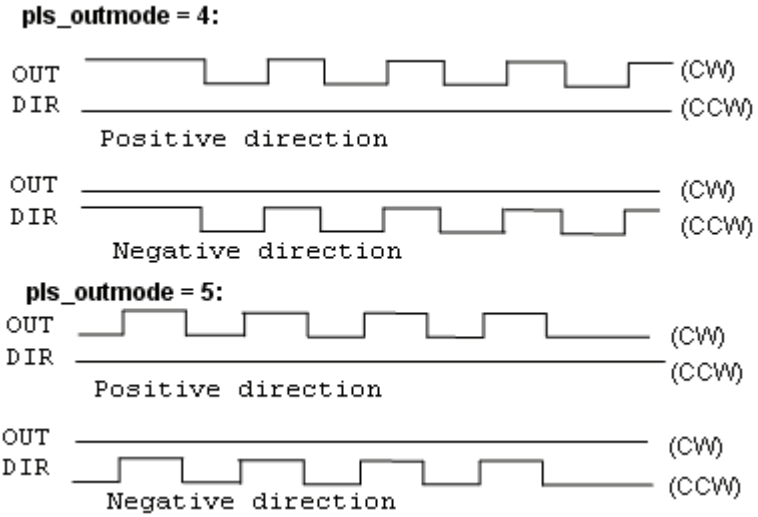


Figure 4-5: Dual Pulse Output Mode (CW/CCW Mode)

- Relative Function:

  `HSL_M_set_pls_outmode()`

Velocity Mode Motion

This mode is used to operate a one-axis motor with Velocity mode motion. The output pulse accelerates from a starting velocity (StrVel) to a specified maximum velocity (MaxVel). The HSL_M_tv_move() function is used for constant linear acceleration while the HSL_M_sv_move() function is use for acceleration according to the S-curve. The pulse output rate is kept at maximum velocity until another velocity command is set or a stop command is issued. The HSL_M_v_change() is used to change the speed during an operation. Before this function is applied, be sure to call HSL_M_fix_speed_range(). Please refer to section 4.6 for more detail explanation. The HSL_M_sd_stop() function is used to decelerate the motion until it stops. The HSL_M_emg_stop() function is used to immediately stop the motion. These change or stop functions follow the same velocity profile as its original move func-

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tions, tv_move or sv_move. The velocity profile is shown as follows:

Note: The v_change and stop functions can also be applied to Preset Mode or Home Mode (refer to 4.1).

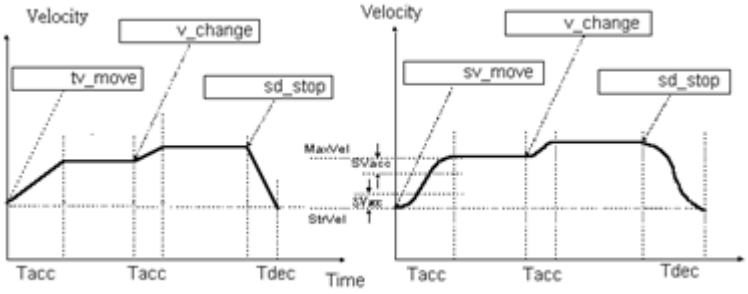


Figure 4-6: Velocity Mode Motion

- Relative Functions:

```
HSL_M_tv_move()
HSL_M_sv_move()
HSL_M_v_change()
HSL_M_sd_stop()
HSL_M_emg_stop()
HSL_M_fix_speed_range()
HSL_M_unfix_speed_range()
```

Trapezoidal Motion

This mode is used to move a singe axis motor to a specified position (or distance) with a trapezoidal velocity profile. The single axis is controlled from point to point. An absolute or relative motion can be performed. In absolute mode, the target position is assigned. In relative mode, the target displacement is assigned. In both cases, the acceleration and deceleration can be different. The function HSL_M_motion_done() is used to check whether the movement is complete.

The following diagram shows the trapezoidal profile:

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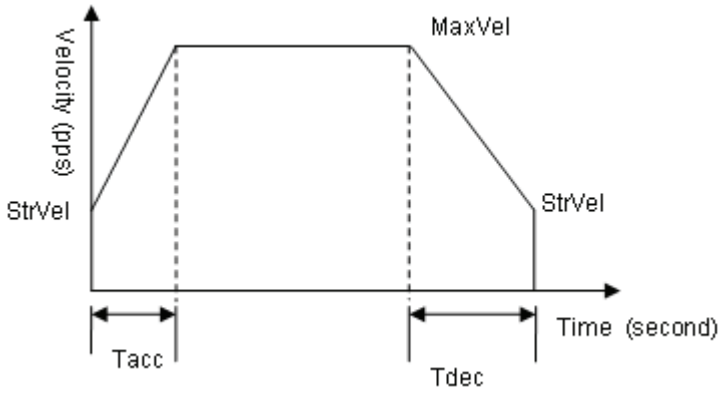


Figure 4-7: Trapezoidal Motion

There are 2 trapezoidal point-to-point functions supported by the HSL-4XMO. In the HSL_M_start_ta_move() function, the absolute target position must be given in units of pulses. The physical length or angle of one movement is dependent on the motor driver and mechanism (including the motor). Since absolute move mode needs the information of current actual position, the “External encoder feedback (EA, EB pins)” should be set in HSL_M_set_feedback_src() function. The ratio between command pulses and external feedback pulse input must be appropriately set by the HSL_M_set_move_ratio() function.

In the HSL_M_start_tr_move() function, the relative displacement must be given in units of pulses. Unsymmetrical trapezoidal velocity profile (Tacc is not equal Tdec) can be specified with both HSL_M_start_ta_move() and HSL_M_start_tr_move() functions.

The StrVel and MaxVel parameters are given in units of pulses per second (PPS). The Tacc and Tdec parameters are in units of second to represent accel./decel. time respectively. Users need to know the physical meaning of “one pulse” to calculate the physical value of the relative velocity or acceleration parameters. The following formula gives the basic relationship between these parameters:

```
MaxVel = StrVel + accel*Tacc;
```

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```
StrVel = MaxVel + decel *Tdec;
```

Where accel/decel represents the acceleration/deceleration rate in units of pps/sec^2. The area inside the trapezoidal profile represents the moving distance.

Units of velocity setting are pulses per second (PPS). Usually, units of velocity of the manual of motor or driver are in rounds per minute (RPM). A simple conversion is necessary to match between these two units. Here we use an example to illustrate the conversion:

Example:

A servomotor with an AB phase encoder is used in a X-Y table. The resolution of encoder is 2000 counts per phase. The maximum rotating speed of motor is designed to be 3600 RPM. What is the maximum pulse command output frequency that you have to set on HSL-4XMO?

Answer: `MaxVel = 3600/60*2000*4 = 480000 PPS`

Multiplying by 4 is necessary because there are four states per AB phase (See Figures in Section 4.4).

Usually, the axes need to set the move ratio if their mechanical resolution is different from the resolution of command pulse. For example, if an incremental encoder is mounted on the working table to measure the actual position of moving part. A servomotor is used to drive the moving part through a gear mechanism. The gear mechanism is used to convert the rotating motion of the motor into linear motion (see the following diagram). If the resolution of the motor is 8000 pulses/round, then the resolution of the gear mechanism is 100 mm/round (i.e., part moves 100 mm if the motor turns one round). Then, the resolution of the command pulse will be 80 pulses/mm. If the resolution of the encoder mounting on the table is 200 pulses/mm, then users have to set the move ratio to 200/80=2.5 using the function HSL_M_set_move_ratio (axis, 2.5).

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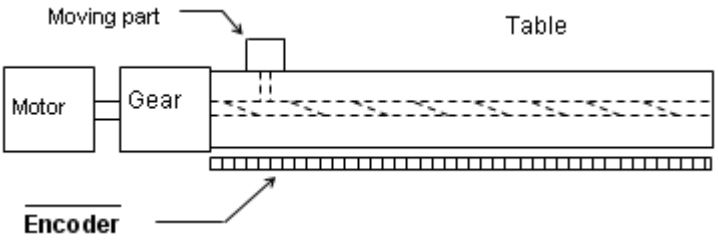


Figure 4-8: Encoder Diagram

If this ratio is not set before issuing the start moving command, it will cause problems when running in “Absolute Mode” because the HSL-4XMO won’t recognize the actual absolute position during motion.

- Relative Functions:

```
HSL_M_start_ta_move()
HSL_M_start_tr_move()
HSL_M_motion_done()
HSL_M_set_feedback_src()
HSL_M_set_move_ratio()
```

S-curve Profile Motion

This mode is used to move a single-axis motor to a specified position (or distance) with a S-curve velocity profile. S-curve acceleration profiles are useful for both stepper and servomotors. The smooth transitions between the start of the acceleration ramp and transition to constant velocity produce less wear and tear than a trapezoidal profile motion. The smoother performance increases the life of the motor and the mechanics of the system.

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There are several parameters that need to be set in order to make a S-curve move. They are:

- Pos: target position in absolute mode, in units of pulses
- Dist: moving distance in relative mode, in units of pulses
- StrVel: start velocity, in units of PPS
- MaxVel: maximum velocity, in units of PPS
- Tacc: time for acceleration (StrVel -> MaxVel), in units of seconds
- Tdec: time for deceleration (MaxVel -> StrVel), in units of seconds
- VSacc: S-curve region during acceleration, in units of PPS
- VSdec: S-curve region during deceleration, in units of PPS

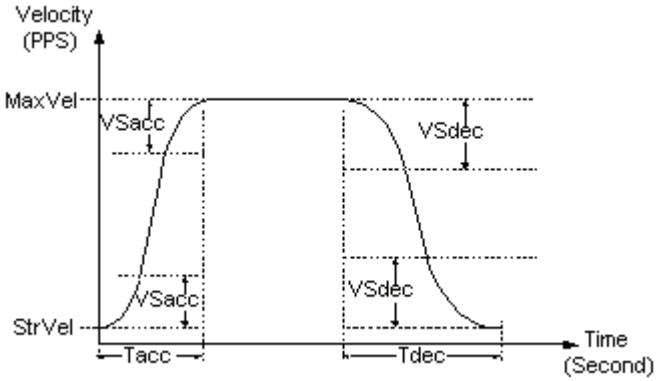


Figure 4-9: S-curve Profile Motion

Normally, the accel/decel period consists of three regions, two VSacc/VSdec curves and one linear. During VSacc/VSdec, the jerk (second derivative of velocity) is constant, and, during the linear region, the acceleration (first derivative of velocity) is constant. In the first constant jerk region during acceleration, the velocity goes from StrVel to (StrVel + VSacc). In the second constant jerk region during acceleration, the velocity goes from (MaxVel – StrVel) to MaxVel. Between them, the linear region accelerates

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velocity from (StrVel + VSacc) to (MaxVel - VSacc) constantly. The deceleration period is similar in fashion.

Note: If user wants to disable the linear region, the VSacc/VSdec must be assigned “0” rather than “0.5” (MaxVel-StrVel).

Remember that the VSacc/VSdec is in units of PPS and it should always keep in the range of [0 to (MaxVel - Strvel)/2], where “0” means no linear region.

The S-curve profile motion functions are designed to always produce smooth motion. If the time for acceleration parameters combined with the final position don’t allow an axis to reach the maximum velocity (i.e. the moving distance is too small to reach MaxVel), then the maximum velocity is automatically lowered (see the following figure).

The rule is to lower the value of MaxVel and the Tacc, Tdec, VSacc, VSdec automatically, and keep StrVel, acceleration, and jerk unchanged. This is also applicable to Trapezoidal profile motion.

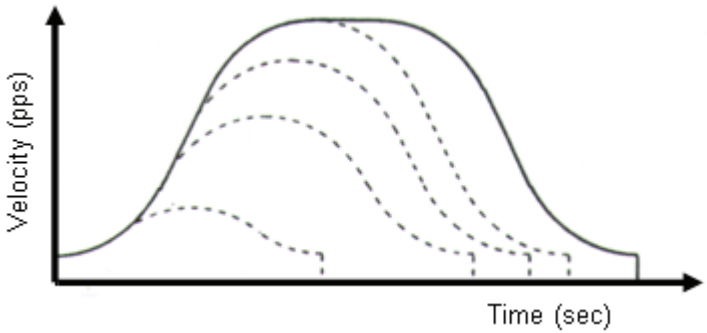


Figure 4-10: Automatic Velocity Decrease

- Relative Functions:

```
HSL_M_start_sr_move()
HSL_M_start_sa_move()
HSL_M_motion_done()
HSL_M_set_feedback_src()
HSL_M_set_move_ratio()
```

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The Following table shows the differences between all single axis motion functions, including preset mode (both trapezoidal and S-curve motion) and constant velocity mode.

	Velocity Profile			
	Trapezoidal	S-Curve	Relative	Absolute
HSL_M_tv_move	Y		----------	----------
HSL_M_sv_move		Y	----------	----------
HSL_M_v_change	Y	Y	----------	----------
HSL_M_sd_stop	Y	Y	----------	----------
HSL_M_emg_stop()	----------	----------	----------	----------
HSL_M_start_ta_move	Y			Y
HSL_M_start_sa_move		Y		Y
HSL_M_start_tr_move	Y		Y	
HSL_M_start_sr_move		Y	Y	

Table 4-3: Single Axis Motion Functions

Linear interpolation for 2-4 axes

In this mode, any 2 of the 4, 3 of the 4, or all 4 axes may be chosen to perform linear interpolation. “Interpolation between multi-axes” means these axes start simultaneously, and reach their ending points at the same time. Linear means the ratio of speed of every axis is a constant value.

Note that you cannot use 2 groups of 2 axes for linear interpolation on a single card at the same time. You can however, use one 2-axis linear and one 2-axis circular interpolation at the same time. If you want to stop an interpolation group, the function HSL_M_sd_stop() or HSL_M_emg_stop() can be used.

2 Axes Linear Interpolation

As in the diagram below, 2-axis linear interpolation means to move the XY position (or any 2 of the 4 axis) from P0 to P1. The 2 axes start and stop simultaneously, and the path is a straight line.

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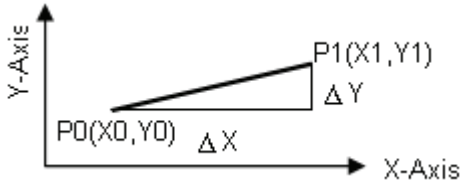


Figure 4-11: 2 Axes Linear Interpolation

The speed ratio along X-axis and Y-axis is (ΔX: ΔY), respectively, and the vector speed is:

$$\frac{\Delta P}{\Delta t} = \sqrt{(\frac{\Delta X}{\Delta t})^2 + (\frac{\Delta Y}{\Delta t})^2}$$

When calling 2-axis linear interpolation functions, the vector speed needs to define the start velocity, StrVel, and maximum velocity, MaxVel. Both trapezoidal and S-curve profiles are available.

Example:

HSL_M_start_tr_move_xy(0, 30000.0, 40000.0, 1000.0, 5000.0, 0.1, 0.2) will cause the XY axes (axes 0 & 1) of Card 0 to perform a linear interpolation movement, in which:

```
ΔX = 30000 pulses; ΔY = 40000 pulses
Start vector speed = 1000pps, X speed=600pps, Y
     speed = 800pps
Max. vector speed = 5000pps, X speed=3000pps, Y
     speed = 4000pps
Acceleration time = 0.1sec; Deceleration time =
     0.2sec
```

There are two groups of functions that provide 2-axis linear interpolation. The first group divides the 4 axes into XY (axis 0 & axis 1) and ZU (axis 2 & axis 3). By calling these functions, the target axes are already assigned.

