NPARM

Installation and Operation Guide

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Revision History

Date	Revision	Description
January 2018	1.20	Added stepper to list of supported motor types
December 2017	1.10	Reformatted
August 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 commandss
Monospace + grey background	Code example.
Italic	Names of other documents.
Blue	Web pages, and e-mail addresses.
[ ]	In GUIs indicates optional item(s)
|	In GUIs 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.

The most updated version of the documents can be downloaded by authorized users 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.
Safe Torque Off Function	An application note providing the technical details for implementing the STO function for drives installed in ACS Motion Control systems.

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1. Introduction

1.1 Document Scope

This document describes how to install and operate the NPArm, including:

- Connectivity
- Current loop filter calibration and tuning

1.2 Product Overview

The NPArm is a rack mount multi-axis, high power drive system. It supports up to eight NanoPWM™ drives. It provides continuous/peak current options of 3.3/10A, 6.6/20A, 10/30A, and 13.3/40A. It includes a power supply with a single output or two outputs, providing 48V or 96V. The NPArm operates with any motion controller with two ±10V sine wave current commutation commands. The NPArm contains a built-in regeneration resistor.

The NPArm system includes the following plug-in modules:

- Power management
- Power supply
- Regeneration
- Up to four NPA3u drive cards

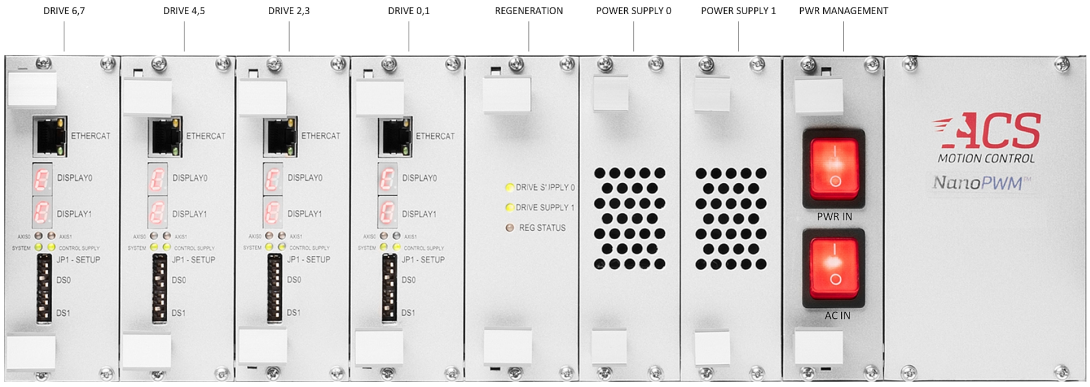


Figure 1-1. Eight drive NPArm

1.3 Interface diagrams

An interface block diagram for the NPArm, a power management interconnection diagram, and a controller-drive interface diagram showing the entire chain from a controller to a motor including connectors for each drive are shown in Figure 1-2, Figure 1-3, and Figure 1-4, respectively.

