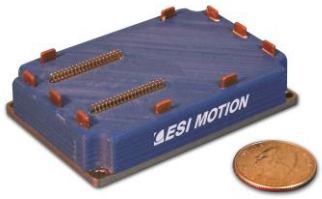
ESI MOTION



Mighty Mite Servo Drive Module
Installation Manual

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Revision D Updated on 3/26/2015

ESI Motion Document 100249

Notice

This installation manual contains proprietary information belonging to ESI Motion.

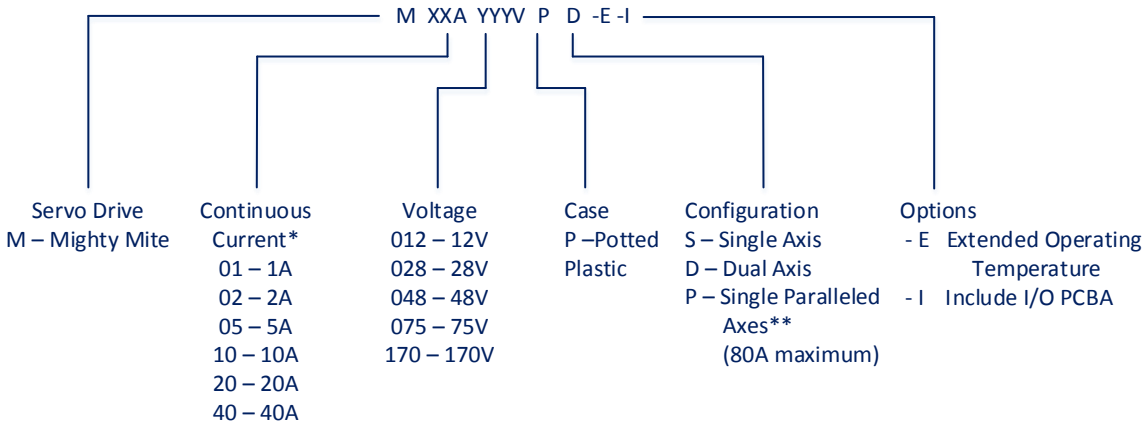
The information provided is solely for the purpose of assisting users of the Mighty Mite Servo Drive Module.

Information supplied in this manual is subject to change without notice.

Revision Control

Revision	Date	Change Description
A	1/15/2015	Initial Release
B	1/16/2015	Corrected Table 7, added Section 6.1
C	1/27/2015	Updated Thermal Data (new potting compound)
D	3/26/2015	Updated Part Number Ordering and Voltage and Current Limits, Added Configuration Options

Part Number Ordering



* Peak Sine Wave
** 2 X Continuous Current
Current and Voltage values are nominal, refer to the Installation Manual for the full operational range.

Figure 1 Mighty Mite Servo Drive Module Part Number

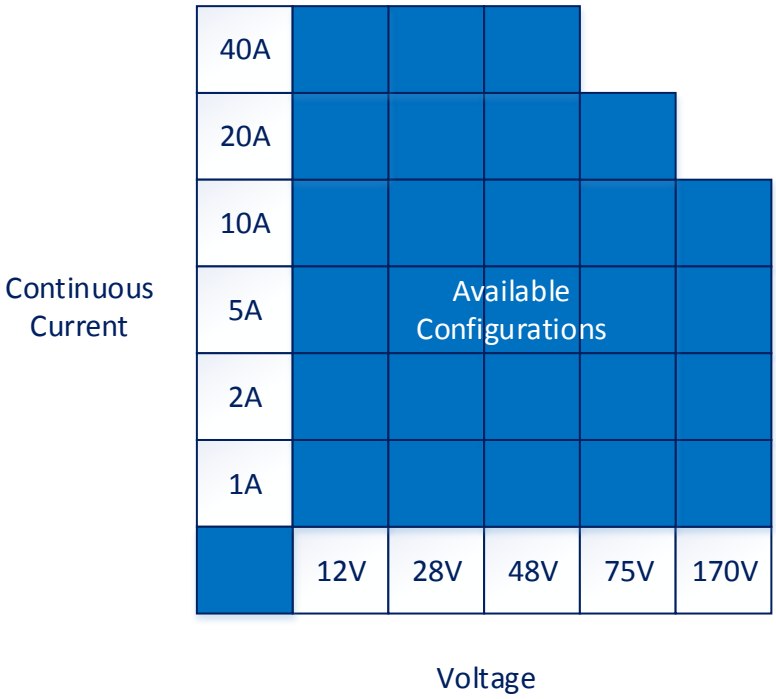


Figure 2 Mighty Mite Servo Drive Configuration Options

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Referenced Documents

ESI Document 100236, Mighty Mite Datasheet
ESI Document 100266, Controller User's Manual
ESI Document 100211, ESI Motion's CAN Protocol
ESI Document 100121, ESI Motion's RS422 Protocol

1 SAFETY INFORMATION

2 INTRODUCTION

This document will provide the user with an overview of the ESI Motion Family of Servo Drives and Servo Drive Modules. Then provide a detailed description of the Mighty Mite Servo Drive Module, the product features and system architecture. This document will provide the user with details on the installation of the Mighty Mite Servo Drive Module. The installation will cover the connections to the servo drive, mounting the servo drive to a printed circuit board assembly (PCBA), heat sinking, powering up the drive, and initializing the system. The connections to the Mighty Mite Servo Drive Module will be explored in more detail; main power and motor power, feedback, service and communication. Other sections of this manual will cover the technical specifications and thermal properties of the Mighty Mite Servo Drive Module. A separate ESI Document 100226, Controller User's Manual is available for a more detailed discussion of the capabilities of ESI Motion's Servo Drive Modules. Refer to the ESI Document 100236, Mighty Mite Datasheet for details on signal connections and electrical characteristics.

2.1 ESI Motion Family of Servo Drives and Servo Drive Modules

The ESI Motion Family of Servo Drives and Servo Drive Modules operate over voltages ranging from 10 to 800V and currents up to 300A.

Servo Drive Modules

The Flea is our smallest servo drive module, measuring XX in^3, and weighing XX oz. The servo drive module is designed to be mounted on a PCBA, allowing it to be integrated with other system level components and possibly other servo drive modules in a multi-axis design. The Flea is designed with XX FETs, which allows the Flea to be clocked at PWM frequency up to XX, making it ideal for applications involving very low inductive loads. The Flea operates between 10 to 50V at currents up to 10A.

The Mite is probably our most versatile servo drive module. The Mite is available as a single-axis module, measuring 2.00 in^3 and weighing 2.2 oz. (62.4 g), and a dual-axis module, measuring 3.42 in^3 and weighing 3.7 oz. (105 g). The Mite provides up to 2kW of power per axis, packaged in a potted plastic case, and an integrated heat sink. The Mite supports several motor feedback options, which are selected via software configuration parameters. The Mite is ideal for precision military, aviation, automotive, robotic, and specialized industrial applications where size and weight are critical. The Mite is also available in an extended operating temperature range. The Mite operates between 10 to 170V at currents up to 30A.

The Tick is our high current, low voltage servo drive module.

The Scorpion is our low current, high voltage servo drive module.

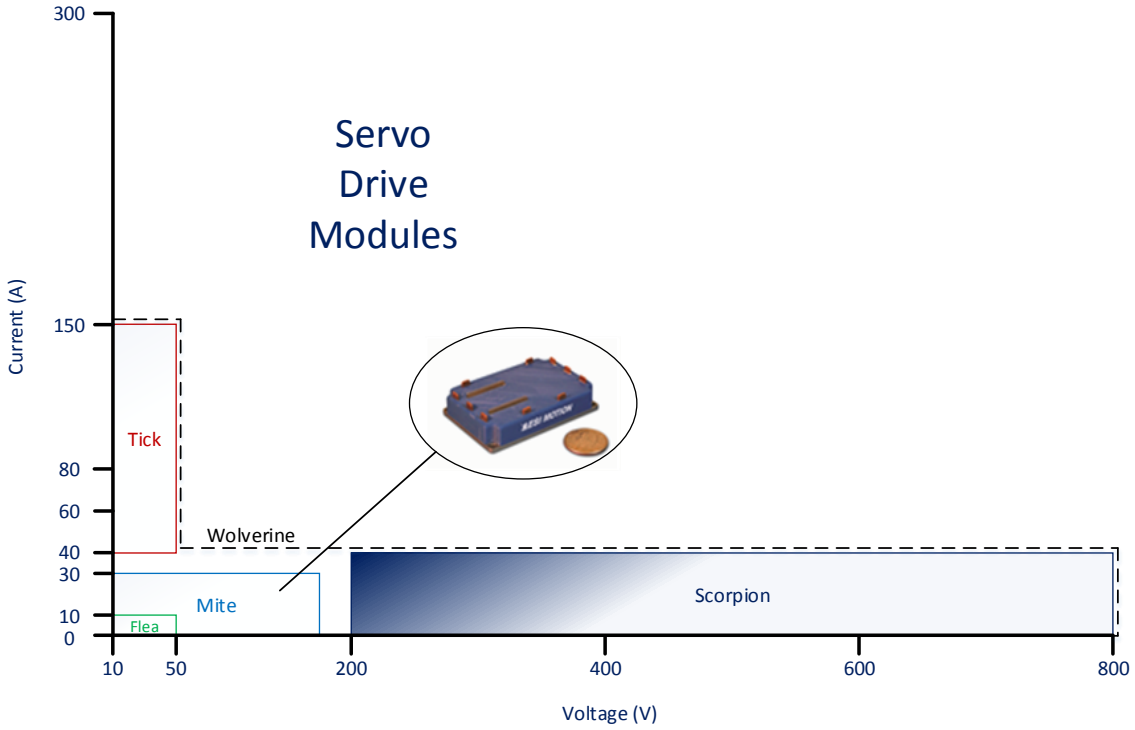


Figure 3 ESI Motion Family of Servo Drive Modules

Servo Drives

The Wolverine is a plug and play, stand-alone, military-grade submersible package, servo drive based on our servo drive modules. An example of a Wolverine configuration would be a Mite servo drive module packaged with supporting hardware to form a stand-alone drive. The Wolverine includes a High Voltage Interlock and Brake Drivers, however provides for optional Integrated EMI Filter, and DC Bus Voltage Regeneration switch and active Inrush limiter. The Wolverine is designed to meet several military standards: MIL-STD-810, MIL-STD-1275, MIL-STD-704, and MIL-STD-461. The Wolverine supports several motor feedback options, which are selected via software configuration parameters. The ruggedized package comes in three cooling options, Chassis, Fan, or liquid. The Wolverine is designed for defense, automotive, energy, and specialized industrial applications where a smaller, lighter weight servo drive is needed. The Wolverine operates between 10 to 610V at currents up to 80A.

