NPApc

Installation and Carrier Board Design Guide

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ACS MOTION CONTROL

NPApc

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Revision History

Date	Revision	Description
September 2020	3.02	Formatting
July 2018	1.90	Added warning note for short circuit protection for drive.
April 2018	1.80	Added caution for short circuit of motor phase
January 2018	1.70	Updated document template
October 2017	1.60	Updated for STO, UL, EMC certifications
August 2017	1.50	Updated list of supported motors. Document reformatted.
June 2016	1.40	Added content for single-phase motors Updated programmable current loop bandwidth
May 2016	1.30	Added note concerning STO
April 2016	1.20	Replaced "EndToEndCalibrationProgram.prg" program Replaced "NPACurrentLoopParametersSaveProgram.prg" program Updated ground pin reference in current command dynamic range activation section
February 2016	1.10	Updated Drive connections Figure Updated Drive enable input, drive fault output, and dynamic range input connections Figure
January 2016	1.00	First Release

Conventions Used in this Guide

Text Formats

Format	Description
Bold	Names of GUI objects or commands
BOLD + UPPERCASE	ACSPL+ variables and commands
`Monospace + grey background`	Code example
Italic	Names of other documents
Blue	Hyperlink
[ ]	In commands indicates optional item(s)
|	In commands indicates either/or items

Flagged Text

	**Note** - includes additional information or programming tips.
	**Caution** - describes a condition that may result in damage to equipment.
	**Warning** - describes a condition that may result in serious bodily injury or death.
	**Model** - highlights a specification, procedure, condition, or statement that depends on the product model
	**Advanced** - indicates a topic for advanced users.

Related Documents

Documents listed in the following table provide additional information related to this document.

Authorized users can download the latest versions of the documents from www.acsmotioncontrol.com/downloads.

Document	Description
SPiiPlus MMI Application Studio User Guide	Explains how to use the SPiiPlus MMI Application Studio and associated monitoring tools.
AN STO - Safe Torque Off Function	Provides the technical details for implementing the STO function.
NPMPC / NPAPC / UDMCB Functional Safety Manual	Describes the use of the STO function in the NPMPC/NPAPC and UDMCB.

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1. Introduction

1.1 Document Scope

The NPAPC is a chip-like module mounted on a custom carrier circuit board. This document provides product installation instructions and design guidelines for the carrier board. The following are described:

- NPAPC mechanical dimensions
- Electrical interface connectivity
- Carrier board design guidelines
  - Mechanical structure requirements
  - Circuits implemented on the carrier board
- Operation modes

1.2 Product Overview

The NPAPC is a dual-axis, NanoPWM™ current amplifier for servo motors, suitable for applications that require nanometer and sub-nanometer position jitter levels.

It accepts two commands for current in two phases of the motor in analog format.

The NPAPC operates from 12V to 100Vdc (drive supply) and provides continuous/peak current options of 3.3/10A, 6.6/20A, 10/30A, and 13.3/40A. The unit works with any controller that provides ±10V (or ±20V) commutation current commands.

The current loop filter is selected by a DIP-Switch that sits on the carrier board provided by the customer. It provides 16 different sets of filters. The filter can be also be fine tuned and programmed by connecting it to an ACS EtherCAT master and using the SPiiPlusMMI current loop tuning utility.

The NPAPC and the NPMPC EtherCAT drive module share the same design. Some of the connectors provide different functionality and some connectors are not used by the NPAPC (such as encoders).

1.2.1 Package Contents

The NPAPC package contains the following items:

- NPAPC module
- STO Connector Kit P/N: STO-ACC1 (supplied only for modules ordered with STO)

1.2.2 Optional Accessories

None.

1.2.3 Order Part Number

The ordered part number (P/N) contains several characters, each which specify a configuration characteristic ordered for the NPAPC module, as shown on the following label and described in the following table.

Figure 1-1. NPAPC Label with Ordered P/N - Example

Table 1-1. NPAPC Configuration as Indicated by P/N

Ordering Options	Field	Example User Selection	Available Ordering Option Values
Number of axes/drives	1	2	1,2
Current	2	A	A - 3.3/10A B - 6.6/20A C - 10/30A D - 13.3/40A
Special options	3	N	N - No
Type of motor	4	T	T - Three phase motor only S - Single phase motor only

As an example, P/N NPApc2ANT would represent the configuration described in the following table.

Table 1-2. NPAPC P/N Example

Field		1	2	3	4
P/N	NPApc	2	A	N	T

TheNPAPC is shipped with the configuration ordered. Modifications can be done by ACS only.

2. Mechanical Description

The NPAPC is a chip-like module which is mounted on a carrier printed circuit board. The carrier printed circuit board is customer provided. The overall dimensions of the NPAPC and the location of the mounting holes are shown in the following figure. For details on mounting the NPAPC onto a carrier board see Mechanical considerations.

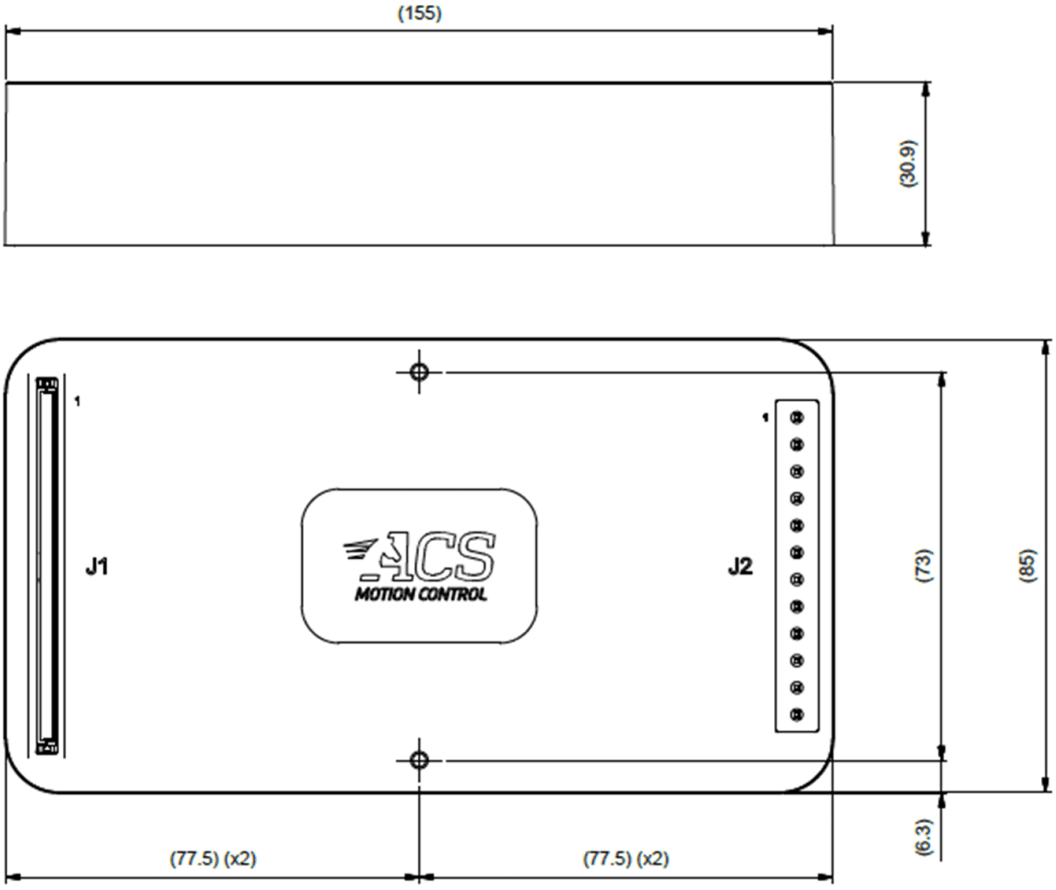

Figure 2-1. NPAPC Dimensions

3. Electrical Interface Description

This section describes how to interface with the NPAPC.

3.1 Connections

The following figure is a standard representation of connections and grounding. Specific settings and configurations are described in the following subsections. The connector assignments are in the following table.

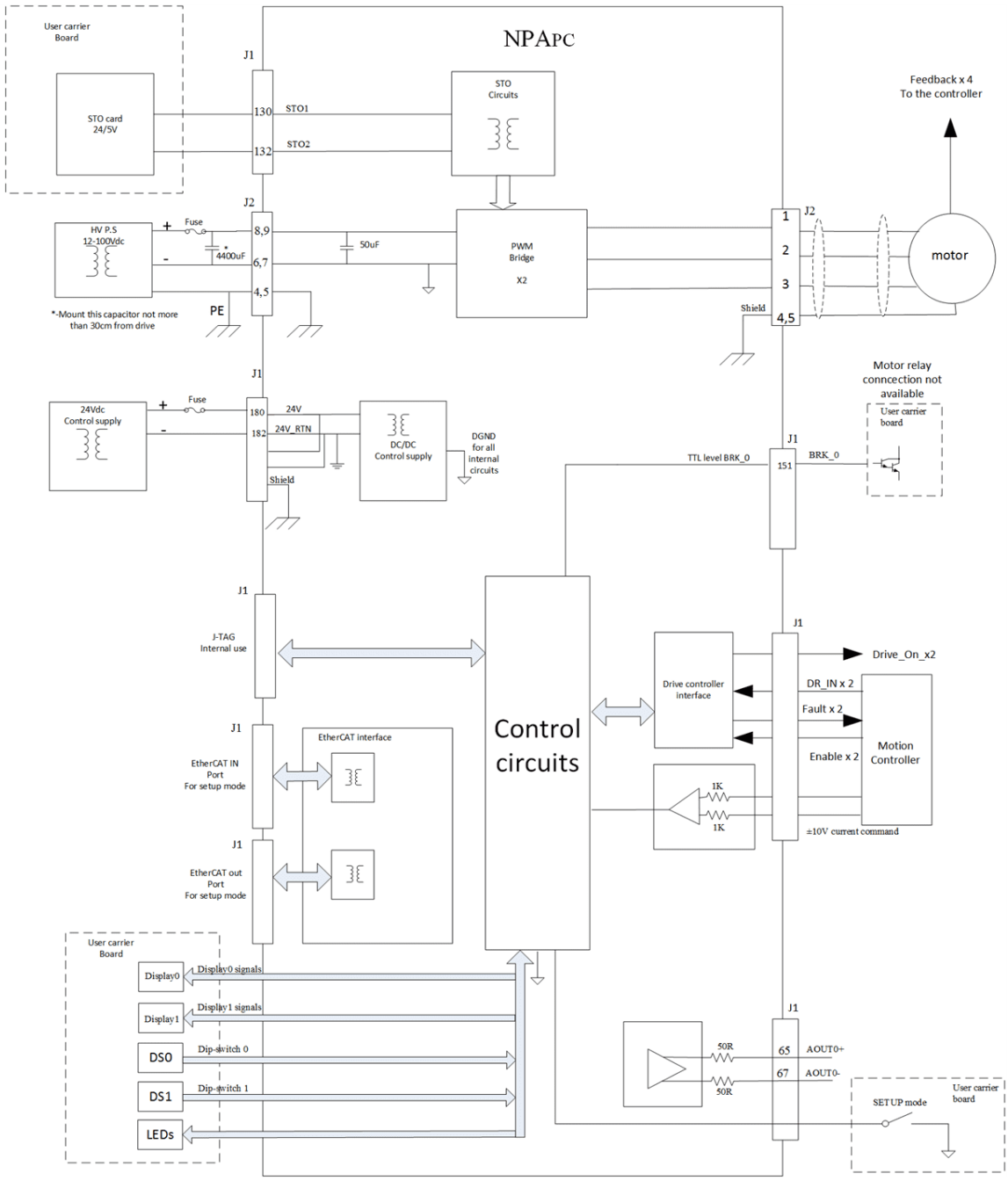

Figure 3-1. Connections and Grounding

Table 3-1. NPAPC Connections

Connector Assignment	Connector Name	Description
J1	Low power signals	Control power supply, drive controller inteface, I/Os, and all other low power signals
J2	High power signals	Drive power supply, motors

3.1.1 Drive-Controller Interface

The NPAPC drive-controller interface includes the following:

- 2 x Current command analog inputs
- 1 x Enable input
- 1 x Fault output
- 1 x Drive ON/OFF
- 1 x Dynamic range control input

Specific settings and configurations are described in the subsections below. The drive connections are shown in Figure 3-2. The drive enable input, drive fault output, and dynamic range input connections are shown in Figure 3-3 .

