SPiiPLUS Motion Controller

SPiiPlus SAR and SAR-LT

Stand-Alone Controllers

Hardware Guide

Version 6.60

SPiiPlus SAR Motion Controller

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Changes in Version 6.60

Page	Change
60 - 61	Corrected figure titles.

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1 About this Guide

This guide provides detailed hardware information concerning the SPiiPlus SAR motion controllers including:

- How to install the SPiiPlus SAR
- How to connect the electrical interface with the system (drives, feedback, I/O, etc.)

For a setup procedure of the SPiiPlus SAR, refer to the SPiiPlus Setup Guide. It includes:

- How to establish communication
- How to configure the drive, motor, feedback for an axis
- How to adjust (tune) the parameters of an axis

1.1 Related SPiiPlus Tools

Table 1 Related SPiiPlus Tools

Tool	Description
SPiiPlus MMI	A multipurpose user interface with the controller including: Program management, Motion management, Communication terminal, Four channel digital oscilloscope, Safety and I/O signals monitor, Signal tuning and adjustment, and a fully interactive simulator. Program and SPii debugging tools and FRF are also included.
SPiiPlus Utilities	The SPiiPlus Upgrader allows upgrading or downgrading of the controller firmware. The SPiiPlus Emergency Wizard allows firmware recovery in case of damage or loss of communication to the controller.
SPiiPlus C Library	A DLL (Dynamic Link Library) that supports host application programming in a variety of languages including C/C++. The library introduces a new level of application support with a built-in controller simulator and it also provides outstanding debugging capabilities. All tools are provided with a full simulator of the controller.
SPiiPlus COM Library	A DLL (Dynamic Link Library) that supports host application programming in a variety of languages including Visual Basic, LabView, and more. The library introduces a new level of application support with a built-in controller simulator and it also provides outstanding debugging capabilities. All tools are provided with a full simulator of the controller.

1.2 SPiiPlus Documentation

Table 2 Related Documents

Document	Description
HSSI Modules Hardware Guide	High-Speed Synchronous Serial Interface (HSSI) for expanded I/O, distributed axes, and nonstandard devices.
SPiiPlus Setup Guide	Communication, configuration and adjustment procedures for SPiiPlus motion control products.
SPiiPlus ACSPL+ Programmer's Guide	Command set and high level language for programming SPiiPlus controllers.
SPiiPlus Command and Variable Reference Guide	Commands and variables of high level language for programming SPiiPlus controllers.
SPiiPlus Utilities User's Guide	Firmware upgrade and recovery procedures.
SPiiPlus C Library Reference	C++ and Visual Basic® libraries for host PC applications. This guide is applicable for all the SPiiPlus motion control products
SPiiPlus COM Library Reference Guide	COM Methods, Properties, and Events for Communication with the Controller
SPiiPlus FRF Analyzer User's Guide	The SPiiPlus FRF (Frequency Response Function) Analyzer™ is a powerful servo analysis GUI for ACS-Tech80 SPiiPlus motion controllers.
SPiiPlus Modbus Setup Guide	Describes Modbus setup and register address.
SPiiPlus Getting Started Guide	Describes the basic elements of using the SPiiPlus MMI.
SPiiPlus Low Level Host Communication Guide	Describes the host protocol.

1.3 Conventions Used in this Guide

1.3.1 Text Conventions

Several text formats and fonts, illustrated in **Table 3** and the samples below, are used in the text to convey information about the text.

Table 3 Text Conventions

Text	Description
BOLD CAPS	ACSPL+ elements (commands, functions, operators, standard variables, etc.) when mentioned in the text. Software tool menus, menu items, dialog box names and dialog box elements.
bold	Emphasis or an introduction to a key concept.
`Monospace`	Code examples.
`Italic monospace`	Information in code examples that the user provides.
ALL CAPS	(Keyboard) key names [example: SHIFT key].
Bold Blue	Links within this document, to web pages, and to e-mail addresses.
|	Used in command syntax to indicate input of one alternative *or* another.
→	Used in GUI descriptions to indicate nested menu items and dialog box options leading to a final action. For example, the sequence: **Debug → New Watch → Real-time** directs the user to open the Debug menu, choose the New Watch command, and select the Real-time option.

1.3.2 Flagged Text

The following symbols are used to flag text in this document:

Note	
	*Notes include helpful information or tips.*

Caution	
	***A Caution describes a condition that may result in damage to equipment.***

Warning 	***A Warning describes a condition that may result in serious bodily injury or death.***

Advanced 	*Indicates a topic for advanced users.*

Model 	*Highlights a specification, procedure, condition, or statement that depends on the product model.*

2 Introduction and Ordering Options

Figure 1 SPiiPlus SAR Motion Controller

2.1 About SPiiPlus SAR

SPiiPlus SAR is a line of advanced standalone multi-axis motion controllers. The SPiiPlus SAR line meets the motion control requirements of the most demanding applications such as semiconductors manufacturing, wafers inspection and Flat Panel Display assembly and testing.

SPiiPlus SAR - The SPiiPlus SAR meets the motion control requirements of the utmost demanding applications such as semiconductors manufacturing, wafers inspecting and Flat Panel Display assembly and testing. The controller is available for four, six and eight axis versions.

SPiiPlus SAR-LT - The SPiiPlus SAR-LT is an advanced stand-alone, multi-axis motion controller. The controller is available for four, six and eight axis versions.

SPiiPlus SAR is the RoHS-compatible replacement for the SPiiPlus SA. SPiiPlus SAR is similar to SPiiPlus SA with the following exceptions:

- SPiiPlus SAR has only two HSSI ports whereas SPiiPlus SA has three.
- SPiiPlus SAR has two Ethernet ports whereas SPiiPlus SA has only one.
- SPiiPlus SAR supports Hall signals whereas SPiiPlus SA does not.
- SPiiPlus SAR has a CAN bus option whereas SPiiPlus SA does not.

2.2 SPiiPlus SAR Features

Each of the SPiiPlus SAR products uses the common D-Type connectors to connect to the drivers, encoders, I/Os and communication bus of the application. The SPiiPlus SAR supports high frequency Sin-Cos encoder signals of up to 2.5MHz to provide sub-nanometer resolution and high speed without compromising accuracy and throughput. As a member of the of the SPiiPlus family of motion controllers it is supported by the SPiiPlus comprehensive set of development and support tools. Each product of the SPiiPlus SAR line is tailored to a specific application as explained in this document. The product line includes:

The following table lists the main features unique to each SPiiPlus SAR product:

Table 4 SPiiPlus SAR Main Features

Product	Drive Interface	Feedback	HSSI Channels
SPiiPlus SAR	One command for torque or two for SW commutation	Digital encoder Sin-Cos encoder* Hall	Two
SPiiPlus SAR-LT	One torque command	Digital encoder	One

* The controller may come with four fast Sin-Cos encoder interfaces. For details, see **Chapter 3 - Specifications**.

All SPiiPlus stand-alone controllers have the following features:

Controller - The servo control algorithm executes at an uncompromising rate of 20kHz for each axis regardless of the number of axis, providing very large bandwidth, exceptional dynamic tracking, fast settling, and excellent smoothness at low velocities.

The controller is manufactured under ISO 9001 certified quality management system, meeting stringent safety and EMC standards and is CE marked.

Communication Channels - The Communication with the controller through all channels can be done simultaneously. The communication channels are as follows:

- Two RS-232 serial communication channels
- Two Ethernet 10/100 BaseT channel
- One CAN bus channel

Digital and Analog I/Os - The SPiiPlus SAR comes with digital and analog I/Os that can be used for general purpose. In addition, there are hardware-based position registration digital outputs (PEG) and hardware-based position capture (MARK) digital inputs.

ACSPL+ - Complex applications are easy to develop with ACSPL+, a powerful, compiled, true multitasking, high-level language that is optimized for motion control applications. Ten programs can run simultaneously, enabling multiple interacting and synchronized processes.

ACSPL+ enables implementation of highly complex motion-time-event sequences with accurate positioning and timing. The program can run directly on the controller or can be implemented in a host PC application using libraries provided for C, C++, and COM.

Suite of Tools - Powerful software tools are also provided for setup, tuning, and programming. Application development is particularly easy with the integrated four-channel soft scope and multi-axis motion simulator.

2.3 Axis Configuration Options

The SPiiPlus SAR and SAR-LT can control up to eight axes which can comprise the following:

Up to eight direct-connected servo drives for DC brush, DC brushless/AC servo motors.

Up to four direct-connected drives for step motors.

Up to four HSSI-Networked Drives for remote servo motors (DC brush, DC brushless commutation by drive/AC servo motors.)

Note	
	*See the SPiiPlus Setup Guide for how to assign an axis to a direct-connected servo/step drive of HSSI-networked servo drive.*

Table 5 lists the SPiiPlus SAR-4/6/8 axis assignment and configuration.

Table 6 lists the SPiiPlus SAR-LT-4/6/8 axis assignment and configuration.

Table 5 SPiiPlus SAR Axis Assignment and Configuration

Product	Motors	Direct Drives		SW Commutation	Dual Loop	HSSI	MPU Cycle
		Servo	Step				
SPiiPlus SAR-4	DC Brush DC Brushless Nanomotion P/D Step	4 (X,A,Y,B)	2(A, B)	Yes (by two ±10V drive commands per axis)	2(X,Y)	2	0.25, 0.5[1)], 1
SPiiPlus SAR-6		6 (X,A,Y,B,Z,C)	3(A, B, C)		3(X,Y,Z)	2	
SPiiPlus SAR-8		8 (X,A,Y,B, Z,C,T,D)	4 (A, B, C, D)		4 (X,Y,Z,T)	2	

[1)] - The default MPU Cycle is 0.5 msec.

Table 6 SPiiPlus SAR-LT Axis Assignment and Configuration

Product	Motors	Direct Drives		SW Commutation	Dual Loop	HSSI	MPU Cycle
		Servo	Step				
SPiiPlus SAR-LT-4	DC Brush DC Brushless (commutation by drive) P/D Step	4 (X,Y,A,B)	2(A, B)	N/A	2(X,Y)	1	1
SPiiPlus SAR-LT-6		6 (X,Y,Z,A,B,C)	3(A, B, C)		3(X,Y,Z)	1	
SPiiPlus SAR-LT-8		8 (X,Y, Z,T,A,B,C,D)	4 (A, B, C, D)		4 (X,Y,Z,T)	1	

2.4 Safety, Digital and Analog I/O

The SPiiPlus stand-alone line of products comes with digital and analog I/Os.

Digital I/Os are used for the following:

- Safety Inputs - Emergency stop input, left and right limit inputs
- Digital Inputs - General purpose inputs, Mark inputs
- Digital Outputs - General purpose outputs, PEG pulse outputs, PEG state outputs

Analog I/Os are used for the following:

- Analog inputs - Sin-Cos encoder 1Vptp or general purpose analog inputs, general purpose ±10V analog inputs
- Analog outputs - Drive commands outputs, drive commands or general purpose analog outputs, general purpose analog outputs

2.4.1 Safety InputS

Table 7 lists the safety inputs for the SPiiPlus stand-alone product lines:

Table 7 SPiiPlus SAR & SPiiPlus SAR-LT Safety Inputs

SPiiPlus Product	Safety Inputs		
	E-Stop	Left & Right Limits	Motor Over Temp.
SAR-4	1 per controller	Pair per axis	1 per axis
SAR-6			
SAR-8			
SAR-LT-4	1 per controller	Pair per axis	1 per axis
SAR-LT-6			
SAR-LT-8			

2.4.2 SPiiPlus SAR Digital and Analog I/O

Table 8 lists the SPiiPlus SAR digital I/O configuration options:

Table 8 SPiiPlus SAR Digital I/O Confgiration

Product SPiiPlus	Digital Encoders	General Purpose I/Os	PEG Pulse Outputs	PEG State Outputs (per axis)	MARK Inputs (per axis)	Mechanical Brake Output
SAR-4	1 per axis	8/8	2(X,Y)	3 per axis (X)	3 (2X,1Y)	1 per axis
SAR-6			3(X,Y,Z)		4 (2X,1Y,1Z)	
SAR-8			4(X,Y,Z,T)		5 (2X,1Y,1Z,1T)	

Table 9 lists the SPiiPlus SAR analog I/O configuration options:

Table 9 SPiiPlus SAR Analog I/O Configuration Options

Analog Inputs	Type	Analog Outputs	Type
SPiiPlus SAR-4 - None	±10 V, or 1 Vptp differential, 14 bit	SPiiPlus SAR-4 - None	±10 V, or 1 Vptp differential, 16 bit
SPiiPlus SAR-6 - Two		SPiiPlus SAR-6 - Two	
SPiiPlus SAR-8 - Four		SPiiPlus SAR-8 - Four	

2.4.3 SPiiPlus SAR-LT Digital and Analog I/O

Table 10 lists the SPiiPlus SAR-LT I/O configuration options

Table 10 SPiiPlus SAR-LT Digital I/O Confgiration Options

Product	Digital Encoders	General Purpose I/Os	PEG Pulse Outputs	PEG State Outputs (per axis)	MARK Inputs (per axis)	Mechanical Brake Outpt
SAR-LT-4	1 per axis	8/8	2(X,Y)	N/A	4 (2X,2Y)	1 per axis
SAR-LT-6			3(X,Y,Z)		5 (2X,2Y,1Z)	
SAR-LT-8			4(X,Y,Z,T)		6 (2X,2Y,1Z,1T)	

Table 11 lists the SPiiPlus SAR-LT analog I/O configuration:

Table 11 SPiiPlus SAR-LT Analog I/O Configuration Options

Product	Analog Inputs	Analog Outputs	Sin-Cos Encoders
SAR-LT-4	N/A	2	N/A
SAR-LT-6	2	3	
SAR-LT-8	4	4	

Note	
	*The four ±10V Analog outputs (AOUT2, AOUT6, AOUT10 and AOUT14) are for general purposes only.*

2.5 Ordering Options

Figure 2 illustrates the SPiiPlus SAR ordering code elements. These elements and options are described in **Table 12**.

SPiiPlus SAR-[A]-[E]-[M#]-F4-I

Figure 2 SPiiPlus SAR Ordering Code Elements

Table 12 SPiiPlus SAR Ordering Code Options

Element and Description	Options
[A] - Number of axes	Number of axes can be: 4, 6, or 8
[E] - Represents the communications options	[E] = Two RS-232 and one Ethernet 10/100BaseT channel
[M] - Represents the total number of optional Sin-Cos encoder multipliers comprising fast and non-fast encoders	M can be: 0, 1, 2,…8
[F] - Represents the number of optional fast Sin-Cos encoder multipliers (2.5MHz)	F can be: [4]
[I] - Optional field	When included refers to Convolve Input Shaping® algorithm to reduce vibration and settling time

Figure 3 illustrates the SPiiPlus SAR-LT ordering code elements. These elements and options are described in **Table 13**.

SPiiPlus SAR-LT-[A]-[E]-[C]

Figure 3 SPiiPlus SAR-LT Ordering Code Elements

Table 13 SPiiPlus SAR-LT Ordering Code Options

Element and Description	Options
[A] - Number of axes	Number of axes can be: 4, 6, or 8
[E] - Represents the communications options	[E] = Two RS-232 and two Ethernet 10/100BaseT channel
[C] - Convolve Input Shaping® algorithm	The Convolve Input Shaping® algorithm serves to reduce vibration and settling time

2.6 Standard Accessories

The SPiiPlus SAR comes with the SPiiPlus ADK (Advanced Development Kit) CD which is intended for aiding programmers in developing ACSPL+ based applications and host based programs. The CD contains:

- **SPiiPlus MMI** - for axis configuration, servo tuning, programming and viewing parameters
- **SPiiPlus Library** - for host programming in C/C++ or Visual Basic™
- **SPiiPlus Utilities** -for upgrading or reinstalling firmware

Caution	
	***If you decide to upgrade or downgrade the firmware be sure and use Upgrader version 6.0 or above.*** ***Never downgrade the firmware to versions below 6.0. Doing this may cause the controller to become inoperable.***

- **SPiiPlus Simulator** – controller simulator for fast application development
- **SPiiPlus FRF Analyzer**™
- **SPiiPlus Command & Variables Reference Guide** - complete details of ACSPL+ commands and variables as well as error messages
- Hardware, software, setup, and programming guides in PDF format
- ACSPL+ and C/C++ training files and programming examples

2.7 Additional Products

2.7.1 SPiiPlus SAR-INT

Interface kit that includes mating connectors to SPiiPlus SAR panel of connectors.

2.7.2 HSSI-IO16

I/O expansion module providing 16 additional opto-isolated digital inputs and 16 opto-isolated digital outputs per module. Up to four HSSI-IO16 units can be daisy chained to an HSSI channel, providing a total of 64 inputs and 63 outputs per channel. For more information, refer to the HSSI-IO16 data sheet.

2.7.3 HSSI-ED2

The HSSI-ED2 is applicable to the SPiiPlus SAR and SPiiPlus SAR-LT only. The HSSI-ED2 is an I/O expansion module providing encoder and drive interface up to 20m from the controller, 8 additional opto-isolated digital inputs and 8 opto-isolated digital outputs per module. For more information, refer to the HSSI-ED2 data sheet.

3 Specifications

This chapter provides the technical specifications for the SPiiPlus SAR and SPiiPlus SAR-LT products.

3.1 SPiiPlus SAR Specifications

For axes specifications, see **Table 5**.

Table 14 Profile Generation

Element	Description
Trajectory Calculation Rate	Programmable 1, 2 (default), 4 kHz
Position Range	$\pm 4x10^{15}$ counts
Velocity	$160x10^{9}$ counts/second
Acceleration	Up to $4x10^{15}$ counts/second^2

Table 15 Control

Element	Description
Position+Velocity Loop	PI type, second order low pass and notch filters
Sampling Rate	20kHz
Accuracy	±1 encoder count
Dual Loop	See **Table 5**.