The Dragon is a plug and play, stand-alone, military-grade submersible package, servo drive based on our rugged controller and power drivers. The Dragon includes a High Voltage Interlock, Brake Drivers, Integrated EMI Filter, and DC Bus Voltage Regeneration switch and active Inrush limiter. The Dragon is designed to meet several military standards: MIL-STD-810, MIL-STD-1275, MIL-STD-704, and MIL-STD-461. The Dragon comes in three motor feedback configurations, Dual Resolver, Dual Encoder, and Single Resolver with BiSS-C. The ruggedized package comes in three cooling options, Chassis, Fan, or liquid. This versatile servo drive is ideal for high performance military, aviation, and specialized industrial applications operating outdoor, at high temperatures, in high vibration, or other extreme environ-mental conditions. The Dragon operates between 24 to 610V at currents up to 80A.

The Roadwind is our high current, low voltage servo drive.

The Vulcan is our low current, high voltage servo drive.

The Hyperion is our high current, high voltage servo drive.

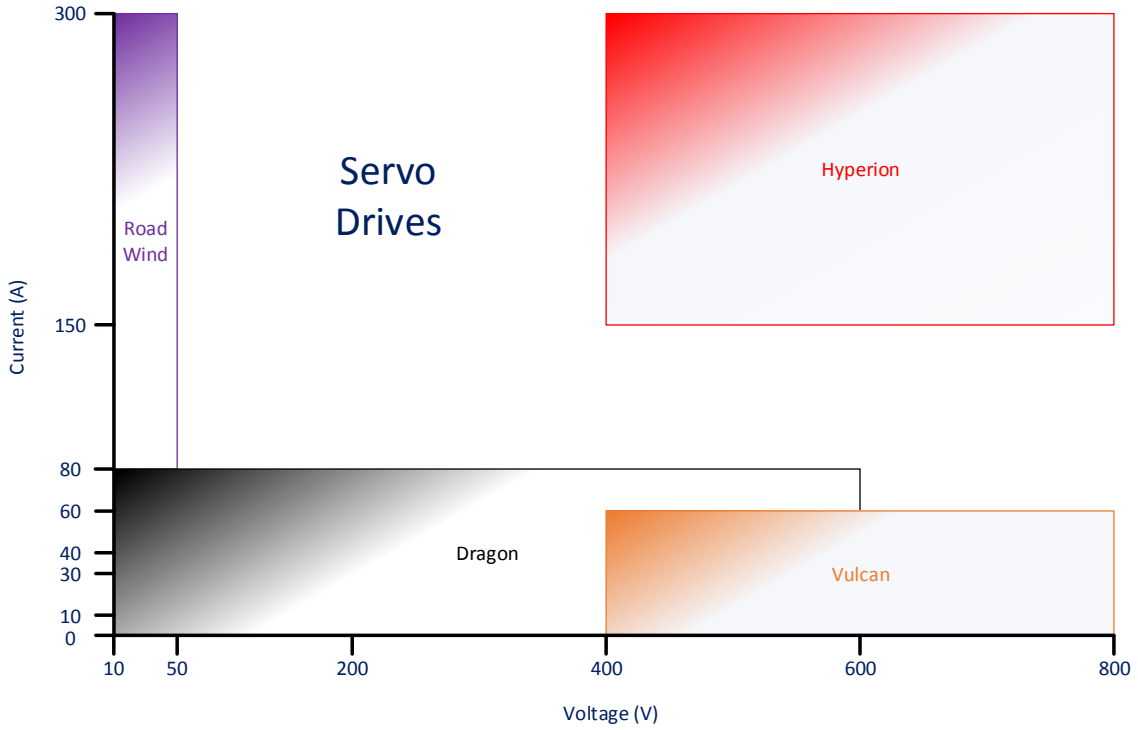


Figure 4 ESI Motion Family of Servo Drives

3 Product Description

The Mighty Mite Servo Drive Module incorporates our rugged controller and power drivers, offers several software configurable feedback options, and is packaged in a potted plastic case with an integrated heat sink. The Mighty Mite Servo Drive Module comes packaged as either a dual or single axis drive. The servo drive can be ordered in a variety of voltage and current configurations. The bus voltage ranges from 10V to 170V and currents up to 40A, at 2kW per axis. The dual axis drive can be ordered as a paralleled axes drive, delivering twice the rated current of a single axis. The paralleled axes functions as a single motor controller with all control and feedback through Motor A, all the Motor B control and feedback is disabled. This versatile servo line is ideal for precision military, aviation, automotive, robotic, and specialized industrial applications where size and weight are critical.

3.1 Functional Description

3.2 Product Features

3.2.1 High Power Density

Each axis in the Mighty Mite Servo Drive Module delivers up to 2000 W of continuous power.

The Mighty Mite Servo Drive Module Dual Axis is 2.00” x 3.00” x 0.57”, a volume of 3.42 in^3, and a weight of 3.7 oz. (105 g). The Dual Axis servo drive has independent axis configuration, torque, velocity, and position control.

The Mighty Mite Servo Drive Module Single Axis is 2.00” x 1.75” x 0.57”, a volume of 2.00 in^3, and a weight of 2.2 oz. (62.4 g). The Single Axis servo drive has torque, velocity, and position control.

3.2.2 Supply Input

Two isolated DC power sources are required, 12 -170V for the main power and 5V for the controller power. The feedback power source, either the same 5V for the controller, or another supply, must share a common ground.

3.2.3 Servo Control

3.2.4 Feedback Ports Options

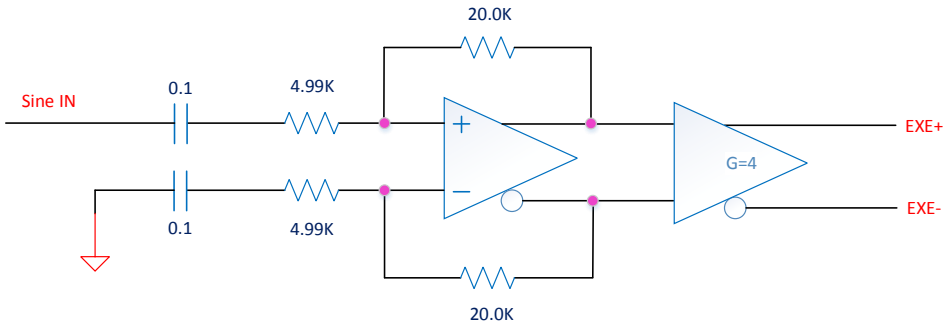
The Mighty Mite Servo Drive Module has five different forms of motor feedback, Sensorless, Digital Encoder, Resolver, Hall, and BiSS-C.

3.2.5 Feedback Sensor Specifications

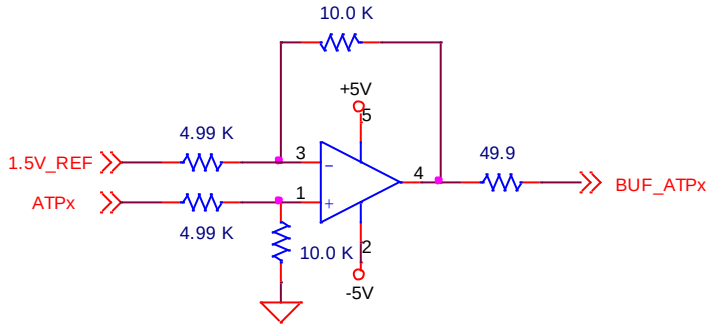
3.2.6 Communications

3.2.7 Outputs

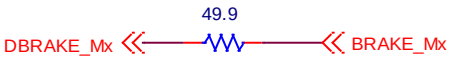
3.2.7.1 Resolver Excitation



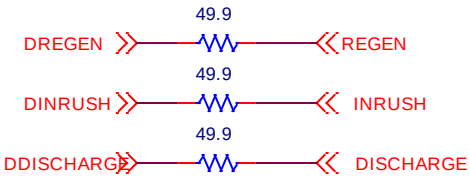
3.2.7.2 Analog Test Points (ATPs)