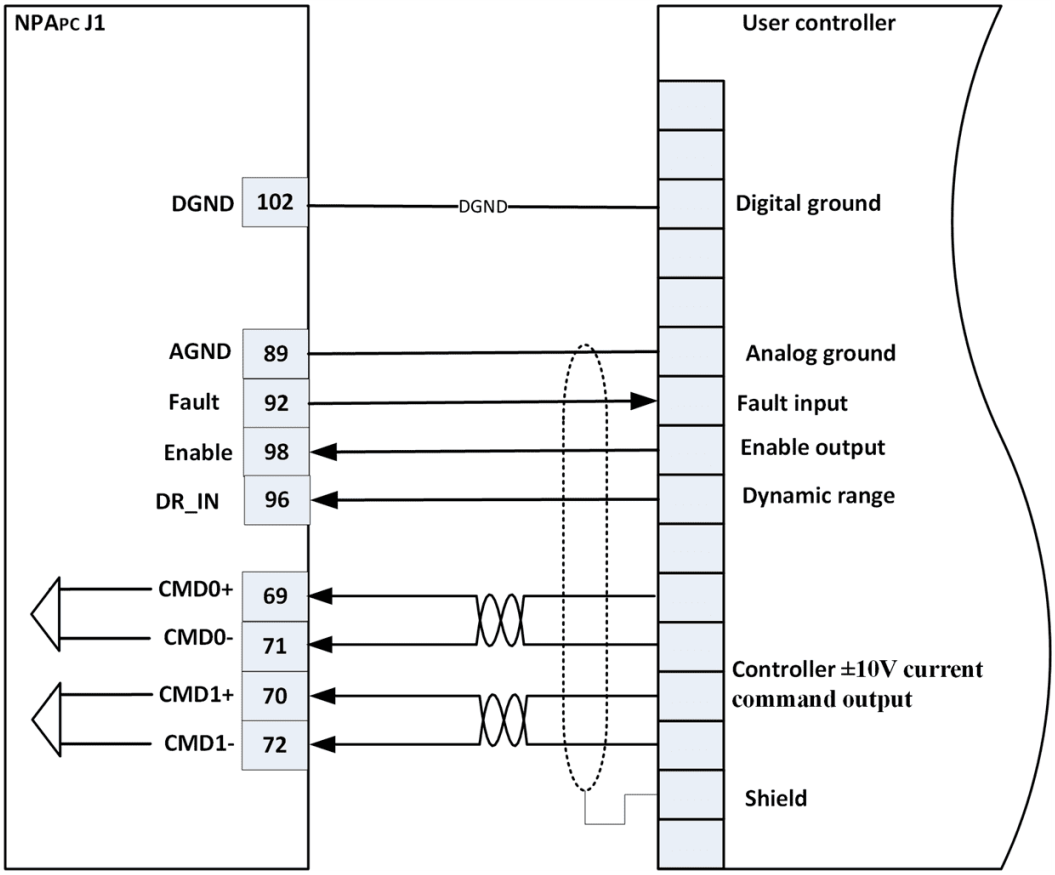

Figure 3-2. Drive connections

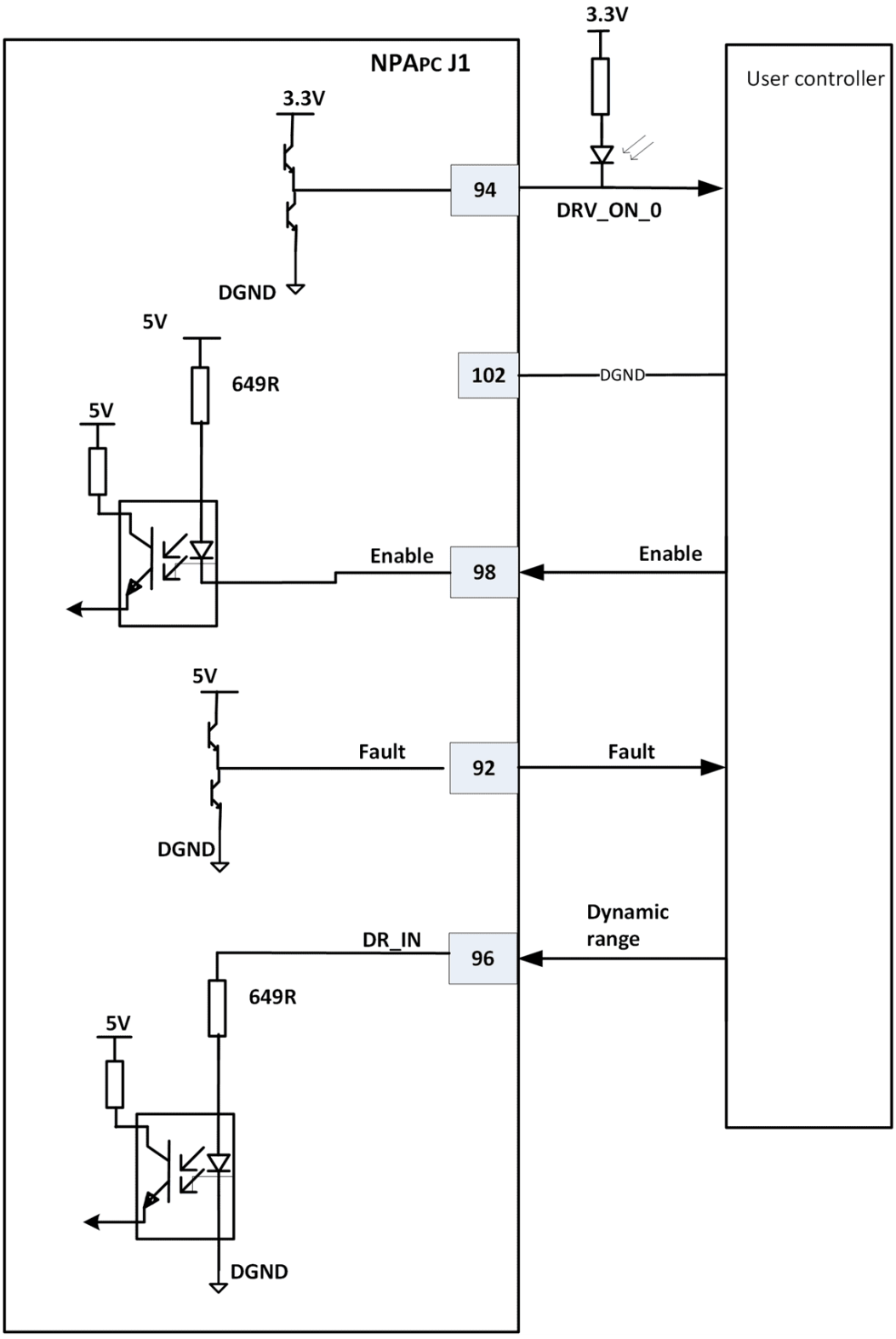

Figure 3-3. Drive enable input, drive fault output, and dynamic range input connections

3.1.1.1 Current Command

Table 3-2. Current Command

Item	Description
Designation	CMD0_#± CMD1_#±
Quantity	4
Interface	±20V or ±10V differential input
Command input filter bandwidth	5KHz
Resolution	16-bit
Offset	<20mV
SNR	>84db

3.1.1.2 Drive Enable Input

Table 3-3. Drive Enable Input

Item	Description
Designation	ENA_#
Quantity	One per axis
Interface	> TTL level, active low. > Reference: DGND
Input current	< 7mA current.
Logic state	> To enable the drive, ENA pin must be asserted low (ground). > When no current flows through the input, the drive is disabled.

3.1.1.3 Drive Fault Output

Table 3-4. Drive Fault Output

Item	Description
Designation	FLT_#

Item	Description
Quantity	One per axis
Interface	> TTL level, active high > Reference: DGND
Output current	1mA per output
Logic state	In the event of a drive fault, the drive is disabled and the output is set to 1. Note: The drive fault is cleared by enable command. The fault reset propagation delay is 60 usec.

3.1.1.4 Drive On/Off Output

Table 3-5. Drive On/Off Output

Item	Description
Designation	DRV_ON_#±
Quantity	1 per axis
Interface	> TTL level > Reference: DGND
Output current	1mA per output
Logic state	> Drive On = 0 > Drive Off = 1 (3.3V)

3.1.1.5 Dynamic Range Control

This feature improves the signal/noise ratio of the current command by up to 18db. The controller should support this feature. Otherwise, it should be left unconnected. The interface includes one TTL level input per axis.

When the input is 0, a 10V command will generate the maximum current specified for the drive. For example, the output of a 10/30A drive from a 10V command generates a 30A current. When the input is 1, a 10V command will generate 1/8 (12.5%) of the maximum specified current. In the above example, 10V command will generate current of 2.5A.

The controller can dynamically change the value and thus improve the quality of the command when a low command is required, during stand still and when moving the motor at a constant speed, see Current command dynamic range activation.

Table 3-6. Dynamic Range Input

Item	Description
Designation	DR1,0
Quantity	One input per axis
Type	> TTL level > Reference: DGND
Interface	5V, opto-isolated, Source input type.
Input current	< 7mA current.
Default state	DR=0 (Actual range = Programmable range)

3.1.2 Analog current monitoring outputs

The analog current monitoring output signals show the motor phase current, see Current Monitor Analog Outputs for details. A connection diagram is shown in the following figure.