```
HSL_M_start_tr_move_xy()
HSL_M_start_tr_move_zu()
HSL_M_start_ta_move_xy(
```

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```
HSL_M_start_ta_move_zu()
HSL_M_start_sr_move_xy()
HSL_M_start_sr_move_zu()
HSL_M_start_sa_move_xy()
HSL_M_start_sa_move_zu()
```

The second group allows user to freely assign the 2 target axes.

```
HSL_M_start_tr_line2()
HSL_M_start_sr_line2()
HSL_M_start_ta_line2()
HSL_M_start_sa_line2()
```

The characters “t”, “s”, “r”, and “a” after HSL_M_start mean:

- t – Trapezoidal profile
- s – S-Curve profile
- r – Relative motion
- a – Absolute motion

3-Axis Linear Interpolation

Any 3 of the 4 axes of the HSL-4XMO may perform 3-axis linear interpolation. As shown the figure below, 3-axis linear interpolation means to move the XYZ (if axes 0, 1, 2 are selected and assigned to be X, Y, Z respectively) position from P0 to P1, starting and stopping simultaneously. The path is a straight line in space.

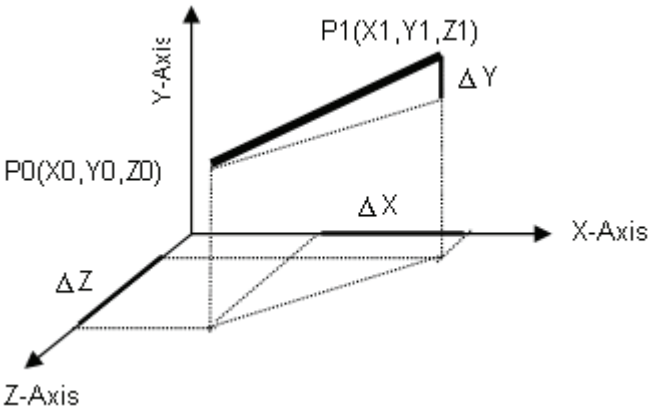


Figure 4-12: 3-Axis Linear Interpolation

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The speed ratio along X-axis, Y-axis, and Z-axis is (ΔX: ΔY: ΔZ), respectively, and the vector speed is:

When calling 3-axis linear interpolation functions, the vector speed is needed to define the start velocity, StrVel, and maximum velocity, MaxVel. Both trapezoidal and S-curve profiles are available.

Example:

```
HSL_M_start_tr_line3(…..,1000.0 /*ΔX */ , 2000.0/
     *ΔY */, 3000.0 /*DistZ*/, 100.0 /*StrVel*/,
     5000.0 /* MaxVel*/, 0.1/*sec*/, 0.2 /*sec*/)
ΔX = 1000 pulse; ΔY = 2000 pulse; ΔZ = 3000 pulse
Start vector speed=100pps,X  speed  =  100/    =
     26.7pps
Y speed = 2*100/  = 53.3pps
Z speed = 3*100/  = 80.1pps
Max. vector speed =5000pps,X  speed=  5000/    =
     1336pps
Y speed = 2*5000/  = 2672pps
Z speed = 3*5000/  = 4008pps
```

The following functions are used for 3-axis linear interpolation:

```
HSL_M_start_tr_line3()
HSL_M_start_sr_line3()
HSL_M_start_ta_line3()
HSL_M_start_sa_line3()
```

The characters “t”, “s”, “r”, and “a” after HSL_M_start mean:

- t – Trapezoidal profile
- s – S-Curve profile
- r – Relative motion
- a – Absolute motion

4-axis Linear Interpolation

With 4-axis linear interpolation, the speed ratio along X-axis, Y-axis, Z-axis and U-axis is (ΔX: ΔY: ΔZ: ΔU), respectively, and the vector speed is:

$$\frac{\Delta P}{\Delta t} = \sqrt{(\frac{\Delta X}{\Delta t})^2 + (\frac{\Delta Y}{\Delta t})^2 + (\frac{\Delta Z}{\Delta t})^2 + (\frac{\Delta U}{\Delta t})^2}$$

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The following functions are used for 4-axis linear interpolation:

```
HSL_M_start_tr_line4()
HSL_M_start_sr_line4()
HSL_M_start_ta_line4()
HSL_M_start_sa_line4()
```

The characters “t”, “s”, “r”, and “a” after HSL_M_start mean:

- t – Trapezoidal profile
- s – S-Curve profile
- r – Relative motion
- a – Absolute motion

Circular interpolation for 2 axes

Any 2 of the 4 axes of the HSL-4XMO can perform circular interpolation. In the example below, circular interpolation means XY (if axes 0, 1 are selected and assigned to be X, Y respectively) axes simultaneously start from initial point, (0,0) and stop at end point,(1800,600). The path between them is an arc, and the Max-Vel is the tangential speed.

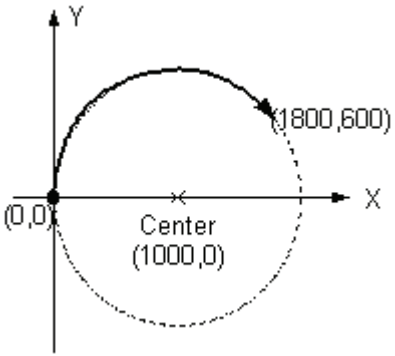


Figure 4-13: Circular interpolation for 2 axes

Example:

```
HSL_M_start_a_arc_xy(0  /*card  No*/,  1000,0  /
     *center X*/, 0 /*center Y*/, 1800.0 /* End X
     */, 600.0 /*End Y */ ,1000.0 /* MaxVel */)
```

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To specify a circular interpolation path, the following parameters must be clearly defined:

- Center point: The coordinate of the center of arc (In absolute mode) or the off_set distance to the center of arc (In relative mode)
- End point: The coordinate of end point of arc (In absolute mode) or the off_set distance to center of arc (In relative mode)
- Direction: The moving direction, either CW or CCW.

It is not necessary to set radius or angle of arc, since the information above gives enough constrains. The arc motion is stopped when either of the 2 axes reached end point.

There are two groups of functions that provide 2-axis circular interpolation. The first group divides the 4 axes into XY (axis 0 & axis 1) and ZU (axis 2 & axis 3). By calling these functions, the target axes are already assigned.

```
HSL_M_start_r_arc_xy()
HSL_M_start_r_ arc _zu()
HSL_M_start_a_ arc _xy()
HSL_M_start_a_ arc _zu()
```

The second group allows user to freely assign any targeted 2 axes.

```
HSL_M_start_r_arc2()
HSL_M_start_a_arc2()
```

Circular Interpolation with Acc/dec Time

In section 4.1, the circular interpolation functions do not support acceleration and deceleration parameters; therefore, they cannot perform a T or S curve speed profile during operation. However, sometimes the need for an Acc/Dec time speed profile will help a machine to make more accurate circular interpolation. The HSL-4XMO has another group of circular interpolation functions to perform this type of interpolation, but requires the use of Axis3 as an aided axis, which means that Axis3 cannot be used for other purposes while running these functions. For example, to perform a circular interpolation with a T-curve speed profile, the function HSL_M_start_tr_arc_xyu() is used. This function will used Axis0

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and Axis1, and also Axis3 (Axis0=x, Axis1=y, Axis2=z, Axis3=u). For the full lists of functions.

To check if the board supports these functions use the HSL_M_version_info() function. If hardware information for the card returns a value with the 4th digit greater then 0, for example '1003', users can use this group of circular interpolation to perform S or T-curve speed profiles. If the hardware version returns a value with the 4th digit being 0, then that board does not support these functions.

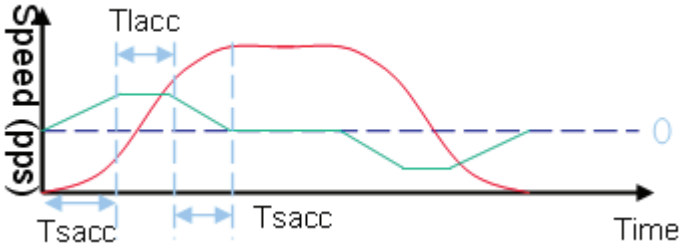


Figure 4-14: Circular Interpolation with Acc/dec Time

Relationship between Velocity and Acceleration Time

The maximum velocity parameter of a motion function will eventually have a minimum acceleration value. This means that there is a range for acceleration time over one velocity value. Under this relationship, to obtain a small acceleration time, a higher maximum velocity value to match the smaller acceleration time is required. Function HSL_M_fix_speed_range() will provide such operation. This function will raise the maximum velocity value, which in turn results in a smaller acceleration time. Note it does not affect the actual end velocity. For example, to have a 1ms acceleration time from a velocity of 0 to 5000(pps), the function can be inserted before the motion function as shown.

```
HSL_M_fix_speed_range(AxisNo,OverVelocity);
HSL_M_start_tr_move(AxisNo,5000,0,5000,0.001,0.0
    01);
```

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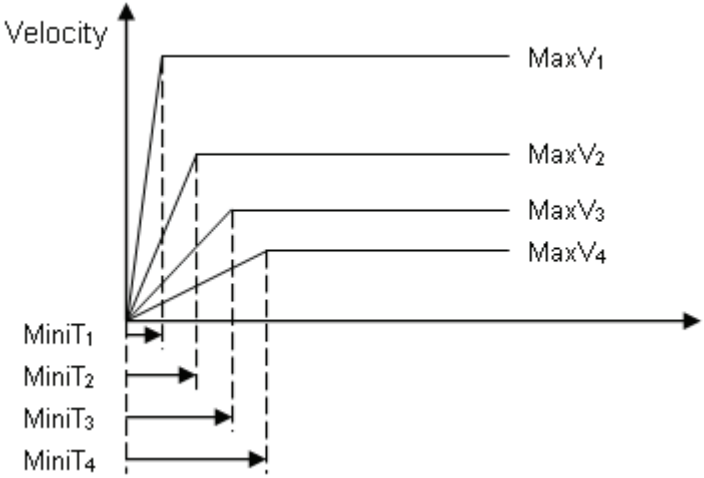


Figure 4-15: Velocity and Acceleration Time A

How do users decide an optimum value for “OverVelocity” in the HSL_M_fix_speed_range() function? The HSL_M_verify_speed() function is provided to calculate such value. The inputs to this function are the start velocity, maximum velocity and over velocity values. The output value will be the minimum and maximum values of the acceleration time.

For example, if the original acceleration range for the command is:

```
HSL_M_start_tr_move(AxisNo,5000,0,5000,0.001,0.0
    01),
```

then use the following function:

```
HSL_M_verify_speed(0,5000,&minAccT,
    &maxAccT,5000);
```

The value miniAccT will be 0.0267sec and maxAccT will be 873.587sec. This minimum acceleration time does not meet the requirement of 1mS. To achieve such a low acceleration time the over speed value must be used.

By changing the OverVelocity value to 140000,

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```
HSL_M_verify_speed(0,5000,&minAccT,
     &maxAccT,140000);
```

The value miniAccT will be 0.000948sec and maxAccT will be 31.08sec. This minimum acceleration time meets the requirements. So, the motion command can be changed to:

```
HSL_M_fix_speed_range(AxisNo,140000);
HSL_M_start_tr_move(AxisNo,5000,0,5000,0.001,0.0
     01);
```

Note: The return value of HSL_M_verify_speed() is the minimum velocity of motion command, it does not always equal to your start velocity setting. In the above example, it will be 3pps more than the 0pps setting.

To disable the fix speed function HSL_M_fix_speed_range() use HSL_M_unfix_speed_range()

Minimize the use of the OverVelocity operation. The more it is used, the coarser the speed interval is.

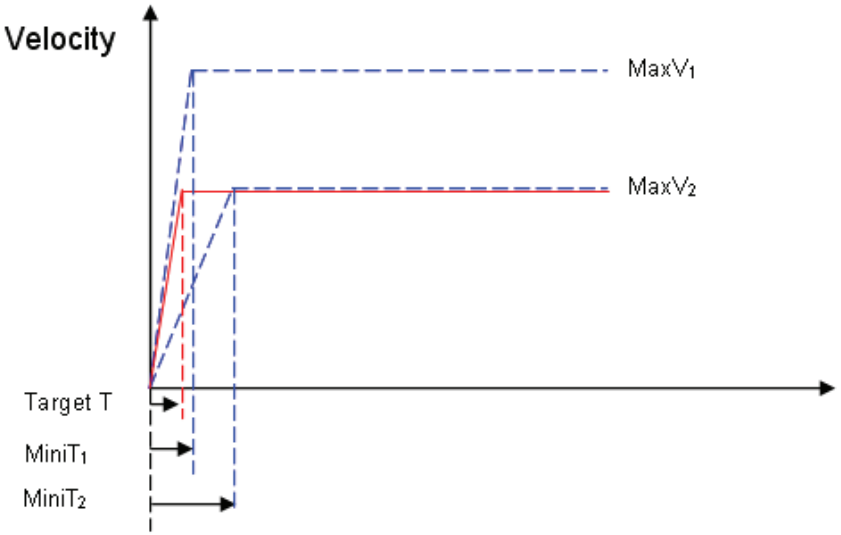


Figure 4-16: Velocity and Acceleration Time B

Example:

User's Desired Profile: (MaxV2, Target T) is not possible under MaxV2 according to the (MaxV, MiniT) relationship. So one must

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change the (MaxV, MiniT) relationship to a higher value, (MaxV1, MiniT1). Finally, the command would be:

```
HSL_M_fix_speed_range(AxisNo, MaxV1);
HSL_M_start_tr_move(AxisNo,Distance, 0 , MaxV2 ,
     Target T, Target T);
```

Relative Functions:

```
HSL_M_fix_speed_range()
HSL_M_unfix_speed_range()
HSL_M_verify_speed()
```

Home Return Mode

In this mode, the HSL-4XMO is allowed to continuously output pulses until the condition to complete the home return is satisfied after writing the command HSL_M_home_move(). There are 13 home moving modes provided by the HSL-4XMO. The “home_mode” of function HSL_M_set_home_config() is used to select whichever mode is preferred.

After completion of home move, it is necessary to keep in mind that all related position information should be reset to be “0.” The HSL-4XMO has 4 counters and 1 software-maintained position recorder. They are:

- Command position counter: counts the number of pulse outputs
- Feedback position counter: counts the number of pulse inputs
- Position error counter: counts the error between command and feedback pulse numbers.
- General-Purpose counter: can be configured as pulse output, feedback pulse, manual pulse, or CLK/2.
- Target position recorder: records the target position.

Refer to section 4.4 for a more detailed explanation about position counters.

After home move is complete, the first four counters will be cleared to “0” automatically, however, the target position recorder will not. Because it is software maintained, it is necessary to manually set

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the target position to “0” by calling the function HSL_M_reset_target_pos().

The following figures show the various home modes and the reset points, when the counter is cleared to “0.”

home_mode=0: ORG -> Slow down -> Stop

- When SD (Ramp-down signal) is inactive.

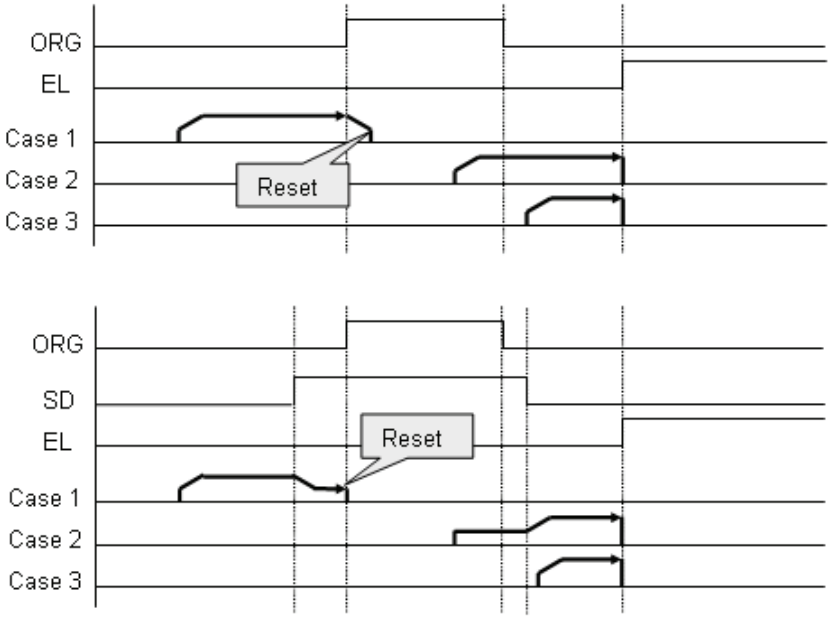


Figure 4-17: home_mode=0

home_mode=1: ORG -> Slow down -> Stop at end of ORG

- When SD (Ramp-down signal) is active.

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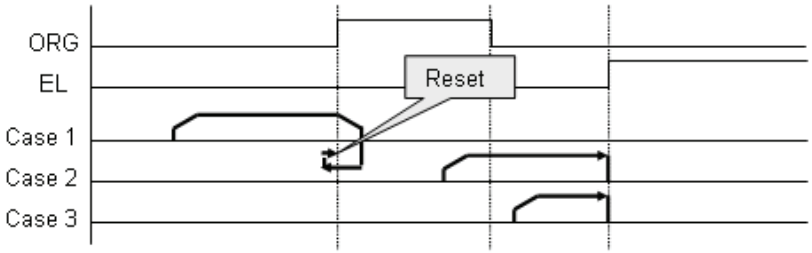


Figure 4-18: home_mode=1

home_mode=3: ORG -> EZ -> Slow down -> Stop

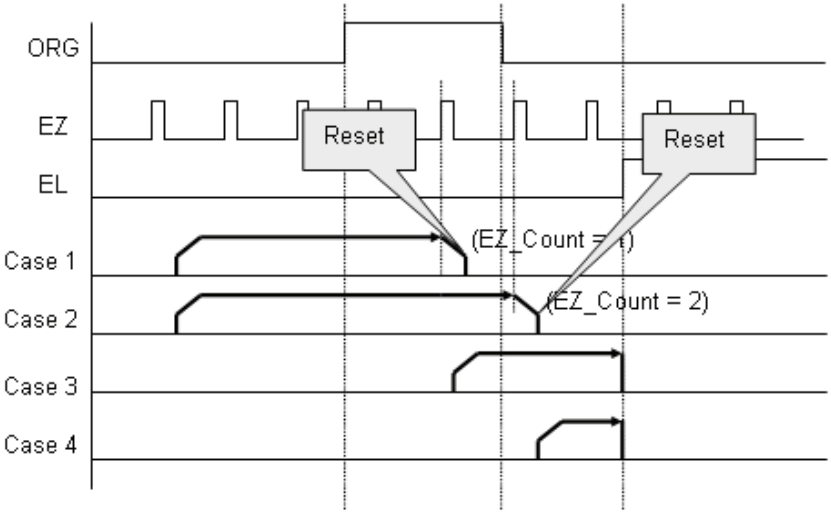


Figure 4-19: home_mode=3

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home_mode=4: ORG -> Slow down -> Go back at FA speed -> EZ -> Stop

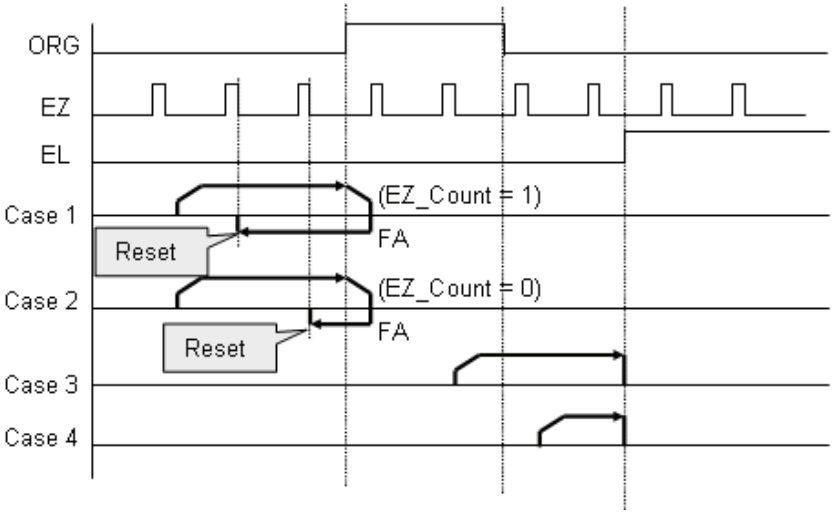
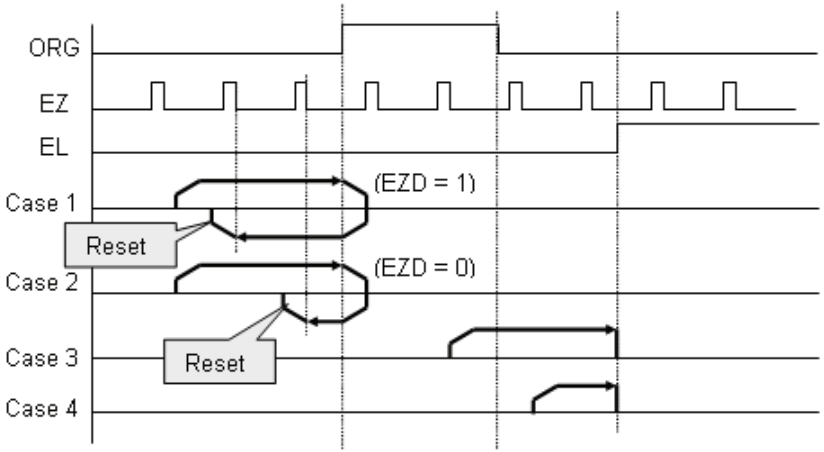


Figure 4-20: home_mode=4

home_mode=5: ORG -> Slow down -> Go back ->? Accelerate to MaxVel -> EZ -> Slow down -> Stop



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Figure 4-21: home_mode=5

home_mode=6: EL only

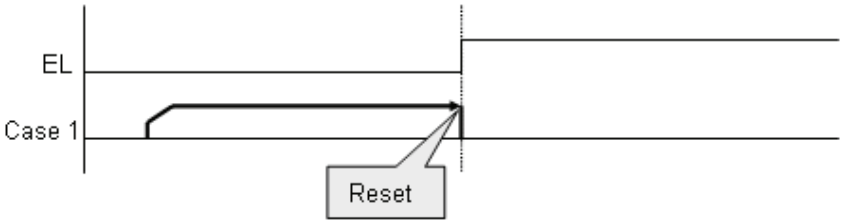


Figure 4-22: home_mode=6

home_mode=7: EL -> Go back -> Stop on EZ signal

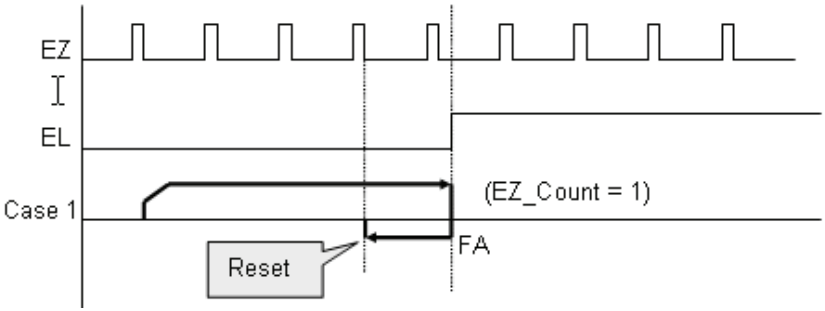


Figure 4-23: home_mode=7

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home_mode=8: EL -> Go back -> Accelerate to MaxVel -> EZ -> Slow down -> Stop

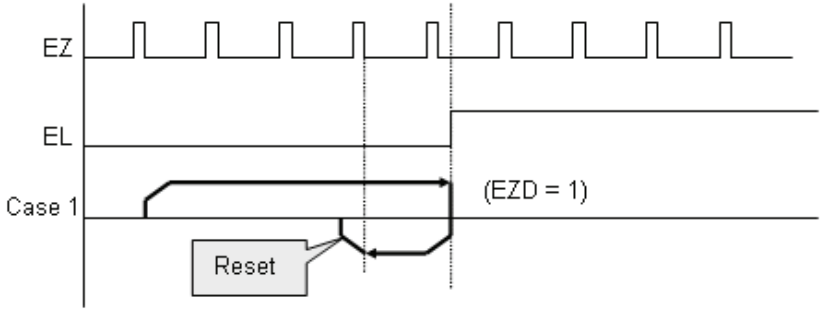


Figure 4-24: home_mode=8

home_mode=9: ORG -> Slow down -> Go back -> Stop at beginning edge of ORG

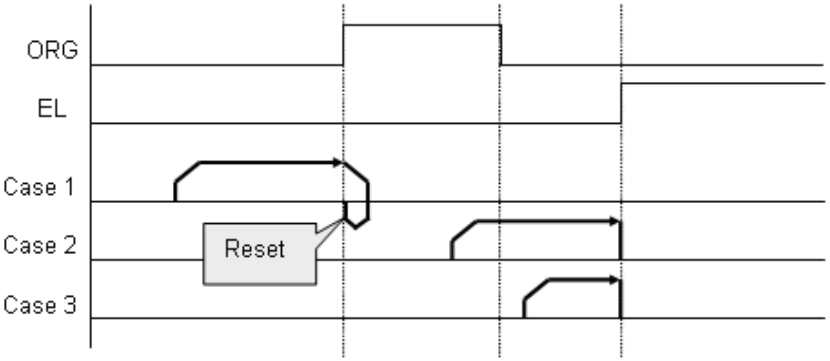


Figure 4-25: home_mode=9

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home_mode=10: ORG -> EZ -> Slow down -> Go back -> Stop at beginning edge of EZ

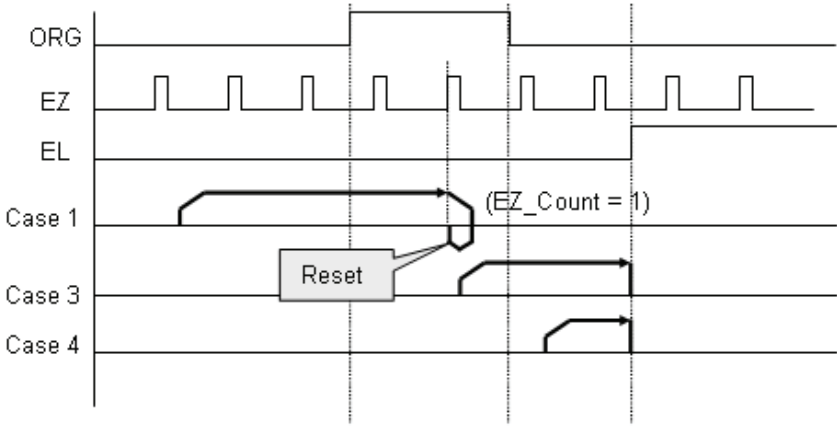
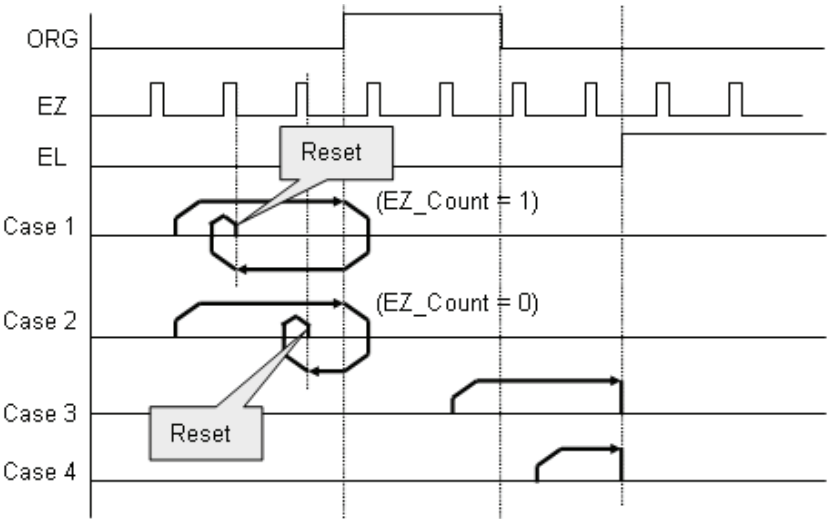


Figure 4-26: home_mode=10

home_mode=11: ORG -> Slow down -> Go back (backward) -> Accelerate to MaxVel -> EZ -> Slow down -> Go back again (forward) -> Stop at beginning edge of EZ



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Figure 4-27: home_mode=11

home_mode=12: EL -> Stop -> Go back (backward) -> Accelerate to MaxVel -> EZ -> Slow down -> Go back again (forward) -> Stop at beginning edge of EZ

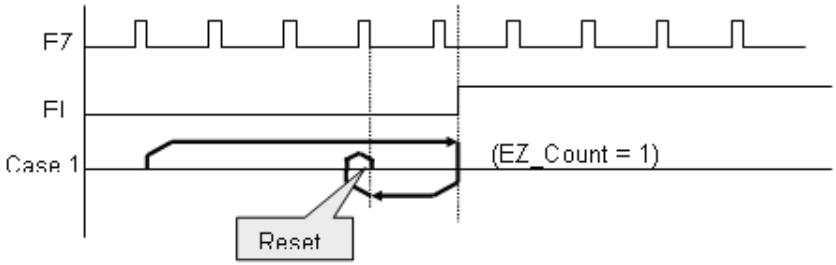


Figure 4-28: home_mode=12

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Home Search Example (Home mode=1)

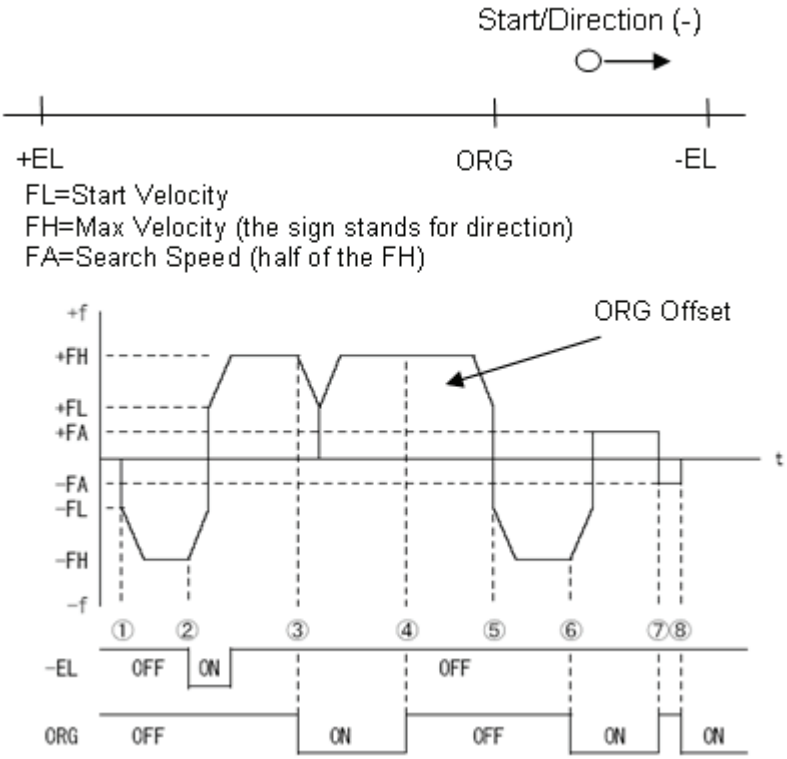


Figure 4-29: Home Search Example

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Moving Steps

1. Home searching start (-)
2. –EL touches, slow down and reverse moving (+)
3. ORG touches, slow down
4. Escape from ORG according to ORG offset
5. Start searching again (-)
6. ORG touches, slow down then using searching speed to escape ORG (+)
7. After escape ORG, search ORG with search speed again (-)

▶ Relative Functions:

```
HSL_M_set_home_config()
HSL_M_home_move()
HSL_M_home_search()
```

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4.7 The Motor Driver Interface

The HSL-4XMO provides the INP, ALM, ERC, SVON, and RDY signals for a servomotor driver control interface. The INP and ALM are used for feedback of the servo driver status, ERC is used to reset the servo driver's deviation counter under special conditions, VON is a general purpose output signal, and RDY is a general purpose input signal. The meaning of "general purpose" is that the processing of the signal is not a build-in procedure of the hardware. The hardware processes INP, ALM, and ERC signals according to pre-defined rules. For example, when receiving ALM signal, the HSL-4XMO stops or decelerate to stop output pulses automatically. However, SVON and RDY are not the case, they actually act like common I/O's.

INP

The processing of the INP signal is a hardware build-in procedure, and it is designed to cooperate with the in-position signal of the servomotor driver.

Usually, servomotor drivers with a pulse train input has a deviation (position error) counter to detect the deviations between the input pulse command and feedback counter. The driver controls the motion of the servomotor to minimize the deviation until it becomes 0. Theoretically, the servomotor operates with some time delay from the command pulses. Likewise, when the pulse generator stops outputting pulses, the servomotor does not stop immediately but keeps running until the deviation counter is zero. Only after stopping does the servo driver send out the in-position signal (INP) to the pulse generator to indicate the motor has stopped running.

Normally the HSL-4XMO stops outputting pulses upon completion of outputting designated pulses. However, by setting parameter inp_enable with the HSL_M_set_inp() function, the delay in completion of the motion to the time the INP signal is issued can be adjusted, i.e., the motor arrives at the target position. Status of HSL_M_motion_done() and INT signal are also delayed. That is, when performing under position control mode, the completion of HSL_M_start_ta_move(), HSL_M_start_sr_move(), etc, is delayed until the INP signal is issued.

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The in-position function can be enabled or disabled, and the input logic polarity is also programmable by the “inp_logic” parameter of HSL_M_set_inp(). The INP signal status can be monitored by software with the function: HSL_M_get_io_status().

- Relative Functions:

```
HSL_M_set_inp()
HSL_M_get_io_status()
HSL_M_motion_done()
```

ALM

The processing of the ALM signal is a hardware build-in procedure, and it is designed to interact with the alarm signal of the servomotor driver.

The ALM signal is an output signal from servomotor driver. Usually, it is designated to indicate when something is wrong with the driver or motor.

The ALM pin receives the alarm signal output from the servo driver. The signal immediately stops the HSL-4XMO from generating any further pulses or stops it after deceleration. If the ALM signal is in the ON status at the start of an operation, the HSL-4XMO will generate the INT signal and thus not generate any command pulses. The ALM signal may be a pulse signal with a minimum time width of 5 microseconds.

Setting the parameters “alm_logic” and “alm_mode” of the HSL_M_set_alm function can alter the input logic of the ALM. Whether or not the HSL-4XMO is generating pulses, the ALM signal allows the generation of the INT signal. The ALM status can be monitored by using the software function: HSL_M_get_io_status().

- Relative Functions:

```
HSL_M_set_alm()
HSL_M_get_io_status()
```

ERC

The ERC signal is an output from the HSL-4XMO. The processing of the ERC signal is a hardware build-in procedure, and it is

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designed to interact with the deviation counter clear signal of the servomotor driver.

The deviation counter clear signal is inserted in the following 4 situations:

1. Home return is complete
2. The end-limit switch is active
3. An alarm signal stops the OUT and DIR signals
4. The software operator issues an emergency stop command

Since the servomotor operates with some delay from the pulse generated from the HSL-4XMO, it continues to move until the deviation counter of the driver is zero even if the HSL-4XMO has stopped outputting pulses because of the ?EL signal or the completion of home return. The ERC signal allows immediate stopping of the servomotor by resetting the deviation counter to zero. The ERC signal is outputted as a one-shot signal. The pulse width is of time length defined by the function call HSL_M_set_erc(). The ERC signal will automatically be generated when the ?EL and ALM signal are turned on and the servomotor is stopped immediately.

- Relative Functions:

  `HSL_M_set_erc()`

SVON and RDY

All axes of the HSL-4XMO are equipped with SVON and RDY signals, which are general purpose output and input channels, respectively. Usually, the SVON is used to interact with the servomotor drivers as a Servo ON command, and RDY to receive the Servo Ready signal. There are no built-in procedures for SVON and RDY.

The SVON signal is controlled by the software function HSL_M_Set_Servo().

RDY pins are dedicated for digital input usage. The status of this signal can be monitored using the software function HSL_M_get_io_status().

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- Relative Functions:

```
HSL_M_Set_Servo()
HSL_M_get_io_status()
```

4.8 The Limit Switch Interface and I/O Status

In this section, the following I/O signal operations are described.

- SD/PCS: Ramping Down & Position Change sensor
- ±EL: End-limit sensor
- ORG: Origin position

In any operation mode, if an ?EL signal is active during any moving condition, it will cause the HSL-4XMO to stop automatically outputting pulses. If an SD signal is active during moving conditions, it will cause the HSL-4XMO to decelerate. If operating in a multi-axis mode, it automatically applies to all related axes.

SD/LTC

SD/LTC signal pins are available for each axis and acts as the input channel. It can be connected to a SD (Slow Down) or Position Latch (LTC).

This input pin is inside connected to both slow down function and latch function. Users can control the slow down function to be active or not. But the latch function is always turned on without any problem. Care must be taken with the logic attributes of the signal not being used.

The slow-down signals are used to force the output pulse (OUT and DIR) to decelerate to and then maintain the StrVel when it is active. The StrVel is usually smaller than MaxVel. This signal is useful in protecting a mechanism moving under high speeds toward the mechanism's limit. SD signal is effective for both plus and minus directions.

The ramping-down function can be enabled or disabled using the software function HSL_M_set_sd(). The input logic polarity, level operation mode, or latched input mode can also be set by this function. The signal status can be monitored using HSL_M_get_io_status().

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The latch function is used to capture values on all 4 counters (refer to section 4.4) at the instant the latch signal is activated.

The latched data can be read by the function HSL_M_get_latch_data(). The latch logic can be set by the function HSL_M_set_ltc_logic().

- Relative Functions:

```
HSL_M_set_sd()
HSL_M_get_io_status()
HSL_M_set_ltc_logic()
HSL_M_get_latch_data()
```

EL

The end-limit signal is used to stop the control output signals (OUT and DIR) when the end-limit is active. There are two possible stop modes, “stop immediately” and “decelerate to StrVel then stop.” To select either mode use HSL_M_set_el().

The PEL signal indicates the end-limit in the positive (plus) direction. MEL signal indicates the end-limit in negative (minus) direction. When the output pulse signals (OUT and DIR) is towards the positive direction, the pulse train will be immediately stopped when the PEL signal is asserted, where the MEL signal is meaningless, and vise versa. When the PEL is asserted, only a negative (minus) direction output pulse can be generated when moving the motor in a negative (minus) direction.

The logic of EL is programmable. You can use HSL_M_set_el_logic() to set is as normal open or normal close mode. The signal status can be monitored using the software function HSL_M_get_io_status().

- Relative Functions:

```
HSL_M_set_el():
HSL_M_get_io_status()
HSL_M_set_el_logic()
```

ORG

The ORG signal is used when the motion controller is operating in the home return mode. There are 13 home return modes (Refer to section 4.1.8), any one of 13 modes cam be selected using

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"home_mode" argument in the function HSL_M_set_home_config(). The logic polarity of the ORG signal level or latched input mode is also selectable using this function as well.

After setting the configuration for the home return mode with HSL_M_set_home_config(), the HSL_M_home_move() command can perform the home return function.

- Relative Functions:

  `HSL_M_set_home_config(), HSL_M_home_move()`

4.9 The Counters

There are four counters for each axis of the HSL-4XMO. They are described in this section:

- Command position counter: counts the number of output pulses
- Feedback position counter: counts the number of input pulses
- Position error counter: counts the error between command and feedback pulse numbers.
- General-purpose counter: The source can be configured as pulse output, feedback pulse, manual pulse, or CLK/2.

Also, the target position recorder, a software-maintained position recorder, is discussed.

Command Position Counter

The command position counter is a 28-bit binary up/down counter. its input source is the output pulse from the HSL-4XMO, thus, it provides accurate information of the current position. Note: the command position is different from target position. The command position increases or decreases according to the pulse output, while the target position changes only when a new motion command has been executed. The target position is recorded by the software, and needs manually resetting after a home move is completed.

The command position counter will clear (reset to "0") automatically after a home move has completed. The function

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HSL_M_set_command() can be executed at any time to set a new command position value. To read current command position use HSL_M_get_command().

- Relative Functions:

  `HSL_M_set_command(), HSL_M_get_command():`

Feedback Position Counter

The HSL-4XMO has a 28-bit binary up/down counter managing the present position feedback for each axis. The counter counts signal inputs from the EA and EB pins.

It accepts 2 kinds of pulse inputs: (1). Plus and minus pulse inputs (CW/CCW mode). (2). 90° phase shifted signals (AB phase mode). 90° phase shifted signals maybe multiplied by a factor of 1, 2 or 4. 4x AB phase mode is the most commonly used in incremental encoder inputs. For example, if a rotary encoder has 2000 pulses per phase (A or B phase), then the value read from the counter will be 8000 pulses per turn or –8000 pulses per turn depending on its rotating direction. These input modes can be selected using the HSL_M_set_pls_iptmode() function.

In cases where the application has not implemented an encoder, it is possible to set the feedback counter source to generate the output pulses, just as with the command counter. Thus, the feedback counter and the command counter will have the same value. To enable the counters to count the number of pulses inputted, set the “Src” parameter of the software function HSL_M_set_feedback_src() to “1.”

Plus and Minus Pulses Input Mode (CW/CCW Mode)

The pattern of pulses in this mode is the same as the Dual Pulse Output Mode in the Pulse Command Output section; except that the input pins are EA and EB.

In this mode, pulses from EA cause the counter to count up, whereas EB caused the counter to count down.

90° Phase Difference Signals Input Mode (AB phase Mode)

In this mode, the EA signal is a 90° phase leading or lagging in comparison with the EB signal. “Lead” or “lag” of phase difference between two signals is caused by the turning direction of the

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motor. The up/down counter counts up when the phase of EA signal leads the phase of EB signal.

The following diagram shows the waveform.

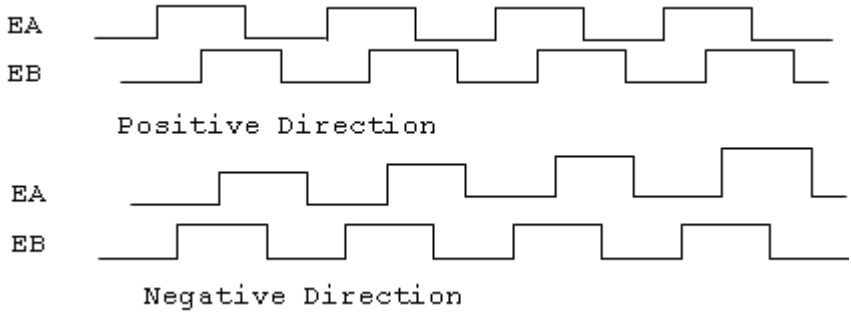


Figure 4-30: 90° Phase Difference Signals

The index input (EZ) signals of the encoders are used as the "ZERO" reference. This signal is common on most rotational motors. EZ can be used to define the absolute position of the mechanism. The input logic polarity of the EZ signals is programmable using software function HSL_M_set_home_config(). The EZ signals status of the four axes can be monitored by get_io_status().

The feedback position counter will be automatically cleared to "0" after a home move is complete. Besides setting a position with the function call, HSL_M_set_position(), it can also be executed at any time to set a new position value. To read the current command position use HSL_M_get_position().

- Relative Functions:

```
HSL_M_set_pls_iptmode()
HSL_M_set_feedback_src()
HSL_M_set_position()
HSL_M_get_position()
HSL_M_set_home_config()
```

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Position Error Counter

The position error counter is used to calculate the error between the command position and the feedback position. It will add one count when the HSL-4XMO outputs one pulse and subtracts one count when the HSL-4XMO receives one pulse (from EA, EB). It is useful in detecting step-loses (stalls) in situations of a stepping motor when an encoder is applied.

Since the position error counter automatically calculates the difference between pulses outputted and pulses fed back, it is inevitable to get an error if the motion ratio is not equal to “1.”

To obtain a position error reading, use the function call HSL_M_get_error_counter(). To reset the position error counter, use the function call HSL_M_reset_error_counter(). The position error counter will automatically clear to “0” after home move is complete.

- Relative Functions:

```
HSL_M_get_error_counter()
HSL_M_reset_error_counter():
```

General Purpose Counter

The general purpose counter is very versatile. It can be any of the following:

1. Pulse output – as a command position counter
2. Pulse input – as a feedback position counter
3. Manual Pulse input – Default status.
4. Clock – an accurate timer (9.8 MHz)

The default setting of the general purpose counter is set to manual pulse. (Refer to section 4.1.9 for a detailed explanation of manual pulsing). To change the source type, use the function HSL_M_set_general_counter(). To obtain the counter status, use the function HSL_M_get_general_counter().

- Relative Functions:

```
HSL_M_set_general_counter()
HSL_M_get_general_counter()
```

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The table below summarizes all functions used for the different counter types

Counter	Description	Counter Source	Function	Function Description
Command	Counts the number of output pulses	Pulse output	HSL_M_set_command	Set a new value for command position
			HSL_M_get_command	Read current command position
Feedback	Counts the number of input pulses	EA/EB or Pulse output	HSL_M_set_pls_iptmode	Select the input modes of EA/EB
			HSL_M_set_feedback_src	Set the counters input source
			HSL_M_set_position	Set a new value for feedback position
			HSL_M_get_position	Read current feedback position:
Position error	Counts the error between command and feedback pulse	EA/EB and Pulse output	HSL_M_get_error_counter	Gets the position error
			HSL_M_reset_error_counter	Resets the position error counter
General Purpose	General purpose counter	Pulse output EA/EB manual pulse CLK/2	HSL_M_set_general_counter	Set a new counter value
			HSL_M_get_general_counter	Read current counter value

Table 4-4: Counter Summary

Target Position Recorder

The target position recorder is used for providing target position information. For example, if the HSL-4XMO is operating in continuous motion with absolute mode, the target position lets the next absolute motion know the target position of previous one.

It is very important to understand how the software handles the target position recorder. Every time a new motion command is executed, the displacement is automatically added to the target position recorder. To ensure the correctness of the target position recorder, users need to manually maintain it in the following two situations using the function HSL_M_reset_target_pos():

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1. After a home move completes
2. After a new feedback position is set

▶ Relative Function:

```
HSL_M_reset_target_pos()
```

4.10 Multiple HSL-4XMO Operations

The software function library can support a maximum of 16 HSL-4XMO modules in one HSL set. This means up to 63 motors(maximum axes) can be connected.

When multiple modules are used, the order of axes number is from low to high and each module takes four axis number.

Connector / Module No.	CM1	CM2	CM3	CM4
1	0	1	2	3
2	4	5	6	7
3	8	9	10	11

Table 4-5: Multiple HSL-4XMO Operations

Example:

To accelerate CM3 of module 2 from 0 to 10000pps in 0.5sec for Constant Velocity Mode operation, the axis number is 6, and the code for the program will be:

```
HSL_M_start_tv_move(6, 0, 10000, 0.5);
```

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4.11 Change Position Or Speed On The Fly

The HSL-4XMO provides the ability to change position or speed while an axis is moving. Changing speed/position on the fly means that the target speed/position can be altered after the motion has started. However, certain limitations do exist. Carefully study all constraints before implementing the on-the-fly function.

Change Speed on the Fly

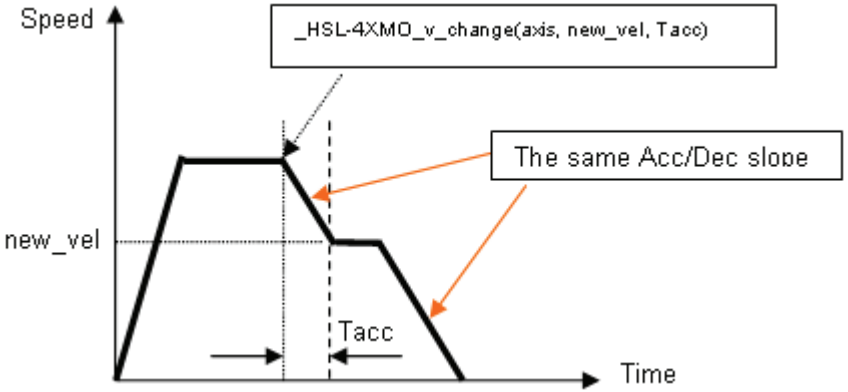


Figure 4-31: Change Speed on the Fly

The change speed on the fly function is applicable on single axis motion only. Both velocity mode motion and position mode motion are acceptable. The graph above shows the basic operating theory.

The following functions are related to changing speed on the fly.

```
HSL_M_v_change() - change the MaxVel on the fly
HSL_M_cmp_v_change() -change velocity when the
     general comparator comes into existence
HSL_M_sd_stop() - slow down to stop
HSL_M_emg_stop() - immediately stop
HSL_M_fix_speed_range() - define the speed range
HSL_M_unfix_speed_range() - release the speed
     range constrain
```

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The first 4 functions can be used for changing speed during a single axis motion. Functions HSL_M_sd_stop() and HSL_M_emg_stop() are used to decelerate the axis speed to “0.” HSL_M_fix_speed_range() is necessary before any HSL_M_v_change() function, and HSL_M_unfix_speed_range() releases the speed range constrained by HSL_M_fix_speed_range().

The function HSL_M_cmp_v_change() almost has the same function as HSL_M_v_change(), except HSL_M_cmp_v_change() acts only when a general comparator comes into existence. Refer to section 4.4.4 for more details about the general comparator.

The last 4 functions are relatively easy to understand and use. So, the discussion below will be focused on HSL_M_v_change().

Theory behind HSL_M_v_change():

The HSL_M_v_change() function is used to change MaxVel on the fly. In a normal motion operation, the axis starts at StrVel speed, accelerates to MaxVel, and then maintains MaxVel until it enters the deceleration region. If MaxVel is change during this time, it will force the axis to accelerate or decelerate to a new MaxVel in the time period defined by the user. Both Trapezoidal and S-curve profiles are applicable. The speed changes at a constant acceleration for a Trapezoidal and constant jerk for a S-curve profile.

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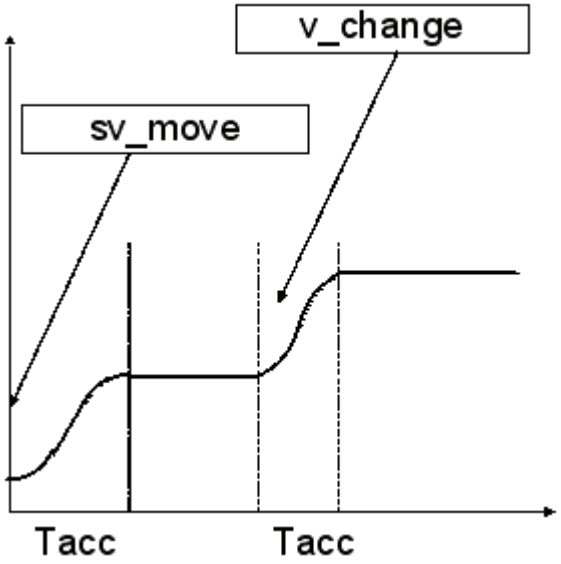


Figure 4-32: HSL_M_v_change() Theory

Constraints of HSL_M_v_change()

In a single axis preset mode, there must be enough remaining pulses to reach the new velocity, else the HSL_M_v_change() will return an error and the velocity remains unchanged.

Example:

A trapezoidal relative motion is applied:

```
HSL_M_start_tr_move(0,10000,0,1000,0.1,0.1).
```

It cause axis 0 to move for 10000 pulses, and the maximum velocity is 1000 PPS.

At 5000 pulses, HSL_M_v_change(0,NewVel,Tacc) is applied

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.

NewVel (PPS)	Tacc (Sec)	Necessary remaining pulses			OK / Error
		Acceleration	Deceleration	Total	
5000	0.1	300	313	613	OK
5000	1	3000	3125	6125	Error
10000	0.1	550	556	1106	OK
50000	0.1	2550	2551	5101	Error

Table 4-6: HSL_M_v_change() Example

1. To set the maximum velocity, the function HSL_M_fix_speed_range() must be used in order for the function HSL_M_v_change() to work correctly. If HSL_M_fix_speed_range() is not applied, MaxVel set by HSL_M_v_move() or HSL_M_start_ta_move() automatically becomes the maximum velocity, where HSL_M_v_change() can not be exceeded.

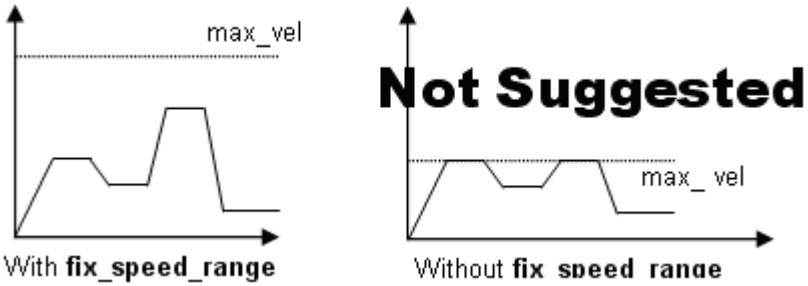


Figure 4-33: Velocity Suggestions A

2. During the acceleration or deceleration period, using HSL_M_v_change() is not suggested, although it does work in most cases, the acceleration and deceleration time is not guaranteed.

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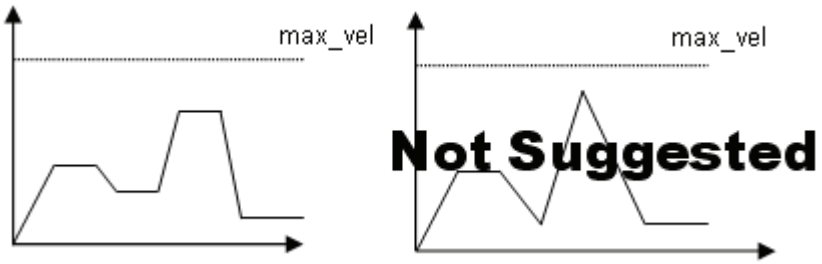


Figure 4-34: Velocity Suggestions B

Example:

There are 3 speed change sensors during an absolute move for 200000 pulses. Initial maximum speed is 10000pps. Change to 25000pps if Sensor 1 is touched. Change to 50000pps if Sensor 2 is touched. Change to 100000pps if Sensor 3 is touched. Then the code for this application and the resulting velocity profiles are shown below.

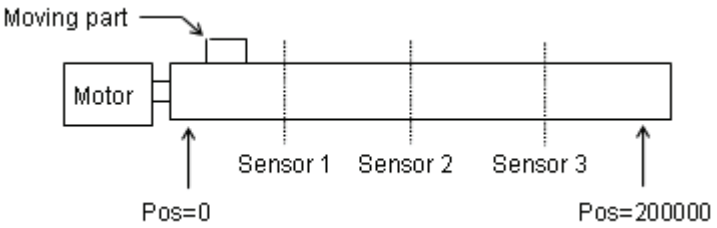


Figure 4-35: Velocity Example