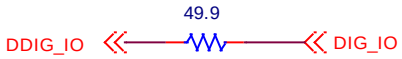
3.2.7.3 Brakes



3.2.7.4 Regen, Inrush, Discharge

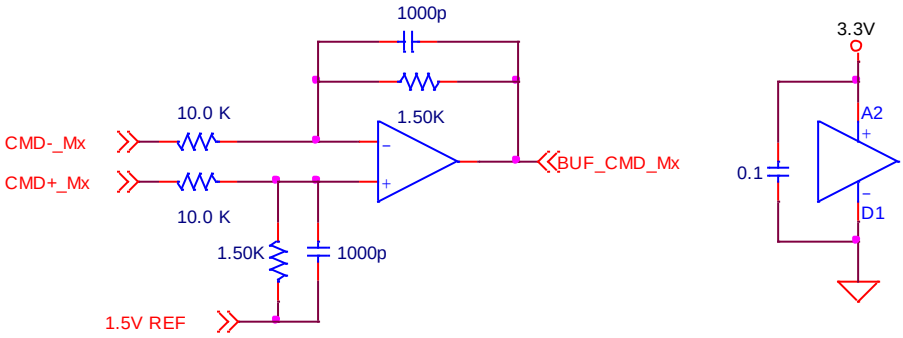


3.2.7.5 Digital IO

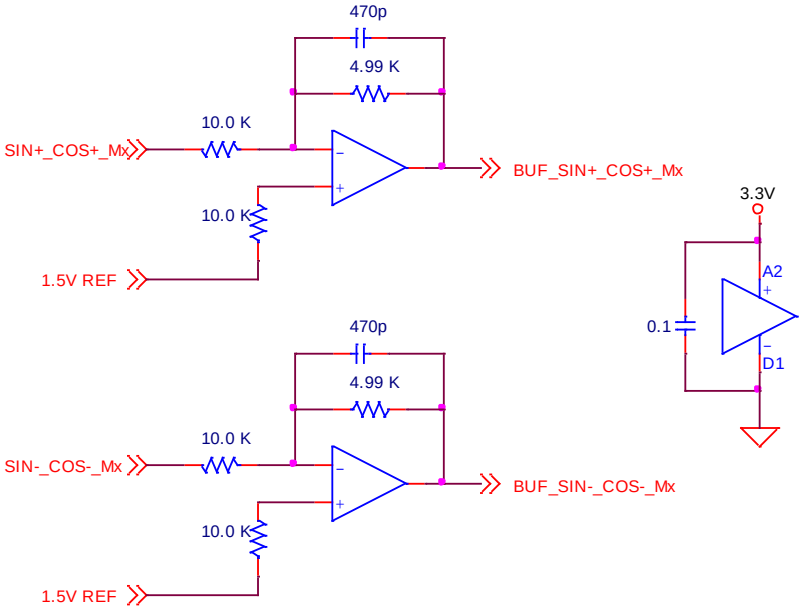


3.2.8 Inputs

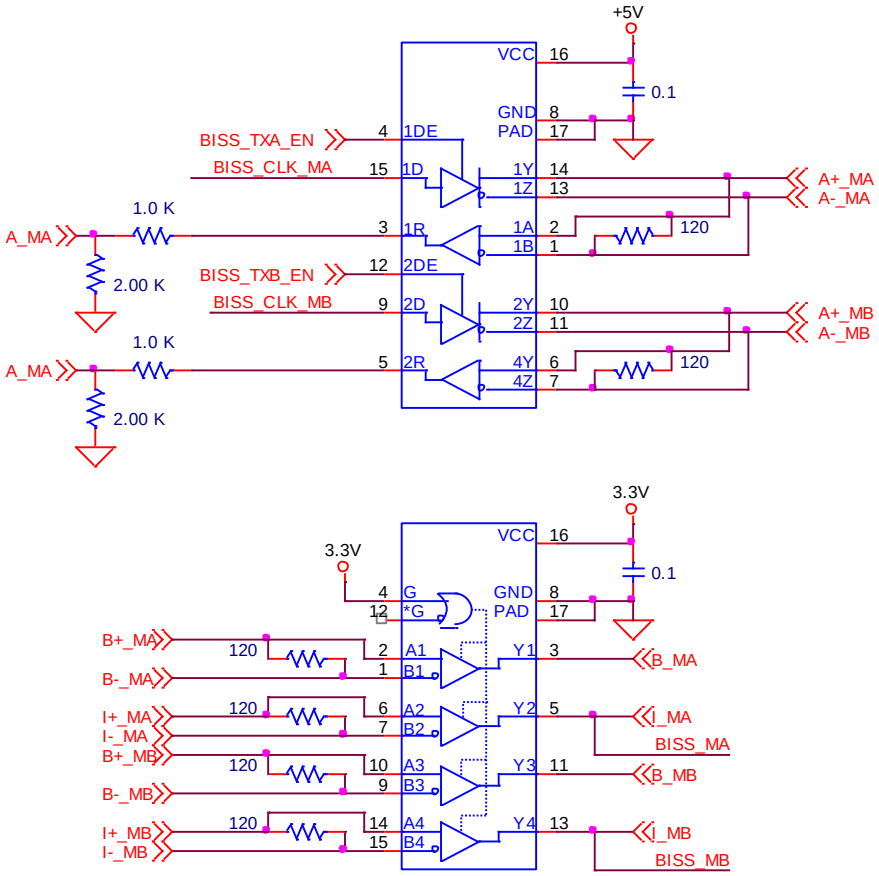
3.2.8.1 Current Command



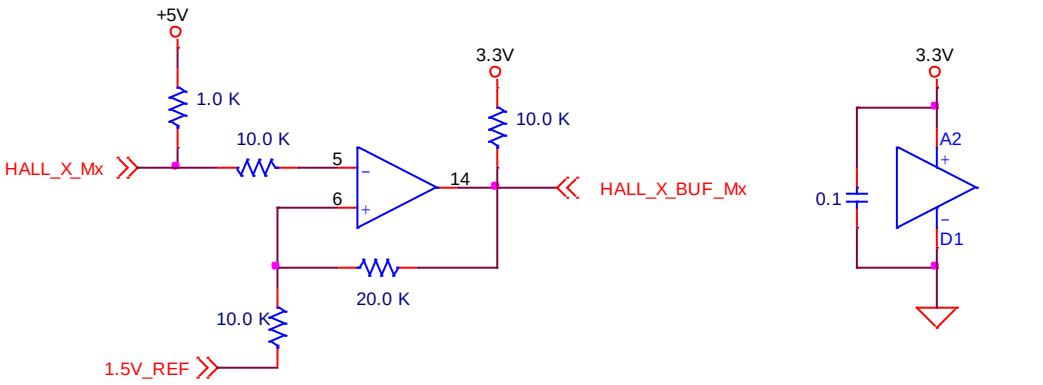
3.2.8.2 Resolver



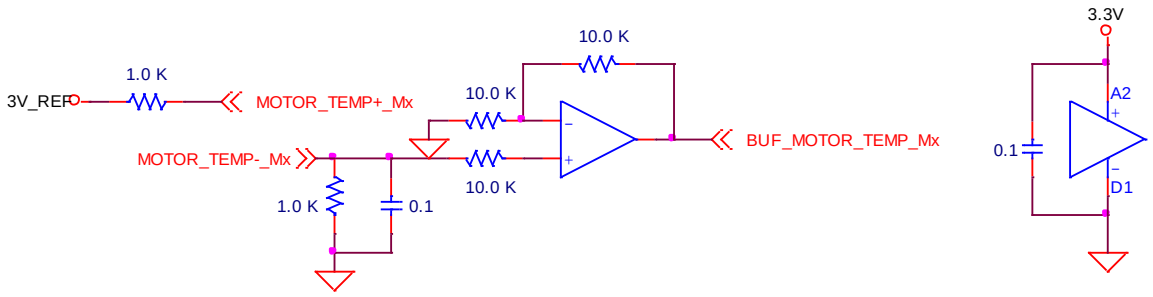
3.2.8.3 Encoder / BiSS-C



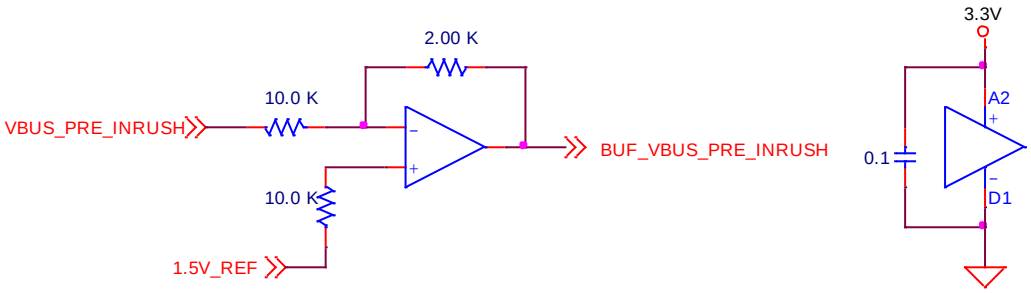
3.2.8.4 Hall



3.2.8.5 Motor Temperature



3.2.8.6 *Vbus_Pre_Inrush*



3.2.9 Built-In Protection

3.2.9.1 Over Current

The Mighty Mite Servo Drive Module's motor phase current is always monitored and when the current on any phase exceeds the over current limit, usually defined to be 1.25 * peak current, the servo drive module will disable its self. The servo drive module can only be re-enabled when the fault is removed and the fault state cleared. Please refer to the ESI Motion Controller User's Manual for details.

3.2.9.2 Over Voltage

The Mighty Mite Servo Drive Module's bus voltage is always monitored and when the bus voltage exceeds the over-voltage limit for motor or the servo drive module, whichever is lower, the servo drive module will disable its self. The servo drive module can only be re-enabled when the fault is removed and the fault state cleared. Please refer to the ESI Motion Controller User's Manual for details.

3.2.9.3 Over Temperature

The Mighty Mite Servo Drive Module has sensors that monitor the processor temperature as well as both motor A and B power driver sections. Software will alert the user with a warning flag, if the temperature nears the critical level, and is programmed to shut itself off or shut down the power driver section if the temperature reaches the critical level. The servo drive module can only be re-enabled when the fault is removed and the fault state cleared. Please refer to the ESI Motion Controller User's Manual for details.

3.2.9.4 Other Built-In Protection

The Mighty Mite Servo Drive Module has other protection a BIT (Built In Test), Motor Over Temperature with a user provided thermistor, Motor Over Speed, Bus Under Voltage, Motor Loss of Feedback, and an I-squared-T (I2T), which is an estimate of the energy content in current transient conditions, this can help protect against motor overheating. The servo drive module can only be re-enabled when the fault is removed and the fault state cleared. Please refer to the ESI Motion Controller User's Manual for details.