Note	
	*Each dual loop consumes another axis which should be defined as a dummy.*

Table 16 Feedback

Element	Description
Type	• Incremental digital encoders - one per axis, A&B,I; UP/DN,I; CLK/DIR,I Type RS-422 Max. rate: 20 million encoder counts/sec • Sin-Cos encoders (optional) - one per axis, three channel, 1Vptp, differential. Programmable multiplication factor x4-x65,536, rate: up to 0.25MHz or 2.5MHz (fast) sinusoidal periods/second. Maximum acceleration with Sin-Cos encoder: 10^8 sinusoidal periods/second^2. • Analog inputs or user defined devices via HSSI channels

Table 17 Drive Interface

Element	Description	
Analog Commands	Quantity	One torque command or two commutation commands per axis. See **Table 5**.
	Type	±10V, differential
	Resolution	16-bit
	Offset Compensation	Programmable, 0.3mV resolution
Pulse-Direction Commands	Quantity	Half of the axes. See **Table 5**.
	Type	RS-422.See **Chapter 9 - Appendix A: Signal Definitions**.
Drive Enable Outputs	Quantity	One per axis
	Type	Two-terminal, opto-isolated, source or sink
	Output Current	Up to 24V/20mA
Drive Fault Inputs	Quantity	One per axis
	Type	Two-terminal, opto-isolated, source or sink
	Input Circuit Current	<7mA

Table 18 Digital I/O

Element	Description	
Safety Inputs	Voltage	Requires an external supply. See, **Table 22**.
Safety Inputs E- stop	Quantity	One Emergency stop
	Type	Two-terminal, source or sink, opto-isolated

Table 18 Digital I/O

Element	Description	
Safety Inputs - Limits	Quantity	Left and Right Limit per axis
	Type	Single-ended, source or sink (default), opto-isolated
	Voltage	5dc (±10%) or 24dc (±20%), requires external supply, see **Table 22**.
Digital Inputs	Voltage	Requires an external supply. See, **Table 22**.
General Purpose Digital Inputs	Quantity	Eight
	Type	5V, or 24V source or sink (default), opto-isolated.
	Input Circuit Current	<15mA
MARK Inputs	Quantity	See **Table 9**.
	Type	RS-422, see **Chapter 9 - Appendix A: Signal Definitions**.
	Propagation Delay	<0.1µsec
Digital Outputs	Voltage	Requires an external supply. See, **Table 22**.
General Purpose Digital Outputs	Quantity	Eight
	Type	5V, or 24V source or sink (default), opto-isolated.
	Output Circuit Current	50mA per output
PEG Digital Output	Quantity	PEG signals - (X, Y, Z, T) Also see **Table 9**.
	Type	RS-422 **Chapter 9 - Appendix A: Signal Definitions**.
	Propagation Delay	<0.1µsec
	PEG Pulse Width	25nsec to 1.6msec
	PEG Position Accuracy	±1 count up to 5,000,000 counts/sec
PEG State Digital Output	Quantity	Three per X axis
	Type	RS-422. See **Chapter 9 - Appendix A: Signal Definitions**.
	Propagation Delay	<0.1µsec

Table 19 HSSI Expansion Channels

Element	Description
Quantity	See **Table 5**.
Input Bits	64 per channel
Output Bits	64 per channel

Table 19 HSSI Expansion Channels

Element	Description
Sampling and Updating Rate	20 kHz
Type	RS-422. See **Chapter 9 - Appendix A: Signal Definitions**.
Comment	Up to an additional 64/63 I/Os via each HSSI channel using HSSI-IO16 modules

Table 20 Analog I/O

Element	Description	
Analog Inputs - Sin-Cos or General Purpose	Quantity	See **Table 9**.
	Type	1V ptp differential, Sin-Cos encoder or general purpose ±10V differential, general purpose
	Resolution	14-bit
	Comment	Analog inputs may be used as Sin-Cos encoder inputs. Each Sin-Cos encoder uses two analog inputs. When axes C and /or D Sin-Cos encoders are not used, the inputs can be used for general purpose (±10V differential).
Analog Outputs - Drive Command	Quantity	See **Table 9**.
	Type	±10V, differential
	Resolution	16-bit
Analog Outputs - Drive Commands or General Purpose	Quantity	See **Table 9**.
	Type	±10V, differential
	Resolution	16-bit
	Comment	Analog outputs may be used as drive command outputs. Each servo axis uses one command for toque or two commands for torque and commutation.
Analog Inputs & Outputs	Signal-to-noise Ratio	≥72dB (3sigma)

Table 21 Communication Channels

Element	Description
RS232	Two ports, up to 115,200bps
Ethernet	Two TCP/IP, 10/100Mbits/sec
CANopen	One

Note	
	*Simultaneous communication through all channels is fully supported.*

Table 22 Controller and Power Supply

Element	Description
User Memory	RAM: 128 MB, Flash: 128 MB
Powerup Time	25sec
Power Supply Voltage/Current	24Vdc (±10%)/2A
I/O Supply Voltage/Current	+5Vdc (±10%)/1A, or 24 Vdc (±20%)/1A
Safety Supply Voltage/ Current	+5Vdc (±10%)/1A, or 24 Vdc (±20%)/1A

Table 23 Environment

Element	Description
Operating Temperature	0^0C to 40^0C
Storage Temperature	-40^0C to 70^0C
Operating Humidity	90%RH, non condensing

3.2 SPiiPlus SAR-LT Specifications

For axes specifications, see **Table 6**.

Table 24 Profile Generation

Element	Description
Trajectory Calculation Rate	Programmable: 0.25, 0.5, 1 (default), 2kHz
Position Range	$\pm 4x10^{15}$ counts
Velocity	$160x10^{9}$ counts/second
Acceleration	Up to $4x10^{15}$ counts/second^2

Table 25 Control

Element	Description
Position+Velocity Loop	PI type, second order low pass and notch filters
Sampling Rate	20kHz
Accuracy	±1 encoder count
Dual Loop	See **Table 6**.

Note	*Each dual loop consumes another axis which should be defined as a dummy.*

Table 26 Feedback

Element	Description
Type	• Incremental digital encoders - one per axis, A&B,I; UP/DN,I; CLK/DIR,I Type RS-422 Max. rate: 30 million encoder counts/sec • Analog inputs or user defined devices via HSSI channels

Table 27 Drive Interface

Element	Description	
Analog Commands	Quantity	One torque command per axis. See **Table 6**.
	Type	±10V, differential; or ±10V, single-ended
	Resolution	12-bit
	Offset Compensation	Programmable
Pulse-Direction Commands	Quantity	Half of the axes. See **Table 6**.
	Type	RS-422.See **Chapter 9 - Appendix A: Signal Definitions**.
Drive Enable Outputs	Quantity	One per axis
	Type	Two-terminal, opto-isolated, source or sink
	Output Current	Up to 24V/20mA
Drive Fault Inputs	Quantity	One per axis
	Type	Two-terminal, opto-isolated, source or sink
	Input Circuit Current	<15mA
Mechanical Brake	One per axis	Opto-isolated source only, up to 24V/7mA

Table 28 Digital I/O (page 1 of 2)

Element	Description	
Safety Inputs	Voltage	Requires an external supply. See, **Table 22**.
Safety Inputs E- stop	Quantity	One Emergency stop
	Type	Two-terminal, source or sink, opto-isolated
Safety Inputs - Limits	Quantity	Left and Right limit per axis
	Type	Single-ended, source or sink (default), opto-isolated
	Voltage	5Vdc (±10%) or 24Vdc (±20%), requires external supply, see **Table 22**.

Table 28 Digital I/O (page 2 of 2)

Element	Description	
Digital Inputs	Voltage	Requires an external supply. See, **Table 22**.
General Purpose Digital Inputs	Quantity	Eight
	Type	5V, or 24V source or sink (default), opto-isolated.
	Input Circuit Current	<15mA
MARK Inputs	Quantity	See **Table 10**.
	Type	RS422 compatible. Input impedance 120Ω. Opto-isolated (optional) IN6, IN7 can be shared with X-axis MARK2 and Y-axis MARK2
	Propagation Delay	<0.1µsec
Digital Outputs	Voltage	Requires an external supply. See, **Table 22**.
General Purpose Digital Outputs	Quantity	Eight
	Type	Single-ended, opto-isolated. Can be configured as sink or source by the user. 5Vdc ±10% to 24Vdc ±20%. Reference: V_RET_IO (Sink) or V_SUP_IO (Source). Upon power-up signal is high impedance (no current through the output transistor).
	Output Circuit Current	100mA per output
PEG Digital Output	Quantity	SPiiPlus SA-4-LT: One PEG pulse per X, and Y SPiiPlus SAR-LT-6: One PEG pulse per X, Y, and Z SPiiPlus SAR-LT-8: One PEG pulse per X, Y, Z, and T Also see **Table 10**.
	Type	RS422 compatible. Opto-isolated (optional) OUT6, OUT7 can be shared with X-axis PEG and Y-axis PEG by JP9 setup
	Propagation Delay	<0.3µS
	PEG Pulse Width	25nsec to 1.6msec
	PEG Position Accuracy	±1 count at up to 5,000,000 count/sec
PEG State Digital Output	Quantity	Three per X axis
	Type	RS-422. See **Chapter 9 - Appendix A: Signal Definitions**.
	Propagation Delay	<0.1µsec
Motor Over-Temperature	One per axes	Single-ended, opto-isolated. There must be a resistance of 3.6kΩ.

Table 29 HSSI Expansion Channels

Element	Description
Quantity	One - see **Table 6**.
Input Bits	64 per channel
Output Bits	64 per channel
Sampling and Updating Rate	20kHz
Type	RS-422. See **Chapter 9 - Appendix A: Signal Definitions**.
Comment	Up to additional 64/63 I/Os via each HSSI channel using HSSI-IO16 modules

Table 30 Analog I/O

Element	Description	
General Purpose/Analog Inputs	Quantity	See **Table 11**.
	Type	±10V, differential
	Resolution	14-bit
	Comment	Analog inputs may be used as current feedback.
Analog Outputs	Quantity	See **Table 11**.
	Type	±10V, single-ended PWM filtered
	Resolution	10-bit

Table 31 Communication Channels

Element	Description
RS232	Two ports, up to 115,200bps
Ethernet	Two TCP/IP, 10/100Mbits/sec
CANopen	One

Note	
	*Simultaneous communication through all channels is fully supported.*

Table 32 Controller and Power Supply

Element	Description
User Memory	RAM: 128 MB, Flash: 128 MB
Powerup Time	25sec
Power Supply Voltage/Current	24Vdc(±15%) /1.5A
I/O Supply Voltage/Current	+5Vdc (±10%)/1A, or 24 Vdc (±20%)/1A
Safety Supply Voltage/ Current	+5Vdc (±10%)/1A, or 24 Vdc (±20%)/1A
Encoder Supply 5U	5Vdc (±2%)/1.2Am - digital ground reference
Optional Encoder Suppy 5F	5Vdc (±2%)/1.2Am - analog ground reference

Table 33 Environment

Element	Description
Operating Temperature	0^0C to 40^0C
Storage Temperature	-40^0C to 70^0C
Operating Humidity	90%RH, non-condensing

4 Mounting and Physical Interface

The following illustrations appear in this chapter:

- **Figure 4 - Mounting Options - Side View**
- **Figure 5 - Front Panel Dimensions**
- **Figure 6 - Side Panel Dimensions**

The SPiiPlus SA can be mounted on a wall or in a dedicated cavity.

4.1 Bracket Mounts

The SA is equipped with two metal brackets with mounting holes for both available mounting configurations - wall mounting and cavity mounting.

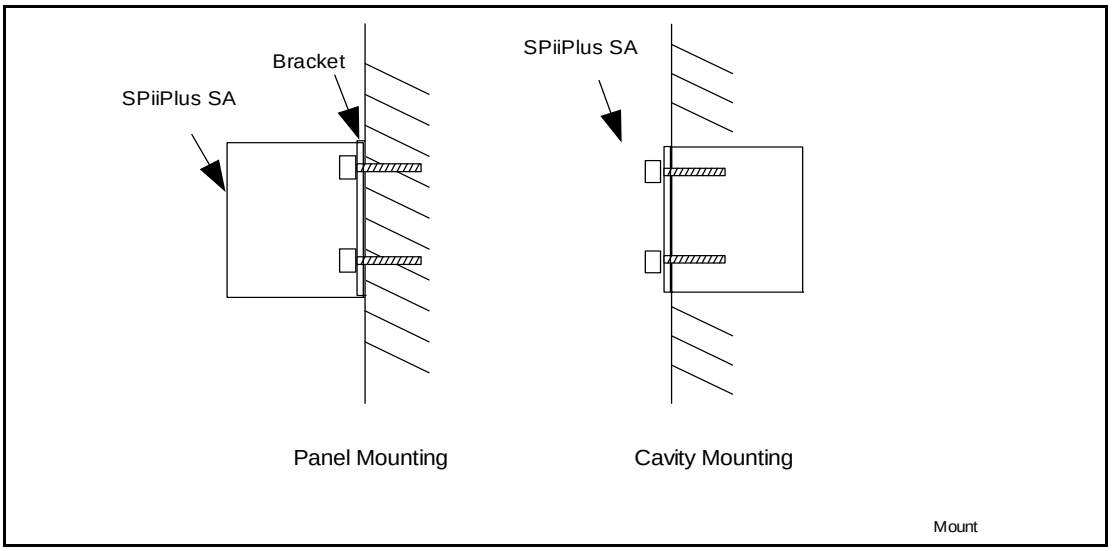


Figure 4 Mounting Options - Side View

4.2 Dimensions

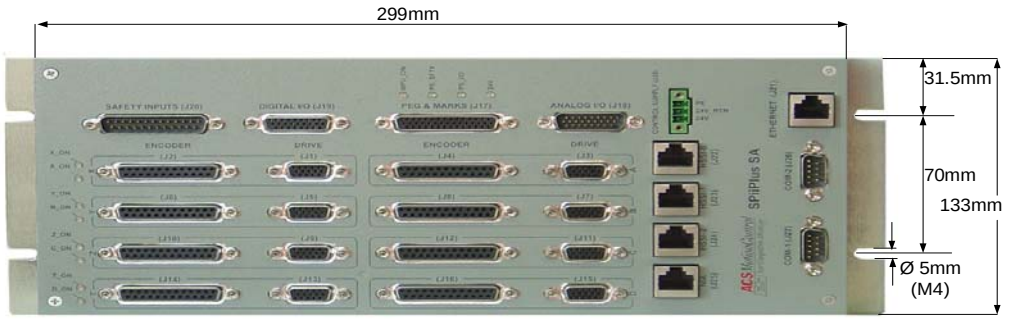


Figure 5 Front Panel Dimensions

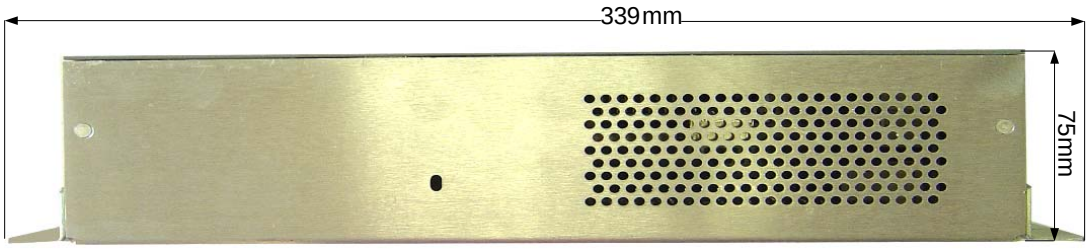


Figure 6 Side Panel Dimensions

5 Safety and EMC Guidelines

Warning	
	***Read and understand the following safety precautions and guidelines before operating the SPiiPlus SAR!***

5.1 General Safety Guidelines

Under emergency situations the SPiiPlus SAR should be completely disconnected from any power supply. The E-Stop Inputs and Left/Right Limits on ACS Motion Control products are designed for use in conjunction with customer-installed devices to protect driver load. The end user is responsible for complying with all electrical codes.

5.1.1 Emergency Stop Device

1. Locate an emergency stop device at each operator control station and other operating stations where an emergency stop may be required.
2. The emergency stop device shall disconnect all electrical equipment connected to the SPiiPlus SAR from their respective power supplies.
3. It will not be possible to restore the circuit until the operator manually resets the emergency stop.
4. In situations with multiple emergency stop devices the circuit shall not be restored until all emergency stops devices are manually reset.

5.1.2 Fail-Safe Logic Recommendation

ACS Motion Control recommends connecting all safety inputs (limit inputs and emergency stop input) with a fail safe logic. The intention is that during normal operation the inputs are active. When a safety event happens (or the input wire is cut) the input becomes zero and the controller identifies that as a fault.

5.1.3 Protective Precautions

- Digital outputs are protected against short circuit with ground. A short circuit on any digital output will disable ALL digital outputs without any indication by the software. The digital outputs will become enabled again only after controller power-up.
- Over-travel Protection–Provide over-travel limit protection where over-travel is hazardous. Design and install the over-travel limiting device to interrupt the power circuit.
- Over-current Protection–Use the software Current/Torque Limit parameters in the MMI Adjuster to provide over-current protection for the motors.
- Thermal Detection–Suitable thermal detection devices to interrupt the power circuit where abnormal temperatures can cause a hazardous condition.
- Cooling Fans–Make sure the cooling fans remain unobstructed at all times
- In order to insure good heat dissipation, make sure that the cooling vanes remain clean at all times.

5.1.4 Routing Signal and Power Cables

Power cables (to the motor, mains outlet, etc.) and signal cables (to I/O, encoder, RS-232, etc.) must be kept as far apart as possible. Keep at least an inch (~2.5 cm) for each 3 feet (~1 m) of parallel run as illustrated in **Figure 7**. For example, if the motor and encoder cables run parallel for 6 feet (~2 m), maintain a 2 inch (~5 cm) separation between them.

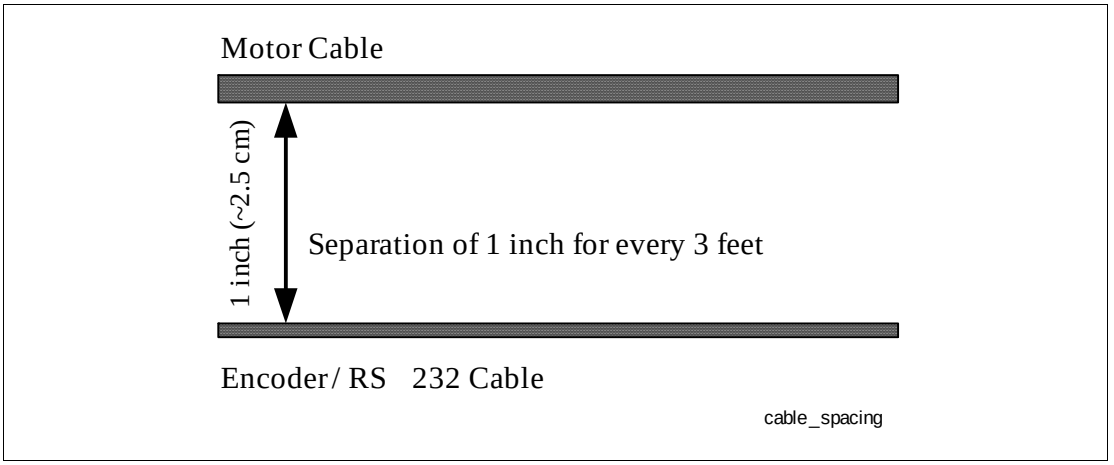


Figure 7 Cable Spacing

It is recommended to use completely shielded cables as illustrated in **Figure 8**.

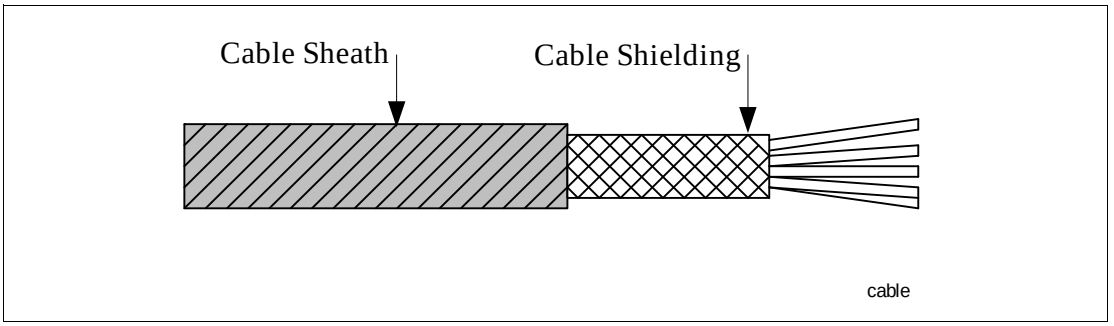


Figure 8 Shielded Cable

5.1.5 Cable Length

Use short cables runs, and route cables as far from other EMI sources as possible.

5.1.6 Shielding

To reduce EMI radiation, do the following:

- ❑ Use shielded cables
- ❑ Install a ferrite core around the cable as close to the SPiiPlus SAR as possible as illustrated in **Figure 9**.

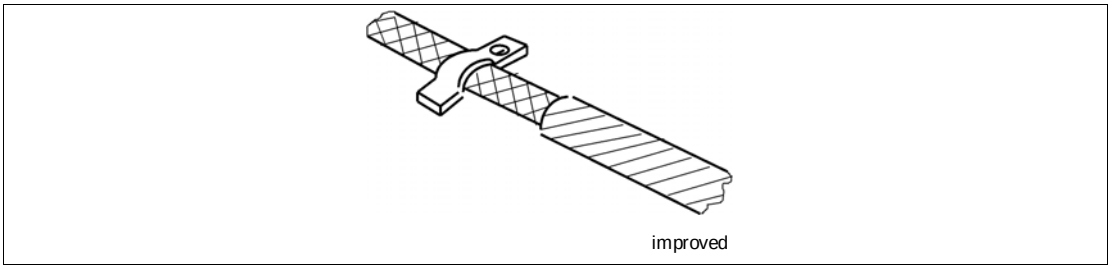


Figure 9 Improved Shielding

The SPiiPlus SAR comes ready for the installation of three spring-loaded clamps to facilitate connecting the motor shielding to the ground.