```
#include "pci_HSL-4XMO.h"
HSL_M_fix_speed_range(axis, 100000.0);
HSL_M_start_ta_move(axis, 200000.0, 1000, 10000,
     0.02,0.01);
while(!HSL_M_motion_done(axis))
   {
     // Get sensor's information from another I/O
     card
```

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```
        if((Sensor1==High)   &&   (Sensor2==Low)   &&
        (Sensor3 == Low))
             HSL_M_v_change(axis, 25000, 0.02);
        else if((Sensor1==Low) && (Sensor2==High) &&
        (Sensor3 == Low))
             HSL_M_v_change(axis, 50000, 0.02);
        else if((Sensor1==Low) && (Sensor2==Low) &&
        (Sensor3 == High))
             HSL_M_v_change(axis, 100000, 0.02);
}
```

The information of the three sensors is acquired from another I/O card, and the resulting velocity profile from experiment is shown below:

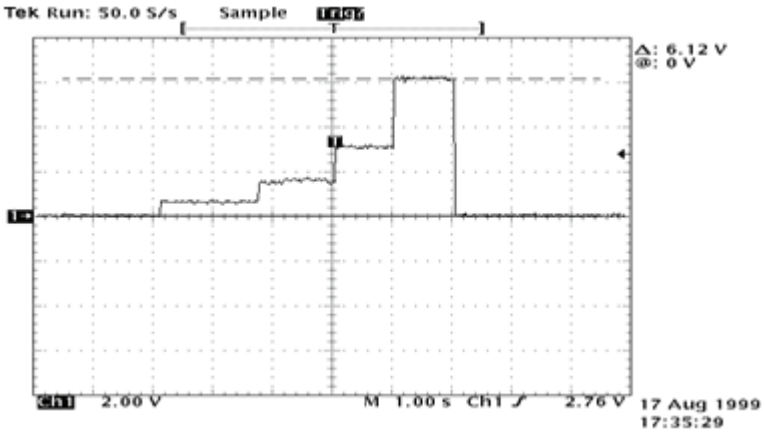


Figure 4-36: Velocity Profile Example

- Relative Functions:

```
HSL_M_v_change()
HSL_M_sd_stop()
HSL_M_emg_stop()
HSL_M_fix_speed_range()
HSL_M_unfix_speed_range()
HSL_M_get_currebt_speed()
```

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Change Position on the Fly

When operating in single-axis absolute pre-set motion, it is possible to change the target position during moving by using the function HSL_M_p_change().

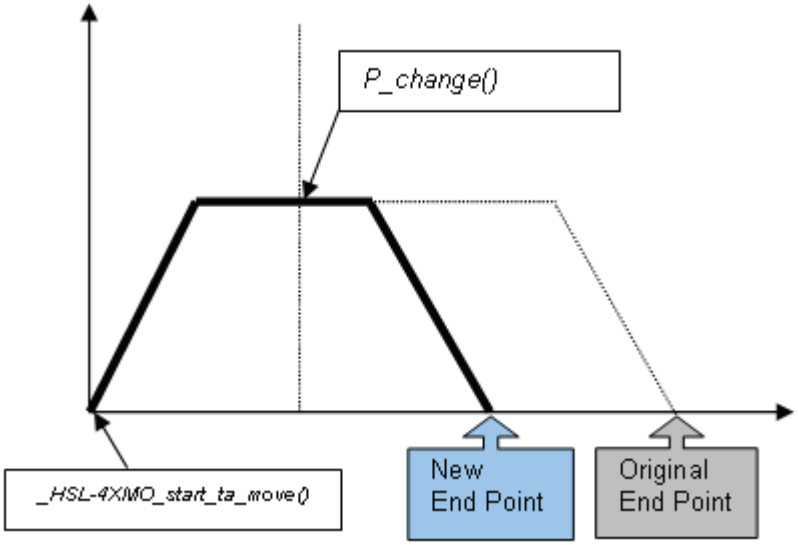


Figure 4-37: Change Position on the Fly

Theory of HSL_M_p_change():

The HSL_M_p_change() is applicable to the HSL_M_start_ta_move(), and HSL_M_start_sa_move() functions only. It is used to change the target position, defined originally by these two functions. After changing position, the axis will move to the new target position and totally disregard the original position. If the new position is in the passed path, it will cause the axis to decelerate and eventually stop, then reverse, as shown in the chart. The acceleration and deceleration rate, and StrVel and MaxVel are kept the same as the original setting.

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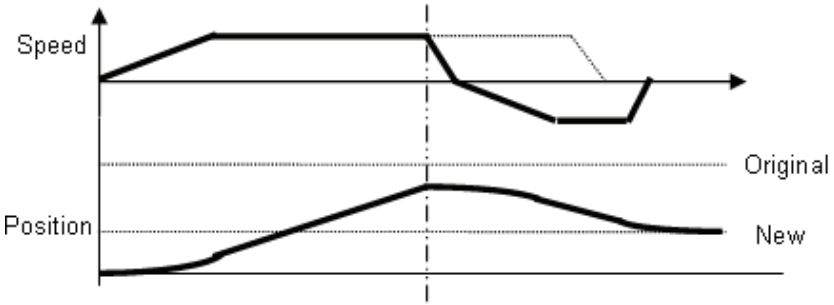


Figure 4-38: Theory of HSL_M_p_change()

HSL_M_p_change() Constraints:

1. HSL_M_p_change() is only applicable on single-axis absolute pre-set motion, i.e., HSL_M_start_ta_move(), and HSL_M_start_sa_move() only.
2. Position change during the deceleration period is not allowed.
3. There must be enough distance between the new target position and current position where HSL_M_p_change() is executed because the HSL-4XMO needs enough space to finish deceleration.

Example:

A trapezoidal absolute motion is applied:

```
HSL_M_start_ta_move(0,10000,0,1000,0.5,1).
```

It cause axis 0 to move to pulse 10000 position with a maximum velocity of 1000 PPS. The necessary number of pulses to decelerate is 0.5*1000*1 = 500.

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At position “CurrentPos,” HSL_M_p_change(0, NewPos) is applied.

NewPos	CurrentPos	OK / Error	Note
5000	4000	OK	
5000	4501	Error	
5000	5000	Error	
5000	5499	Error	
5000	6000	OK	Go back
5000	9499	OK	Go back
5000	9500	Error	
5000	9999	Error	

Table 4-7: HSL_M_p_change() Constraints

- Relative Function:

```
HSL_M_p_change()
```

4.12 Position Compare

The HSL-4XMO provides position comparison functions for all axes. The comparison function is used to output a trigger pulse when the counter reaches a preset value set by the user. CMP1~CMP4 are used as a comparison trigger.

Comparators of the HSL-4XMO

There are 5 comparators for each axis of the HSL-4XMO. Each comparator has its unique functionality. Below is a table for comparison:

	Compare Source	Description	Function Related
Comparator 1	Command position counter	Soft Limit (+) (Refer to section 4.9)	HSL_M_set_softlimit HSL_M_enable_softlimit HSL_M_diable_softlimit
Comparator 2	Command position counter	Soft Limit (-) (Refer to section 4.9)	
Comparator 3	Position error counter	Step-losing detection	HSL_M_error_counter_check

Table 4-8: HSL-4XMO Comparators

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Comparator 4	Any counters	General-purpose	HSL_M_set_general_comparator
Comparator 5 (Only Axes 0 & 1)	Feedback position counter	Position compare function (Trigger)	HSL_M_set_trigger_comparator HSL_M_build_compare_function HSL_M_build_compare_table HSL_M_set_auto_compare

Table 4-8: HSL-4XMO Comparators

Note: Only comparator 5 has the ability to trigger an output pulse via the CMP.

Comparators 1 and 2 are used for soft limits. Refer to section 4.9. Comparator 3 is used to compare with the position error counter. It is useful for detecting if a stepping motor has lost any pulses. To enable/disable the step-losing detection, or set the allowable tolerance use HSL_M_set_error_counter_check()

Comparator 4 is a general purpose comparator. The comparing source counter can be any counter. The compared value, source counter, comparing method, and reaction are set by the function HSL_M_set_general_comparator().

Position Compare

The 5th comparator, whose comparing source is the feedback position counter, performs the position compare function. Only the first 2 axes (0 and 1) can do a position comparison. The position comparison function triggers a pulse output via the CMP, when the comparing condition comes into existence.

The comparing condition consists of 2 parts, the first is the value to be compared, and the second is the comparing mode. Comparing mode can be “>“, “=“ or “<“. The easiest way to use the position comparison function is to call the function:

```
HSL_M_set_trigger_comparator (AxisNo, CmpSrc,
    Method, Data)
```

The second parameter, “Method,” indicates the comparing method, while the third parameter, “Data,” is for the value to be compared. In continuous comparison, this data will be ignored automatically since the compare data is built by other functions.

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Continuously Comparison with Trigger Output

To compare multiple data continuously, functions for building comparison tables are provided and are shown below:

```
HSL_M_build_comp_function(AxisNo,   Start,   End,
     Interval)
HSL_M_build_comp_table(AxisNo, tableArray, Size)
HSL_M_set_auto_compare(AxisNo, SelectSource)
```

The first function builds a comparison list using start and end points and constant intervals. The second function builds on an arbitrary comparison table (data array). The third function is a source comparing selection function. Users can check current values used for comparison using the function HSL_M_check_compare_data():

Example:

Using the continuous position comparison function.

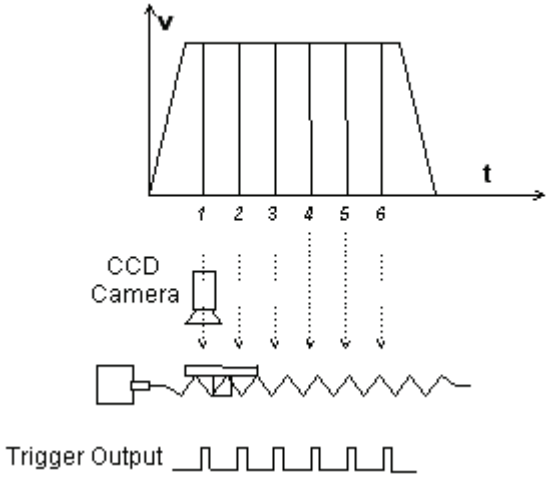


Figure 4-39: Continuously Comparison with Trigger Output

In this application, the table is controlled by the motion command, and the CCD Camera is controlled by the position comparison out-

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put of the HSL-4XMO. An image of the moving object is easily obtained.

- Working Spec: 34000 triggering points per stroke, trigger speed is 6000 pts/sec)
- Program Settings:
  - Table starts moving from 0 to 36000
  - Compare points are on 1001 35000, total 34000 pts, points to points interval=1pulse
  - Moving Speed is 6000 pps
  - Compare condition is “=“
- Program codes:

```
HSL_M_set_trigger_comparator(0, 1, 1, 1001);
HSL_M_build_compare_function(0, 1001, 35000, 1,
     1);
HSL_M_set_auto_compare(0, 1);
HSL_M_start_tr_move(0, 36000, 0, 6000, 0.01,
     0.01);
```

- Monitoring or Check the current compare data:

```
HSL_M_check_compare_data(0, 5, *CurrentData);
```

Users can use this function to check if auto-trigger is running.

The “Value” block in this figure is the position where the comparison occurs, and where the data can be checked by using HSL_M_check_compare_data().

Note that at the final compared point will still load an “After-final” point into the “Value” block. Fill a dummy point into the comparison table array at the final position. This value must be far enough from the table’s stroke.

If using _build_compare_function(), a dummy “after-final” point is automatically loaded. This value is equal to (End point + Interval x Total counts) x moving ratio.

- Relative Functions:

```
HSL_M_set_trigger_comparator(),
HSL_M_build_comp_function()
HSL_M_build_comp_table()
HSL_M_set_auto_compare()
HSL_M_check_compare_data()
```

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```
HSL_M_set_trigger_type ()
```

4.13 Backlash Compensator and Vibration Suppression

Whenever direction change has occurred, the HSL-4XMO outputs a backlash corrective pulse before sending the next command. The function HSL_M_backlash_comp() is used to set the pulse number.

In order to minimize vibration when a motor stops, the HSL-4XMO can output a single pulse for a negative direction and then single pulse for a positive direction right after completion of a command movement. Refer to the timing chart below, the HSL_M_suppress_vibration() function is used to set T1 & T2.

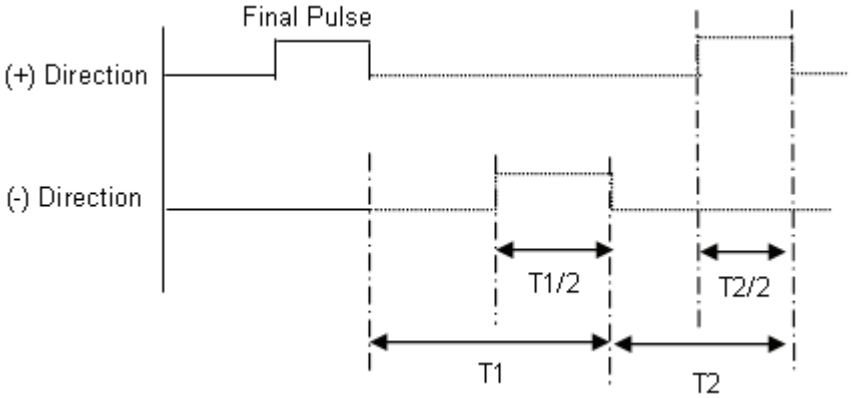


Figure 4-40: Vibration Suppression

- Relative Functions:

```
HSL_M_backlash_comp()
HSL_M_suppress_vibration()
```

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4.14 Software Limit Function

The HSL-4XMO provides 2 software limits for each axis. The soft limit is extremely useful in protecting a mechanical system as it works like a physical limit switch when correctly set.

The soft limits are built on comparators 1 and 2 (Refer to section 4.7), and the comparing source is the command position counter.

A preset limit value is set in comparators 1 and 2, then, when the command position counter reaches the set limit value, the HSL-4XMO reacts by generating the stop immediately or decelerates to stop pulse output.

- To set the soft limit: HSL_M_set_softlimit();
- To enable soft limit: HSL_M_enable_softlimit();
- To disable soft limit: HSL_M_diable_softlimit();

Note: The soft limit is only applied to the command position and not the feedback position (Refer to 4.4). In cases where the moving ratio is not equal to "1," it is necessary to manually calculate its corresponding command position where the soft limit would be, when using HSL_M_set_softlimit().

- Relative Functions:

```
HSL_M_set_softlimit()
HSL_M_enable_softlimit()
HSL_M_diable_softlimit()
```

4.15 Point Table Management

For rapid and multiple point-to-point motion application, it would take much more time to do communucation between host PC and HSL-4XMO module. Consequently, we design a series of functions for users to build definite points inside the modules, named "Point Table". Therefore, users can assign a point number of the table to save transmission time in order to get a better response.

Before using this feature, users must know and plan the points of their applications, download the point table into the module and call them at any time. It will send out the pulse train to let the motor run to the assigned position in a shortest time with the predefined speed profile and acceleration parameters.

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4.16 Motion Script Download

For time-critical applications or specific motion sequences, users can pre-define a motion squence with simple script file. HSL-4XMO will interpret the motion script command line-by-line and realize the motion sequence as what users want.

This feature is much more useful because the module plays as a standalone system and execute the motion commands by itself. Windows context switching would not interrupt the module. Consequently, it has a better timing performance than non-standalone system.

The motion script supports standard “G” code, and many traditional users are familiar with it. Users can use any text editor program to define their motion sequence and download it into the HSL-4XMO. At any moment, you may want to execute it by issuing a run command or run it cyclically by a repeat command.

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5 Motion Creator in LinkMaster

After installing the hardware (Chapters 2 and 3), it is necessary to correctly configure all modules and double check the system before running. This chapter gives the guidelines for establishing a control system and manually testing the HSL-4XMO module to verify correct operation. The Motion Creator software provides a simple and powerful way to setup, configure, test, and debug a motion control system that uses HSL-4XMO module.

Note: Motion Creator is only available for Windows OS with a screen resolution higher than 800x600.

5.1 Execute Motion Creator in LinkMaster

After installing the software drivers for the HSL-4XMO in Windows, the motion creator program can be located at <chosen path >\LinkMaster. To execute the program, double click on the executable file or use Start->Program Files->HSL->LinkMaster.

5.2 About Motion Creator in LinkMaster

Before Running Motion Creator, the following issues should be kept in mind.

1. Motion Creator is available only for Windows system with a screen resolution higher than 800x600. It cannot be run under DOS.
2. Motion Creator allows users to save settings and configurations for HSL-4XMO modules. Saved configurations will be automatically loaded the next time Motion Creator is executed. Two files, HSL-4XMO.ini and HSL-4XMOMC.ini, in the windows root directory are used to save all settings and configurations.
3. To duplicate configurations from one system to another, copy HSL-4XMO.ini and HSL-4XMOMC.ini into the windows root directory.
4. If multiple HSL-4XMO modules use the same Motion Creator saved configuration files, the DLL function call HSL_M_config_from_file() can be invoked within a user

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developed program. This function is available in a DOS environment as well.

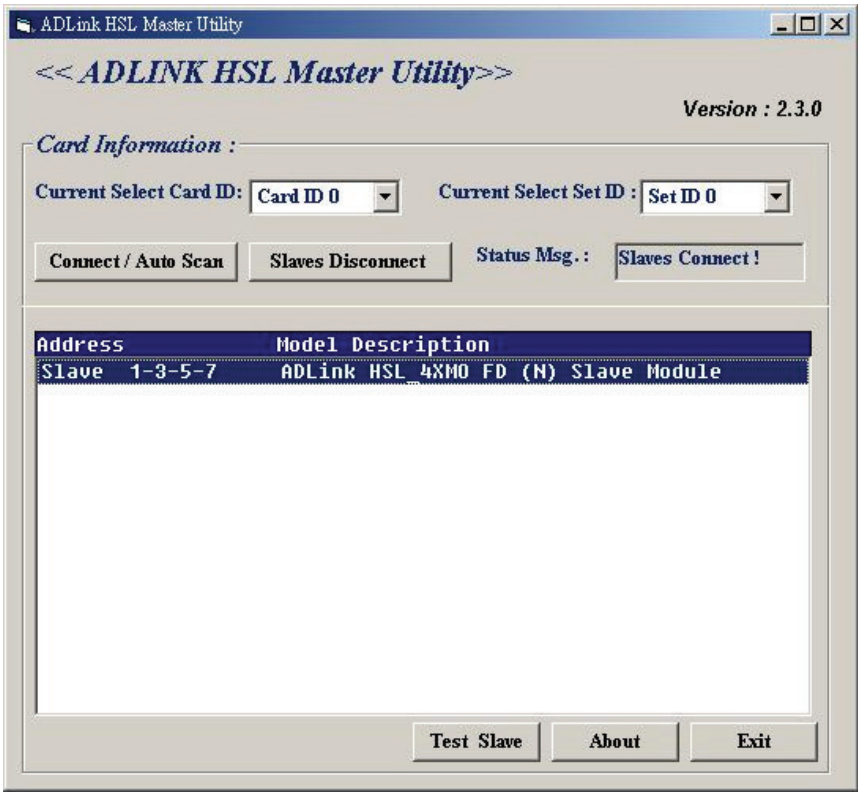


Figure 5-1: HSL Master Utility

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5.3 Motion Creator Form Introducing

Main Menu

The main menu appears after running Motion Creator. It is used to:

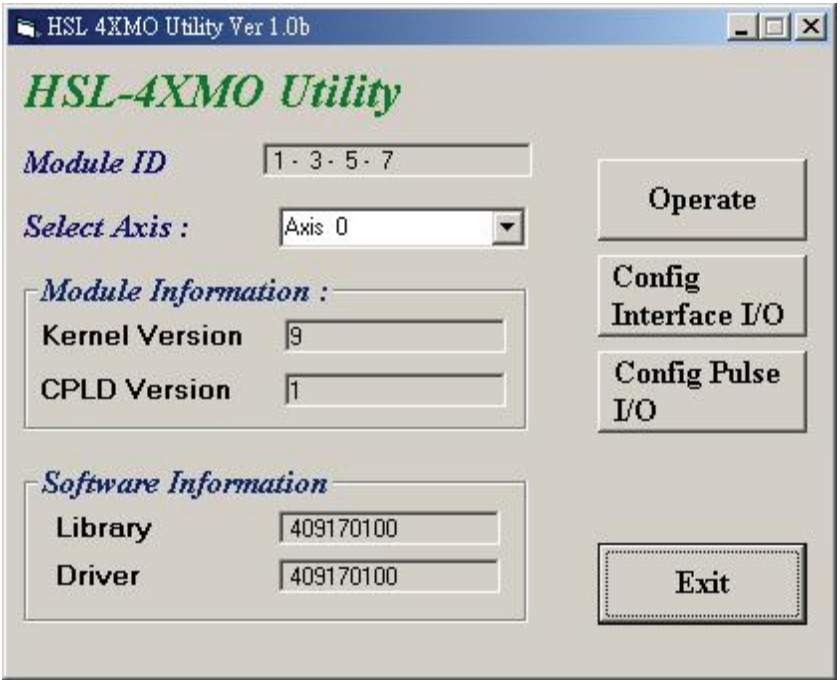


Figure 5-2: Main Menu

- Select Axis
- Go to Operate menus
- Go to Interface I/O configuration menus
- Go to Config Pulse I/O menus
- Show Module information
- Show Software information
- Exit Motion Creator

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Interface I/O Configuration Menu

In this menu, users can configure EL, ORG, EZ, ERC, ALM, INP, SD, and LTC.

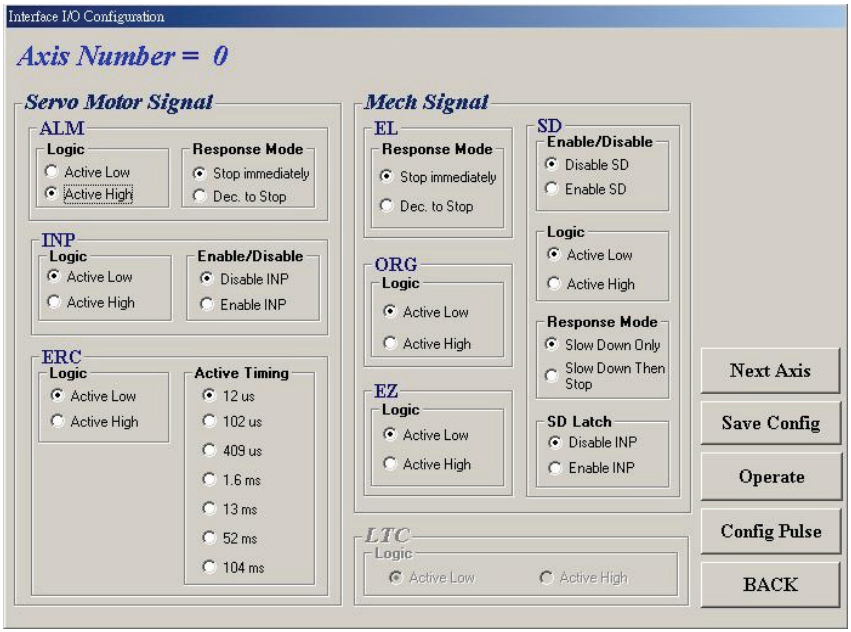


Figure 5-3: Interface I/O Configuration Menu

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ALM Logic and Response mode: Select logic and response modes of ALM signal. The related function call is HSL_M_set_alm().

1. INP Logic and Enable/Disable selection: Select logic, and Enable/ Disable the INP signal. The related function call is HSL_M_set_inp()
2. ERC Logic and Active timing: Select the Logic and Active timing of the ERC signal. The related function call is HSL_M_set_erc().
3. EL Response mode: Select the response mode of the EL signal. The related function call is HSL_M_set_el().
4. ORG Logic: Select the logic of the ORG signal. The related function call is HSL_M_set_home_config().
5. EZ Logic: Select the logic of the EZ signal. The related function call is HSL_M_set_home_config().
6. SD Configuration: Configure the SD signal. The related function call is HSL_M_set_sd().
7. LTC Logic: Select the logic of the LTC signal. The related function call is HSL_M_set_ltc_logic().
8. Buttons:

- Next Axis: Change operating axis.
- Save Config: Save current configuration to HSL-4XMO.ini.
- Operate: Go to the operation menu, refer to section 5.3.4
- Config Pulse : Go to the Pulse IO Configuration menu, refer to section 5.3.3
- Back: Return to the main menu.

Pulse IO Configuration Menu

In this menu, users can configure pulse input/output and move ratio and INT factor.

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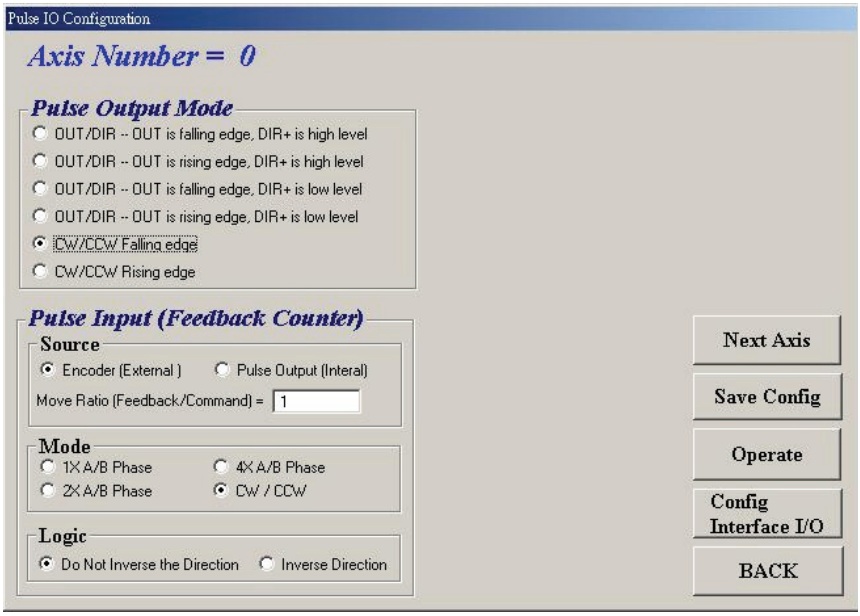


Figure 5-4: Pulse IO Configuration Menu

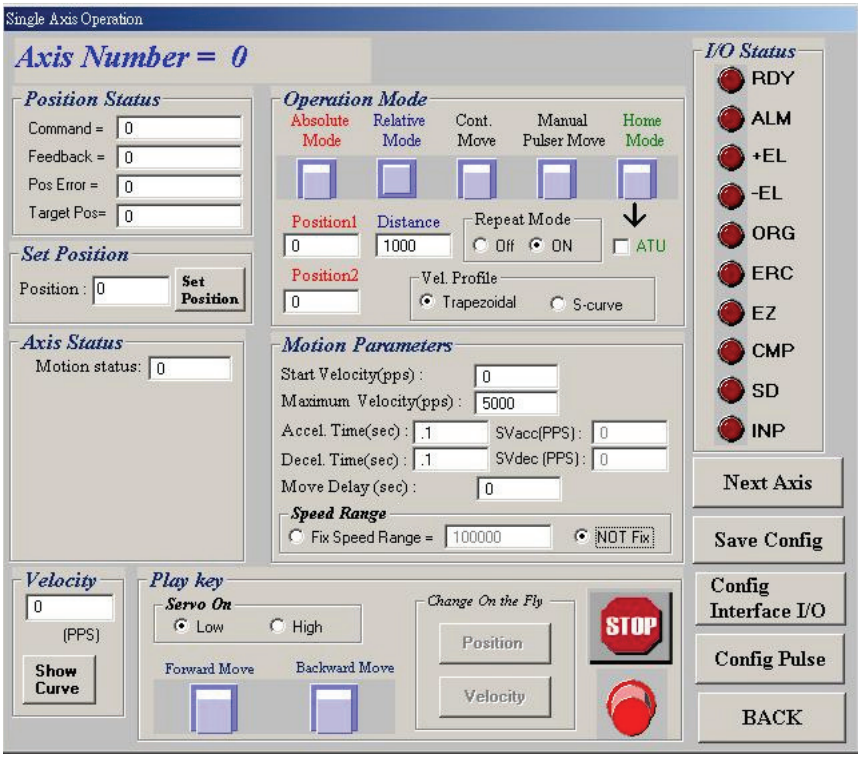
1. Pulse Output Mode: Select the output mode of the pulse signal (OUT/ DIR). The related function call is HSL_M_set_pls_outmode().
2. Pulse Input: Sets the configurations of the Pulse input signal(EA/EB). The related function calls are HSL_M_set_pls_iptmode(), HSL_M_set_feedback_src().
3. Buttons:

- ▶ Next Axis: Change operating axis.
- ▶ Save Config: Save current configuration to HSL-4XMO.ini.
- ▶ Operate: Go to the operation menu, refer to section 5.3.4
- ▶ Config Pulse: Go to the Pulse IO Configuration menu, refer to section 5.3.3
- ▶ Back: Return to the main menu.

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Operation Menu

In this menu, users can change the settings a selected axis, including velocity mode motion, preset relative/absolute motion, manual pulse move, and home return.



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Figure 5-5: Operation Menu

1. Position:

- Command: displays the value of the command counter. The related function is HSL_M_get_command().
- Feedback: displays the value of the feedback position counter. The related function is HSL_M_get_position()
- Pos Error: displays the value of the position error counter. The related function is HSL_M_get_error_counter().
- Target Pos: displays the value of the target position recorder. The related function is HSL_M_get_target_pos().

2. Position Reset: clicking this button will set all positioning counters to a specified value. The related functions are:

```
HSL_M_set_position()
HSL_M_set_command()
HSL_M_reset_error_counter()
HSL_M_reset_target_pos()
```

3. Motion Status: Displays the returned value of the HSL_M_motion_done function. The related function is HSL_M_motion_done().
4. Velocity: The absolute value of velocity in units of PPS. The related function is HSL_M_get_current_speed().
5. Show Velocity Curve Button: Clicking this button will open a window showing a velocity vs. time curve. In this curve, every 100ms, a new velocity data point will be added. To close it, click the same button again. To clear data, click on the curve.

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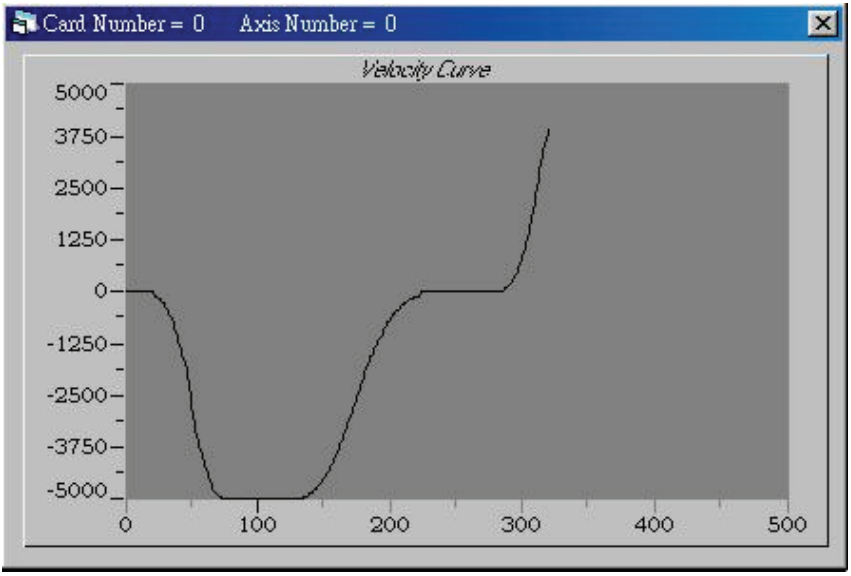


Figure 5-6: Show Velocity Curve

6. Operation Mode: Select operation mode.

- Absolute Mode: “Position1” and “position2” will be used as absolution target positions for motion. The related functions are HSL_M_start_ta_move(), HSL_M_start_sa_move().
- Relative Mode: “Distance” will be used as relative displacement for motion. The related function is HSL_M_start_tr_move(), HSL_M_start_sr_move().
- Cont. Move: Velocity motion mode. The related function is HSL_M_tv_move(), HSL_M_start_sv_move().
- Home Mode: Home return motion. Clicking this button will invoke the home move configuration window. The related function is HSL_M_set_home_config().If the check box “ATU” is checked, it will execute auto homing when motion starts.

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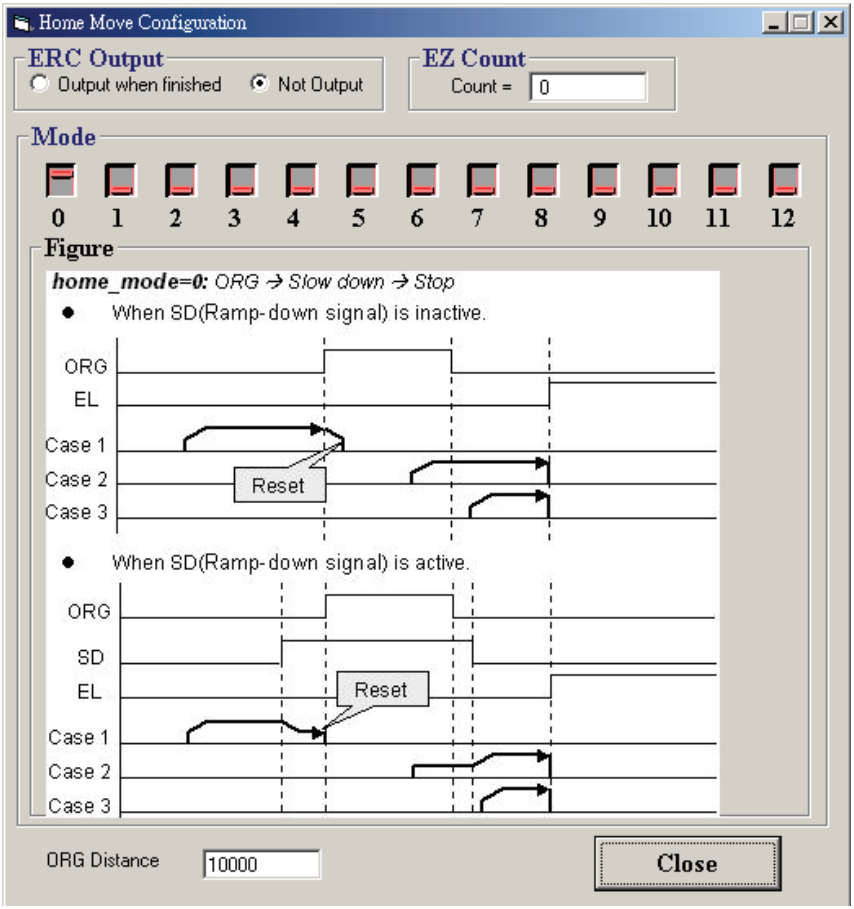


Figure 5-7: Home Mode Configuration

- ERC Output: Select if the ERC signal will be sent when home move completes.
- EZ Count: Set the EZ count number, which is effective on certain home return modes.
- Mode: Select the home return mode. There are 13 modes available.
- Home Mode figure: The figure shown explains the actions of the individual home modes.

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- Close: Click this button close this window.
- ORG Distance: The length during ORG is ON

7. Position: Set the absolute position for “Absolute Mode.” It is only effective when “Absolute Mode” is selected.
8. Distance: Set the relative distance for “Relative Mode.” It is only effective when “Relative Mode” is selected.
9. Repeat Mode: When “On” is selected, the motion will become repeat mode (forward<->backward or position1<->position2). It is only effective when “Relative Mode” or “Absolute Mode” is selected.
10. Vel. Profile: Select the velocity profile. Both Trapezoidal and S-Curve are available for “Absolute Mode,” “Relative Mode,” and “Cont. Move.”
11. Motion Parameters: Set the parameters for single axis motion.

- Start Velocity: Set the start velocity of motion in units of PPS. In “Absolute Mode” or “Relative Mode,” only the value is effective. For example, -100.0 is the same as 100.0. In “Cont. Move,” both the value and sign are effective. –100.0 means 100.0 in the minus direction.
- Maximum Velocity: Set the maximum velocity of motion in units of PPS. In “Absolute Mode” or “Relative Mode,” only the value is effective. For example, -5000.0 is the same as 5000.0. In “Cont. Move,” both the value and sing is effective. –5000.0 means 5000.0 in the minus direction.
- Accel. Time: Set the acceleration time in units of second.
- Decel. Time: Set the deceleration time in units of second.
- SVacc: Set the S-curve range during acceleration in units of PPS.
- SVdec: Set the S-curve range during deceleration in unit sof PPS.
- Move Delay: This setting is effective only when repeat mode is set “On.” It will cause the HSL-4XMO to delay for a specified time before it continues to the next motion.

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12. Speed Range: Set the max speed of motion. If “Not Fix” is selected, the “Maximum Speed” will automatically become the maximum speed range, which can not be exceeded by on-the-fly velocity change.

13. Servo On: Set the SVON signal output status. The related function is HSL_M_set_servo().

14. Play Keys

- Left play button: Clicking this button will cause the HSL-4XMO start to outlet pulses according to previous setting.
  - In “Absolute Mode,” it causes the axis to move to position1.
  - In “Relative Mode,” it causes the axis to move forward.
  - In “Cont. Move,” it causes the axis to start to move according to the velocity setting.
- Right play button: Clicking this button will cause the HSL-4XMO start to outlet pulses according to previous setting.
  - In “Absolute Mode,” it causes the axis to move to position.
  - In “Relative Mode,” it causes the axis to move backwards.
  - In “Cont. Move,” it causes the axis to start to move according to the velocity setting, but in the opposite direction.

15. Change Position On The Fly Button: When this button is enabled, users can change the target position of the current motion. The new position must be defined in “Position2.” The related function is HSL_M_p_change().

16. Change Velocity On The Fly Button: When this button is enabled, users can change the velocity of the current motion. The new velocity must be defined in “Maximum Velocity.” The related function is HSL_M_v_change()

17. Stop Button: Clicking this button will cause the HSL-4XMO to decelerate and stop. The deceleration time is

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defined in “Decel. Time.” The related function is HSL_M_sd_stop().

18. I/O Status: The status of motion I/O. Light-On means Active, while Light-Off indicates inactive. The related function is HSL_M_get_io_status().

19. Buttons:

- Next Axis: Change operating axis.
- Save Config: Save current configuration to HSL-4XMO.ini.
- Config Pulse: Go to the Pulse IO Configuration menu, refer to section 5.3
- Config Interface I/O: Go to the Interface I/O Configuration menu, refer to section 5.3
- Back: Return to the main menu.

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6 Appendix

6.1 HSL-4XMO Commmand Executuion Time

The testing is conducted at 6MHz baud rate and full-deplux mode. We list the execution time depending on the command delivering counts.

The time is measured with one, four, and eight modules respectively. The time unit is mini-second. We have the classification as follows.

Command Type	Contents	Note
1	Send simple command	None
2	Send U16 command	None
3	Send U32 command	None
4	Get U16 command	None
5	Get U32 command	None
6	One-axis motion	6 Delivering Times
7	Two-axis motion	7 Delivering Times
8	Short-term motion	2 Delivering Times

Table 6-1: Commmand Executuion Classifications

The time is averaged with one thousand testing. The result is as follows.

Command Type	Time (ms)			Example
	One module (ID: 1, 3, 5, 7)	Four modules (ID: 1-16)	Eight modules (ID: 1-32)	
1	0.413	0.500	1.000	HSL_M_set_pls_outmode
2	0.429	0.501	1.000	HSL_M_set_home_config
3	0.453	0.501	1.000	HSL_M_set_position
4	0.497	0.505	1.000	HSL_M_get_io_status
5	0.500	0.509	1.000	HSL_M_get_position
6	2.588	3.023	6.000	HSL_M_start_tr_move
7	3.026	3.500	7.000	HSL_M_start_tr_move_xy
8	0.850	1.012	2.000	HSL_M_move_t_distance

Table 6-2: HSL-4XMO Commmand Executuion Times

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Notes: The cycle time is equal to maximum slave number *30.1 us.

Theoretical command time is recommend as follows:

- ▷ If the module is smaller than 4, the time is roughly 0.5 ms.
- ▷ If the quantity of the modules is odd, the time is about

  `0.5 + (Num +1- 4)/2 * 0.24 ms.`
- ▷ If the quantity of the modules is even, the time is about

  `0.5 + (Num - 4)/2 * 0.24 ms.`

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Warranty Policy

Thank you for choosing ADLINK. To understand your rights and enjoy all the after-sales services we offer, please read the following carefully.

1. Before using ADLINK's products please read the user manual and follow the instructions exactly. When sending in damaged products for repair, please attach an RMA application form which can be downloaded from: http://rma.adlinktech.com/policy/.
2. All ADLINK products come with a limited two-year warranty, one year for products bought in China:
   - The warranty period starts on the day the product is shipped from ADLINK's factory.
   - Peripherals and third-party products not manufactured by ADLINK will be covered by the original manufacturers' warranty.
   - For products containing storage devices (hard drives, flash cards, etc.), please back up your data before sending them for repair. ADLINK is not responsible for any loss of data.
   - Please ensure the use of properly licensed software with our systems. ADLINK does not condone the use of pirated software and will not service systems using such software. ADLINK will not be held legally responsible for products shipped with unlicensed software installed by the user.
   - For general repairs, please do not include peripheral accessories. If peripherals need to be included, be certain to specify which items you sent on the RMA Request & Confirmation Form. ADLINK is not responsible for items not listed on the RMA Request & Confirmation Form.

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3. Our repair service is not covered by ADLINK's guarantee in the following situations:
   - Damage caused by not following instructions in the User's Manual.
   - Damage caused by carelessness on the user's part during product transportation.
   - Damage caused by fire, earthquakes, floods, lightening, pollution, other acts of God, and/or incorrect usage of voltage transformers.
   - Damage caused by unsuitable storage environments (i.e. high temperatures, high humidity, or volatile chemicals).
   - Damage caused by leakage of battery fluid during or after change of batteries by customer/user.
   - Damage from improper repair by unauthorized ADLINK technicians.
   - Products with altered and/or damaged serial numbers are not entitled to our service.
   - This warranty is not transferable or extendible.
   - Other categories not protected under our warranty.
4. Customers are responsible for shipping costs to transport damaged products to our company or sales office.
5. To ensure the speed and quality of product repair, please download an RMA application form from our company website: http://rma.adlinktech.com/policy. Damaged products with attached RMA forms receive priority.

If you have any further questions, please email our FAE staff: service@adlinktech.com.

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