3.3 System Architecture

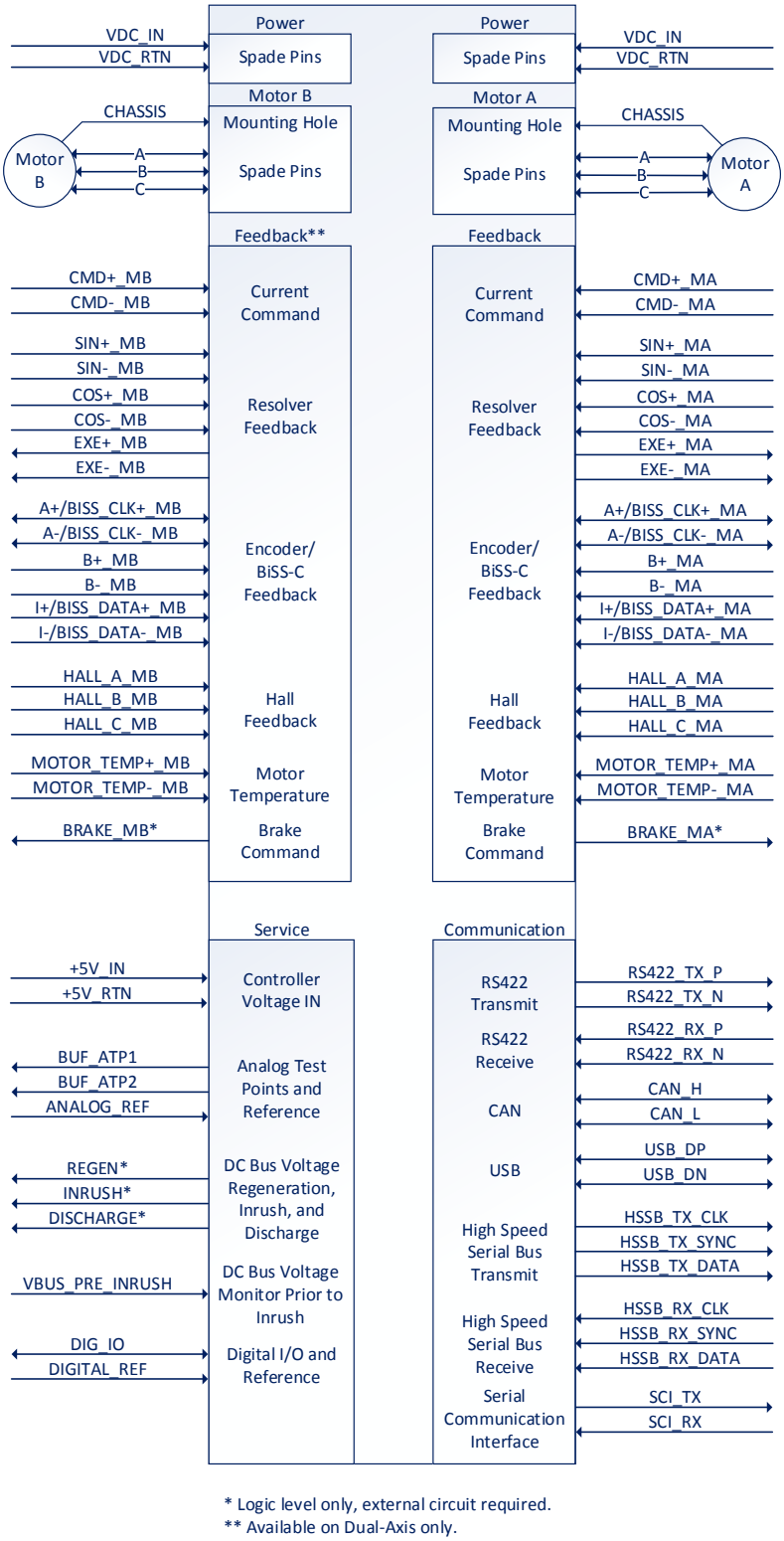


Figure 5 System Architecture

4 TECHNICAL INFORMATION

4.1 Physical Specification

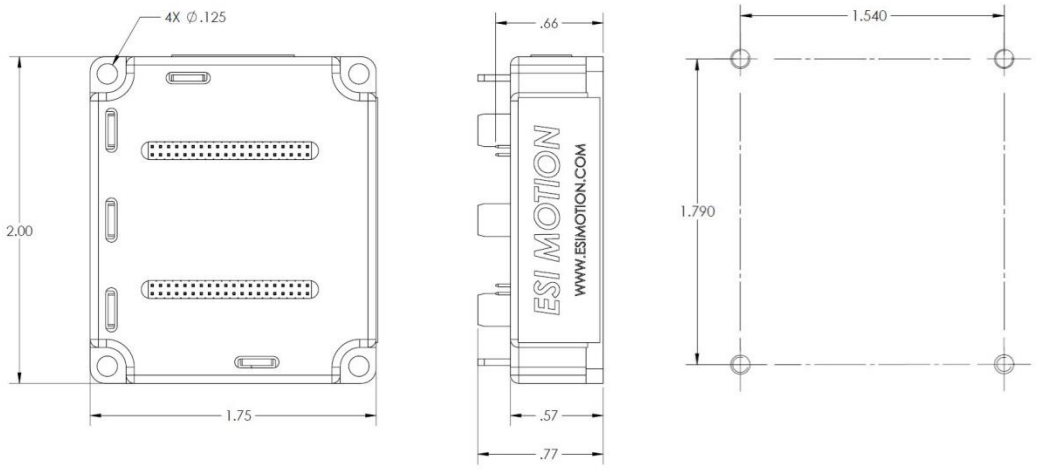


Figure 6 Single Axis Package Dimensions and Mounting Pattern (in)

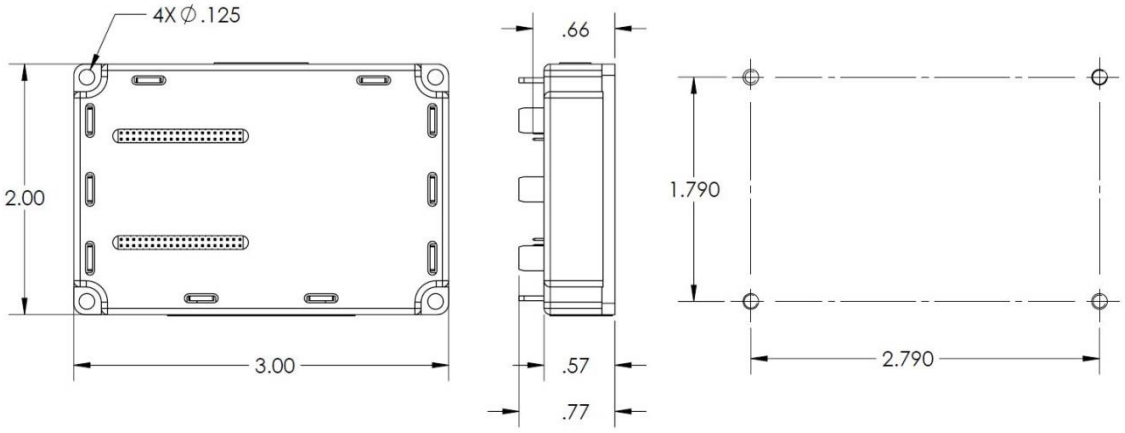


Figure 7 Dual Axis Package Dimensions and Mounting Pattern (in)

4.2 Technical Data

5 INSTALLATION

The Mighty Mite Servo Drive Module is designed to mount to a PCBA. The Mighty Mite Servo Drive Module can be purchased with an ESI furnished I/O PCBA, designed to be used for system development, please refer to Figure 1 Mighty Mite Servo Drive Module Part Number, - I option. The mechanical and electrical interfaces for the ESI furnished I/O PCBA can be found in the Mighty Mite Servo Drive Module's Datasheet. This section will provide the user with the information required to design and develop a PCBA to interface to the Mighty Mite Servo Drive Module.

5.1 Connections

The connections to the Mighty Mite Servo Drive Module can be divided up into four groups, Main Power and Motor Power, Feedback, Service, and Communication. Please refer to Figure 5 System Architecture for details. These connections are available in both the Dual and Single-Axis drive; however the Single-Axis drive does not have any connections on Motor B Feedback.

The Mighty Mite Servo Drive Module Dual-Axis is shown below.

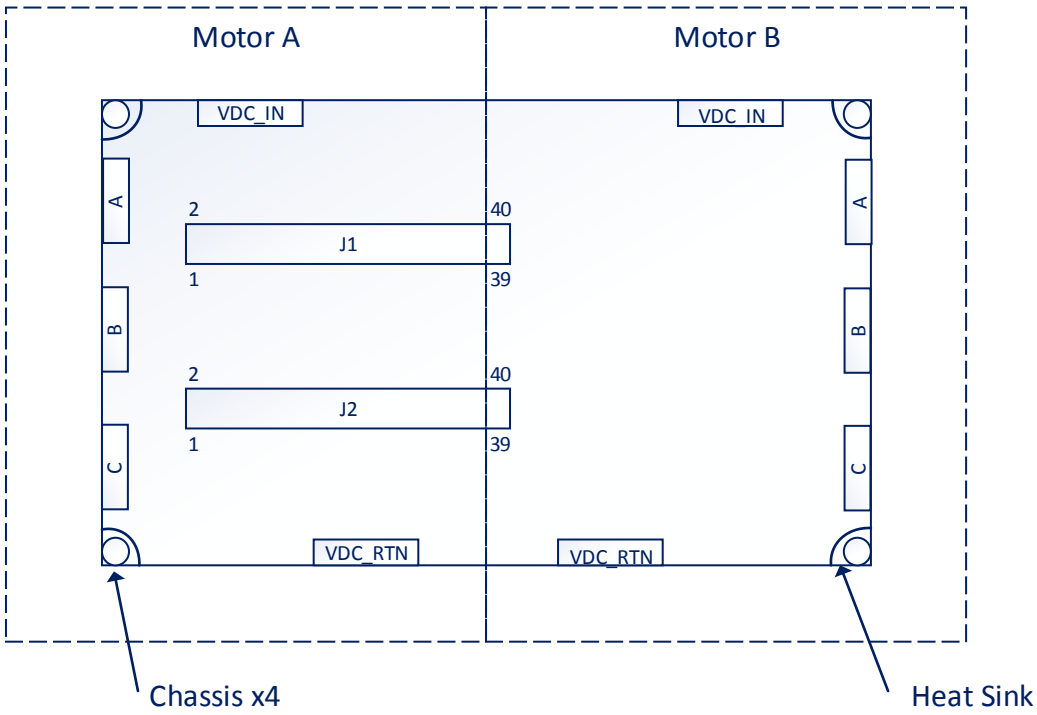


Figure 8 Dual-Axis Connections

The Mighty Mite Servo Drive Module Single-Axis is shown below.