5.1.7 Grounding

Grounding system electrical components is crucial in two aspects:

- Safety grounding

Warning	
	***Verify that all electric circuits and electrical components including motion controllers, power drives, motors, etc. have a grounding system. Grounding of AC and DC equipment shall be in accordance with 29 CFR 1910.304(f).***

- High frequency grounding:

  The primary objective of a high-frequency ground system is to provide a well defined path for HF currents and to minimize the loop area of the HF current paths. It is also important to separate HF grounds from sensitive circuit grounds. A single-point, parallel connected ground system is recommended.

6 Electrical Interface

Model	
	*This chapter describes the interface of the SPiiPlus SAR-8. The interfaces of the SPiiPlus SAR-4, SpiiPlus SAR-6 are identical to those of SPiiPlus SAR-8 with the derived model dependent exceptions.* *SPiiPlus SAR-LT-4, SPiiPlus SAR-LT-6 and SPiiPlus SAR-LT-8 have a slightly different arrangement of interfaces. These differences are noted where they exist.*

6.1 General Purpose Output Protection

All versions of the SPiiPlus SAR provide the follow output protection:

- ❑ The 5V supply outputs are fully protected
- ❑ The 24V Logic Supply outputs are fully protected in the Source mode of operation
- ❑ The 24V Logic Supply outputs are fully protected in the Sink mode of operation

6.2 SPiiPlus SAR Connector Layout

The following illustrations show the layout of the connectors of each product of the SPiiPlus SAR and SPiiPlus SAR-LT series:

Figure 10 illustrates the SPiiPlus SAR-4 front panel.

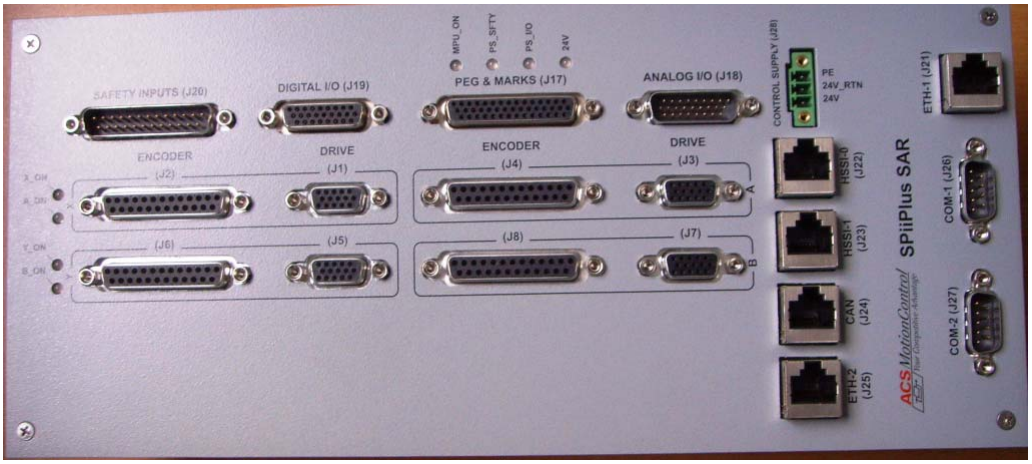


Figure 10 SPiiPlus SAR-4 Front Panel

Figure 11 illustrates the SPiiPlus SAR-6/8 front panel.

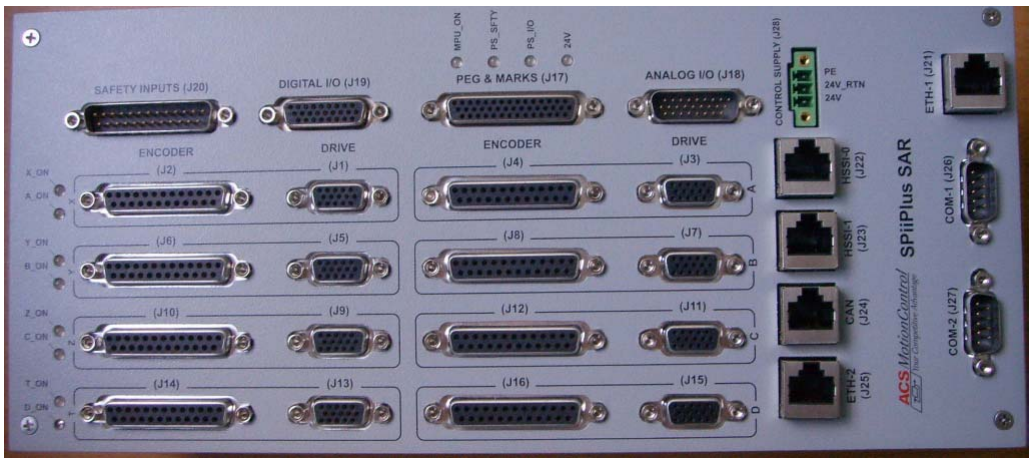


Figure 11 SPiiPlus SAR-6 and SAR-8 Front Panel

Figure 12 illustrates the SPiiPlus SAR-LT front panel.

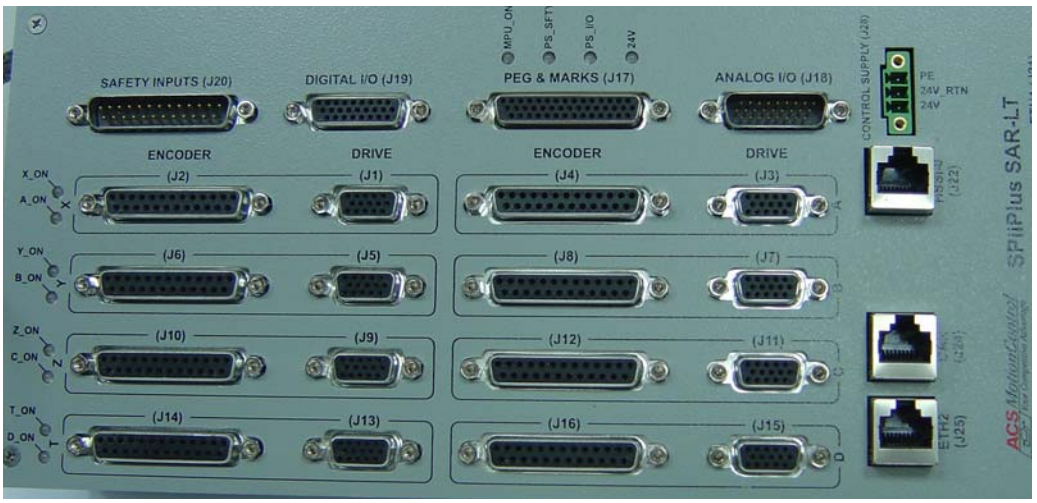


Figure 12 SPiiPlus SAR-LT Front Panel

For front panel dimensions, refer to **Figure 5**.

Table 34 lists the SPiiPlus SAR electrical interfaces by group.

Table 34 Electrical Interface by Group

Group	Functionality	Connector
Supply	Control Supply (24vdc)	J28
I/O	Digital Inputs	J19
	Digital Outputs	J19
	Mechanical Brake	J19
	Mark Fast Digital Inputs	J17
	PEG Pulse Fast Digital Outputs	J17
	PEG States Fast Digital Output	J17
	General Purpose differential Analog Inputs ±10V	J18
	General Purpose differential Analog Outputs ±10V	J18
Digital Encoder	Digital Encoder Differential Inputs	J2, J6, J10, J14, J4, J8, J12, J16
	Sin-Cos Encoder 1Vptp Differential Inputs	J2, J6, J10, J14, J4, J8, J12, J16
	Fast Sin-Cos Differential Inputs	J2, J4, J6, J8
Drive Commands	±10V drive commands	J1, J5, J7, J9, J11, J13, J15, J17
	Pulse-Direction commands	J3, J7,J11, J15
Safety	Emergency Stop	J20
	Right & Left Limits	J2, J4, J6, J8, J10, J12, J14, J16
Communication	RS232	J26, J27
	Ethernet, 10/100BaseT	J21
	High Speed Synchronous Serial Interface (HSSI)	J22, J23
	CAN bus	J24

6.3 J28 - Control Supply Connector

The power supply circuit is protected against current inversion and over voltage. The connector is a Phoenix MCV 1.5/ 3-GF-3.81that mates to a Phoenix MCV 1.5/ 3-STF-3.81. The recommended wire to be employed is a Safety Approved 18-14AWG.

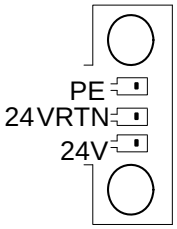


Table 35 provides the J28 pinout.

Table 35 J28 - Control Supply Pinout

Pin	Name	Description
1	24VDC	+24 Vdc supply
2	24VRTN	24 Vdc supply return
3	PE	Power Earth

Note	
	*24V control supply is protected by one internal 4A fuse, not accessible to the user.* *Power supply should be in the range of 24Vdc ±20% for SAR ; 24Vdc ±15% for SAR-LT.*

6.4 J18 - Analog I/O Connector

The SPiiPlus SAR is equipped with a single differential analog I/O connector. The connector provides:

- Four differential general purpose analog inputs - AIN10, AIN11, AIN14 & AIN15 with voltage range of ±10V.

Model	
	*SPiiPlus SAR only:* *General purpose analog inputs AIN10, AIN11, AIN14, AIN15 are connected in parallel to analog Sin-Cos encoder inputs for axes C and D. The general purpose analog inputs may be used only when analog Sin-Cos encoder inputs are not connected.*

- Four differential general purpose analog outputs - AOUT10, AOUT11, AOUT14 & AOUT15 with voltage range of ±10V.

  In the SPiiPlus SAR-LT the names of the outputs are: AOUT2, AOUT6, AOUT10, & AOUT14.

- Analog Inputs - when no Sin-Cos encoder is connected to an axis, you may use each axis drive command as an analog input for general purpose. See ***Section 6.5.3 - "Defining Sin-Cos Encoder Inputs as General Purpose"***.

- Analog Output - when no motor is connected to the axis, you may use each axis drive command as an analog output for general purpose. See ***Section 6.6.7 - "Defining Drive Commands as General Purpose Analog Outputs"***.

The J18 connector is a 26-pin, male HD D-Type connector that mates with a 26-pin female HD D-Type connector. The recommended wires to be employed are: AWG22 wires with shielding. Twisted pair cable for each differential signal (+ and -).

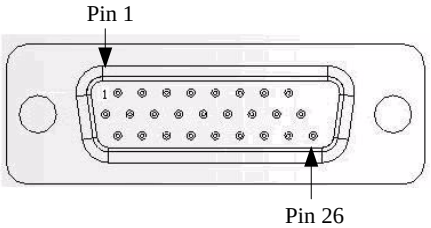


Figure 13 J18 - Analog I/O Connector Pin Layout

Table 36 provides the J18 pinout for SPiiPlus SAR and SPiiPlus SAR-LT. **Table 37** provides the J18 pinout for SPiiPlus SAR-LT.

Table 36 J18 - Analog I/O Connector Pinout (SAR & SAR-LT)

Pin	Name	Description
1	AOUT10+	Analog output non inverted
2	AOUT11+	Analog output non inverted
3	AOUT14+	Analog output non inverted
4	AOUT15+	Analog output non inverted
5	N.C	Not connected
6	AIN10-	Analog input inverted
7	AIN11-	Analog input inverted
8	AIN14-	Analog input inverted
9	AIN15-	Analog input inverted
10	AOUT15-	Analog output inverted
11	AOUT11-	Analog output inverted
12	AOUT14-	Analog output inverted
13	AOUT10-	Analog output inverted
14	AGND	Internal analog supply return
15	AIN10+	Analog input non inverted
16	AIN11+	Analog input non inverted
17	AIN14+	Analog input non inverted
18	AIN15+	Analog input non inverted
19	N.C	Not connected
20	N.C	Not connected
21	N.C	Not connected
22	N.C	Not connected
23	N.C	Not connected
24	N.C	Not connected

Table 37 J18 - Analog I/O Connector Pinout (SAR-LT) (page 1 of 2)

Pin	Name	Description
1	AOUT6	Analog output
2	AOUT14	Analog output
3	AOUT2	Analog output
4	AOUT10	Analog output
5	N.C	Not connected
6	AIN10-	Analog input inverted

Table 37 J18 - Analog I/O Connector Pinout (SAR-LT) (page 2 of 2)

Pin	Name	Description
7	AIN11-	Analog input inverted
8	AIN14-	Analog input inverted
9	AIN15-	Analog input inverted
10	N.C	Not connected
11	N.C	Not connected
12	N.C	Not connected
13	N.C	Not connected
14	AGND	Internal analog supply return
15	AIN10+	Analog input non inverted
16	AIN11+	Analog input non inverted
17	AIN14+	Analog input non inverted
18	AIN15+	Analog input non inverted
19	N.C	Not connected
20	N.C	Not connected
21	N.C	Not connected
22	N.C	Not connected
23	N.C	Not connected
24	N.C	Not connected

6.4.1 General Purpose Analog Inputs

Table 38 provides details of the general purpose Analog Inputs.

Table 38 J18 - General Purpose Analog Inputs (page 1 of 2)

Item	Value
Quantity	SPiiPlus SAR-4: N/A SPiiPlus SAR-6: 2 SPiiPlus SAR-8: 4 SPiiPlus SAR-LT-4: N/A SPiiPlus SAR-LT-6: 2 SPiiPlus SAR-LT-8: 4
Type	Differential
Voltage Range	±10V
Input Impedance	>20K
Restriction	Sin-Cos inputs for axes C and D are connected in parallel with general purpose analog inputs (±10V) AIN10, AIN11, AIN14 AIN15. Hence it is impossible to use both voltage range simultaneously per each input.
Signal-to-Noise Ratio	≥72dB

Table 38 J18 - General Purpose Analog Inputs (page 2 of 2)

Item	Value
Digital representation of input voltage (AIN variable)	-8192 to +8192
A/D conversion resolution	14 bit
Corresponding ACSPL+ Variables	AIN10, AIN11, AIN14, AIN15

6.4.2 General Purpose Analog Input Examples

The following figures show common uses of the general purpose Analog Input:

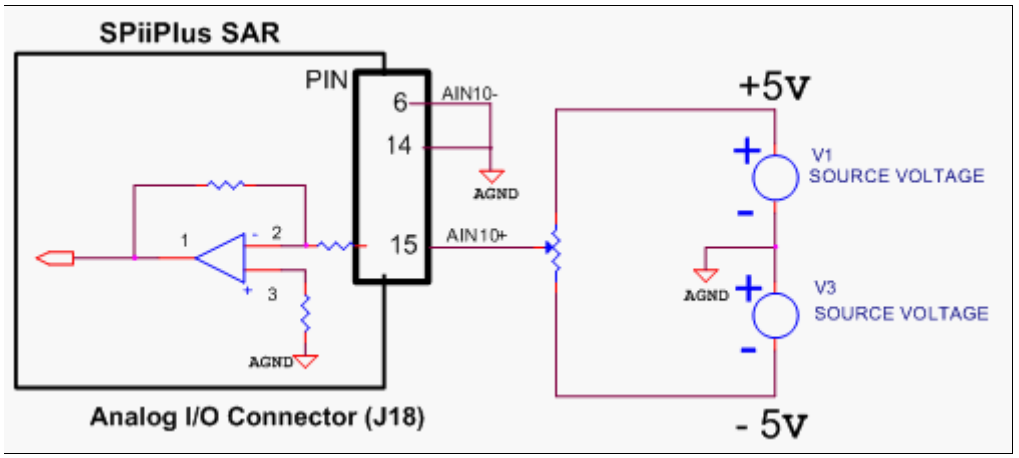


Figure 14 Single-ended Joystick through AIN10

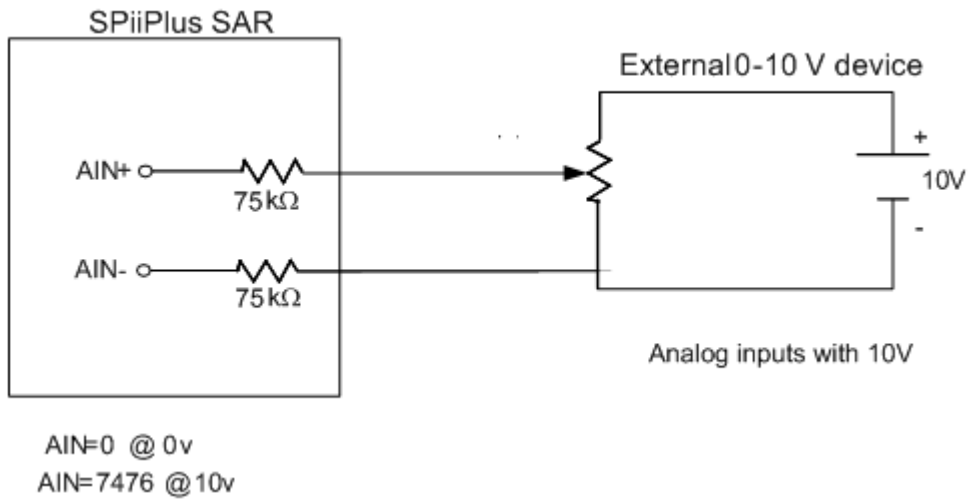


Figure 15 Analog Inputs with ±10V Configuration

Note	
	*The voltage range of analog input in a single-ended configuration is ±5V.*

6.4.3 General Purpose Analog Outputs

Table 39 provides details of the general purpose Analog Outputs.

Table 39 General Purpose Analog Outputs

Item	Value
Quantity	SPiiPlus SAR-4: N/A SPiiPlus SAR-6: 2 SPiiPlus SAR-8: 4 SPiiPlus SAR-LT-4: 2 SPiiPlus SAR-LT-6: 3 SPiiPlus SAR-LT-8: 4
Type	Differential - for SPiiPlus SAR Single-ended - for SPiiPlus SAR-LT
Signal-to-Noise Ratio	≥72dB
Voltage Range	±10V
D/A Resolution	16 bit - for SPiiPlus SAR 10 bit - for SPiiPlus SAR-LT
Voltage Representation in Controller	-32768 to +32768 - for SPiiPlus SAR -511 to +511 - for SPiiPlus SAR-LT
Maximum Current	5mA per output
Protection	Short circuit and short to ground
Corresponding ACSPL+ Variables	AOUT10, AOUT11, AOUT14, AOUT15 (SPiiPlus SAR) AOUT2, AOUT6, AOUT10, AOUT14 (SPiiPlus SAR-LT)

6.4.4 General Purpose Analog Output Examples

The following illustration shows the interface of the general purpose analog output in a single-ended configuration.