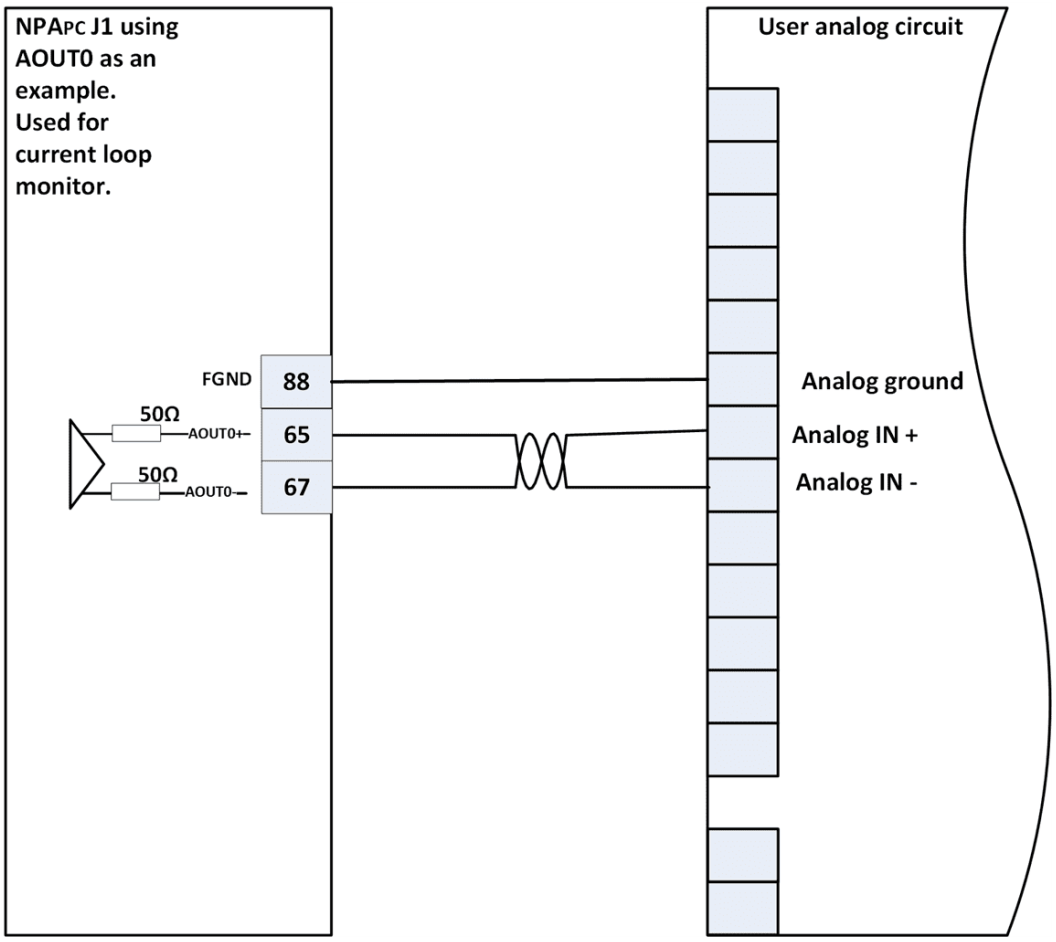

Figure 3-4. Analog Output Connections

3.1.3 Motors

The NPAPC supports the following motors:

- Two- and three-phase permanent magnet (DC brushless/AC servo)
- DC brush
- Voice coil
- Two- and three-phase stepper (micro-stepping open or closed loop)

For motor connections with relays see Motor connection with relays.

A connectivity diagram for a three-phase motor and for a single-phase motor are shown in Figure 3-5 and Figure 3-6, respectively.

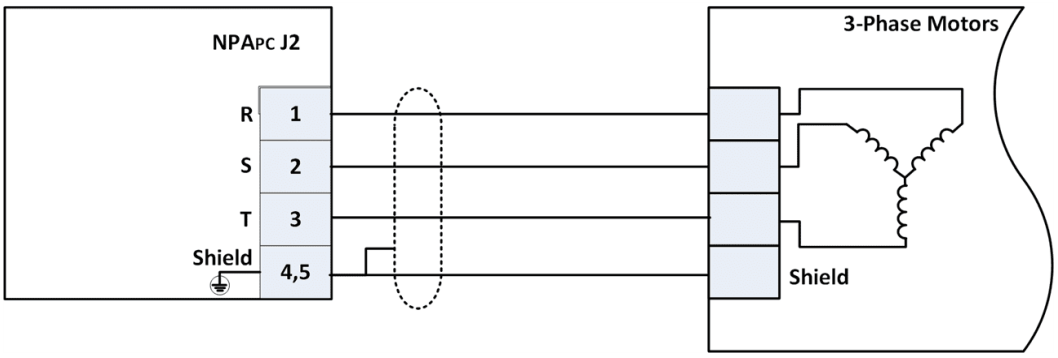

Figure 3-5. Three-Phase Motor Connections

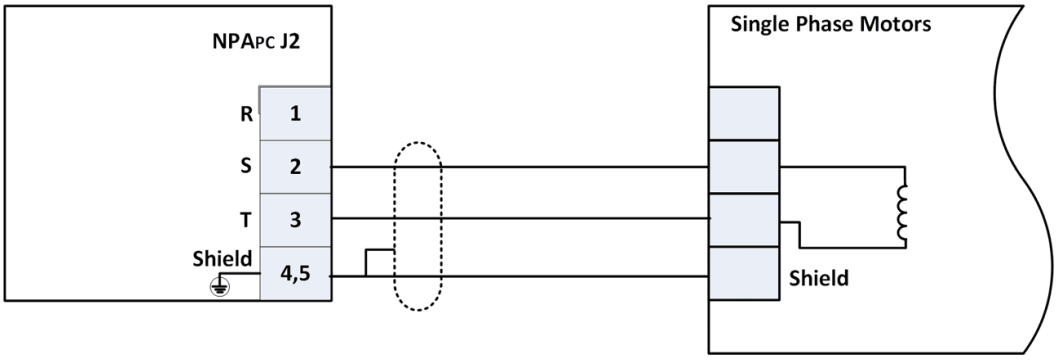

Figure 3-6. DC brush motor or DC voice coil actuator

3.1.4 Control and drive power supplies

The NPMPC is fed by two power supplies:

- 24Vdc control supply
- 12Vdc to 100Vdc drive supply

The supplies can be turned on and off in any order. During emergency situations, the drive supply can be disconnected while the control supply is to remain connected.

3.1.4.1 Control Supply Guidelines

When selecting the control power supply, use the following guidelines:

- The control power supply must be isolated.
- The control power supply must be CE and UL approved.
- The control power supply must be short circuit protected.
- The control power supply must have very low noise and ripple.
- The control power supply must be connected to the unit via 3A fuse.
- An example of a suitable 24V/70W control power supply is the XP Power P/N VCS70US24 supply.
- To comply with European standards (CE), it is recommended to use an AC line filter.

For detailed specifications including current load with and without motor relays see Control Supply. The following figure shows the control supply connections.

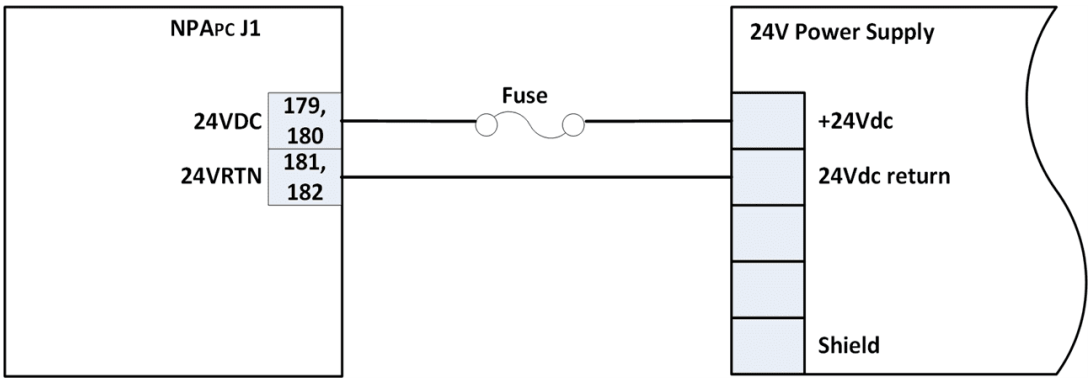

Figure 3-7. Control Supply Connections

3.1.4.2 Drive Supply Guidelines

When selecting the drive power supply, use the following guidelines:

- The drive power supply must be isolated.
- The drive power supply must be CE and UL approved.
- The drive power supply must be short circuit protected.
- The drive power supply must have very low noise and ripple.
- A drive power supply not exceeding 96Vdc is recommended.
- Do not use a drive power supply with voltage greater than 100V under any conditions.
- If the drive power supply cannot absorb the regeneration energy from the motor when decelerating, you must use an external regeneration circuit. Connect the regeneration circuit in parallel to the motor supply. The voltage activation level should not exceed 102V.
- The drive power supply must be able to provide the peak current required by the motor (inductance load). Adding an external capacitor of 4400uF, installed as close as possible to the drive (no further than 30cm from the drive), can help the power supply to handle the peak current and reduce the bus current ripple.
- The drive power supply must be selected based on the power consumed by drive 1 and drive 2 (if applicable).
- The drive power supply must be connected to the unit via fuse. The value of the filter depends on the power supply voltage and the current consumption.
- An example of a suitable drive power supply is from XP Power. The 48V/1500W power supply has the P/N HPU1K5PS48.
- To comply with European standards (CE), it is recommended to use an AC line filter. The value of the filter depends on the power supply voltage and the current consumption. The filter is to be as close as possible to the NPAPC.

For detailed specifications see Drive Power Specifications. The following figure shows the drive supply connection.

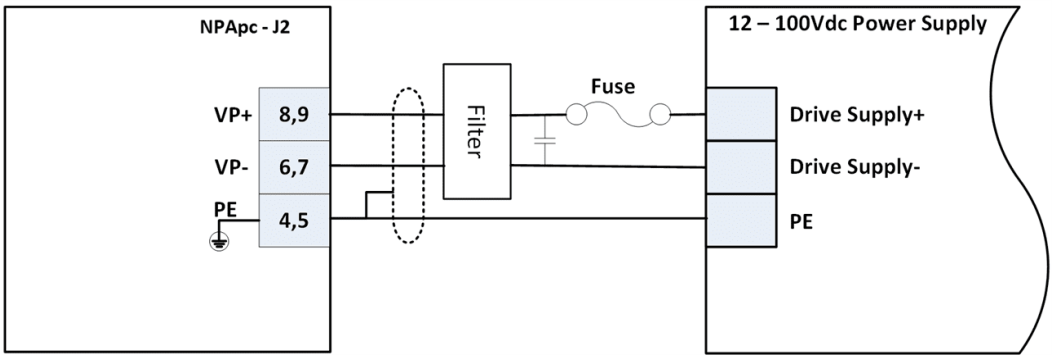

Figure 3-8. Drive Supply Connections

3.1.4.3 Regeneration

- A drive power supply with voltage not exceeding 96Vdc is recommended.
- Do not use a drive power supply with voltage greater than 100V under any conditions.
- If the drive power supply cannot absorb the regeneration energy from the motor when decelerating, you must use an external regeneration circuit. Connect the regeneration circuit in parallel to the motor supply. The voltage activation level should not exceed 102V.