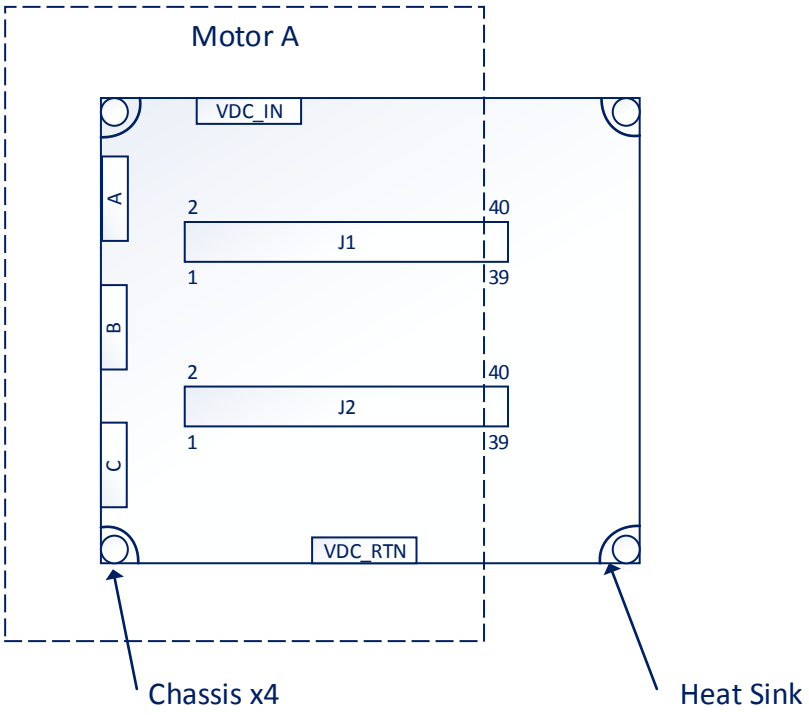


Figure 9 Mighty Mite Servo Drive Module Single-Axis Connections

5.1.1 Main Power and Motor Power

The Main Power and Motor Power are the high current connections to the Mighty Mite Servo Drive Module. The Main Power connections are located on the top (VDC_IN) and bottom (VDC_RTN) of the servo drive module. The Dual-Axis servo drive provides two VDC_IN and two VDC_RTN pins. Motor A and B have their own dedicated Main Power pins; refer to Figure 8 Dual-Axis Connections. The two VDC_IN pins and two VDC_RTN pins are electrically equivalent; however the current carrying capability is through the motor dedicated pins and should not be interchanged. The Motor Power, phase A, B, and C are located on the sides of the servo drive module. Table I shows nominal voltage and continuous current used for ordering the Mighty Mite Servo Drive Module, based on Figure 1 Mighty Mite Servo Drive Module Part Number, and the peak voltage and current, which should not be exceeded.

Voltage (V)	
Nominal	Maximum
12	20
28	35
48	70
75	100
170	200

Continuous Current (A)	
Nominal	Maximum
1	2
2	4
5	10
10	20
20	40
40	60

Table 1 Voltage and Current Limits

5.1.2 Feedback

The Mighty Mite Servo Drive Module Feedback connections are divided into motor A and motor B feedback. The Feedback has motor Current Command, Feedback options, Temperature, and Brake. The Current Command is an analog input, mapped and scaled through software configuration, to the motor current control loop. The Temperature input is an active circuit that measures an NTC thermistor which is directly proportional to motor temperature. The temperature vs resistance polynomial can be configured through software.

The Brake output is a TTL discrete that can be used to engage or disengage an external brake circuit. The user will be required to implement the external brake circuit using i.e. a MOSFET switch. When the logic level is high the brake is assumed to be engaged or that the MOSFET switch is open and no current is flowing through the brake coil.

The Mighty Mite Servo Drive Module has five different forms of motor feedback, Sensorless, Digital Encoder, Resolver, Hall, and BiSS-C. Feedback options are selected through software configuration settings, each motor feedback can be configured exclusive of the other. The majority of the feedback options have their own independent hardware interface, only the Encoder and BiSS-C share common hardware connections. Sensorless is the only feedback that does not require any external connections. Figure 10 Feedback Options shows the connections required for each feedback implementation.

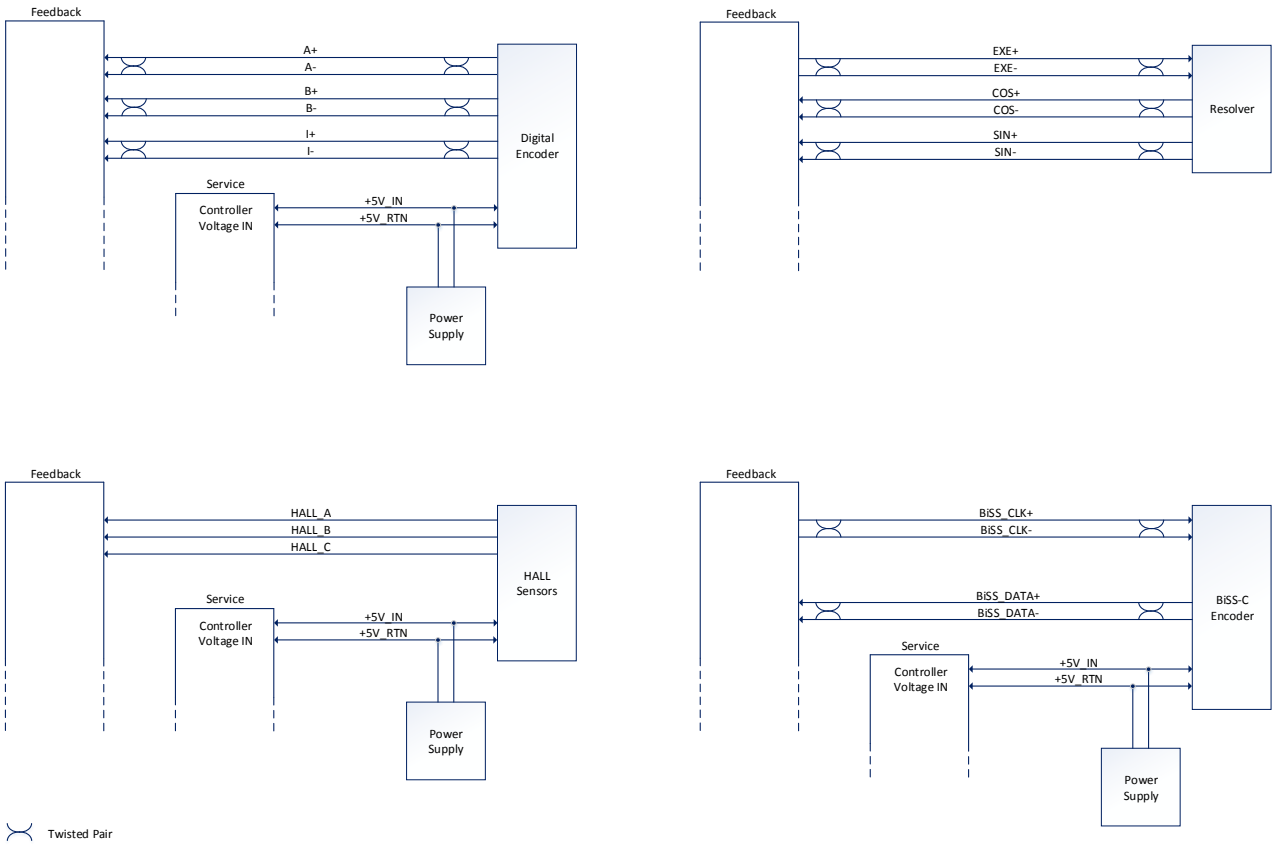


Figure 10 Feedback Options

5.1.3 Service

The Mighty Mite Servo Drive Module Service signals are:

Controller Voltage In	(+5V In)
Analog Test Points, Buf_ATP#	(Analog Outputs)
Regeneration, Inrush, and Discharge	(Digital Outputs)
Vbus_Pre_Inrush	(Analog Input)
Digital I/O	(Digital In/Output)

The Controller Voltage In is the +5V input to power the servo drive controller. The power to any external motor feedback sensors should be referenced to the +5V supply. There are two Analog Test Point outputs, Buf_ATP1 and Buf_ATP2, which are configured through software. These signals can be mapped to various control parameters. The Analog_Ref signal should be used as the reference for the analog test points. The Regeneration discrete can be used, with an external circuit, to switch the bus voltage (VDC_IN) to a load resistor, when the bus voltage exceeds a software configurable limit. The duty cycle and duration of the Regeneration discrete is also configurable through software. The Inrush discrete can be used to control an external switch that will slow the RC rise time of the bus voltage as it charges the capacitor bank during power up. When the bus voltage reaches a software configurable limit the Inrush discrete will switch off. The Discharge discrete can be used, with an external circuit, to discharge the bus voltage capacitor bank, during power down, safely removing power from the system in a timely fashion. The Vbus_Pre_Inrush is an analog input that can be used to monitor the bus voltage prior to the Inrush switch. The Digital I/O is a software configurable input or output pin and can be mapped to various system events. Refer to the section on Software for further details.