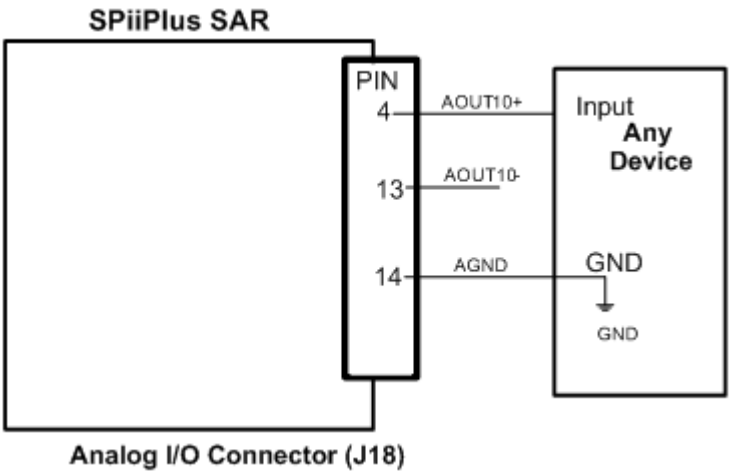


Figure 16 General Purpose Analog Output in Single-ended Configuration

Note	
	*The voltage range of analog output in a single-ended configuration is ±5V.*

6.5 Encoder Connectors

The Encoder connectors are J2, J4, J6, J8, J10, J12, J14, J16. The Encoder connector interfaces with the following:

- Digital and analog encoders as explained below
- Motor over temperature input
- Right and left limits inputs

The Encoder interface includes the following connectors:

Connector	Axis	Connector	Axis
J2	X	J10	Z
J4	A	J12	C
J6	Y	J14	T
J8	B	J16	D

The controller supports the following Encoder types:

- A & B, I: Quadrature encoder with index
- CLK-Dir, I: Clock - direction encoder with index
- UP-DN, I: Up - down encoder with index
- Sin-Cos,I: anlaog encoder with index encoder frequency of 250KHz or 2.5MHz. The following table displays the configuration for supported Sin-Cos encoders:

Table 40 Supported Sin-Cos Encoders

SPiiPLus	Non Fast 250 KHz Sin-Cos Encoder	Fast 2.5 MHz Sin-Cos Encoder
SPiiPLus SAR-4	X, Y, A, B	None
SPiiPLus SAR-6	X, Y A, B, Z, C	None
SPiiPLus SAR-8	X, Y, A, B, Z, C, T, D	X, Y, A, B

Model	*SPiiPlus SAR-LT does not support the Sin-Cos encoder interface.*

The Encoder connector is a 25-pin female D-Type connector which mates with a 25-pin male D-Type connector. The recommended wires to be employed are: AWG22 wires with shielding. Twisted pair cable for each differential signal (+ and -).

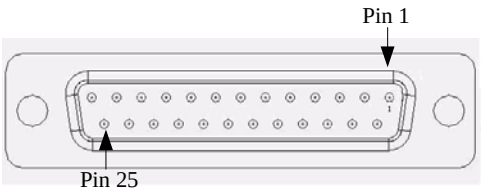


Figure 17 Encoder Connector Pin Layout

Note	*In the following table the # symbol stands for the axis designation, for example, #_SIN+ can be X_SIN+, Y_SIN+, T_SIN+, depending on the SAR model and connector.*

Table 41 Encoder Interface Pinout

Pin	Name	Description
1	#_SIN+	SIN non inverted input
2	#_COS+	COS non inverted input
3	#_SC_HI+	Sin-Cos index non inverted input
4	5VF	Sin-Cos supply +5V 100mA max.
5	#_LL	Left limit
6	#_RL	Right limit
7	#_CHA-	Channel A inverted digital encoder input
8	#_CHB-	Channel B inverted digital encoder input
9	#_CHI-	Index inverted digital encoder input
10	#_OVER_T	Over temperature input
11	5VU	Digital encoder supply +5V 100mA max.
12	#_HA	Motor Hall A
13	#_HC	Motor Hall C
14	#_SIN-	SIN inverted input
15	#_COS-	COS inverted input
16	#_SC_HI-	Sin-Cos index inverted input
17	AGND	Internal analog supply return
18	DGND	Digital ground internal digital supply return
19	#_CHA+	Channel A non inverted digital encoder input
20	#_CHB+	Channel B non inverted digital encoder input
21	#_CHI+	Index non inverted digital encoder input
22	DGND	Internal digital supply return
23	V_RTN_IO	Input/Output supply return
24	V_RTN_SFTY	Safety Supply Return
25	#_HB	Motor Hall B

6.5.1 Sin-Cos Encoder Inputs

Table 42 Non Fast Sin-Cos Encoder Input (page 1 of 2)

Item	Value
Quantity	SPiiPlus SAR-4 four for X, Y, A, B SPiiPlus SAR-6 six for X, A ,Y, B, Z, C SPiiPlus SAR-8 eight for X,Y, Z, T, A, B, C, D
Type	1V ptp differential signals
Offset Compensation	±0.5V, 16 bit resolution adjustable by user

Table 42 Non Fast Sin-Cos Encoder Input (page 2 of 2)

Item	Value
Input Impedance	120Ω
Restriction	Sin-Cos inputs for axes C and D are connected in parallel with general purpose analog inputs (±10V) AIN10, AIN11, AIN14 AIN15. Hence its impossible to use both voltage range simultaneously per each input.
Input frequency	Up to 250K sine or cosine periods per second
Signal-to-Noise Ratio	>72dB
Digital representation of input voltage (AIN variable)	-8192 to +8192
A/D conversion resolution	14 bit
Internal Multiplier	2^2 - 2^{16}
Corresponding ACSPL+ Variables	AIN0…AIN15 (When used as general purpose inputs)

Table 43 Fast Sin-Cos Encoder Input

Item	Value
Quantity	SPiiPlus SAR-8: Four fast encoders for X, Y, A, B
Type	1V ptp differential signals
Offset Compensation	±0.5V, 16 bit resolution adjustable by user
Input Impedance	120Ω
Restriction	N/A
Input frequency	Up to 2.5M sine or cosine periods per second
Signal-to-Noise Ratio	>72dB
Digital representation of input voltage (AIN variable)	–8192 to +8192
A/D conversion resolution	14 bit
Internal Multiplier	2^2 - 2^{16}
Corresponding ACSPL+ Variables	AIN0…AIN7 when used as general purpose inputs

The SPiiPlus SAR allows you to manually adjust the offset compensation for sine and cosine encoder analog signals for axes X, Y, Z, T, A, B. Manual adjustment for axes C and D is unavailable and you should use the corresponding outputs (AOUT10, AOUT11, AOUT13, AOUT14, AOUT15) for general purpose. The offset compensation tuning is performed by ASCPL+ variables AOUT0 to AOUT15 as the following table shows.

Table 44 Offset Compensation

Axis	ACSPL+ Variable	Axis	ACSPL+ Variable
X sine	AOUT0	Z sine	AOUT8
X cosine	AOUT1	Z cosine	AOUT9

Table 44 Offset Compensation

Axis	ACSPL+ Variable	Axis	ACSPL+ Variable
A sine	AOUT2	C sine	N/A
A cosine	AOUT3	C cosine	N/A
Y sine	AOUT4	T sine	AOUT12
Y cosine	AOUT5	T cosine	AOUT13
B sine	AOUT6	D sine	N/A
B cosine	AOUT7	D cosine	N/A

Table 45 Power Supply for Sin-Cos Encoders

Item	Value
Source	onboard
Range	5Vdc
Max. supply load current per encoder	100mA

6.5.2 Sin-Cos Encoder Example

Figure 18 illustrates the Sin-Cos encoder interface for an X axis.

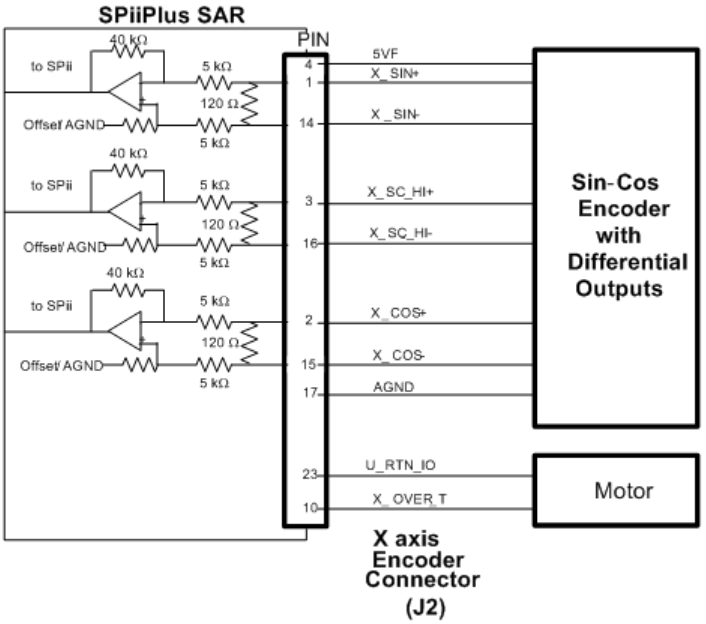


Figure 18 Sin-Cos Encoder Interface (X Axis)

6.5.3 Defining Sin-Cos Encoder Inputs as General Purpose

When no analog encoder is connected to an axis, these analog inputs may be used as general purpose inputs with voltage range of 1V ptp according to the following table:

Table 46 Analog Inputs as general purpose

Signal	ACSPL+ Variable
X_SIN	AIN0
X_COS	AIN1
A_SIN	AIN2
A_COS	AIN3
Y_SIN	AIN4
Y_COS	AIN5
B_SIN	AIN6
B_COS	AIN7
Z_SIN	AIN8
Z_COS	AIN9
C_SIN	AIN10
C_COS	AIN11
T_SIN	AIN12
T_COS	AIN13
D_SIN	AIN14
D_COS	AIN15

6.5.4 Digital Encoder Inputs

Table 47 Digital Encoder Inputs

Item	Value
Quantity	SPiiPlus SAR-4 four for X, Y, A, B SPiiPlus SAR-6 six for X, A ,Y, B, Z, C SPiiPlus SAR-8 eight for X,Y, Z, T, A, B, C, D
Interface Type	RS-422. See **Chapter 9 - Appendix A: Signal Definitions**.
Input Impedance	120Ω
Input frequency	Up to 30,000,000 counts/sec
Voltage Supply	5V, up to 100mA

Table 48 Power Supply for Analog Encoders

Item	Value
Source	onboard
Range	5 Vdc
Max. supply load current per encoder	100 mA

6.5.5 Digital Encoder Inputs Example

The following illustration shows the digital encoder interface.

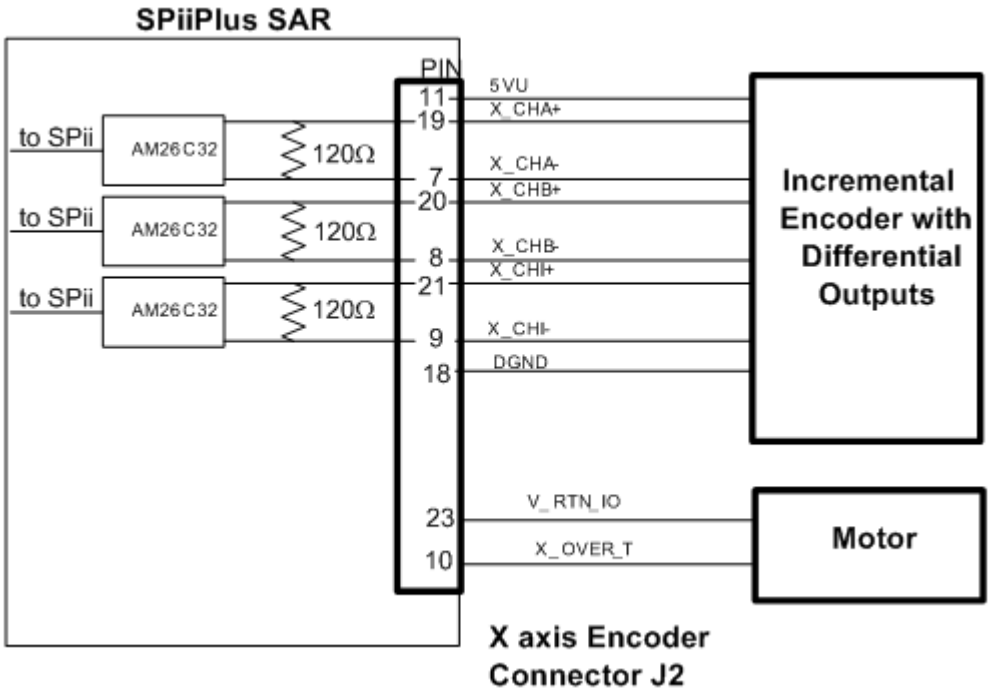


Figure 19 Digital Encoder Interface (X axis)

6.5.6 Motor Temperature Input

Table 49 Motor Temperature Input

Item	Value
Quantity	1 per axis
Type	Opto-isolated single ended
Logic	When the resistance between OVER_T (pin 10) and V_RTN_IO (pin 23) becomes greater than 3.6 kΩ, ±5% the Overheat fault of the SPiiPlus SAR ia activated.

Table 49 Motor Temperature Input

Item	Value
Overheat OFF	Resistance to ground that guarantees that OVERHEAT is off is <3.42kΩ
Overheat On	Resistance to ground that guarantees that OVERHEAT is on is >3.8kΩ.

Note	
	*To guarantee Over Temperature circuit operation, pin 9 (V_SUP_IO) of J19 Digital I/O connector has to receive 5V or 24V.*

Note	
	*A relay with the same resistance may be connected between OVER_T and V-RT_IO.*

The following illustration shows the motor temperature input for B axis.

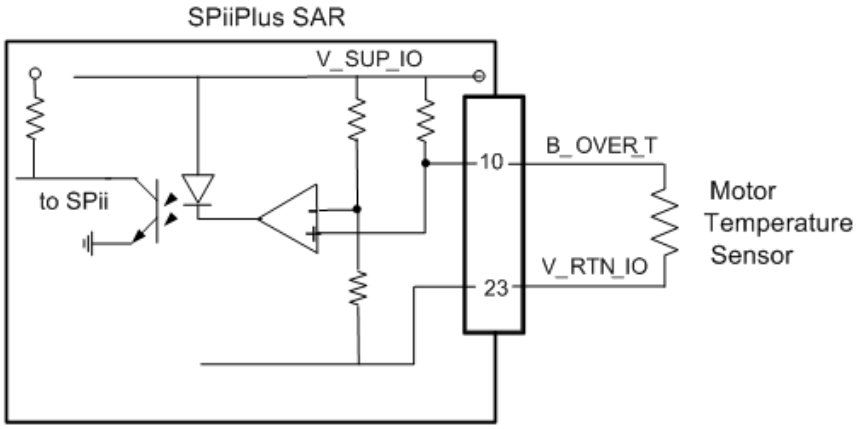


Figure 20 Connection to Motor Temperature Input (B axis)

6.5.7 Right and Left Limit Inputs

For detailed explanation, see **Section 6.9.1 - "J20 - Left and Right Limit Inputs"**.

6.6 Drive Connectors

The available drive connectors are: J1, J3, J5, J7, J9, J11, J13, J15.

The Drive connector interfaces with a third party amplifier by drive ±10V commands or Pulse Direction outputs, Enable output and Fault input.

The Drive connector is a 15-pin female HD D-Type connector which mates with a 15-pin male HD D-Type connector. The recommended wires to be employed are: AWG22 wires with shielding. Twisted pair cable for each differential signal (+ and -).

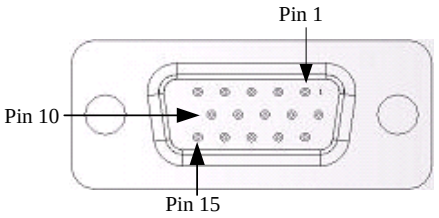


Figure 21 Drive Connectors Pin Layout

Note	
	• *Only connectors J3, J7, J11, and J15 have pins that interface with a Stepper motor.* • *The # symbol stands for the axis number.*

Table 50 provides the pinout for the Drive connector.

Table 50 J1, J5, J9 and J13 Drive Connector Pinout (page 1 of 2)

Pin	Name	Description
1	#_CMD0+	Command 0 non-inverted
2	#_CMD1+	Command 1 non-inverted
3	#_CMD0	Command 0 single-ended
4	N.C	Not connected
5	N.C	Not connected
6	AGND	Internal analog supply return
7	#_CMD0-	Command 0 inverted
8	#_CMD1-	Command 1 inverted
9	#_CMD1	Command 1 single-ened.
10	N.C	Not connected
11	#_FLT+	Fault input non-inverted
12	#_FLT-	Fault input inverted

Table 50 J1, J5, J9 and J13 Drive Connector Pinout (page 2 of 2)

Pin	Name	Description
13	#_ENA+	Enable output non-inverted
14	#_ENA-	Enable output inverted
15	DGND	Internal digital supply return

Table 51 J3, J7, J11 and J15 Drive Connector Pinout

Pin	Name	Description
1	#_CMD0+	Command 0 non-inverted
2	#_CMD1+	Command 1 non-inverted
3	#_CMD0	Command 0 single-ended
4	#_DIR-	Direction inverted
5	#_PULSE-	Clock inverted
6	AGND	Internal analog supply return
7	#_CMD0-	Command 0 inverted
8	#_CMD1-	Command 1 inverted
9	#_DIR+	Direction non-inverted
10	#_PULSE+	Clock non-inverted
11	#_FLT+	Fault input non-inverted
12	#_FLT-	Fault input inverted
13	#_ENA+	Enable output non-inverted
14	#_ENA-	Enable output inverted
15	DGND	Internal digital supply return

Note	
	*For single-ended outputs the recommended load is more than 20kΩ.*

6.6.1 Drive Command Outputs

SPiiPlus SAR provides 16 differential drive command outputs (two drive commands per axis) that you can use for sending drive commands to a third party drive for the following motor types:

Motor	Explanation
DC Brush motor	Consumes one analog output per axis
Three phase DC brushless/AC Servo motor	❑ Requires one analog output per axis when commutation is performed by the third pary drive. ❑ Requires two analog outputs per axis when commutation is performed by the controller (Software commutation)
Two phase DC brushless/AC Servo motor	Contact ACS Motion Control Technical Support
Nanomotion motor	Requires one analog output per axis

When you do not use the analog outputs as drive commands for axes X, A, Y, B, Z, T, you may use them as general purpose analog outputs as explained in **Section 6.6.7 - "Defining Drive Commands as General Purpose Analog Outputs"**. In addition, when the analog outputs for axes C and D are not used as drive commands, they may be used as general purpose analog outputs (ACSPL+ variables: AOUT10, AOUT11, AOUT14, AOUT15).

Table 52 Drive Command Outputs (page 1 of 2)

Item	Value
Quantity	SPiiPlus SAR: Two per axis SPiiPlus SAR-LT One per axis
Type	Differential, not isolated, or single-ended
Voltage Range	SPiiPlus SAR: Between the output's two differential lines -10V to 10V. Between (GND) and the output's (+) or (-) line: -5V to +5V. Between (GND) and the output -10V to 10V for single-ended SPiiPlus SAR-LT: Between the output's differential line -10V to 10V. Between (GND) and the output -10V to 10V for single-ended
D/A Resolution	16 bit
Digital Representation of Voltage Range	SPiiPlus SAR: -32768 to +32768 SPiiPlus SAR-LT: -511 to +511
Maximum Current	5 mA for differential outputs 2mA for single-ended outputs

Table 52 Drive Command Outputs (page 2 of 2)

Item	Value
D/A Conversion Circuit Accuracy	±2%
Protection	Short circuit and short to ground
Corresponding ACSPL+ Variables	DCOM0…DCOM15 in open loop DOUT0...DOUT15 in open loop

6.6.2 Drive Command Outputs Examples

The following diagrams show the drive outputs interface for an X axis.

Figure 22 shows (for the X axis) an output command connection for a DC **brush** motor.

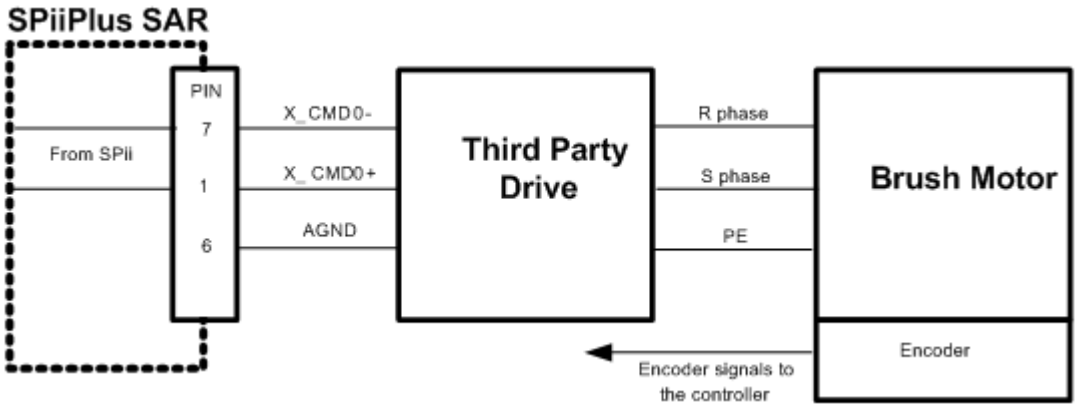


Figure 22 J1 Connection of Output Commands to DC Brush Motor Drive (X axis)

Figure 23 shows for (the X axis), an output command connection for a DC **brushless** motor.