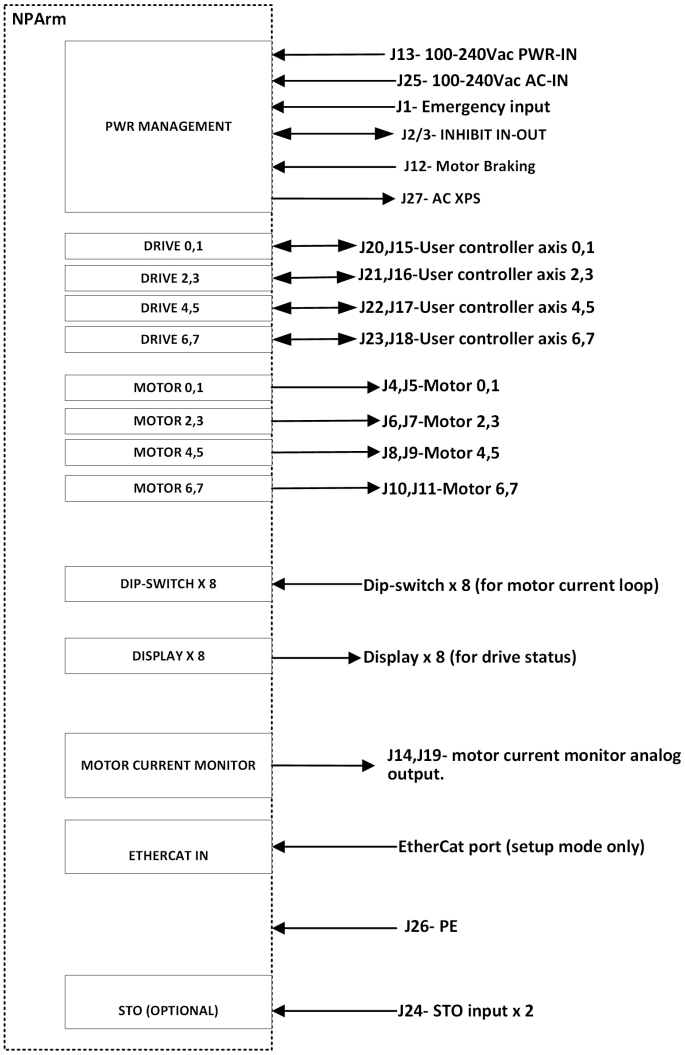


Figure 1-2. Interface bock diagram

If the emergency stop is not used, then create a short circuit between pin #1 and pin #2 on connector J1.

When motor braking is used, do not switch the relay on/off while the axis is enabled. If the relay is switched on/off while the axis is enabled, then damage to the drive can occur.

The propagation delay for the internal brake relay is approximately 200mS. Take the following extra measures when enabling/disabling the motor.

> When enabling the motor, switch on the relays (by creating a short circuit between pin #3 and #4 on connector J12) 200mS before the ENABLE command is issued.

> When disabling the motor, the brake relays must remain on (that is pin #3 and #4 short circuited) for 200mS after the DISABLE command was issued.

If the internal brake relays are not used, then create a permanent short circuit between pin #3 and pin #4 on connector J12.

If AC-XPS (controller supply output) is not used, then create a short circuit between pin #1 to pin #2 on connector J27.