5.1.4 Communication

The Mighty Mite Servo Drive Module has several forms of communication. The RS422, CAN, and USB are standard on the servo drive and have a defined software protocol. The High Speed Serial Bus (HSSB) and Serial Communication Interface (SCI) are to be used for customer specific applications and are not accessible with the standard servo drive software package. This document will only discuss the RS422, CAN and USB interfaces. All three interfaces provide the user with complete flexibility in controller configuration, commands, and feedback. The CAN and USB interfaces work directly with the Host Interface for the Dragon Servo (HiDS), user friendly GUI with enhanced data collection capability. The uses and capability and of HiDS can be found in ESI Document 100266, Controller User's Manual. ESI Document 100211, ESI Motion's CAN Protocol and ESI Document 100121, ESI Motion's RS422 Protocol are also available.

5.2 Mounting to a PCBA

The Mighty Mite Servo Drive Module has two pin headers J1 and J2, Samtec part number FTS-120-01-L-DV, 2 x 20 pins and 0.05" pitch. The main power and motor power are "spade" shaped copper pins that are soldered to the PCBA. The dimension and location of the mounting holes for the "spade" shaped pins is shown in Figure 11 through Figure 14, Mighty Mite Dual and Single-Axis PCBA Footprints. The headers J1 and J2 can be soldered directly to the PCBA or mated with Samtec part number CLP-120-02-F-D-TR. The mating height for J1 and J2 to Samtec part number CLP-120-02-F-D-TR is 0.14". The length of the "spade" pins will accommodate either configuration. If PCBA area is at a premium, the use of mating connectors for J1 and J2 will allow the user to place low profile components underneath the Mighty Mite Servo Drive Module.