3.1.5 EtherCAT Connection Instructions

The EtherCAT is used to connect the unit to an ACS EtherCAT Master for setup purposes. When connected to such a controller, it is possible to tune the current loop filter. EtherCAT communication is active only when the unit is set to operate in setup mode by plugging a jumper to the JP1, see Calibration in setup mode. The following figure shows the EtherCAT connection.

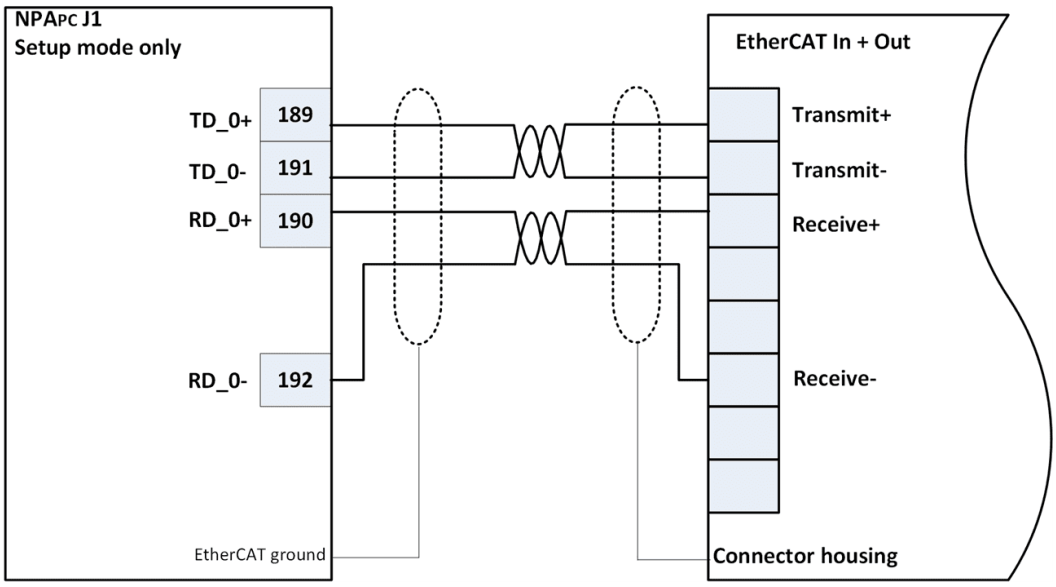

Figure 3-9. EtherCAT Connections

3.1.6 Low and High Power Signal Connectors

The following figure shows connector J1 and connector J2 for the NPAPC. Pin 1 for each connector is indicated with the red arrow.

Figure 3-10. NPAPC Connectors

3.1.6.1 J1 - Low Power Signals Connector

Label: J1

Figure 3-11 shows the connector on the NPAPC, Figure 3-12 shows the mating connector for the carrier board, and Table 3-7 lists the signal pinouts.

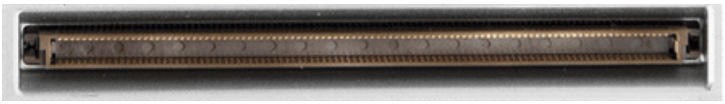

Figure 3-11. Connector: Molex P/N 536272074

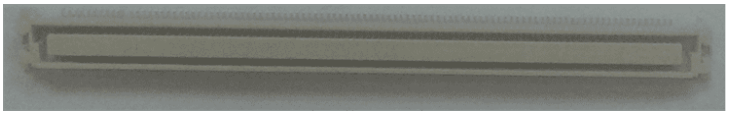

Figure 3-12. Mating connector: Molex P/N 528852074

Table 3-7. J1 - Low Level Signals Pinout

	Name	Description
1	AIN2+	Not used
2	AIN3+	Not used

	Name	Description
3	AIN2-	Not used
4	AIN3-	Not used
5	AOUT2+	S+ phase current of drive 1
6	AOUT3+	T+ phase current of drive 1
7	AOUT2-	S- phase current of drive 1
8	AOUT3-	T- phase current of drive 1
9	CMD1_0+	Current command 0 for axis 1 non-inverted input
10	CMD1_1+	Current command 1 for axis 1 non-inverted input
11	CMD1_0-	Current command 0 for axis 1 inverted input
12	CMD1_1-	Current command 1 for axis 1 inverted input
13	SIN2+	Not used
14	SIN3+	Not used
15	SIN2-	Not used
16	SIN3-	Not used
17	COS2+	Not used
18	COS3+	Not used
19	COS2-	Not used
20	COS3-	Not used
21	SC_I_2+	Not used
22	SC_I_3+	Not used
23	SC_I_2-	Not used
24	SC_I_3-	Not used
25	1_DSW1	DIP switch 1 for axis 1
26	FLT1	Axis 1 drive fault output

	Name	Description
27	1_DSW2	DIP switch 2 for axis 1
28	ENA1	Axis 1 drive enable input
29	1_DSW3	DIP switch 3 for axis 1
30	AXIS1_DIS_LED	Axis 1 disable LED (red)
31	1_DSW4	DIP switch 4 for axis 1
32	AXIS1_ENA_LED	Axis 1 enable LED (green)
33	2_CHA+	Not used
34	3_CHA+	Not used
35	2_CHA-	Not used
36	3_CHA-	Not used
37	2_CHB+	Not used
38	3_CHB+	Not used
39	2_CHB-	Not used
40	3_CHB-	Not used
41	2_CHI+	Not used
42	3_CHI+	Not used
43	2_CHI-	Not used
44	3_CHI-	Not used
45	PEG1+	Not used
46	DR_IN1_0	Dynamic range input for axis 1
47	PEG1-	Not used
48	DRV_1_ON	Drive 1 on/off output status
49	1_HA	Not used
50	1_HC	Not used

	Name	Description
51	1_HB	Not used
52	1_OVER_T	Motor 1 over temperature input
53	7-SEG_1_A	7 segment 1 , A segment output
54	7-SEG_1_E	7 segment 1 , E segment output
55	7-SEG_1_B	7 segment 1 , B segment output
56	7-SEG_1_F	7 segment 1 , F segment output
57	7-SEG_1_C	7 segment 1 , C segment output
58	7-SEG_1_G	7 segment 1 , G segment output
59	7-SEG_1_D	7 segment 1 , D segment output
60	7-SEG_1_DO	7 segment 1 , DO segment output
61	AIN0+	Not used
62	AIN1+	Not used
63	AIN0-	Not used
64	AIN1-	Not used
65	AOUT0+	S+ phase current of drive 0
66	AOUT1+	T+ phase current of drive 0
67	AOUT0-	S- phase current of drive 0
68	AOUT1-	T- phase current of drive 0
69	CMD0_0+	Current command 0 for axis 0 non-inverted input
70	CMD0_1+	Current command 1 for axis 0 non-inverted input
71	CMD0_0-	Current command 0 for axis 0 inverted input
72	CMD0_1-	Current command 1 for axis 0 inverted input
73	SIN0+	Not used
74	SIN1+	Not used

	Name	Description
75	SIN0-	Not used
76	SIN1-	Not used
77	COS0+	Not used
78	COS1+	Not used
79	COS0-	Not used
80	COS1-	Not used
81	SC_I_0+	Not used
82	SC_I_1+	Not used
83	SC_I_0-	Not used
84	SC_I_1-	Not used
85	5F	Not used
86	5F	Not used
87	AGND	Analog ground for CMD signals
88	FGND	Analog ground for AOUT signals
89	AGND	Analog ground for CMD signals
90	AGND	Analog ground for CMD signals
91	0_DSW1	DIP switch 1 for axis 0
92	FLT0	Drive fault output
93	0_DSW2	DIP switch 2 for axis 0
94	DRV_0_ON	Drive 0 on/off output status
95	0_DSW3	DIP switch 3 for axis 0
96	DR_IN0_0	Dynamic range input for axis 0
97	0_DSW4	DIP switch 4 for axis 0
98	ENA0	Axis 0 drive enable input

	Name	Description
99	5U	5.1V Auxiliary voltage up to 0.5A reference to DGND
100	5U	5.1V Auxiliary voltage up to 0.5A reference to DGND
101	DGND	Not used
102	DGND	Not used
103	0_CHA+	Not used
104	1_CHA+	Not used
105	0_CHA-	Not used
106	1_CHA-	Not used
107	0_CHB+	Not used
108	1_CHB+	Not used
109	0_CHB-	Not used
110	1_CHB-	Not used
111	0_CHI+	Not used
112	1_CHI+	Not used
113	0_CHI-	Not used
114	1_CHI-	Not used
115	TCK	Servo processor JTAG TCK signal (for ACS use only)
116	VCC3	3.3V auxiliary voltage (for ACS use only)
117	EMU0	Servo processor JTAG EMU0 signal (for ACS use only)
118	TMS	Servo processor JTAG TMS signal (for ACS use only)
119	EMU1	Servo processor JTAG EMU1 signal (for ACS use only)
120	TDI	Servo processor JTAG TDI signal (for ACS use only)
121	TRST	Servo processor JTAG TRST signal (for ACS use only)
122	TDO	Servo processor JTAG TDO signal (for ACS use only)

	Name	Description
123	MPU_LED_ENA	Communication LED green
124	0_HA	Not used
125	MPU_LED_DIS	Communication LED red
126	0_HB	Not used
127	AXIS_0_DIS_LED	Axis 0 disable LED (red)
128	0_HC	Not used
129	AXIS_0_ENA_LED	Axis 0 enable LED (green)
130	5V_STO_1	5V supply from STO card, input 1
131	STO1	STO1 input status (from STO card)
132	5V_STO_2	5V supply from STO card, input 2
133	STO2	STO2 input status (from STO card)
134	7-SEG_0_E	7 segment 0 , E segment output
135	7-SEG_0_A	7 segment 0 , A segment output
136	7-SEG_0_F	7 segment 0 , F segment output
137	7-SEG_0_B	7 segment 0 , B segment output
138	7-SEG_0_G	7 segment 0 , G segment output
139	7-SEG_0_C	7 segment 0 , C segment output
140	7-SEG_0_DO	7 segment 0 , DO segment output
141	7-SEG_0_D	7 segment 0 , D segment output
142	RJ45_IN_D2P	Run LED for RJ45 input port anode (yellow LED)
143	SA_MODE	Setup mode input, connect to DGND
144	RJ45_IN_D2N	Run LED for RJ45 input port cathode (yellow LED)
145	RJ45_OUT_D2P	Control supply LED for RJ45 output port anode (yellow LED)
146	RJ45_IN_D1N	Link LED for RJ45 input port cathode (yellow LED)

	Name	Description
		Note: the anode of this LED must be connected to 3.3V
147	RJ45_OUT_D2N	Control supply LED for RJ45 output port cathode (yellow LED)
148	PEG0+	Not used
149	RJ45_OUT_D1N	Link LED for RJ45 output port cathode (yellow LED) Note: the anode of this LED must be connected to 3.3V
150	PEG0-	Not used
151	BRK0	Control for dynamic brake relay of axis 0
152	0_OVER_T	Motor 0 over temperature input
153	BRK1	Control for dynamic brake relay of axis 1
154	NC	Not connected
155	NC	Not connected
156	NC	Not connected
157	NC	Not connected
158	NC	Not connected
159	NC	Not connected
160	NC	Not connected
161	MARK0+	Not used
162	MARK2+	Not used
163	MARK0-	Not used
164	MARK2-	Not used
165	MARK1+	Not used
166	MARK3+	Not used
167	MARK1-	Not used
168	MARK3-	Not used