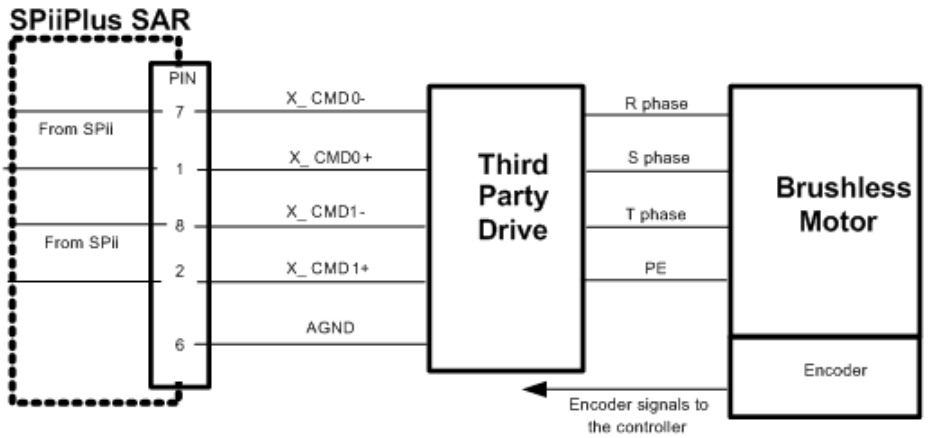


Figure 23 J1 Connection of Output Commands to DC Brushless Motor Drive (X

axis)

6.6.3 Pulse Direction Commands for Step Motor

The connector interfaces with Pulse Direction commands for Step motors. The controller can work with up to four Step motors powered by a third party drive in an open control loop. For information about the configuration of a step axis, refer to the *SPiiPlus Setup Guide*.

Table 53 Pulse Direction Commands

Item	Value
Quantity	SPiiPlus-SAR-4 - one pulse and one direction output per A, B axes SPiiPlus-SAR-6 - one pulse and one direction output per A, B, C axes SPiiPlus-SAR-8 - one pulse and one direction output per A, B, C, D axes
Type	Differential, RS422, not isolated
Maximum Current	10 mA
Maximum Pulse Rate	4,000,000 pulse/second
Protection	Short circuit

6.6.4 Pulse Direction Commands Example

The following figure illustrates a B axis implementation of a differential step drive connection:

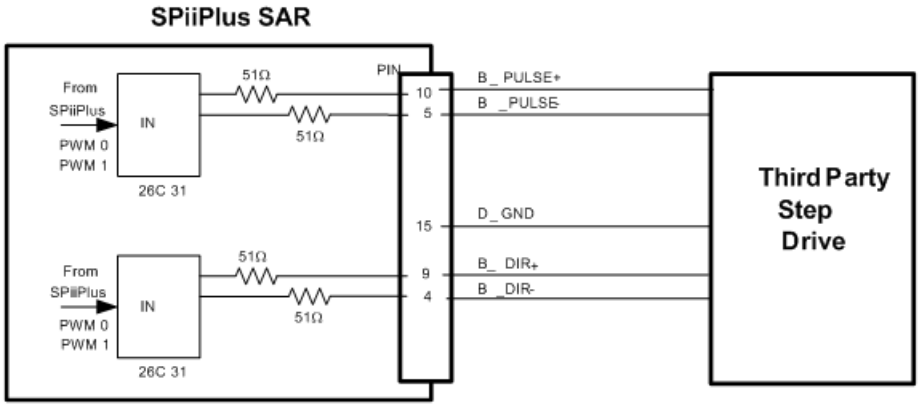


Figure 24 B Axis Implementation of a Differential Step Drive Connection

Note	
	*If the step drive has a single ended input command interface, use only the* **DIR+** *and the* **PULSE+** *commands.*

6.6.5 Drive Fault Input

The SPiiPlus-SAR provides one drive fault input per axis with user supplied 5V or 24V. You can use the drive fault input as sink or source type configuration.

Table 54 Drive Fault Input

Item	Value
Quantity	One per axis
Type	Two terminal, opto-isolated
Input Voltage	5Vdc (±10%) or 24Vdc(±20%),
Input Current	From 2.8mA to 14mA
Connection	Sink/Source configured by user
Reference	V_SUP_IO (for Sink configuration) or V_RTN_IO (for Source configuration).
Corresponding ACSPL+ Variables	(AXIS)_FAULT.#DRIVE

6.6.5.1 Drive Fault Illustrations

The following illustrations show an X axis drive fault interface for direct-connected servo drives. The same interface applies for direct-connected stepper drives.

Note	
	*If a power supply is not connected to the Fault circuit, connect the following:* *Third party drive ±5/24 volt input to* **V_SUP_IO** *(J19 connector) and* **X_FLT-** *to* **V_RTN_IO** *(J19 connector)*

Figure 25 shows (for axis X) the interface of a source type drive fault input from a servo drive.

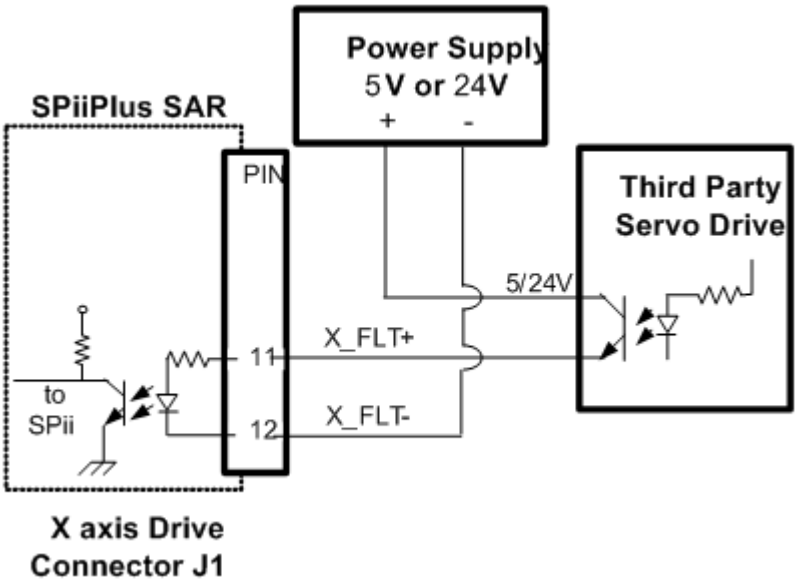


Figure 25 Source Type Drive Fault Input from a Servo Drive (X axis)

The following figure, **Figure 26**, shows the interface of a sink type drive fault input connection with external power supply from a servo drive for X axis.

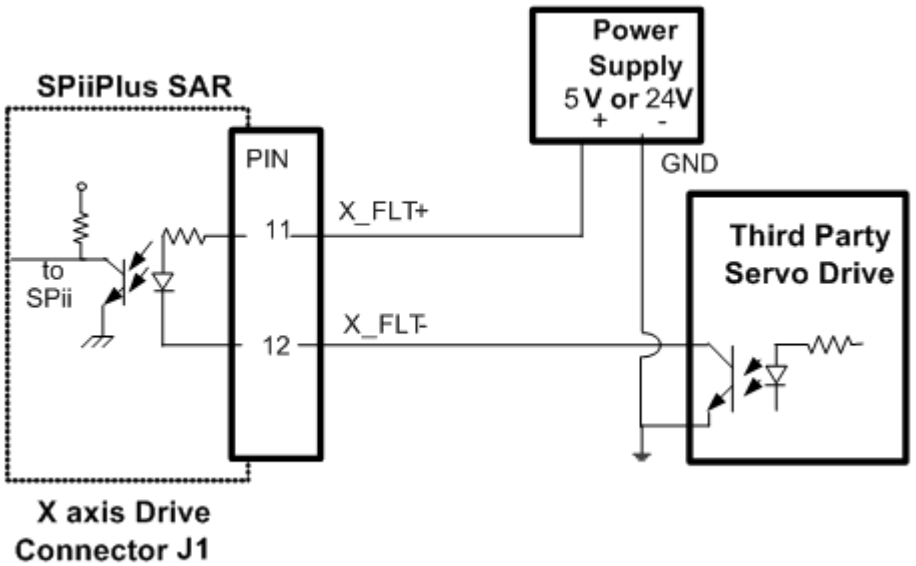


Figure 26 Connection to Drive with Sink Fault Input (X axis)

6.6.6 Drive Enable Output

Table 55 Drive Enable Output

Item	Value
Quantity	One per axis
Type	Single-ended, opto-isolated
Input Voltage	5 Vdc (±10%) or 24 Vdc(±20%),
Maximum Current	Up to 20 mA
Connection	Sink/Source configured by user
Reference	V_RTN_IO (for Source configuration - see **Figure 27**) or V_SUP_IO (for Sink configuration - see **Figure 28**).
Protection	Short circuit and short to ground.
Corresponding ACSPL+ Variables	ENABLE(AXIS)

The following diagrams show the drive enable interface of an X-axis direct-connected servo drive. The same interface applies for direct-connected step drives.

Caution	
	***The value of the pull-up or pull-down resistor must ensure that the enable output current does not exceed the controller's rated maximum current (20 mA).***

Figure 27 shows (for X axis) the interface of a source-type enable output connection to a servo drive, the drive having internal pull-down resistor. When the drive receives external 5V/24V, it becomes enabled.

,

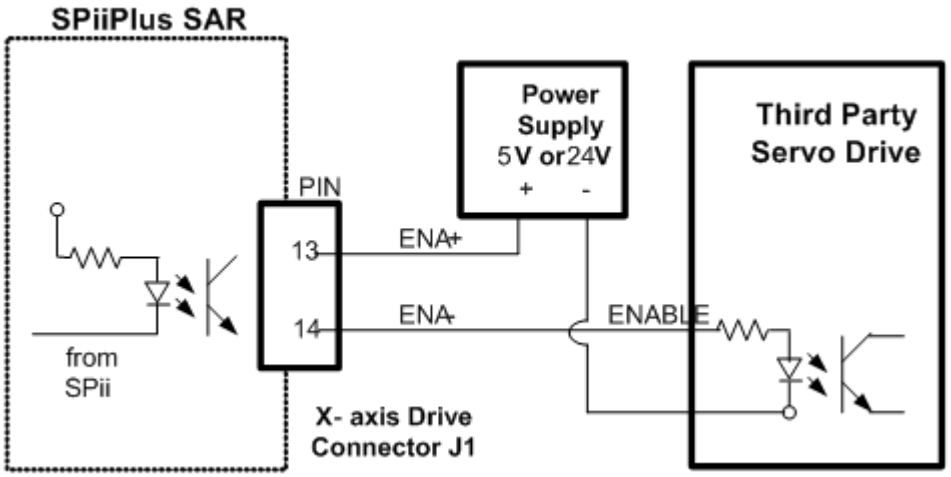


Figure 27 Source-Type Drive Enable Output (X axis)

Figure 28 shows (for the X axis) the interface of a sink enable connection to a servo drive, the drive having an external pull-up resistor and an external power supply. When the drive receives GND and source (5V/24V), it becomes enabled.

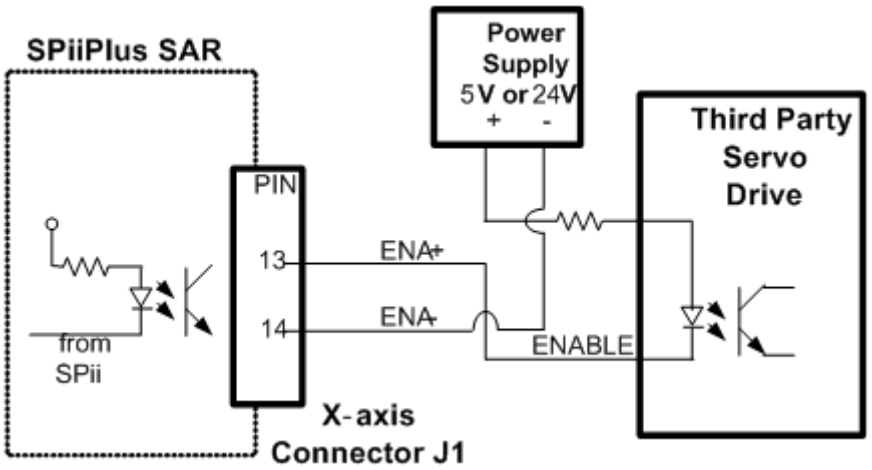


Figure 28 Sink-Type Drive Enable Output (X axis)

Figure 29 shows (for the X axis) the interface of a source-type enable output connection to a servo drive, the drive having an internal pull-down resistor and internal power supply. When the drive receives GND, it becomes enabled.

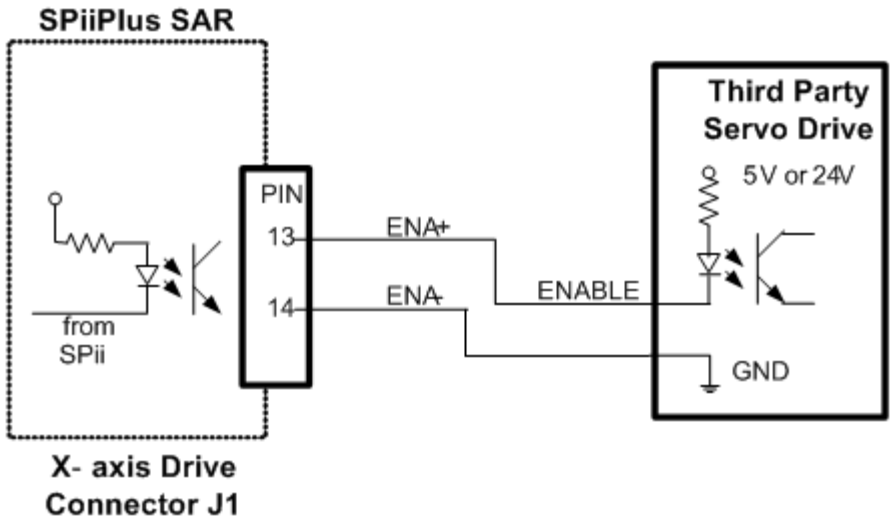


Figure 29 Sink-Type Drive Enable Output (X axis)

Figure 30 illustrates how to connect the SPiiPlus ENABLE outputs to a third side driver with TTL inputs.

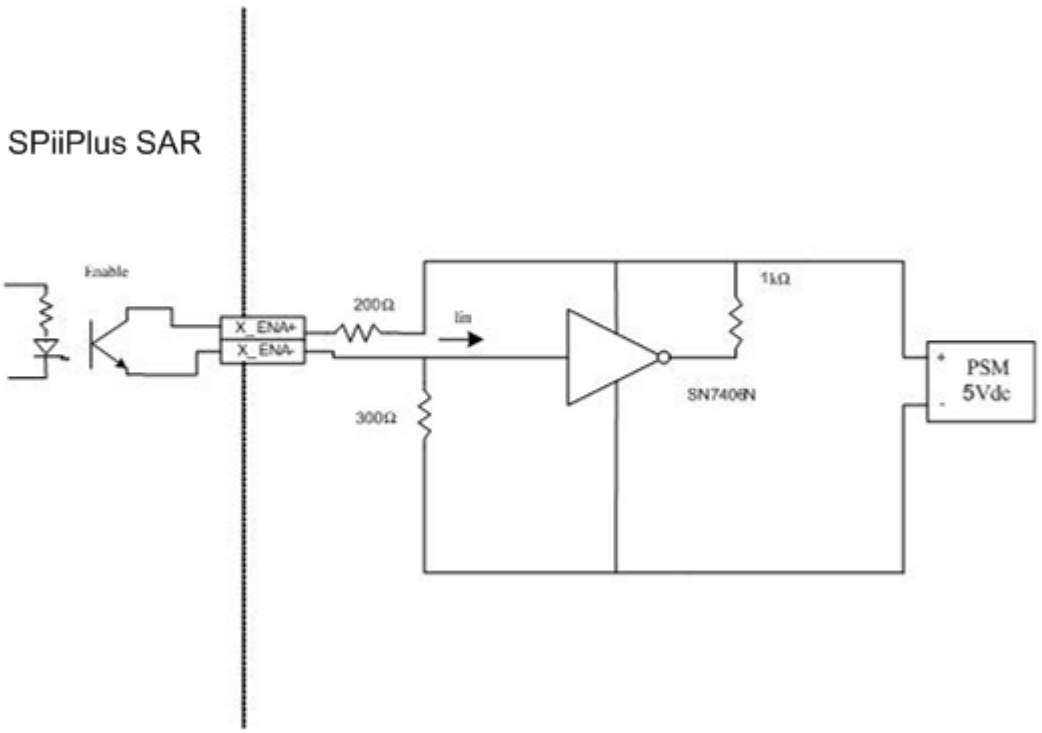


Figure 30 Connecting Enable Output to Third Side Drivers with TTL Inputs

6.6.7 Defining Drive Commands as General Purpose Analog Outputs

To define the drive command as general purpose analog outputs, do the following using ACSPL+:

1. Define **MFLAGS(axis).#OPEN=1**
2. Mask all faults for *axis*: **FMASK(axis) = 0**
3. Execute: **ENABLE(axis)**
4. Set the current limits to 100%: **XCURI(axis) = 100; XCURV(axis) = 100**

Note	
	*It is essential to run these commands because* **XCURI** *is 50% by default, which limits the maximum output to ±5V.*

5. Set the value of the analog output using the **DCOM** command. See **Table 56**.
   The scale of the **DCOM** command ranges from -100% to +100% which corresponds to analog output voltages from -10V to +10V.

Table 56 Drive Used for General Purpose - Differential

Axis	ACSPL+ Variable	Signal Name	Pin Number	
			+	-
X	DCOM0	X_CMD0±	J1/1	J1/7
A	DCOM4	A_CMD0±	J3/1	J3/7
Y	DCOM1	Y_CMD0±	J5/1	J5/7
B	DCOM5	B_CMD0±	J7/1	J7/7
Z	DCOM2	Z_CMD0±	J9/1	J9/7
C	DCOM6	C_CMD0±	J11/1	J11/7
T	DCOM3	T_CMD0±	J13/1	J13/7
D	DCOM7	D_CMD0±	J15/1	J15/7

Table 57 Drive Used for General Purpose - Single-Ended
(page 1 of 2)

Axis	ACSPL+ Variable	Signal Name	Pin Number	
			+	AGND
X	DCOM0	X_CMD0-	J1/1	J1/6
A	DCOM4	A_CMD0-	J3/1	J3/6
Y	DCOM1	Y_CMD0-	J5/1	J5/6

Table 57 Drive Used for General Purpose - Single-Ended (page 2 of 2)

Axis	ACSPL+ Variable	Signal Name	Pin Number	
			+	AGND
B	DCOM5	B_CMD0±	J7/1	J7/6
Z	DCOM2	Z_CMD0±	J9/1	J9/6
C	DCOM6	C_CMD0±	J11/1	J11/6
T	DCOM3	T_CMD0±	J13/1	J13/6
D	DCOM7	D_CMD0±	J15/1	J15/6

6.7 J19 - Digital I/O Connector

SPiiPlus SAR includes eight digital inputs and eight digital outputs. In addition, the connector provides a mechanical brake output for each axis.