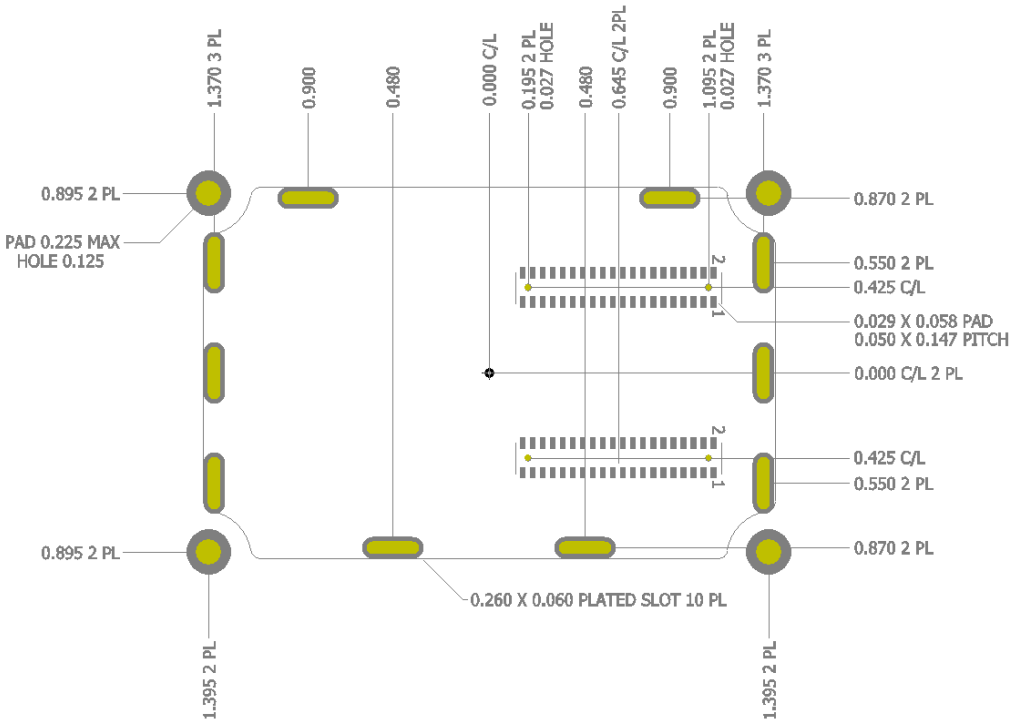


Figure 11 Dual-Axis PCBA Footprint w/ Mating Connectors

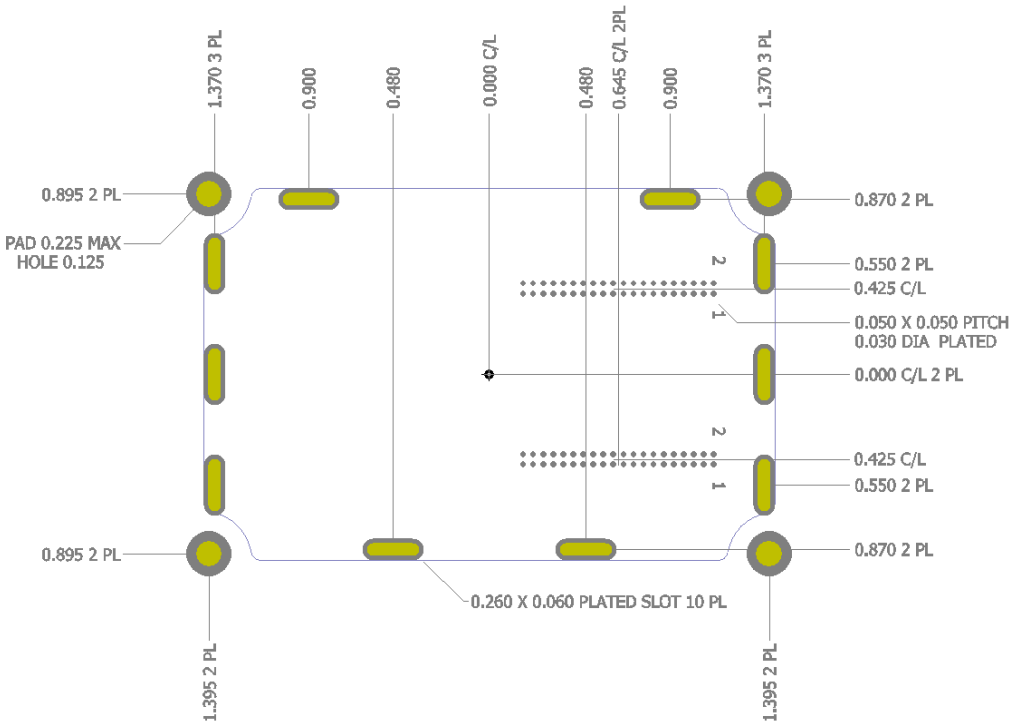


Figure 12 Dual-Axis PCBA Footprint w/o Mating Connectors

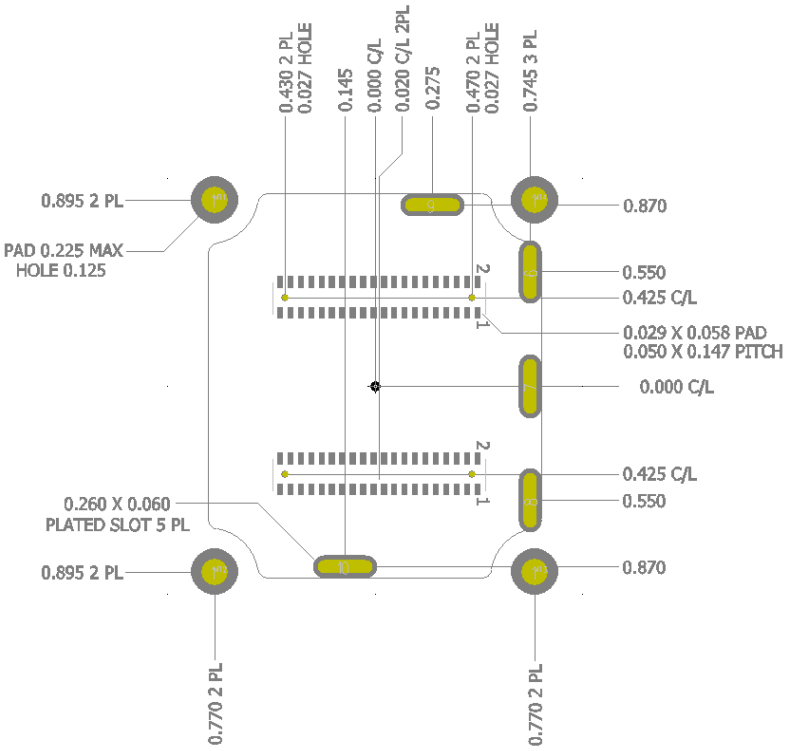


Figure 13 Single-Axis PCBA Footprint w/ Mating Connectors

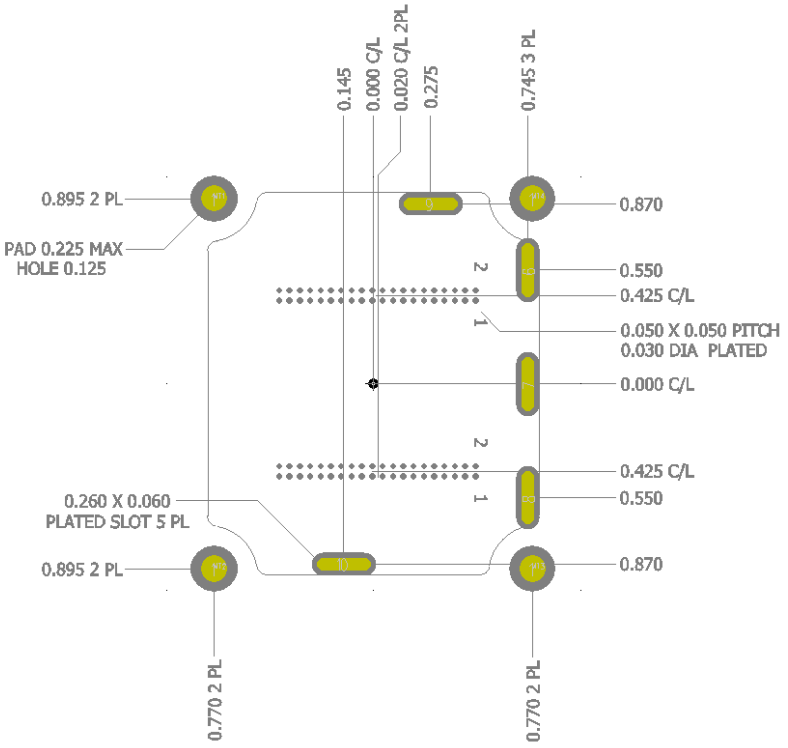


Figure 14 Single-Axis PCBA Footprint w/o Mating Connectors

5.3 Heat Sinking

The Mighty Mite Servo Drive Module comes with an integrated heat sink on the side opposite to PCBA mounting. The integrated heat sink is designed to be used alone, without any external heat sink mass, for motor currents, up to 5A per axis. For applications requiring higher currents a proper heat sink design must be used with the Mighty Mite Servo Drive Module, please refer to the section on Heat Dissipation for details.

5.4 Powering Up

The Mighty Mite Servo Drive Module has two voltage sources, bus and controller voltage. The bus voltage should be set to a voltage below the configuration peak voltage, see Table 1 Voltage and Current Limits, Mighty Mite Servo Drive Module Voltage and Current Limits. If the peak voltage is exceeded, software will trigger a bus over voltage fault, and disable the servo drive. The controller voltage should be set to +5V +/- 10%. The bus and controller voltages can be applied to the servo drive in either order. When the controller voltage is applied to the servo drive the configuration of the module is read and voltage and current limits are set to their default values.

5.5 Initializing the System

The Mighty Mite Servo Drive Module will remain disabled, until it receives a command to enable and no system faults are active. If the servo drive module is disabled, due to a system fault, the system fault or faults must be resolved and a reset command sent to servo drive module prior to another enable command. ESI Motion Controller User's Manual will provide the user with the information necessary to successfully configure and run the Mighty Mite Servo Drive Module.

5.6 Heat Dissipation

5.6.1 Thermal Conductivity Data

The Mighty Mite Servo Drive Module thermal resistance was measured from component junction to the heat sink base plate. Refer to Table 2 Thermal Resistance.

Symbol	Description	°C/W
Tjb	Theta Junction to Base Plate	9.52

Table 2 Thermal Resistance

The following is thermal data collected from the Mighty Mite Servo Drive Module mounted on a 5" x 6" x 0.5" aluminum heat sink with phase change thermal interface compound, Aavid Thermalloy, part number 100300F00000G.

Current Command (A)	Case Temperature Rise (°C)
10	3.5
20	6.0
30	9.8
40	14.3
50	20.9
60	27.5
70	36.4

Table 3 Current Command vs Case Temperature Rise

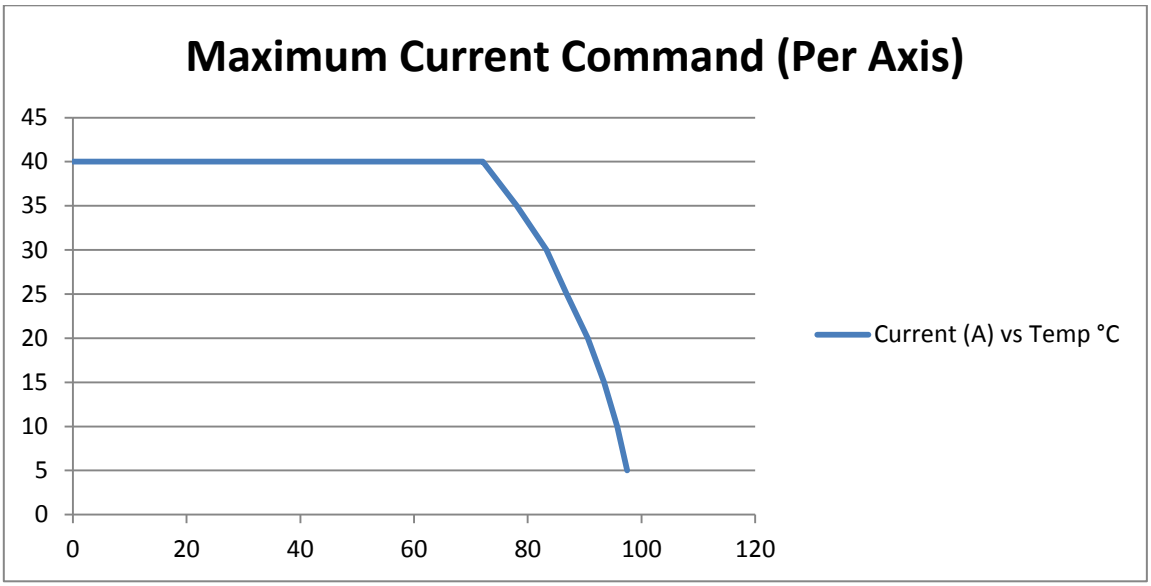


Figure 15 Maximum Current Command vs Case Temperature (Per Axis)

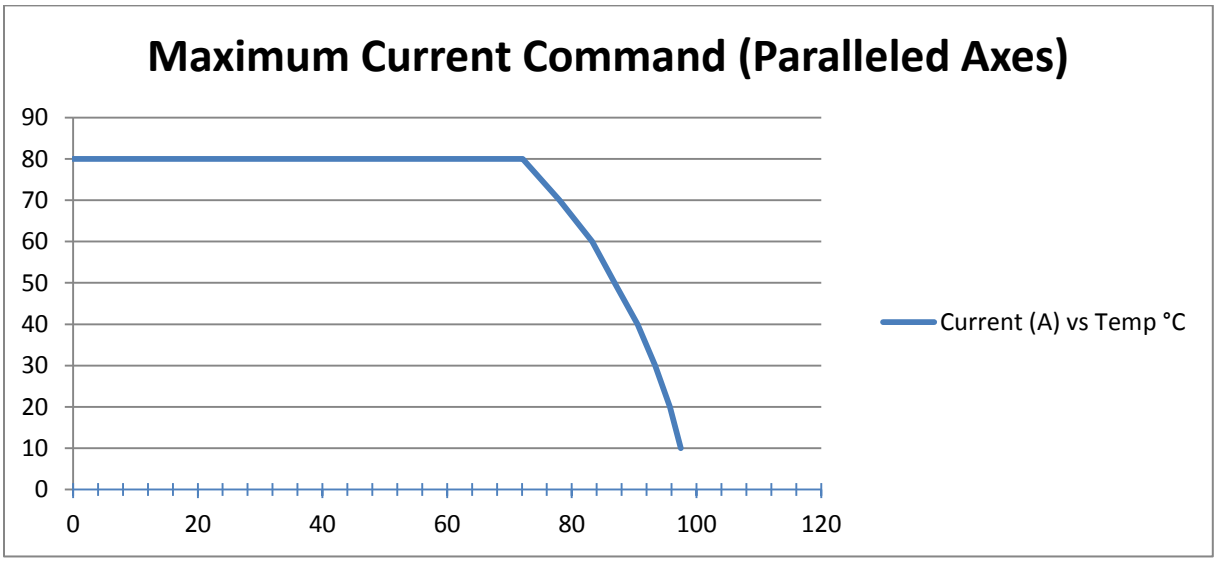


Figure 16 Maximum Current Command vs Case Temperature (Paralleled Axes)

5.6.2 Heat Sink Interface Materials

If a heat sink is needed, effective coupling of the Mighty Mite base plate to the heat sink is essential for optimum heat transfer. Depending on the operating current and the amount of heat dissipated, various methods are available to achieve a good thermal bond. Table 4 Thermal Interface Compounds shows examples of thermal interface compounds which can be used with the Mighty Mite Servo Drive Module.

Thermal Interface Compound	Supplier	Part Number	Thermal Conductivity	Operating Temperature
Phase Change	Aavid Thermalloy	100300F00000G	0.79 W/(m-°C)	-40°C to 200°C
Gap Pad	Bergquist	GP1500	1.5 W/(m-°C)	-60°C to 200°C
Thermal Grease	Aavid Thermalloy	100100F00000G	0.73 W/(m-°C)	-40°C to 200°C

Table 4 Thermal Interface Compounds

6 TECHNICAL SPECIFICATIONS

[Insert objective here.]