	Name	Description
169	OUT1	Not used
170	OUT0	Not used
171	0_RL	Not used
172	V_SUP_IO	Not used
173	0_LL	Not used
174	V_RTN_IO	Not used
175	1_RL	Not used
176	V_SUP_SFTY	Not used
177	1_LL	Not used
178	V_RTN_SFTY	Not used
179	24V	24V control supply
180	24V	24V control supply
181	24V_RTN	24V control supply return
182	24V_RTN	24V control supply return
183	NC	Not connected
184	NC	Not connected
185	NC	Not connected
186	NC	Not connected
187	NC	Not connected
188	NC	Not connected
189	RJ45_IN_1	EtherCAT input RJ45 pin 1
190	RJ45_IN_3	EtherCAT input RJ45 pin 3
191	RJ45_IN_2	EtherCAT input RJ45 pin 2
192	RJ45_IN_6	EtherCAT input RJ45 pin 6

	Name	Description
193	RJ45_IN_4	EtherCAT input RJ45 pin 4
194	RJ45_IN_7	EtherCAT input RJ45 pin 7
195	RJ45_OUT_1	EtherCAT output RJ45 pin 1
196	RJ45_OUT_3	EtherCAT output RJ45 pin 3
197	RJ45_OUT_2	EtherCAT output RJ45 pin 2
198	RJ45_OUT_6	EtherCAT output RJ45 pin 6
199	RJ45_OUT_4	EtherCAT output RJ45 pin 4
200	RJ45_OUT_7	EtherCAT output RJ45 pin 7

3.1.6.2 J2 - High Power Signal Connector

Label: J2

Figure 3-13 shows the connector on the NPAPC, Figure 3-14 shows the mating connector for the carrier board, and Table 3-8 lists the signal pinouts.

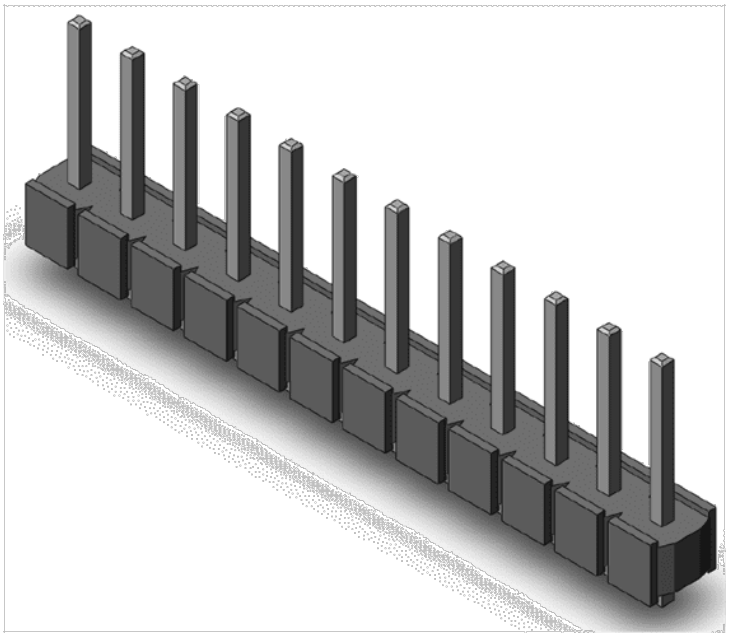

Figure 3-13. Connector: Samtec P/N HPW-12-04-T-S-200-511

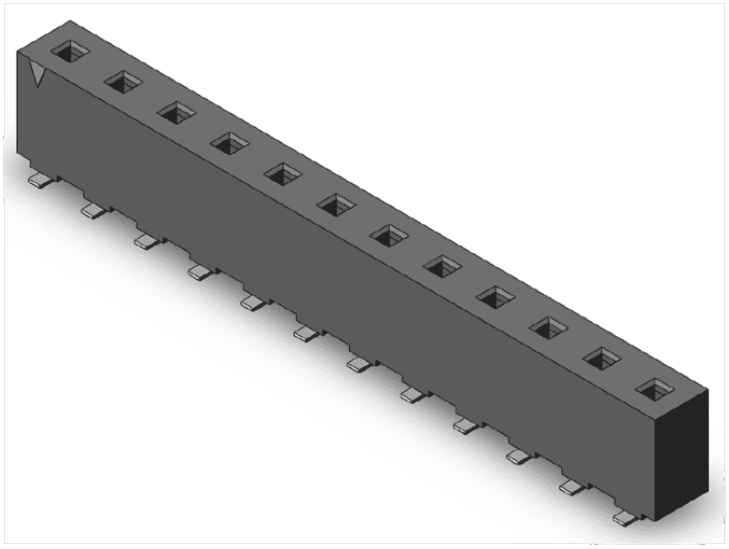

Figure 3-14. Mating connector: Samtec P/N HPF-12-02-T-S-LC

Table 3-8. J2 High Power Signals Pinout

Pin	Name	Description
1	R1	Motor 1 R phase for three-phase motor
2	S1	Motor 1 S phase for three-phase motor, single-phase motor
3	T1	Motor 1 T phase for three-phase motor, single-phase motor
4	PE	Protected earth
5	PE	Protected earth
6	VP-	Drive supply return
7	VP-	Drive supply return
8	VP+	Drive supply positive edge
9	VP+	Drive supply positive edge
10	R0	Motor 0 R phase for three-phase motor
11	S0	Motor 0 S phase for three-phase motor, single-phase motor

Pin	Name	Description
12	T0	Motor 0 T phase for three-phase motor, single-phase motor

4. Carrier Board Design

This section provides guidelines for the NPAPC carrier board design. The following guidelines are given:

- Mechanical structure requirements
- Circuits implemented on the carrier board

The NPAPM carrier board (internal ACS P/N SB-18027-400/LF) can be used as a design reference. The following design files are available for authorized users from https://www.acsmotioncontrol.com/NPMpc#downloads.

Table 4-1. NPAPC Carrier Design Reference Files

File Name	File Type
NPMPC printed circuit board	PCB
NPMPC mechanical design	DXF
NPMPC support bracket	PDF
UDMNP electrical design	OrCAD DSN

The NPMPM can be used as a prototype.

4.1 Mechanical considerations

When designing the carrier board, use the following guidelines:

- Traces between the NPAPC module and the end use connectors must be as short as possible.
- Use at least 2.5mm PCB thickness to insure mechanical stability and easy plug-in and out of the NPAPC connectors.

Figure 4-1 shows a potential carrier board layout with an NPAPC attached. The minimum size required for the NPAPC, the location of the mounting holes, and the connectors are shown. Figure 4-2 and Figure 4-3 are pictures for a top view and isometric view.