The J19 connector is a 26-pin, male HD D-Type connector that mates with a 26-pin female HD D-Type connector. The recommended wires to be employed are: AWG22 wires with shielding. Twisted pair cable for each differential signal (+ and -).

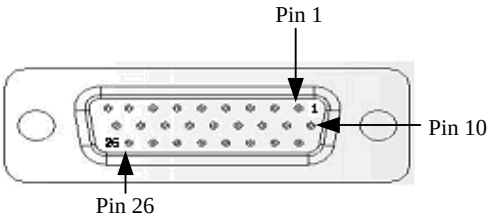


Figure 31 J19 - Digital I/O Connector Pin Layout

Table 58 provides the J19 pinout.

Table 58 J19 - Digital I/O Connector Pinout (page 1 of 2)

Pin	Name	Description	ACSPL+ Variable
1	OUT1	Digital output 1	OUT0.1
2	OUT3	Digital output 3	OUT0.3
3	OUT5	Digital output 5	OUT0.5
4	OUT7	Digital output 7	OUT0.7
5	IN1	Digital input 1	IN0.1
6	IN3	Digital input 3	IN0.3
7	IN5	Digital input 5	IN0.5
8	IN7	Digital input 7	IN0.7
9	V_SUP_IO	Input/Output Supply	
10	OUT0	Digital output 0	OUT0.0

Table 58 J19 - Digital I/O Connector Pinout (page 2 of 2)

Pin	Name	Description	ACSPL+ Variable
11	OUT2	Digital output 2	OUT0.2
12	OUT4	Digital output 4	OUT0.4
13	OUT6	Digital output 6	OUT0.6
14	IN0	Digital input 0	IN0.0
15	IN2	Digital input 2	IN0.2
16	IN4	Digital input 4	IN0.4
17	IN6	Digital input 6	IN0.6
18	V_RTN_IO	Input/Output Supply Return	
19	X_BRK	Mechanical brake X	OUT1.0
20	A_BRK	Mechanical brake A	OUT1.4
21	Y_BRK	Mechanical brake Y	OUT1.1
22	B_BRK	Mechanical brake B	OUT1.5
23	Z_BRK	Mechanical brake Z	OUT1.2
24	C_BRK	Mechanical brake C	OUT1.6
25	T_BRK	Mechanical brake T	OUT1.3
26	D_BRK	Mechanical brake D	OUT1.7

6.7.1 J19 - Digital Inputs

Table 59 J19 - Digital Inputs

Item	Value
Quantity	Eight
Type	Single-ended, opto-isolated
Maximum Propagation Delay	< 1msec
Input Voltage	5Vdc (±10%) or 24Vdc (±20%), detected automatically. Must be connected between the V_SUP_IO and V_RET_IO pins.
Maximum Current per input	From 2mA to 14mA per input, depending on external supply voltage.
Connection	Sink/source – jumper configured (JP3)
Corresponding ACSPL+ Variables	IN0.0…IN0.7

6.7.2 J19 - Digital Inputs Examples

Figure 32 shows the source-type switched general purpose digital input interface for IN0

Figure 33 shows the source-type PNP general purpose digital input interface for IN0

Figure 34 shows the sink-type switched general purpose digital input interface for IN0

Figure 35 shows the sink-type NPN general purpose digital input interface for IN0

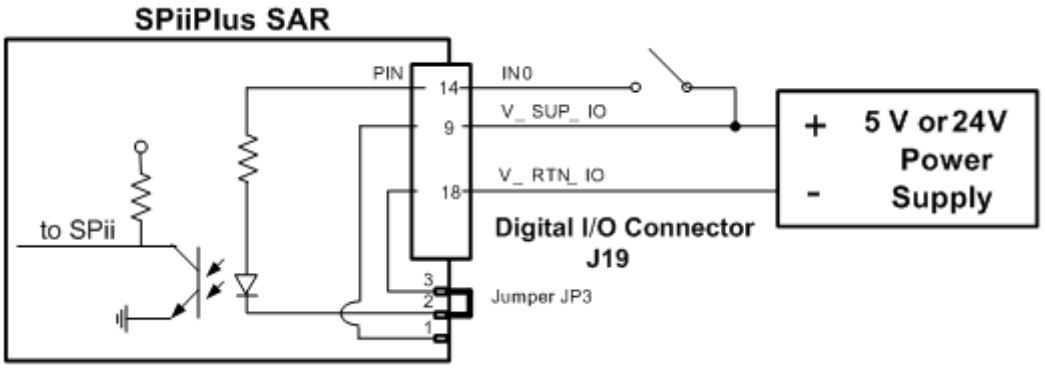


Figure 32 Source (Switched) Connection for Digital Input 0

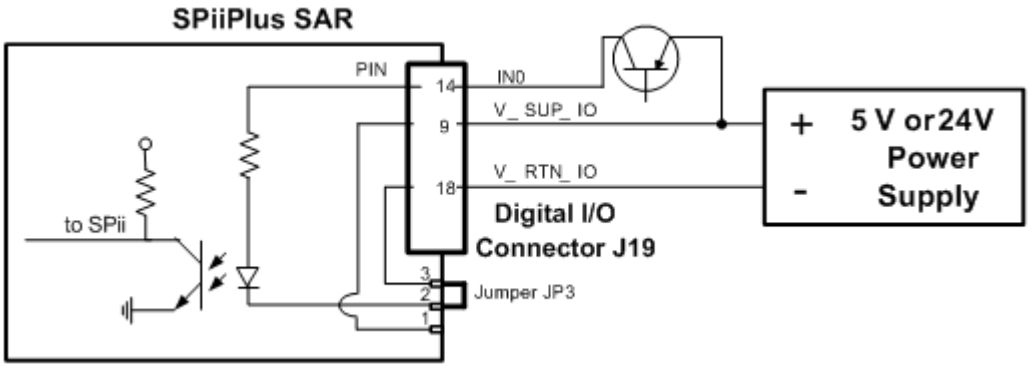


Figure 33 Source (PNP) Connection for Digital Input 0

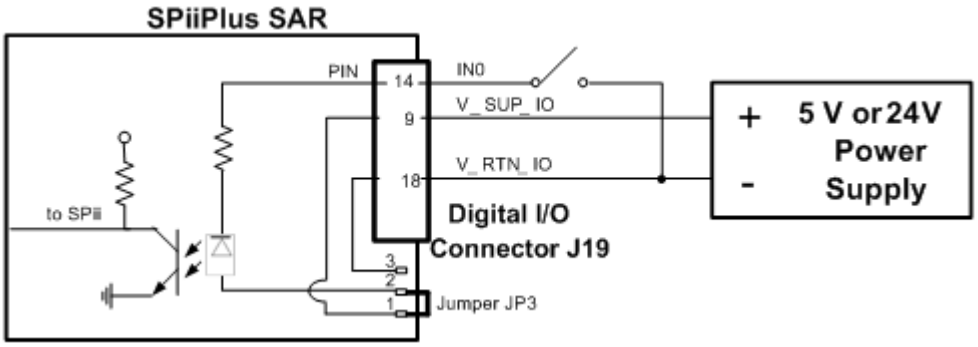


Figure 34 Sink (Switched) Connection for Digital Input 0

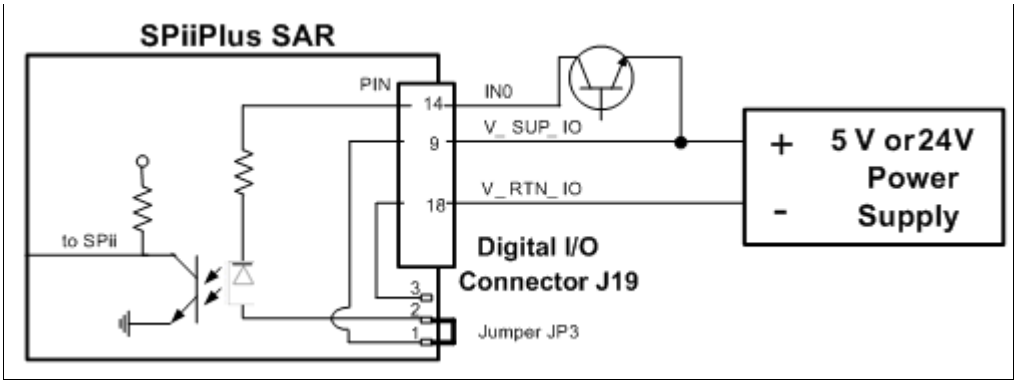


Figure 35 Sink (PNP) Connection for Digital Input 0

6.7.3 J19 - Digital Outputs

Table 60 J19 - Digital Outputs (page 1 of 2)

Item	Value
Quantity	Eight
Type	Single-end, opto-isolated
Input Voltage	5Vdc (±10%) or 24Vdc (±20%), detected automatically. Must be connected between the V_SUP_IO and V_RET_IO pins
Maximum Current per Output	350 mA, voltage drop < 2.5V (SPiiPlus SAR) 100 mA, voltage drop < 2.5 (SPiiPlus SAR-LT)
Maximum Current for all Outputs	400 mA (SPiiPlus SAR) 800 mA (SPiiPlus SAR-LT)
Protection	Overload (total current > 400mA) or short circuit with ground. A short circuit on any digital output will disable ALL digital outputs without any indication by the software. The digital outputs will become enabled again only after controller power-up.

Table 60 J19 - Digital Outputs (page 2 of 2)

Item	Value
Connection	Sink/source – jumper configured (JP2)
Corresponding ACSPL+ Variables	OUT0.0... OUT0.7

Note	
	*To test an output in source/sink configuration without a load, connect a pull-down/pull-up resistor.*

6.7.4 J19 - Digital Output Examples

Figure 36 illustrates the **source-type** general purpose digital output interface for output 0.

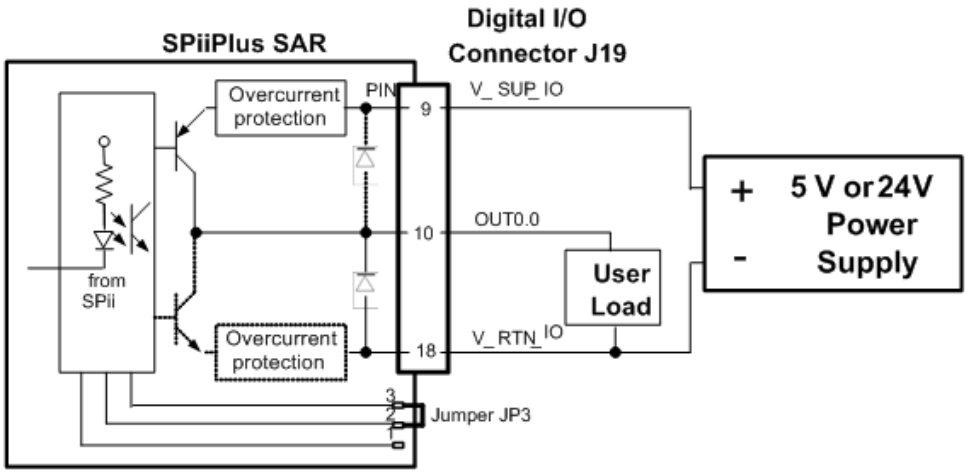


Figure 36 Source Connection for Digital Output 0

Note	
	*When jumper JP2 is set to pins 2 and 3, the circuit shown in a dashed line is inactive.*

Figure 37 illustrates the **sink-type** general purpose digital output interface for output 0.

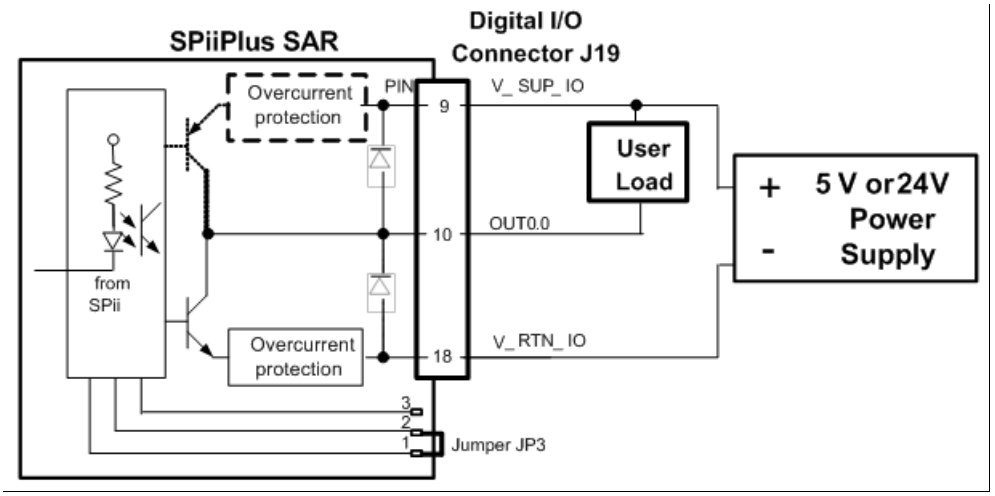


Figure 37 Sink Connection for Digital Output 0

Note	*When jumper JP2 is set to pins 1 and 2, the circuit shown in a dashed line is inactive.*

6.7.5 Mechanical Brake Outputs

Note	*When the axis is not equipped with a mechanical brake, the mechanical brake outputs can be used as general purpose outputs.*

Table 61 Mechanical Brake Outputs

Item	Value
Quantity	One per axis
Type	Single-end, opto-isolated, source only
Input Voltage	5Vdc (±10%) or 24Vdc (±20%), detected automatically. Must be connected between the V_SUP_IO and V_RET_IO pins
Maximum Current per Output	7mA
Maximum Current for All Outputs	56mA
Maximum Drop Voltage in Controller Circuit	2V (SPiiPlus SAR & SAR-LT) ≤0.3V (SPiiPlus SAR-LT)
ACSPL+ Variables	OUT1.0...OUT1.7

6.7.6 Digital Brake Output Example

Figure 38 illustrates the brake output interface for axis X.

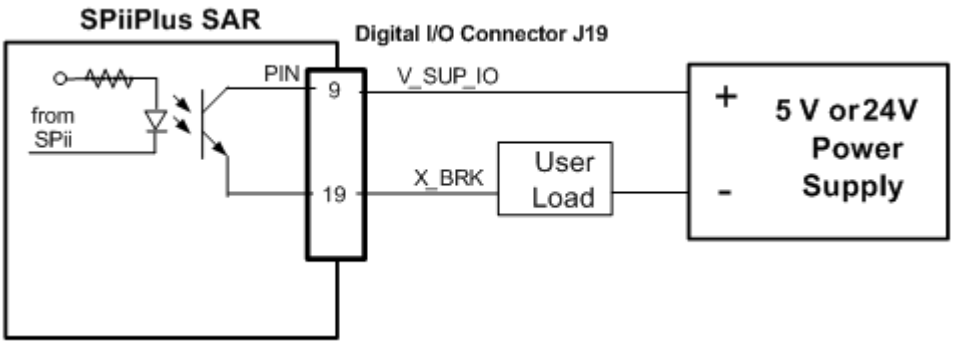


Figure 38 Source Connection for Using X_BRK as a General Purpose Output

6.8 J17 - PEG & Mark Connector

The SPiiPlus SAR connector J17 interfaces with PEG and PEG State outputs, and Mark inputs:

- The SPiiPlus SAR provides up to four PEG pulse outputs
- The SPiiPlus SAR provides three PEG State outputs for X axis only.
- The SPiiPlus SAR provides two Mark inputs for X axis and one for Y, Z, T axes.
- The SPiiPlus SAR-LT provides two Mark inputs for both X and Y axes, and one for Z and T axes.

The J17 connector is a 44-pin, female HD-Type connector that mates with a 44-pin male HD-Type connector. The recommended wires to be employed are: AWG22 wires with shielding. Twisted pair cable for each differential signal (+ and -).

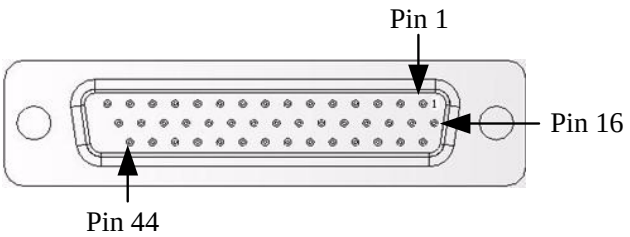


Figure 39 J17 - PEG & Mark Connector Pin Layout

Table 62 provides the J17 pinout.

Table 62 J17 - PEG & Mark Connector Pinout (page 1 of 2)

Pin	Name	Description	ACSPL+ Variable
1	N.C	Not connected	
2	N.C	Not connected	
3	N.C	Not connected	
4	X_STATE2+	STATE digital output, non-inverted	
5	X_STATE1+	STATE digital output, non-inverted	
6	X_STATE0+	STATE digital output, non-inverted	
7	N.C	Not connected	
8	N.C	Not connected	
9	DGND	Internal digital supply return	
10	DGND	Internal digital supply return	
11	T_PEG+	PEG Digital output non inverted	
12	Z_PEG+	PEG Digital output non inverted	
13	Y_PEG+	PEG Digital output non inverted	
14	X_PEG+	PEGDigital output non inverted	
15	N.C	Not connected	
16	N.C	Not connected	
17	N.C	Not connected	
18	N.C	Not connected	
19	X_STATE2-	State Digital output inverted	
20	X_STATE1-	State Digital output inverted	
21	X_STATE0-	State Digital output inverted	
22	N.C	Not connected	
23	N.C	Not connected	
24	N.C	Not connected	
25	N.C	Not connected	
26	T_PEG-	PEG Digital output inverted	
27	Z PEG-	PEG Digital output inverted	
28	Y_PEG-	PEG Digital output inverted	
29	X_PEG-	PEG Digital output inverted	
30	N.C	Not connected	
31	X_MARK1+	Mark Digital input non inverted	IN8.8 or MARK0
32	X_MARK1-	Mark Digital input inverted	IN8.8 or MARK0
33	X_MARK2+	Mark Digital input 2 non inverted	IN8.10 or M2ARK0
34	X_MARK2-	Mark Digital input 2 inverted	IN8.10 or M2ARK0
35	Y_MARK1+	Mark Digital input non inverted	IN9.8 or MARK1
36	Y_MARK1-	Mark Digital input inverted	IN9.8 or MARK1
37	N.C	Not connected	

Table 62 J17 - PEG & Mark Connector Pinout (page 2 of 2)

Pin	Name	Description	ACSPL+ Variable
38	N.C	Not connected	
39	Z_MARK1+	Mark Digital input non inverted	IN10.8 or MARK2
40	Z_MARK1-	Mark Digital input inverted	IN10.8 or MARK2
41	N.C	Not connected	
42	N.C	Not connected	
43	T_MARK1+	Mark Digital input non inverted	IN11.8 or MARK3
44	T_MARK1-	Mark Digital input inverted	IN11.8 or MARK3

Model	
	*Pins 19, 20, 21, 33 and 34 are not used by SPiiPlus SAR-LT.*

6.8.1 J17 - PEG Outputs Interface

Table 63 Fast Digital Outputs (PEG)

Item	Value
Quantity	SPiiPlus SAR-4: one PEG pulse for X, Y axes SPiiPlus SAR-6: one PEG pulse for X, Y, Z axes SPiiPlus SAR-8: one PEG pulse for X, Y, Z, T axes **Note**: these quantities also apply to SPiiPlus SAR-LT
Type	RS-422, see **Chapter 9 - Appendix A: Signal Definitions**.
Maximum Propagation Delay	< 0.1µsec. The propagation delay includes both the encoder processing logic time and the delay of PEG logic.
PEG generated pulse width range	25nSec to 1.6mSec, programmable
Edge Separation between Two PEG Events	>200nSec
Number of PEG Events in Random PEG mode	Up to 30,000
Interface	TI AM26C32 line receiver (recommended)
Associated ACSPL+ Commands	**PEG_I** and **PEG_R**.

6.8.2 J17 - PEG Examples

Figure 40 illustrates the PEG pulse output interface for axis X.