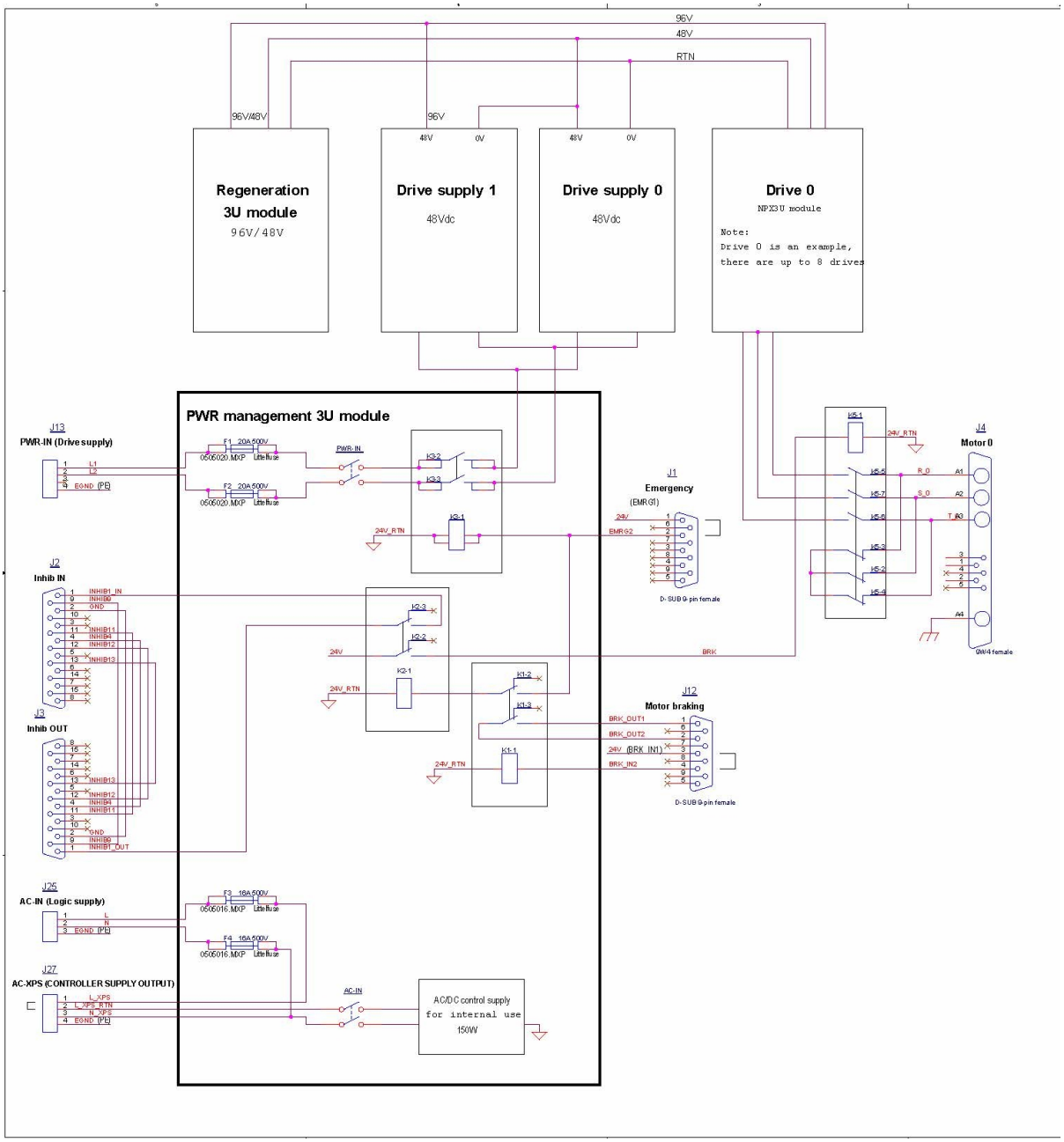


Figure 1-3. Power management interconnection diagram

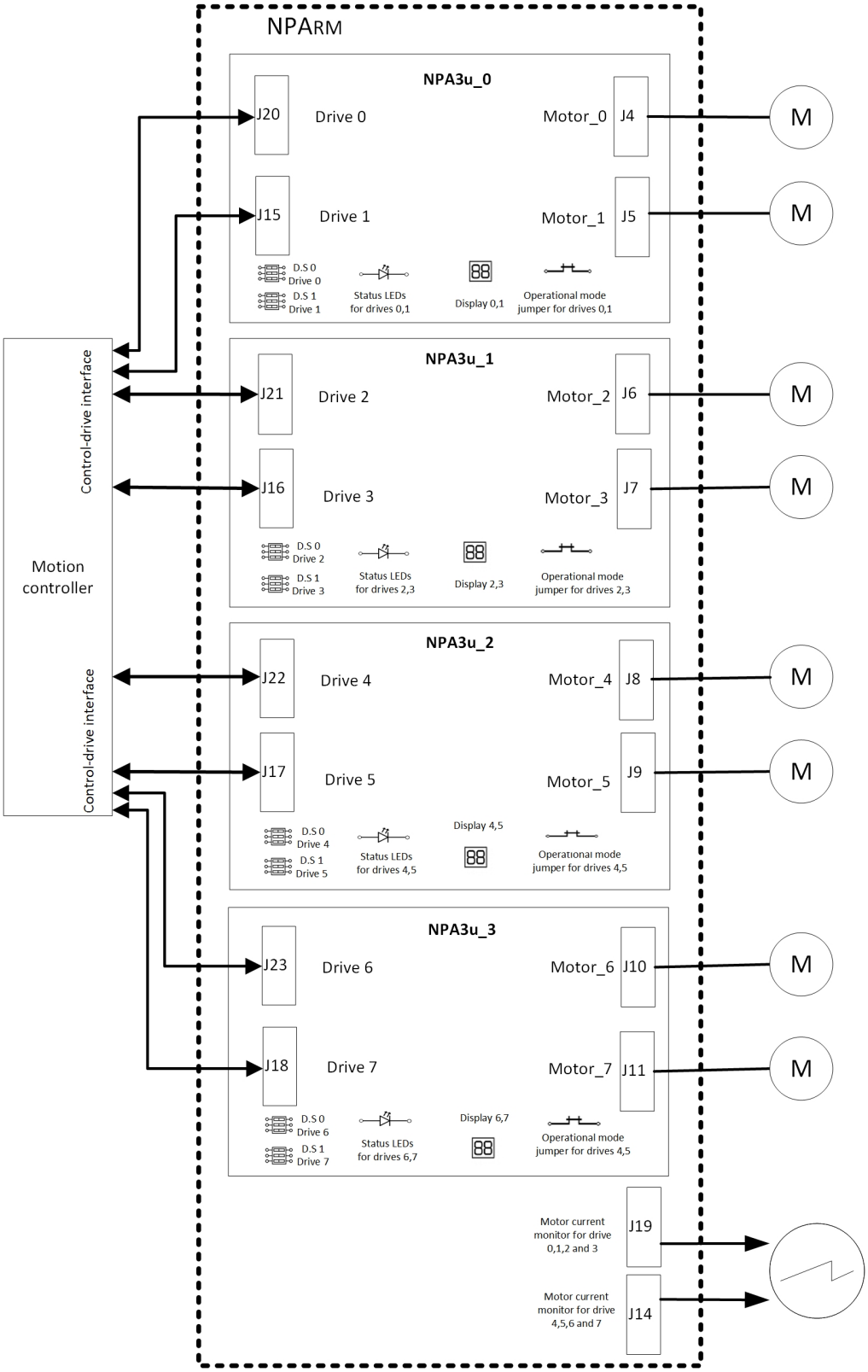


Figure 1-4. Controller-drive inteface diagram

2. Description of product

2.1 Order Part Number

The ordering part number (P/N) contains several characters (see Figure 2-1) that each specify a configuration characteristic ordered for the NPARM module, as described in Table 2-1.