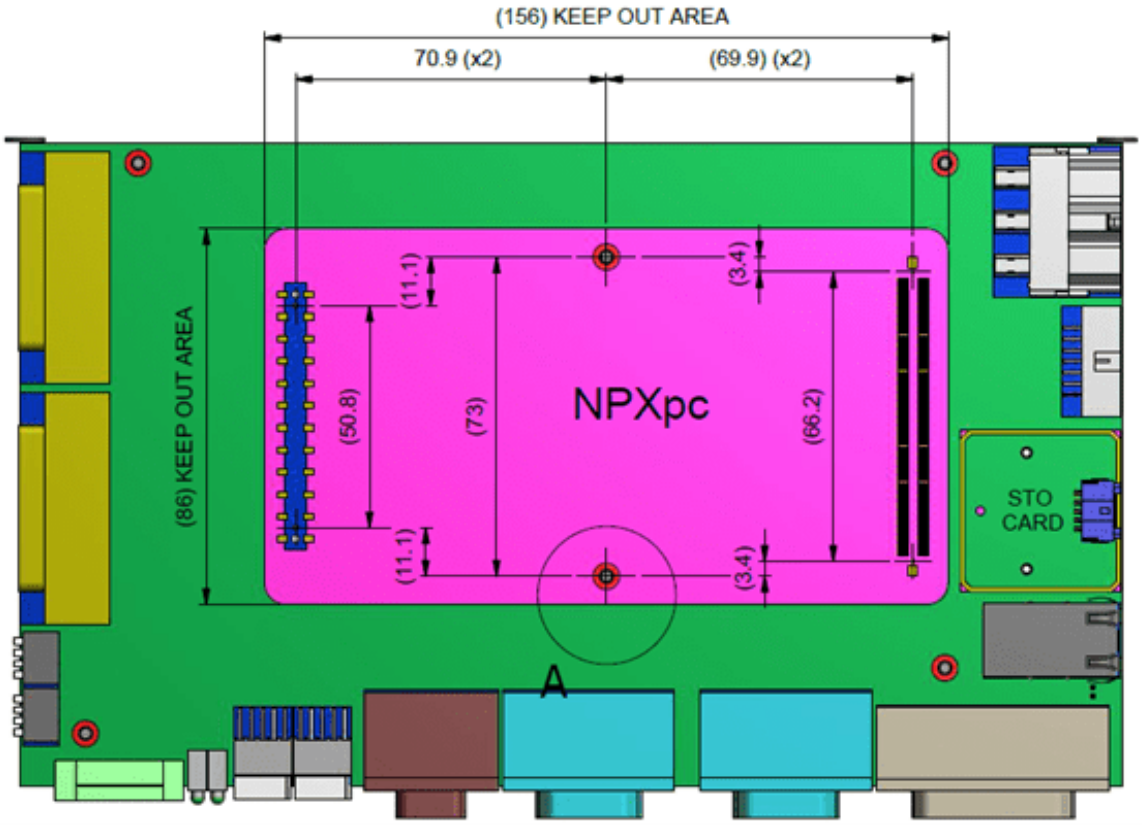

Figure 4-1. NPAPC Carrier Board Layout

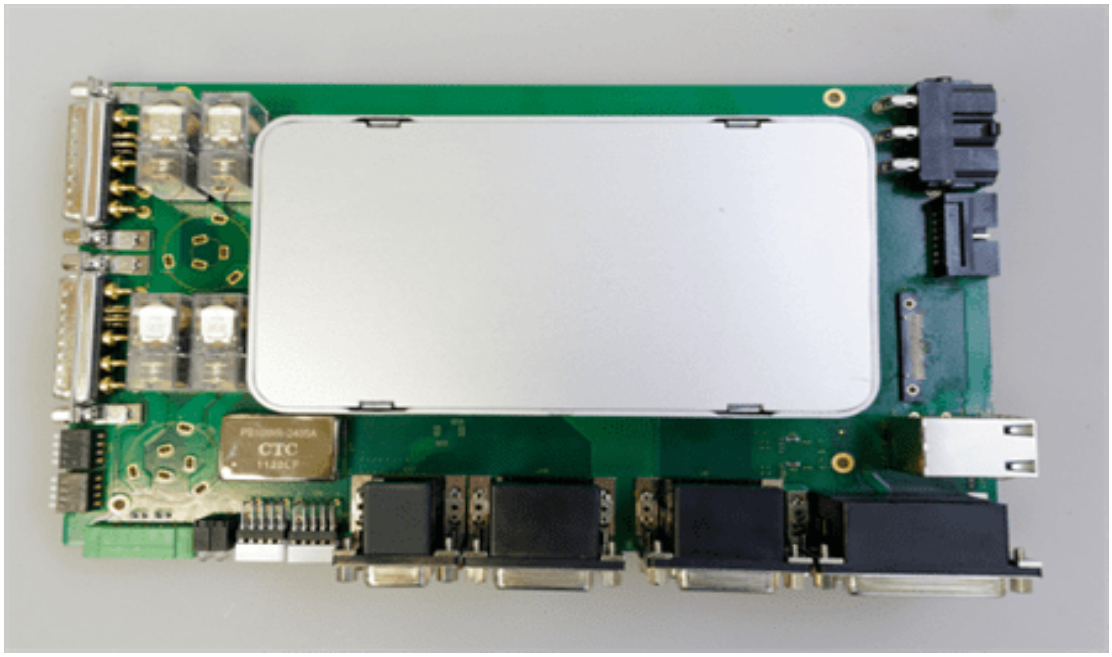

Figure 4-2. Top View

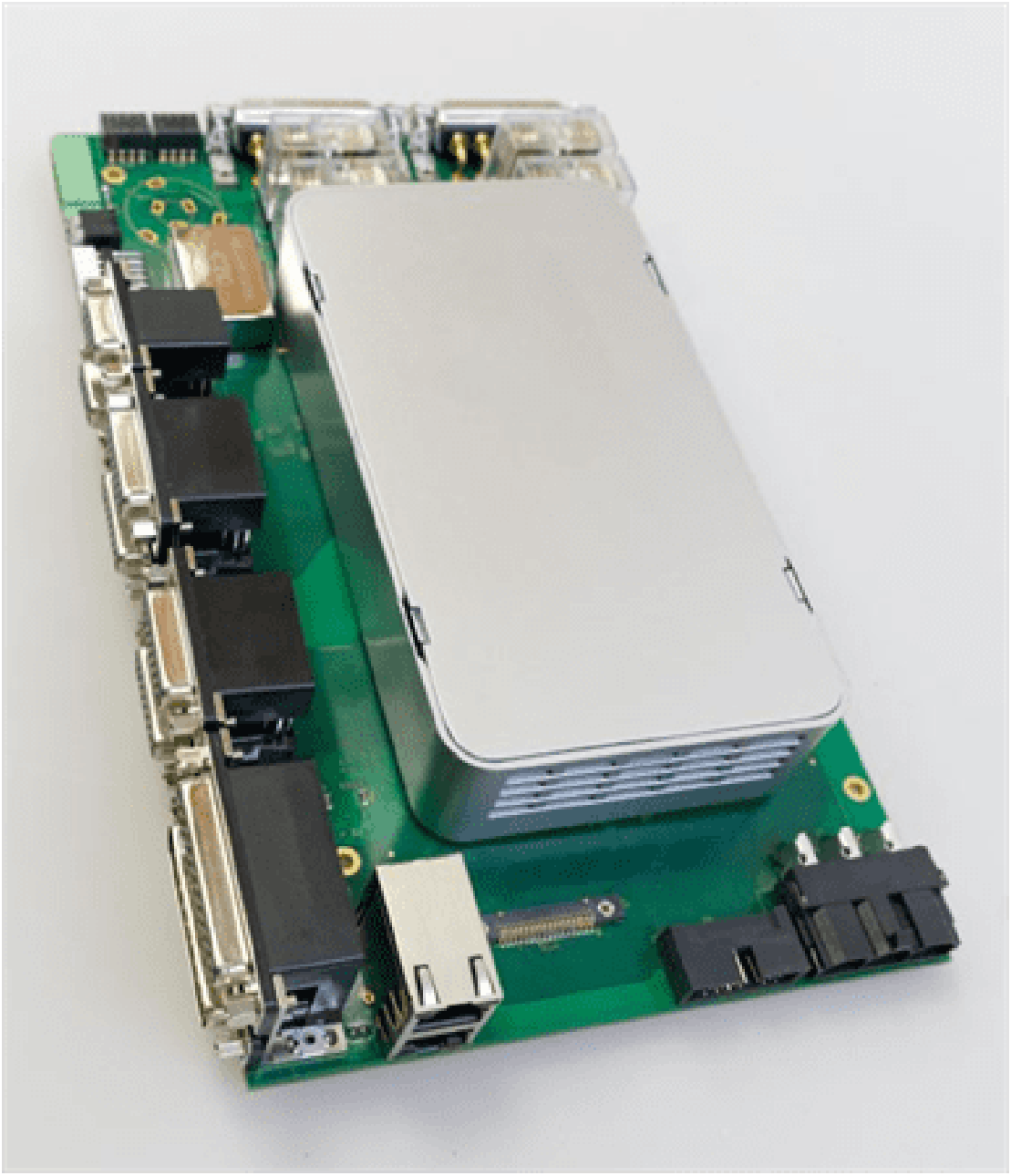

Figure 4-3. Isometric View

4.2 Electrical considerations

The carrier board should include interface circuits tailored to specific needs. This section provides guidelines including shielding, grounding, and a description of components such as resistors and capacitors.

The following are carrier board design guidelines:

- Observe industry standard practices for circuit layout.
- The traces must be as short as possible to minimize EMI.

- The width and thickness of the traces are to be calculated so that the temperature of the PCB will not exceed 100°C under any condition.
- Use ground planes wherever possible to minimize the inductance and the temperature of the traces.

4.2.1 Grounding

The NPAPC has groups of signals which utilize different grounds.

The following are carrier board design guidelines:

- Avoid cross conduction between the grounds to eliminate any cross talk and malfunction.
- Use a ground plane under the component-side and in last layer before print-side to protect the signals from EMI and to avoid radiated emission.

The following table shows the different signal groups.

Table 4-2. Grounding

Type of Signal or Circuit	Name	Description
Drive supply circuit	VP-	Drive supply return
PE/Shield	PE	Protected earth
Opto-isolated ground	24V_RTN V_RTN_SFTY V_RTN_IO	24V control supply return Supply return for safety input Supply return for general purpose digital output
Digital low level signals	DGND	
Current command signals	AGND	Analog ground for CMD signals
General purpose analog signal ground	FGND	Analog ground for AIN and AOUT signals
EtherCAT communication signals	All EtherCAT signals are to be fully isolated from all other circuits.	

4.2.2 Separation between high and low power signals

- The high and low power traces must be kept as far away as possible from the feedback, control, and communication traces.

- Clearance and creepage between the high voltage circuit and the low voltage circuits must be according to UL61800-5-1 and EN61800-5-1.
- The carrier design should comply with related safety and EMC standards.

4.2.3 EMC guidelines

- Use a ground plane under the component-side and in last layer before print-side to protect the signals from EMI and to avoid radiated emission.
- Use internal planes to avoid cross talk between signals inside a group .

4.2.4 Considerations for each function

This section provides guidelines for the Implementation of the interfacing circuits including motor phase inductors and termination resistors.

Guidelines for the following are provided:

- Encoders
- Motor connection with relays
- Motor over temperature
- STO
- Display LED
- Jumpers

4.2.4.1 Motor connection with relays

The NPAPC provides control signals for two external motor relays, one per axis. A motor relay will short circuit the motor phases if a drive is disabled or for a drive fault. The default state for the relay is open. When the drive is disabled, the relay closes, for detailed specifications see Motor Relay Control. The following figure shows the connections for motor relay.

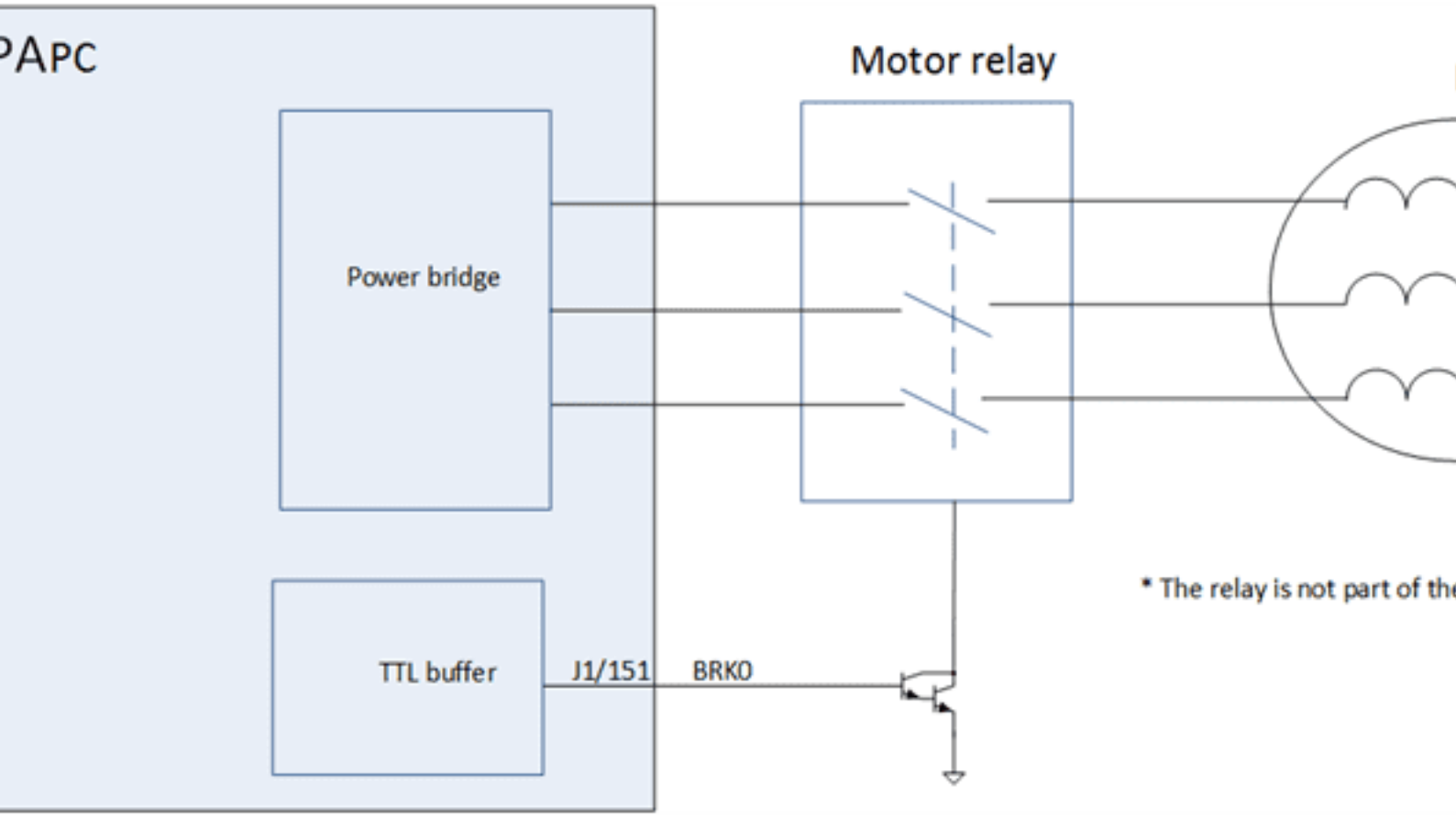

Figure 4-4. Motor Relay Connection

The motor connection without a relay is described in section Motors.