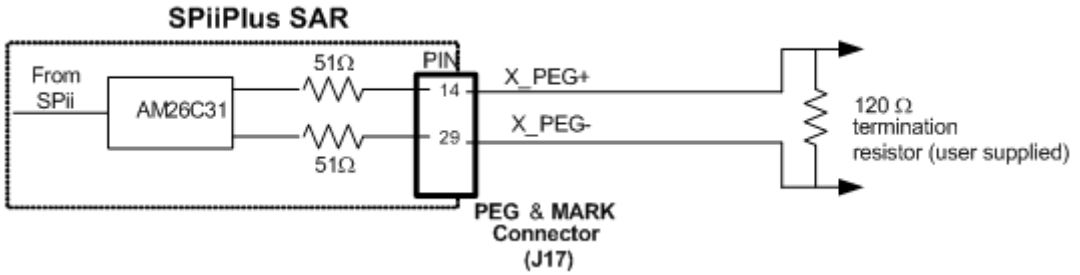


Figure 40 Example of X PEG Pulse Output Connection

Note	*A user-supplied 120Ω resistor must be installed between the two differential signals of the PEG outputs.*

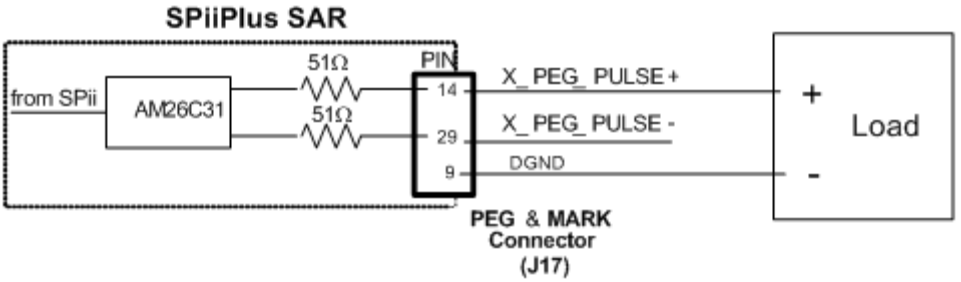


Figure 41 Example of X PEG Pulse Single-Ended Configuration

Note	*Single-ended PEG confutation is not recommended due to noise.*

6.8.3 J17 - PEG States Interface

Table 64 PEG States

Item	Value
Quantity	SPiiPlus SAR-4: Three PEG states for X axis SPiiPlus SAR-6: Three PEG states for X axis SPiiPlus SAR-8: Three PEG states for X axis **Note:** SPiiPlus SAR-LT does not support PEG state outputs
Type	RS-422, see **Chapter 9 - Appendix A: Signal Definitions**.
Maximum Propagation Delay	< 0.1µsec. The propagation delay includes both the encoder processing logic time and the delay of PEG logic.
Interface	TI AM26C32 line receiver (recommended)

For J17 PEG illustrations, see **Section 6.8.2 - "J17 - PEG Examples"**.

6.8.4 J17 - MARK Interface

The MARK inputs may be handled as general purpose digital input as described in **Table 62**.

Table 65 J17 - Mark Interface

Item	Value
Quantity	SPiiPlus SAR-4: Three Mark pulses; two for X and one for Y SPiiPlus SAR-6: Four Mark pulses; two for X, one for Y, Z SPiiPlus SAR-8: Five Mark pulses; two for X, one for Y, Z, T **Note**: These quantities also apply to SPiiPlus SAR-LT
Type	RS-422, see **Chapter 9 - Appendix A: Signal Definitions**.
Maximum Propagation Delay	< 0.1µsec. The propagation delay includes both the encoder processing logic time and the delay of PEG logic.
Interface	TI AM26C32 line tranceiver (recommended)
Associated ACSPL+ Commands	**MARK** and **M2ARK**.

6.8.5 J17 - MARK Interface Examples

Figure 42 shows the MARK/general purpose differential input interface for X axis.

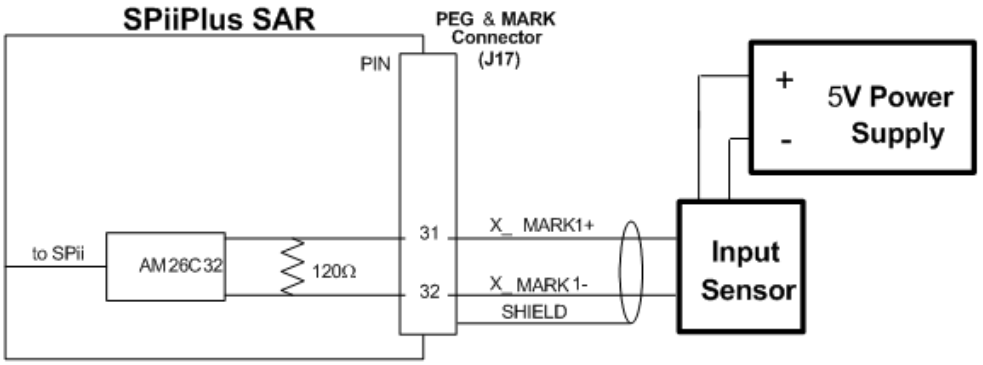


Figure 42 Differential Connection for MARK1 Input (X axis)

Figure 43 shows the MARK/general purpose purpose single-ended input interface for X axis.

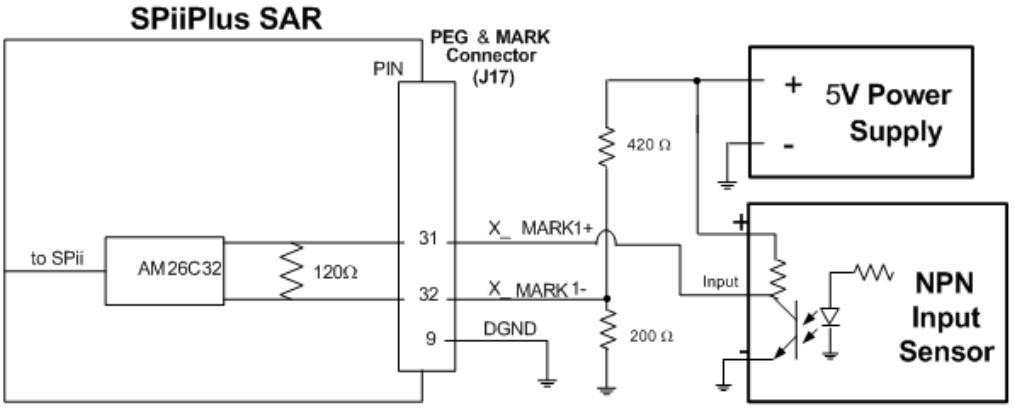


Figure 43 Single-Ended (NPN) Connection for MARK1 Input (X axis)

6.9 J20 - Safety Inputs Connector

The SPiiPlus SAR provides the following safety inputs:

- **J20 - Left and Right Limit Inputs**
- **J20 - Emergency Stop Inputs**

The J20 connector is a 25-pin, male D-Type connector that mates with a 25-pin female D-Type connector. The recommended wires to be employed are: AWG22 wires with shielding. Twisted pair cable for each differential signal (+ and -).

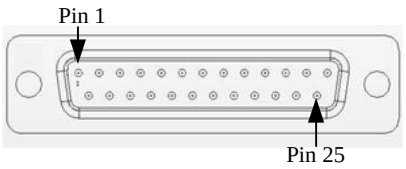


Figure 44 J20 - Safety Input Connector Pin Layout

Table 66 provides the J20 pinout.

Table 66 J20 - Safety Connector Pinout (page 1 of 2)

Pin	Name	Description
1	V_SUP_SFTY	Safety supply +5/24Vdc
2	N.C	Not connected
3	X_LL	Y axis left limit
4	A_LL	A axis left limit
5	Y_LL	Y axis left limit
6	B_LL	B axis left limit
7	Z_LL	Z axis left limit
8	C_LL	C axis left limit
9	T_LL	T axis left limit
10	D_LL	D axis left limit
11	N.C	Not connected
12	N.C	Not connected
13	N.C	Not connected
14	V_RTN_SFTY	Safety supply return
15	N.C	Not connected
16	X_RL	X axis right limit
17	A_RL	A axis right limit
18	Y_RL	Y axis right limit
19	B_RL	B axis right limit
20	Z_RL	Z axis right limit
21	C_RL	C axis right limit

Table 66 J20 - Safety Connector Pinout (page 2 of 2)

Pin	Name	Description
22	T_RL	T axis right limit
23	D_RL	D axis right limit
24	ES+	Emergency stop non inverted
25	ES-	Emergency stop inverted

6.9.1 J20 - Left and Right Limit Inputs

Table 67 J20 - Limit Inputs

Item	Value
Quantity	One left limit and one right limit for each axis
Type	Single-ended, opto-isolated
Connection	Sink/Source configured by user with JP1
Maximum Input Current	<15mA
External Supply Voltage	5Vdc (±10%)/1A or 24Vdc (±20%)/1A, detected automatically. Must be connected between the V_SUP_SFTY and V_RET_SFTY pins
Maximum Propagation Delay	1msec
Corresponding ACSPL+ Variables	**<AXIS>_FAULT.#LL** and **<AXIS>_FAULT.#RL** (example: X_FAULT.#LL)

Note	
	*To guarantee Right and Left Limit operation, pin 1 (V_SUP_SFTY) of J20 Safety Inputs connector has to receive 5V or 24V.*

6.9.2 J20 - Right and Left Limits Examples

The following diagrams show the right and left limit available in the encoder connectors, in the illustrations connector J2. Right and Left limit pins for all axes are also available in Safety Inputs connector J20. When using Right and Left limit in either connector (Safety or Encoder) pin 1 of J20 V_SUP_SFTY has to be connected to 5V or 24V.

Figure 45 shows a source-type switched for Right Limit input interface for axis X.

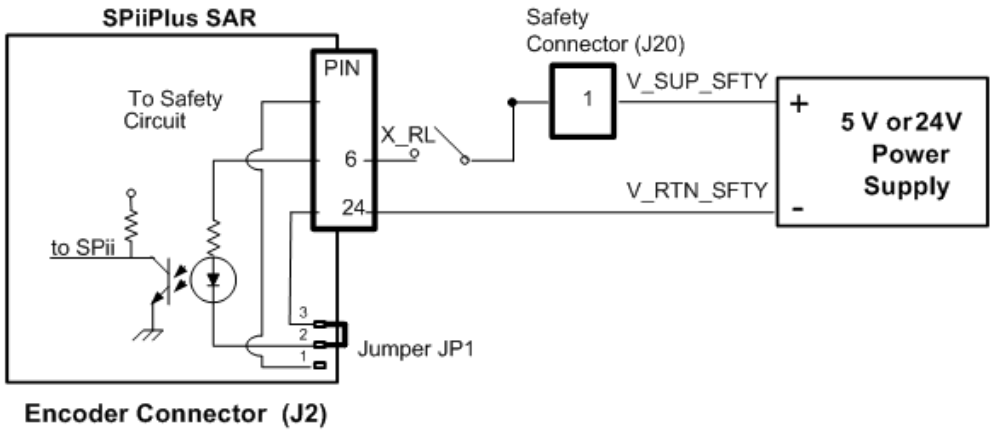


Figure 45 Source (Switched) Right Limit Input Connection (X axis)

Figure 46 shows a source type PNP Right Limit input interface for axis X.

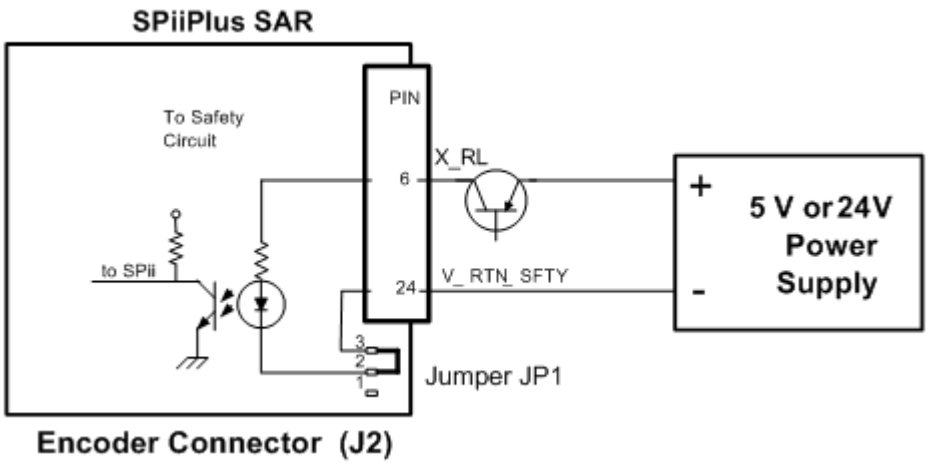


Figure 46 Source (PNP) Right Limit Input Connection (X axis)

Figure 47 illustrates a sink type switched Right Limit input interface for axis X.

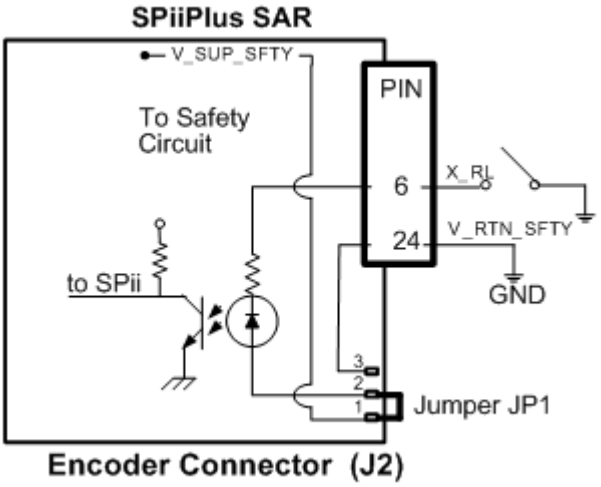


Figure 47 Sink (Switched) Right Limit Input Connection (X axis)

Figure 48 illustrates a sink type NPN Right Limit interface for axis X.

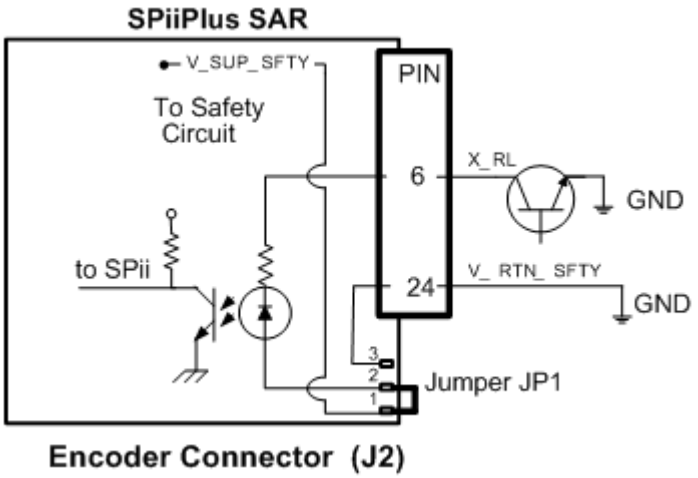


Figure 48 Sink (NPN) Right Limit Connection (X Axis)

6.9.3 J20 - Emergency Stop Inputs

Table 68 J20 - Emergency Stop Inputs

Item	Value
Quantity	One
Type	Two-terminal, opto-isolated, sink or source
External Supply Voltage	5Vdc (±10%)/1A or 24Vdc (±20%)/1A, detected automatically. Must be connected between the V_SUP_SFTY and V_RET_SFTY pins
Maximum Input Current	<15mA
Maximum Propagation Delay	<1msec
Connection	Sink/source, configured by user with JP1
Corresponding ACSPL+ Variables	SFAULT.#ES

6.9.4 J20 - Emergency Stop Examples

The following diagrams illustrate the emergency stop input interface for axis X.

Figure 49 shows a **source** emergency stop input interface.

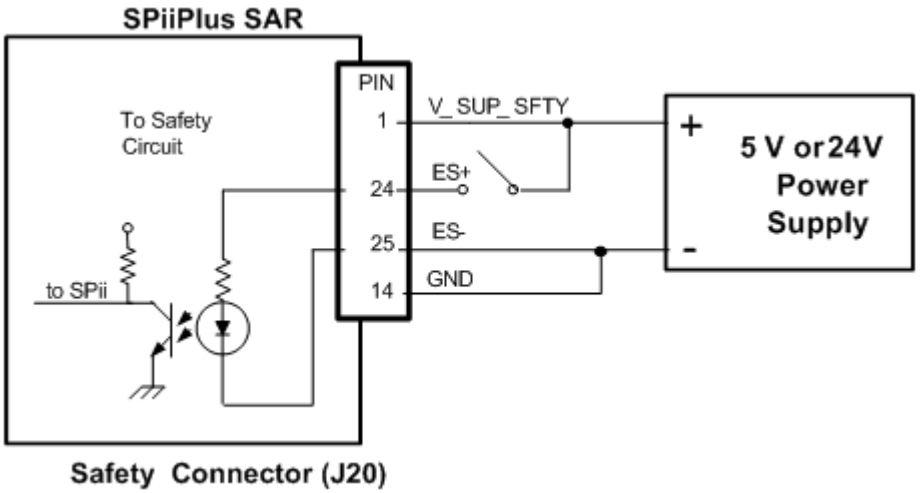


Figure 49 Source Connection for Emergency Stop Input

Figure 50 illustrates a **sink** emergency stop input interface.

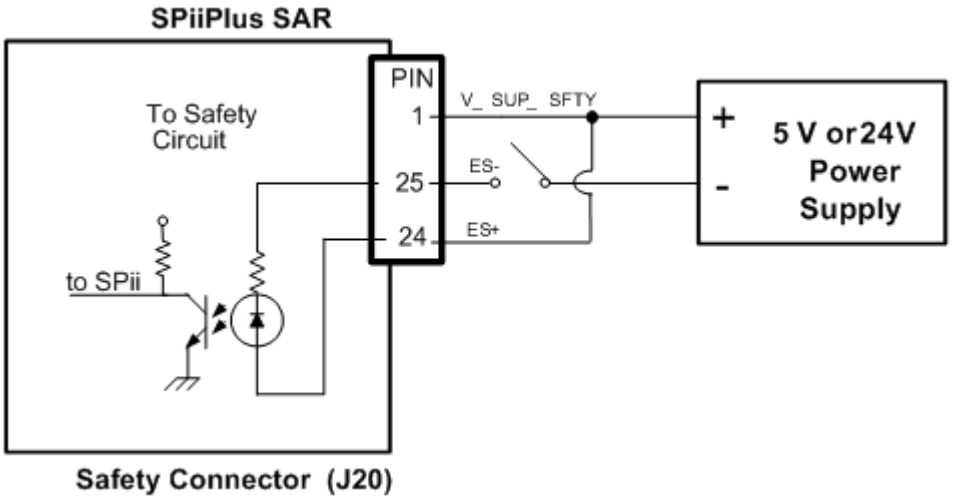


Figure 50 Sink Connection for Emergency Stop Input

6.10 HSSI Network Connectors

SPiiPlus SAR provides two HSSI channels: connectors J22 and J23.

SPiiPlus SAR-LT only provides one HSSI channel: connector J22.

Use these channels to communicate with:

- Remote HSSI modules
- HSSI-IO16 (I/O expansion) and
- HSSI-ED2 (two remote axes interface module).

For more information refer to the *HSSI Modules Hardware Guide*.

The HSSI connectors are 8-pin, RJ-45 sockets that mate with an 8-pin, RJ45 plug. The recommended wires are: Standard Ethernet cable FTP type, category 5, 20 m maximum length.

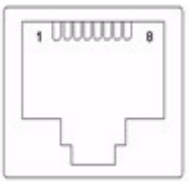


Figure 51 J22 and J23 - HSSI Connectors Pin Layout

Table 69 provides the HSSI connectors pinout.