6.1 Control Specifications

6.1.1 Current Loop

Feature	Details
Controller Type	Vector, digital
Compensation for bus voltage variations	Automatic compensation
Motor Types	DC Brushless, Brushed, and Induction
Current Control	Fully digital, Sinusoidal with vector control
Current Loop Bandwidth	Contact ESI Motion for details
Current Sampling Time	Contact ESI Motion for details
Current Sampling Rate	10 Khz, 20 Khz
Current Command options	Analog, HiDS, RS422, or CAN

Table 5 Current Loop Specification

6.1.2 Velocity Loop

Feature	Details
Controller Type	PID
Velocity Control	Fully digital
Velocity and Feedback options	Encoder Incremental (quadrature) BISS-C Encoder Hall Resolver Sensorless
Velocity Loop Bandwidth	Contact ESI Motion for details
Velocity Sampling Time	Contact ESI Motion for details
Velocity Sampling Rate	5 Khz
Velocity Command options	Analog, HiDS, RS422, or CAN

Table 6 Velocity Loop Specification

6.1.3 Position Loop

Feature	Details
Controller Type	PID
Position Loop Bandwidth	Contact ESI Motion for details
Position Sampling Time	Contact ESI Motion for details
Position Sampling Rate	1 Khz
Position Command options	Analog, HiDS, RS422, or CAN

Table 7 Position Loop Specification

6.2 I/O PCBA

The I/O PCBA is an optional circuit board that can be purchased along with the Mighty Mite Servo Module. The I/O PCBA provides the user with a platform that can be used for system development, prior to the design of a user defined PCBA that will mate with the Mighty Mite Servo Drive Module. The I/O PCBA provides all the connections necessary for motor control, the signals are arranged into three groups, J11 Motor A Feedback, J12 Service and Communication, and J13 Motor B Feedback. Refer to ESI Document 100236, Mighty Mite Datasheet for the electrical characteristics of each signal. A 5V regulator on the I/O PCBA is used to power both the Mighty Mite Servo Module controller and external motor feedback devices. The I/O PCBA is designed to work with Main Power (VDC_IN) from 10V to 95V and provides a regulated 5V at 2.5A. The I/O PCBA that will be used with Main Power (VDC_IN) that exceeds 95V will require the 5V regulator to be disabled. An I/O PCBA that is purchased with a Mighty Mite Servo Module that uses a Main Power (VDC_IN) that exceeds 95V will already have the 5V regulator disabled. Refer to ESI Document 100236, Mighty Mite Datasheet for the mechanical details of the I/O PCBA.

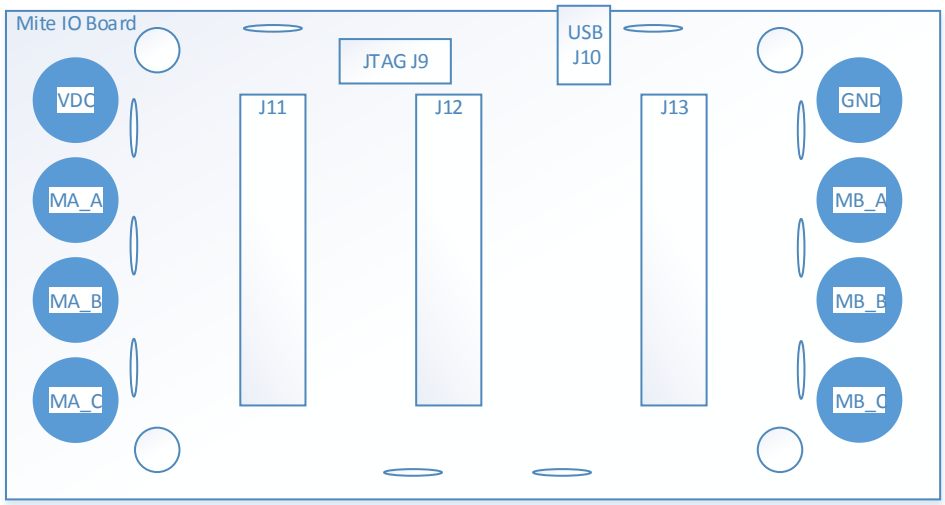


Figure 17 I/O PCBA

PIN	Name	Description	Type
1	CMD+_MA	Current Command Positive Motor A	Analog In
2	CMD-_MA	Current Command Negative Motor A	Analog In
3	SIN+_MA	Resolver Sin Positive Motor A	Analog In
4	SIN-_MA	Resolver Sin Negative Motor A	Analog In
5	COS+_MA	Resolver Cos Positive Motor A	Analog In
6	COS-_MA	Resolver Cos Negative Motor A	Analog In
7	EXE+_MA	Resolver Excitation Positive Motor A	Analog Out
8	EXE-_MA	Resolver Excitation Negative Motor A	Analog Out
9	+5V_OUT	Power to Feedback Devices	Digital Power
10	+5V_RTN	Power Return	Digital Power
11	A+_MA	Digital Encoder A Positive / BiSS-C Clock Positive Motor A	Digital In / Out
12	A-_MA	Digital Encoder A Negative / BiSS-C Clock Negative Motor A	Digital In / Out
13	B+_MA	Digital Encoder B Positive Motor A	Digital In
14	B-_MA	Digital Encoder B Negative Motor A	Digital In
15	I+_MA	Digital Encoder I Positive / BiSS-C Data Positive Motor A	Digital In/Out
16	I-_MA	Digital Encoder I Negative / BiSS-C Data Negative Motor A	Digital In / Out
17	+5V_OUT	Power to Feedback Devices	Digital Power
18	+5V_RTN	Power Return	Digital Power
19	HALL_A_MA	Hall A Motor A	Digital In
20	HALL_B_MA	Hall B Motor A	Digital In
21	HALL_C_MA	Hall C Motor A	Digital In
22	PWR_REF	Power Reference	Analog
23	PWR_REF	Power Reference	Analog
24	PWR_REF	Power Reference	Analog
25	MOTOR_TEMP+_MA	Temperature Positive Motor A	Analog
26	MOTOR_TEMP-_MA	Temperature Negative Motor A	Analog
27	BRAKE_MA	Brake Command Motor A	Digital Out
28	DIG_REF	Digital Reference	Digital
29	PWR_REF	Power Reference	Analog
30	PWR_REF	Power Reference	Analog

Table 8 I/O PCBA, J11 Motor A Feedback

PIN	Name	Description	Type
1	RS422_TX_P	RS422 Transmit Positive	Digital Out
2	RS422_TX_N	RS422 Transmit Negative	Digital Out
3	RS422_RX_P	RS422 Receive Positive	Digital In
4	RS422_RX_N	RS422 Receive Negative	Digital In
5	CAN_H	CAN High	Digital
6	CAN_L	CAN Low	Digital
7	HSSB_TX_CLK	High Speed Serial Bus Transmit Clock	Digital Out
8	HSSB_RX_CLK	High Speed Serial Bus Receive Clock	Digital In
9	HSSB_TX_SYNC	High Speed Serial Bus Transmit Sync	Digital Out
10	HSSB_RX_SYNC	High Speed Serial Bus Receive Sync	Digital In
11	HSSB_TX_DATA	High Speed Serial Bus Transmit Data	Digital Out
12	HSSB_RX_DATA	High Speed Serial Bus Receive Data	Digital In
13	PWR_REF	Power Reference	Analog
14	PWR_REF	Power Reference	Analog
15	DIG_REF	Digital Reference	Digital
16	DIG_IO	Digital Input / Output	Digital In / Out
17	+5V_OUT	Power to Feedback Devices	Digital Power
18	+5V_RTN	Power Return	Digital Power
19	SCI_TX	Serial Communication Interface (SCI) Transmit	Digital Out
20	SCI_RX	Serial Communication Interface (SCI) Receive	Digital In
21	BUF_ATP1	Analog Test point 1	Analog Out
22	BUF_ATP2	Analog Test point 2	Analog Out
23	ANALOG_REF	Analog Reference	Analog
24	PWR_REF	Power Reference	Analog
25	REGEN	DC Bus Voltage Regeneration Command	Digital Out
26	INRUSH	DC Bus Voltage Inrush (Precharge) Command	Digital Out
27	DISCHARGE	DC Bus Voltage Discharge Command	Digital Out
28	VBUS_PRE_INRUSH	DC Bus Voltage Monitor Prior to Inrush	Analog In
29	PWR_REF	Power Reference	Analog
30	PWR_REF	Power Reference	Analog

Table 9 IO PCBA, J12 Service and Communication

PIN	Name	Description	Type
1	CMD+_MB	Current Command Positive Motor B	Analog In
2	CMD-_MB	Current Command Negative Motor B	Analog In
3	SIN+_MB	Resolver Sin Positive Motor B	Analog In
4	SIN-_MB	Resolver Sin Negative Motor B	Analog In
5	COS+_MB	Resolver Cos Positive Motor B	Analog In
6	COS-_MB	Resolver Cos Negative Motor B	Analog In
7	EXE+_MB	Resolver Excitation Positive Motor B	Analog Out
8	EXE-_MB	Resolver Excitation Negative Motor B	Analog Out
9	+5V_OUT	Power to Feedback Devices	Digital Power
10	+5V_RTN	Power Return	Digital Power
11	A+_MB	Digital Encoder A Positive / BiSS-C Clock Positive Motor B	Digital In / Out
12	A-_MB	Digital Encoder A Negative / BiSS-C Clock Negative Motor B	Digital In / Out
13	B+_MB	Digital Encoder B Positive Motor B	Digital In
14	B-_MB	Digital Encoder B Negative Motor B	Digital In
15	I+_MB	Digital Encoder I Positive / BiSS-C Data Positive Motor B	Digital In / Out
16	I-_MB	Digital Encoder I Negative / BiSS-C Data Negative Motor B	Digital In / Out
17	+5V_OUT	Power to Feedback Devices	Digital Power
18	+5V_RTN	Power Return	Digital Power
19	HALL_A_MB	Hall A Motor B	Digital In
20	HALL_B_MB	Hall B Motor B	Digital In
21	HALL_C_MB	Hall C Motor B	Digital In
22	PWR_REF	Power Reference	Analog
23	PWR_REF	Power Reference	Analog
24	PWR_REF	Power Reference	Analog
25	MOTOR_TEMP+_MB	Temperature Positive Motor B	Analog
26	MOTOR_TEMP-_MB	Temperature Negative Motor B	Analog
27	BRAKE_MB	Brake Command Motor B	Digital Out
28	DIG_REF	Digital Reference	Digital
29	PWR_REF	Power Reference	Analog
30	PWR_REF	Power Reference	Analog

Table 10 I/O PCBA, J13 Motor B Feedback

7 APPENDICES

7.1 TBD