4.2.4.2 Motor Over Temperature

The NPAPC can be fed with a signal that the motor is overheated. One signal per axis is supported. The user can define the response of the controller. The default response is no action, see Motor Over Temperature Specifications for detailed specifications. The following figure shows the motor over temperature connection.

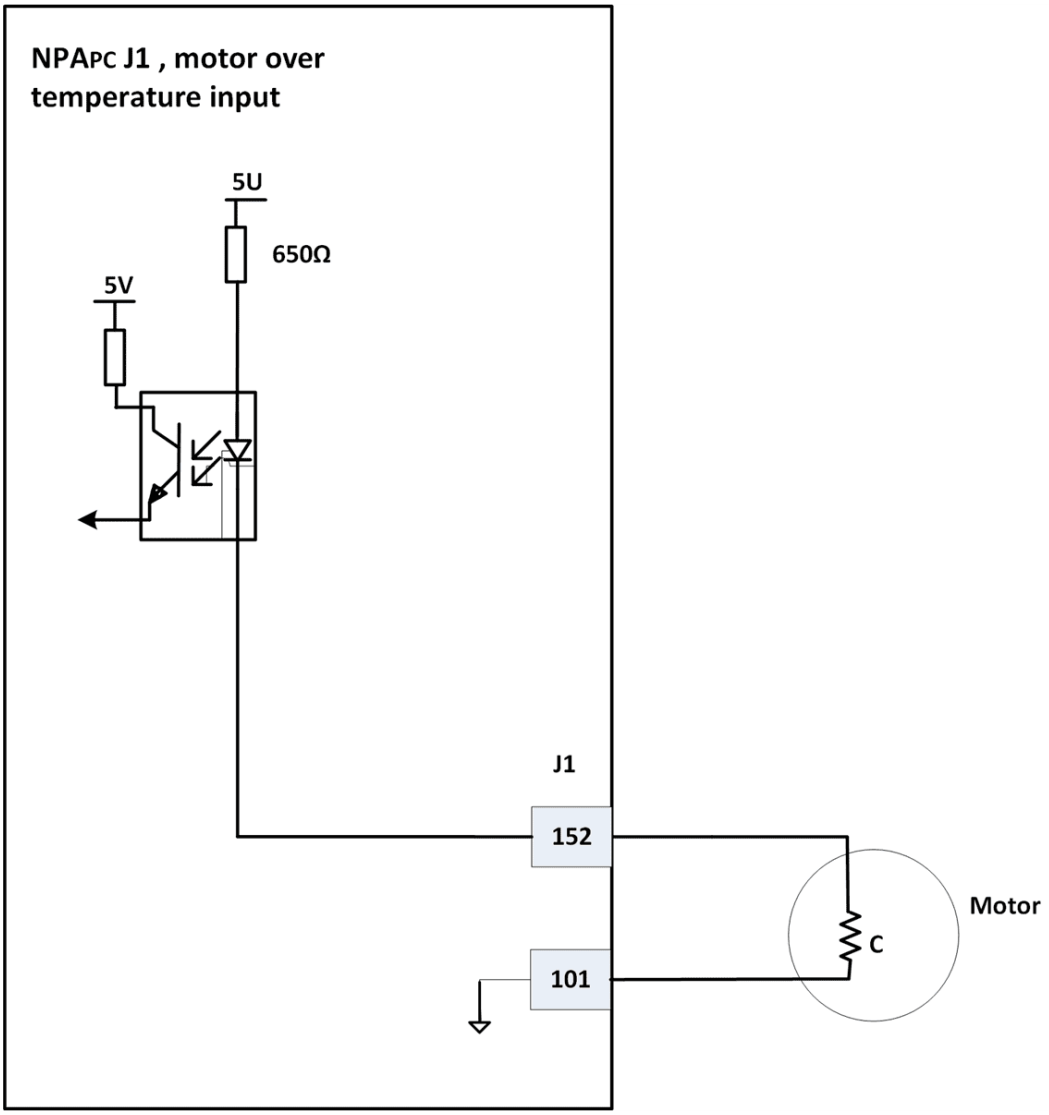

Figure 4-5. Motor Over-Temperature Connection

4.2.4.3 STO Connection Instructions

The NPAPC Safe Torque Off option module is certified for use in safety applications up to and including SIL-3 according to:

- EN/IEC 61800-5-2 Ed. 2 (second environment)
- EN/ IEC 61800-5-1
- IEC 61508
- IEC 62061

Performance Level PLe and Category 3 according to:

- EN ISO 13849-1/-2

The ACS STO module P/N SB-16530-200/LF is not part of the NPAPC and should be ordered separately.

The following figure shows the STO connection. For detailed information on STO, see *AN Safe Torque Off Function* and *NPMPC NPAPC UDMCB Funtional Safety Manual.*.

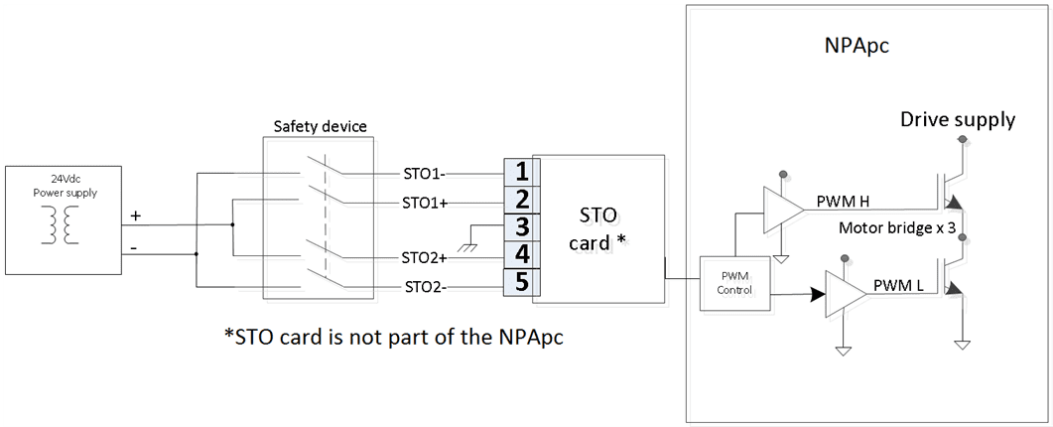

Figure 4-6. STO Connection

If the STO is not used:

1. Connect 5V to pin J1/130 (5V_STO_1) and pin J1/132 (5V_STO_2).
2. Connect pin J1/131 (STO1) and pin J1/133 (STO2) to DGND (pin 102).

4.2.4.4 Display

The NPAPC supports two 7-segment displays and several LEDs. These show drive status and report fault conditions.

4.2.4.5 Jumpers

The carrier board should have one jumper called SA_MODE.

When using more than one NPAPC module, it is necessary to make two shorts on the carrier board between modules. The first is between J1/148 of the first unit to J1/103 of the second unit. The second is between J1/150 of the first unit to J1/105 of the second unit. If more than two units are in service, then use the same procedure for each following module in the chain. That is make a short between J1/148 of a leading (first) module to J1/103 of a following module and between J1/150 of the leading (first) module to J1/105 of a following module.

5. Product Specifications

Drive Power Specifications

Feature	Specifications			
Per Drive	A	B	C	D
Continuous/peak current sin amplitude [A]	3.3/10	6.6/20	10/30	13.3/40
Continuous current RMS per axis [A]	2.3/7	4.6/14.1	7/21.2	9.4/28.2
Maximum cont. Input current [A] @ continuous current	2.6	5.3	8	10.6
Maximum cont. Input current [A] @ peak current	8	15	24	32
Heat dissipation [W] (power loss in standby is 7[W])	7+0.9x (no. of drives)	7+2.1x (no. of drives)	7+3.7x (no of drives)	7+5.6x (no of drives)
Maximum cont./peak output power @ 100Vdc [W] (±5%)	260/780	520/1560	790/2340	1050/3120
Peak current time [sec]	1			
Minimum load inductance @100Vdc [mH] Can be derated linearly for lower voltages	0.05			
Type	3-phase NanoPWM bridge			
Phase Designation per axis	R, S, T			
Quantity	1 or 2			
Protections	> Short & over current: 60A±5% > Over temperature: 100°C (on PCB) > Over voltage:106V±1% > Under voltage: 9V±3%			
Per Module				
Control voltage input [Vdc]	24 ±10%			

Feature	Specifications			
Drive voltage input range [Vdc]	12 – 100 (96 recommended)			
Maximum drive voltage [Vdc]	(Vin motor) x 88%			
Maximum cont. input current per module [A]	5.2	10.6	16	21.2

Motor Relay Control

Item	Description	Remarks
Designation	#_BRK	Per axis.
Type	TTL level Reference: DGND	
Output current	10mA per output	
Logic state	When enabled, this signal set to logic 1	

Motor Over Temperature Specifications

Item	Description	Remarks
Designation	Motor over temperature: #_OVER_T	
Quantity	Two, one per motor	
Type	> Single-ended, opto-isolated > Reference: DGND	
Threshold	> Over temperature protection is on, when the impedance between $_Motor_OVER pin to ground is above 10kΩ > Over temperature protection is off, when the impedance between $_Motor_OVER pin to ground is below 1kΩ	When this protection is not used, the Motor_OVER pin should be shorted to ground.
Default state	Over temperature off = Low impedance <1kΩ	

Feature	Specifications
Drives	> Type: Digital current control with field oriented control and space vector modulation > Current ripple frequency: 40 kHz > Current loop sampling rate: 20 kHz > Programmable current loop bandwidth: up to 4 kHz. Will vary with tuning and load parameters. > Commutation type: Sinusoidal. Initiation with and without hall sensors > Switching method: Advanced unipolar PWM > Protection: > Over & under voltage > Phase to phase > Phase to ground short  Short circuit on one of the motor phases might damage the drive. > Over current > Over-temperature  Commutation is performed using the external controller.
Supply	The module is fed by two power sources.: > Motor supply > 24Vdc control supply. During emergency conditions there is no need to remove the 24Vdc control supply.

Feature	Specifications
Motor Drive Supply	> Range: 12Vdc to 100Vdc, recommended 96Vdc. > Current rating of the power supply should be calculated based on actual load. > External shunt power resistor, activated at 102V, should be added in parallel to motor drive supply in the event external regeneration is required. The drive supply voltage-bus voltage must not exceed 105V under any operating conditions. > Maximum In-rush current: 100A for 40uS @100Vdc > Designation: VP, VP_RTN
Control Supply	> Range: 24Vdc ± 10% > Maximum input current / power: 0.9A @21.6V/ 20W without motor brakes > With 2 motor brakes: 1.9A @ 21.6Vdc) / 42W > Protection: Reverse polarity (3A external fuse must be used) > Designation: 24V_CON_SUP, CON_ RTN.
Motor Type	> Three- and two-phase permanent magnet synchronous, (DC brushless/ AC servo) > DC brush > Voice coil > Two- and three-phase stepper (micro-stepping open or closed loop)
Drive-Controller Interface	Current command Type: Sin wave current commutation commands, ±10V differential, 16 bit resolution, Offset: <20mV, Bandwidth <5KHz. Dynamic range input 0, 5V, opto-isolated, source. Input current < 7mA.