Table 69 HSSI Connector Pinout

Pin	Name	Description
1	CONTROL_0+	Control signal non-inverted output for channel 0. The signal includes START (synchronization for data transfer) and SER_CLK (data clock) information.
2	CONTROL_0-	Control signal inverted output for channel 0.
3	SER_DI_0+	Serial data non-inverted input for channel 0.
4	SER_DI-0-	Serial data inverted input for channel 0.
5	SER_DO_0+	Serial data non-inverted output for channel 0.
6	SER_DO_0-	Serial data inverted output for channel 0.
7	DGND	Digital ground for 5L
8	DGND	Digital ground for 5L

6.10.1 HSSI Interface

Table 70 HSSI Interface

Item	Value	
	SPiiPlus SAR	SPiiPlus-SAR-LT
Quantity	SPiiPlus SAR-4: two SPiiPlus SAR-6: two SPiiPlus SAR-8: two	SPiiPlus SAR-LT-4: one SPiiPlus SAR-LT-6: one SPiiPlus SAR-LT-8: one
Input Word Size	64 bits per HSSI channel	
Output Word Size	64 bits per HSSI channel	
Tx/Rx Type	RS422 compatible. See **Chapter 9 - Appendix A: Signal Definitions**.	
Sampling & Update rate	20KHz	

6.11 Communication Connectors

The following communication channels are supported:

- Two RS-232 serial communication ports (COM1, COM2) - Connectors J26 and J27, respectively
- Two Ethernet TCP/IP, 10/100 Mbits/sec Base -T communication ports (ETH1, ETH2) - Connectors J21 and J25, respectively
- One CANopen communication port (CAN) - Connector J24

6.11.1 J26, J27 - COM Connectors

Note	
	*Refer to the SPiiPlus Setup Guide for how to establish serial(RS-232) and Ethernet communication.*

The COM connectors are 9-pin, male D-Type connectors that mate with 9-pin, female D-Type connectors. The recommended wires are: AWG22 wires with shielding.

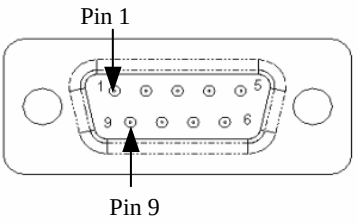


Figure 52 J26, J27 - COM Connectors Pin Layout

Table 71 provides the COM connector pinout.

Table 71 J26, J27 - COM 1, COM 2 Connectors Pinout

Pin	Name	Description
1	SHIELD	Cable shield connection
2	RX232	RS-232 receive signal
3	TX232	RS-232 transmit signal
4	NC	Not connected
5	DGND	Digital ground.
6	N.C	Not connected
7	N.C	Not connected
8	N.C	Not connected
9	N.C	Not connected

6.11.2 J26, J27 - COM Port Interface Specifications

Table 72 J26, J27 - COM Port Interface Specifications

Item	Value
Quantity	Two
Type	RS232
Maximum Baud rate	115,200 bps

6.11.3 J21, J25 - Ethernet Connector

The Ethernet connector is an 8-pin, RJ-45 sockets that mates with an 8-pin, RJ45 plug. The recommended wires are: Standard Ethernet cable FTP type, category 5.

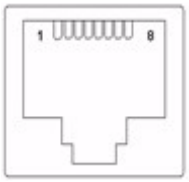


Figure 53 J21, J25 - Ethernet Connector Pin Layout

Table 73 provides the J21, 25pinout.

Table 73 J21, 25- Ethernet Connector Pinout

Pin	Name	Description
1	TD+	Positive transmit signal
2	TD-	Negative transmit signal
3	RD+	Positive receive signal
4	N.C	Not connected
5	N.C	Not connected
6	RD-	Negative receive signal
7	N.C	Not connected
8	N.C	Not connected

6.11.4 J21, J25 - Ethernet Port Specifications

Table 74 J21 - Ethernet Port Specifications

Item	Value
Quantity	Two
Type	TCP/IP 10/100Mpbs

6.11.5 J24 - CANopen Connector

The CANopen connector is an 8-pin, RJ-45 sockets that mates with an 8-pin, RJ45 plug. The recommended cable is a shielded twisted-pair cable with maxium length of up to 30m, for example, a STP cable cat 5 with RJ45 plug connectors.

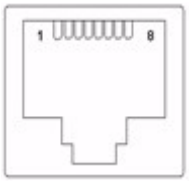


Figure 54 J24 - CANopen Connector Pin Layout

Table 75 provides the pinout for J24.

Table 75 J24 - CANopen Connector Pinout

Pin	Name	Description
1	CAN_H	CAN_H bus line
2	CAN_L	CAN_L bus line
3	CAN_GND	Ground, return CAN supply (optional)
4	N.C	Not connected
5	N.C	Not connected
6	CAN_SHLD	CAN shield (optional)
7	CAN_GND	Ground, return CAN supply (optional)
8	CAN_V+	CAN external positive power supply (optional)
Shell	Shield	Shield (drain wire)

The typical CAN bus connection is shown in **Figure 55**.

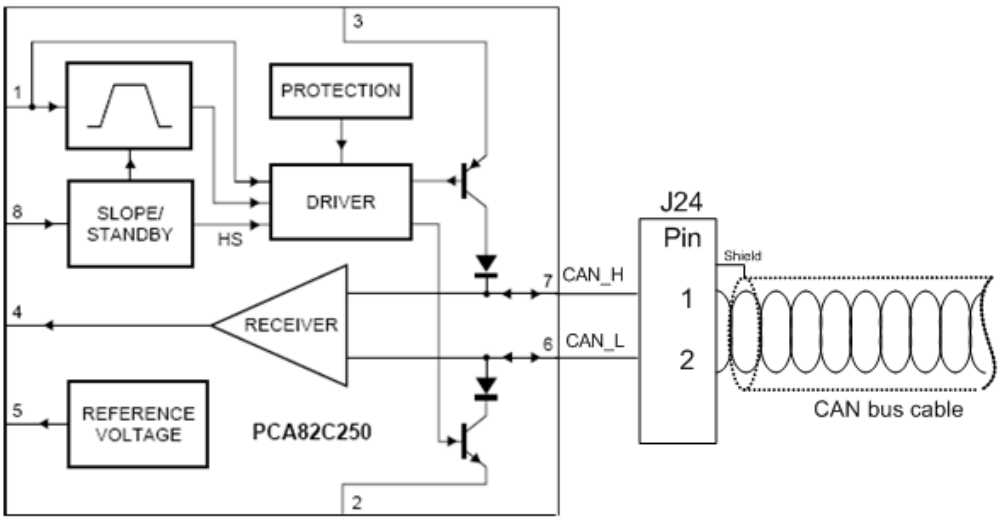


Figure 55 Typical CAN bus Connection

When employing an external power supply (for example, in a network), a 120Ω termination resistor is required between CAN-H and CAN-L at both ends of the cabling (as shown in **Figure 56**).

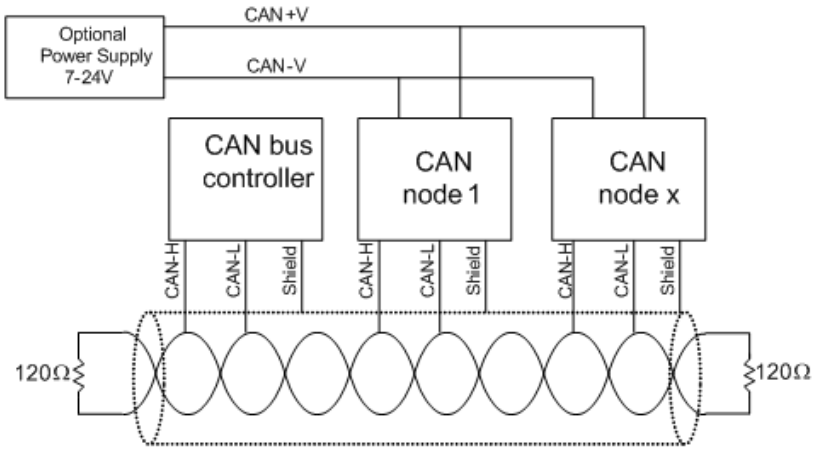


Figure 56 CAN bus with Optional Power Supply

7 Jumpers

The sink and source configuration of the digital inputs, digital outputs and safety inputs is jumper dependent.

7.1 SPiiPlus SAR Jumpers

SPiiPlus SAR has three jumpers:

- JP1 - Safety Inputs
- JP2 - Digital Outputs
- JP3 - Digital Inputs

7.1.1 SPiiPlus SAR Jumper Locations

Figure 57 shows the location of the jumpers on the SPiiPlus SAR card:

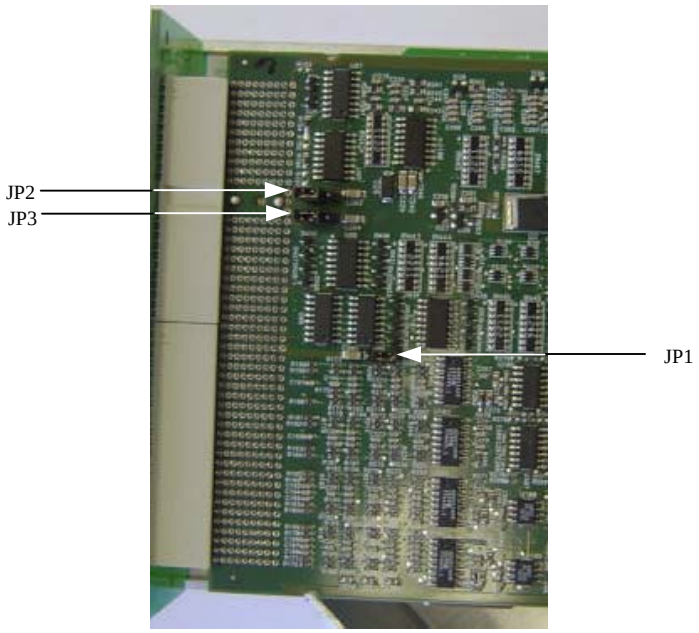


Figure 57 Jumper Locations

7.1.2 SPiiPlus SAR Jumper Settings

Table 76 SPiiPlus SAR Jumper Settings

Name	Position	Description
JP1	Sink - 1, 2 (Default) Source - 2, 3	Safety Inputs
JP2	Sink - 1, 2 (Default) Source - 2, 3	Digital Outputs
JP3	Sink - 1, 2 (Default) Source - 2, 3	Digital Inputs

The order of the pins is illustrated in **Figure 58**.

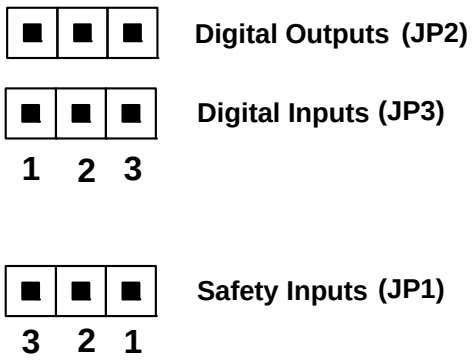


Figure 58 SPiiPlus SAR Jumper Settings

7.2 SPiiPlus SAR-LT Jumpers

SPiiPlus SAR-LT has six jumpers:

- JP1 - Safety Inputs
- JP2 - Digital Outputs
- JP3 - Digital Inputs
- JP7 - I^2C slave device
- JP8 - CANbus termination
- JP9 - Opto-isolated fast input/output

Note	
	*There is a jumper, JP4, on the board that serves for factory testing of the software. When it is installed, it puts the SPiiPlus SAR-LT in the Debug mode. A plug for JP4 is not supplied.*

7.2.1 SPiiPlus SAR-LT Jumper Locations

Figure 59 shows the location of the jumpers on the SPiiPlus SAR-LT card:

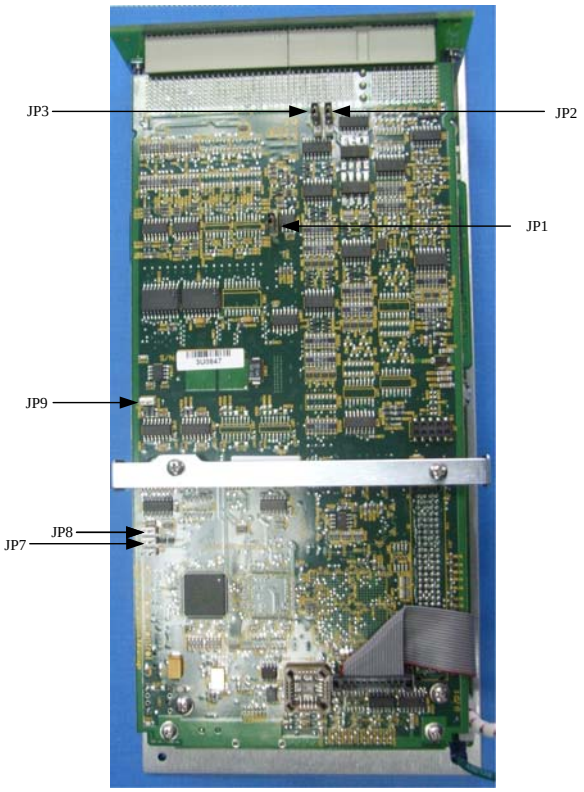


Figure 59 SPiiPlus SAR-LT Jumper Locations

7.2.2 SPiiPlus SAR-LT Jumper Settings

Table 77 SPiiPlus SAR-LT Jumper Settings

Name	Position	Description
JP1	Sink - 1, 2 (Default) Source - 2, 3	Safety Inputs
JP2	Sink - 1, 2 (Default) Source - 2, 3	Digital Outputs
JP3	Sink - 1, 2 (Default) Source - 2, 3	Digital Inputs
JP7	Default - not connected	I^2C slave device EEPROM data protection
JP8	Default - not connected	CANbus termination 120Ω
JP9	Default - not connected	Opto-isolated fast inputs/outputs • ON - opto-isolated • OFF - fast input/output

Note	
	*The order of the pins for JP1, JP2 and JP3 are the same as given in* ***Figure 58****.*

Note	
	*Jumper JP9 is generic for all optional opto-isolated PEG and States input and output.*

7.3 Setting the SPiiPlus SAR Jumpers

To set the SPiiPlus SAR (SPiiPlus SAR-LT) jumpers for the required configuration, do the following:

Caution	
	***Open the SPiiPlus SAR (SPiiPlus SAR-LT) casing only for setting the jumpers. Opening the casing for any other purpose may cause irreversible damage to the controller and void the warranty.***

1. Unscrew the four retaining screws located in the corners of the SPiiPlus SAR front panel.
2. Unscrew the two retaining screws located on each side of the casing, and extract the card assembly.
3. Flip the assembly over.
4. Locate the jumpers according to **Figure 57** (**Figure 59** for the SPiiPlus SAR-LT) and connect them as needed.
5. Exercising extreme care, reinsert the assembly into the casing and align the screw holes.
6. Screw in the six retaining screws.

8 LED Indicators

Note	
	*In the following table the # symbol stands for any axis.*

Table 78 LED Indicators

LED Indicator	Color	Description
MPU_ON	Green	Motion Processor Unit (MPU) works. Off for a fraction of a minute - receives a message and communication works properly.
PS_SFTY	Green	External safety voltage supply is available
	Off	External safety voltage supply is not available
PS_IO	Green	External IO voltage supply is available
	Off	External IO voltage supply is not available
24V	Green	Control voltage supply is available
	Off	Control voltage supply is not available
#_ON	Green	The #_axis is enabled
	Red	The #_axis has failed
	Off	The #_axis is disabled

9 Appendix A: Signal Definitions

The following tables list signal definitions:

Table 79 RS 422 Compatible Input

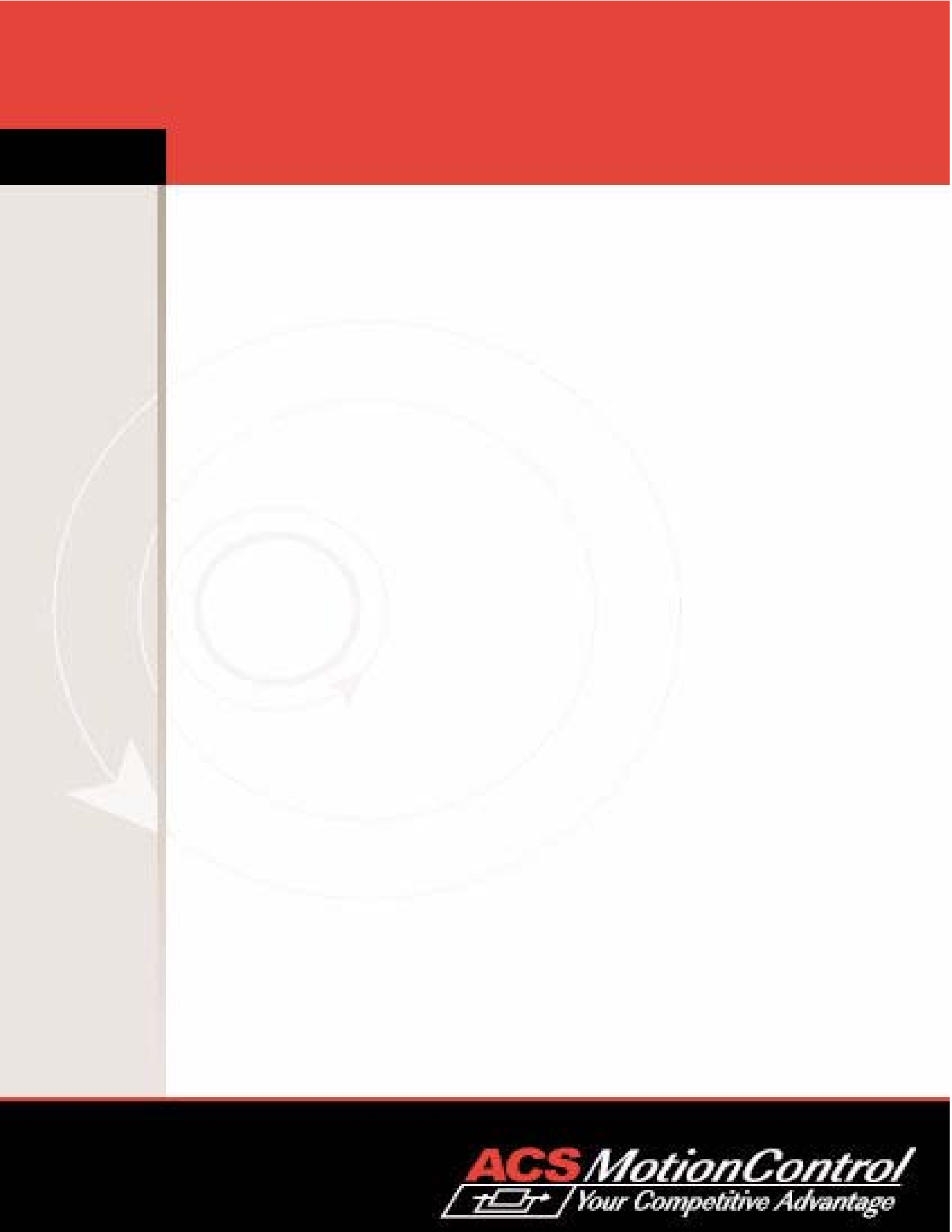
Parameter	Description	Comments
Vth	Differential input voltage	200mv, | Vth | , 14v
Vcm	Common mode input voltage	-14v < Vcm <14v

Table 80 RS 422 Compatible Output

Parameter	Description	Comments
Voh	Output voltage high	2.5v<Voh<5v
Vol	Output voltage low	Vol,0.5v
Vt	Differential output voltage at R1=100ohms	>2.0v

Table 81 TTL Compatible

Parameter	Description	Comments
Vil	Input voltage low	0.0 < Vil < 0.8v
Vih	Input voltage high	2.0 < Vil < 5.0v
Vol	Output voltage low	0.0 < Vol < 0.4v
Voh	Output voltage high	2.4 < Voh < 5.0v


ACS MotionControl
Your Competitive Advantage