Feature	Specifications
	When 0, a 10V command will generate the specified maximum current. When 5V, a 10V command will generate 1/8 of the specified maximum current. Drive On/Off output: TTL. 1mA. Drive enable input: TTL, active low. Input current: <7mA. Drive fault output: TTL, active high. Output current 1mA.
Current Monitor Analog Outputs	> Four, ±10V, differential, two terminal,16 bit resolution > Offset: ±50mV, Bandwidth: 5KHz > Max. output load: 10kΩ > Noise & Ripple: <40mV > Designation: AOUT_#± (# = analog output number 0-3)
Communication (in setup mode)	> Two EtherCAT: In and Out > Interface: EtherCAT protocol > Speed: 100Mbps > Designation: Transmit: ETH#_TX±, Receive: ETH#_RX±
Environment	> Operating range: 0 to + 40°C > Storage and transportation range: -25 to +60°C > Humidity (operating range): 5% to 90% non-condensing

Table 5-1. Drive Power Specifications

Feature	Specifications			
Per Drive	A	B	C	D
Continuous/peak current sin amplitude [A]	3.3/10	6.6/20	10/30	13.3/40

Feature	Specifications			
Continuous current RMS per axis [A]	2.3/7	4.6/14.1	7/21.2	9.4/28.2
Maximum cont. Input current [A] @ continuous current	2.6	5.3	8	10.6
Maximum cont. Input current [A] @ peak current	8	15	24	32
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Peak current time [sec]	1			
Minimum load inductance @100Vdc [mH] Can be derated linearly for lower voltages	0.05			
Type	3-phase NanoPWM bridge			
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Quantity	1 or 2			
Protections	> Short & over current: 60A±5% > Over temperature: 100°C (on PCB) > Over voltage:106V±1% > Under voltage: 9V±3%			
Per Module				
Control voltage input [Vdc]	24 ±10%			
Drive voltage input range [Vdc]	12 – 100 (96 recommended)			
Maximum drive voltage [Vdc]	(Vin motor) x 88%			
Maximum cont. input current per module [A]	5.2	10.6	16	21.2

Table 5-2. Motor Relay Control

Item	Description	Remarks
Designation	#_BRK	Per axis.
Type	TTL level Reference: DGND	
Output current	10mA per output	
Logic state	When enabled, this signal set to logic 1	

Table 5-3. Motor Over Temperature Specifications

Item	Description	Remarks
Designation	Motor over temperature: #_OVER_T	
Quantity	Two, one per motor	
Type	> Single-ended, opto-isolated > Reference: DGND	
Threshold	> Over temperature protection is on, when the impedance between $_Motor_OVER pin to ground is above 10kΩ > Over temperature protection is off, when the impedance between $_Motor_OVER pin to ground is below 1kΩ	When this protection is not used, the Motor_OVER pin should be shorted to ground.
Default state	Over temperature off = Low impedance <1kΩ	

5.1 STO

The NPAPC supports STO. The STO is applicable only when using ACS STO module P/N SB-16530-200/LF which is not part of the NPAPC and should be ordered separately. For detailed information on STO, see *AN Safe Torque Off Function* and *NPMPC NPAPC UDMCB Functional Safety Manual*.

5.2 Dimensions

- Length: 155 mm
- Depth: 85 mm
- Height: 30 mm

5.3 Weight

> 360g

5.4 Compliance with Standards

5.4.1 Environment

Mount NPAPC the vertically or horizontally with the metal heatsink facing up. Leave enough clearance to enable free air convection around the module. Forced air flow may be required if the temperature of the module exceeds its threshold. Use the following graphs to calculate if forced air cooling is required.

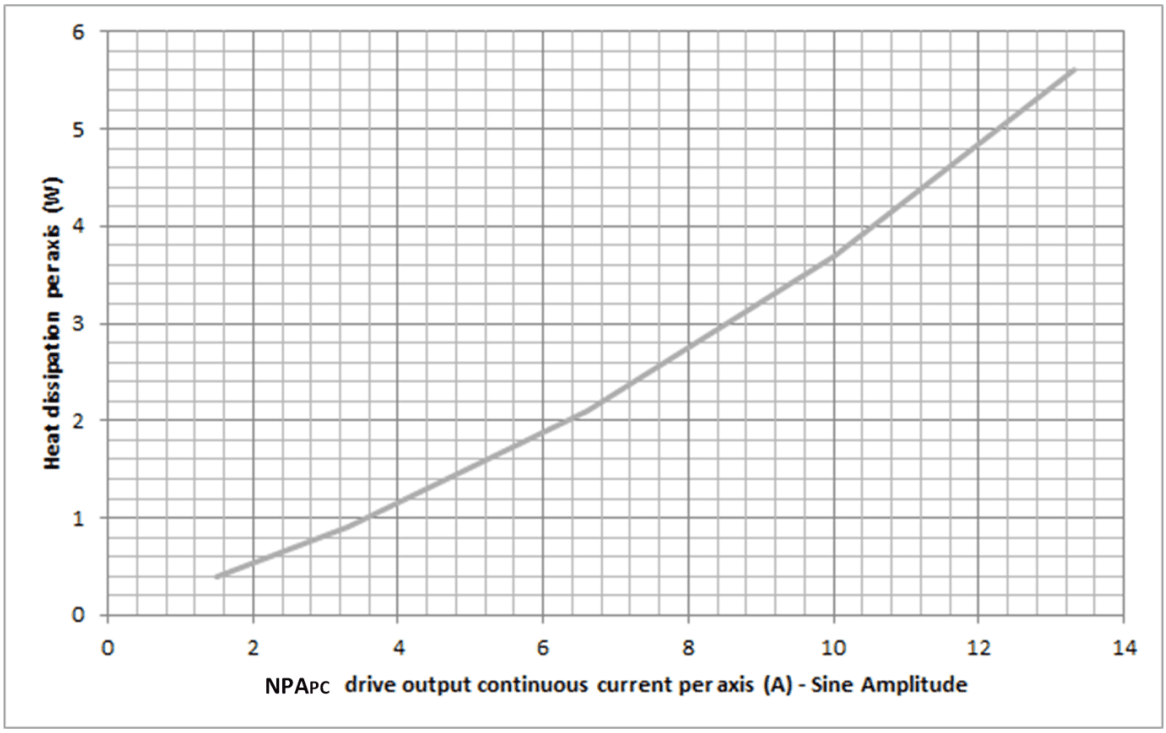

Figure 5-1. NPAPC Heat Dissipation per Axis

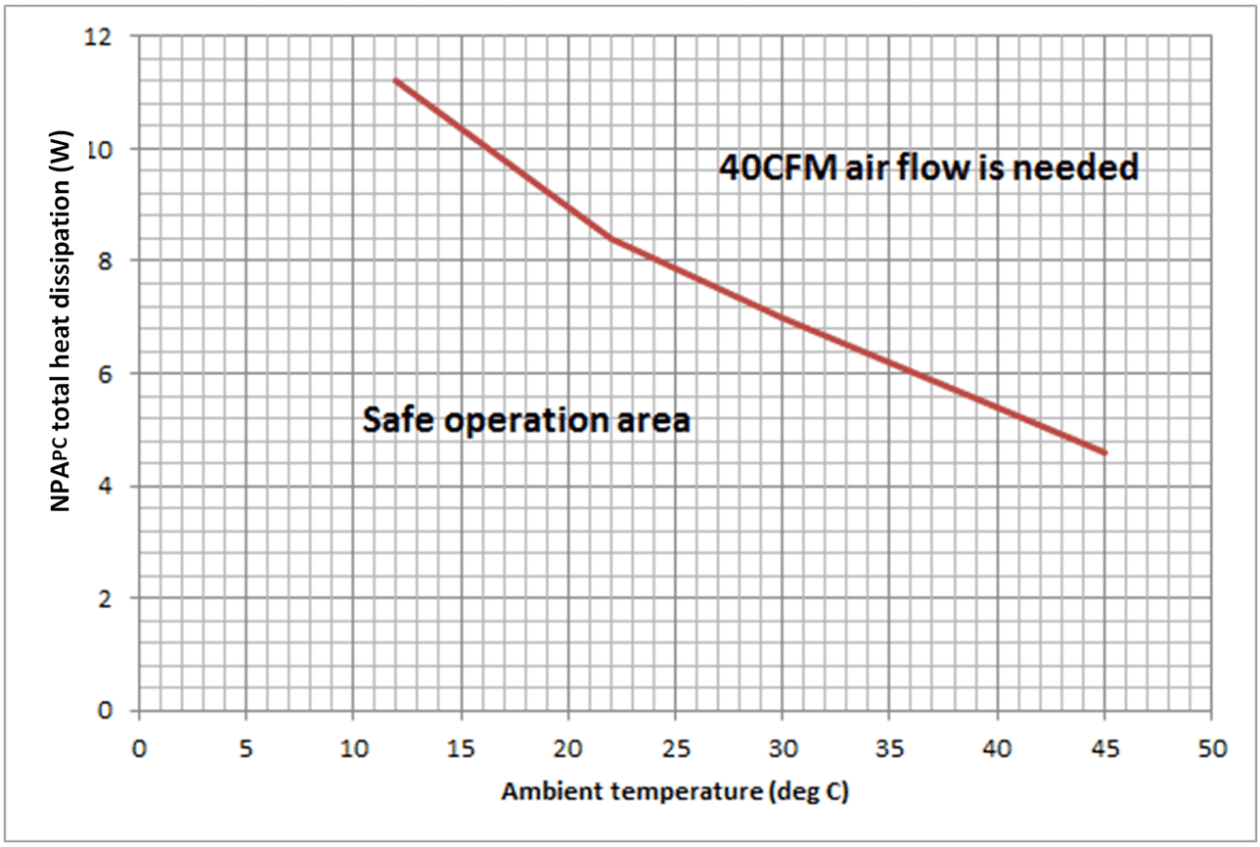

Figure 5-2. NPAPC Total Heat Dissipation

5.4.2 CE

- IEC 61800-3:2012(2.1nd Edition) follwing the provisions of 2014/30/EU directive
- EN61800-5-2 follwing the provisions of 2014/30/EU directive

5.4.3 Safety

- Functional safety
  - EN 60204-1 : 2006 (+A1`:2009, + AC :2010 Stop Category 0)
  - EN ISO 13849-1 : (+ AC :2009 Category 3; PL e)
  - EN 62061 : 2005 (+ AC :2010, + A1 :2013 SIL CL 3)
  - IEC61800-5-2:2016 Safe Totque Off (STO)
  - EN 618000-5-1:2007
  - IEC 618000-3 :2017
- Electrical safety
  - UL61800-5-1
  - IEC 61800-5-1:2007 (2nd Edition) follwing the provisions of 2014/35/EU (Low Voltage Directive)

5.4.4 RoHS

> Design complies with ROHS requirements.

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