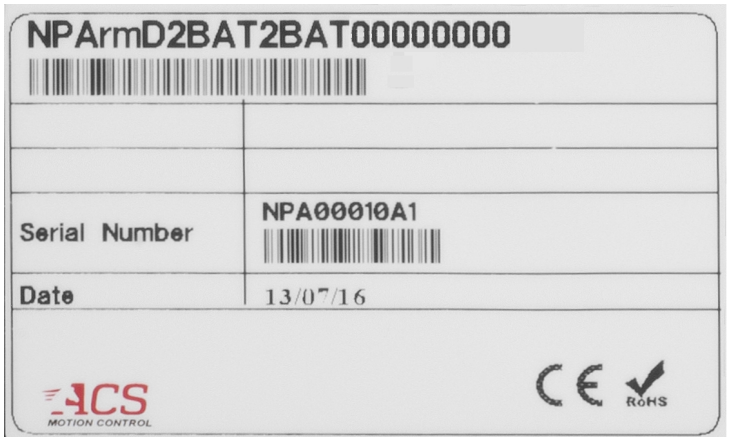


Figure 2-1. Label with ordered P/N - example

Table 2-1. Configuration as indicated by P/N

Ordering Options	Field	Example User Selection	Available Ordering Option Values
Power supply		D	A - 48V, 32A B - 48V, 64A C - 96V, 32A D - 96V&48V
Drive slot 1			
Number of drives		2	1, 2
Current		B	A - 3.3/10A B - 6.6/20A C - 10/30A D - 13.3/40A
Voltage connected to		A	A - 48V B - 96V
Type of motor		T	T - Three phase motor only S - Single phase motor only
Drive slot 2*			

Ordering Options	Field	Example User Selection	Available Ordering Option Values
Number of drives		2	0, 1, 2
Current		B	A - 3.3/10A B - 6.6/20A C - 10/30A D - 13.3/40A
Voltage connected to		A	A - 48V B - 96V
Type of motor		T	T - Three phase motor only S - Single phase motor only
Drive slot 3**			
Number of drives		0	0, 1, 2
Current		0	A - 3.3/10A B - 6.6/20A C - 10/30A D - 13.3/40A
Voltage connected to		0	A - 48V B - 96V
Type of motor	13	0	T - Three phase motor only S - Single phase motor only
Drive slot 4***			
Number of drives	14	0	0, 1, 2
Current	15	0	A - 3.3/10A B - 6.6/20A C - 10/30A D - 13.3/40A
Voltage connected to	16	0	A - 48V B - 96V
Type of motor	17	0	T - Three phase motor only

Ordering Options	Field	Example User Selection	Available Ordering Option Values
			S - Single phase motor only

* If "Number of Drives" for field 6 is selected as 0, then fields 7, 8, 9 are also to be set as 0.

** If "Number of Drives" for field 10 is selected as 0, then fields 11, 12, 13 are also to be set as 0.

*** If "Number of Drives" for field 14 is selected as 0, then fields 15, 16, 17 are also to be set as 0.

As an example, P/N NPAD2BAT2BAT00000000 would represent the configuration described in Table 2-2 below.

Table 2-2. P/N example

Field		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
P/N	NPA	D	2	B	A	T	2	B	A	T	0	0	0	0	0	0	0	0

TheNPArm is shipped with the configuration set as ordered. Modifications can be done by ACS only.

2.2 Package content

The NPArm package contains the following items:

> Rack enclosure containing the following plug-in components:
  - Power management plug-in module
  - Power supply plug-in modules
  - Regeneration plug-in module
  - Up to four NPA3u plug-in modules (according to specific configuration)

2.3 Optional accessories

2.3.1 Ethernet Cables

While in Setup mode, the unit should be connected to an ACS Motion controller using an EtherCAT cable. ACS offers the following Ethernet CAT5e cables:

Table 2-3. Ethernet cables

Length [m]	Part Number
0.3	SP+ECAT-CA-30CM-00
0.5	SP+ECAT-CA-50CM-00
1	SP+ECAT-CA-1M-00
2	SP+ECAT-CA-2M-00
3	SP+ECAT-CA-3M-00
5	SP+ECAT-CA-5M-00
10	SP+ECAT-CA-10M-00
15	SP+ECAT-CA-15M-00
20	SP+ECAT-CA-20M-00

2.3.2 Mating connectors kit

A four-axis or eight-axis mating connector kit is available. The part number is in the table below. Figure 2-2 shows the parts in the kit and Table 2-5 provides a detailed description.

Table 2-4. Mating connectors kit

Part Number (P/N)	Description
NPArm-ACC1	Four-axis mating connector kit
NPArm-ACC2	Eight-axis mating connector kit

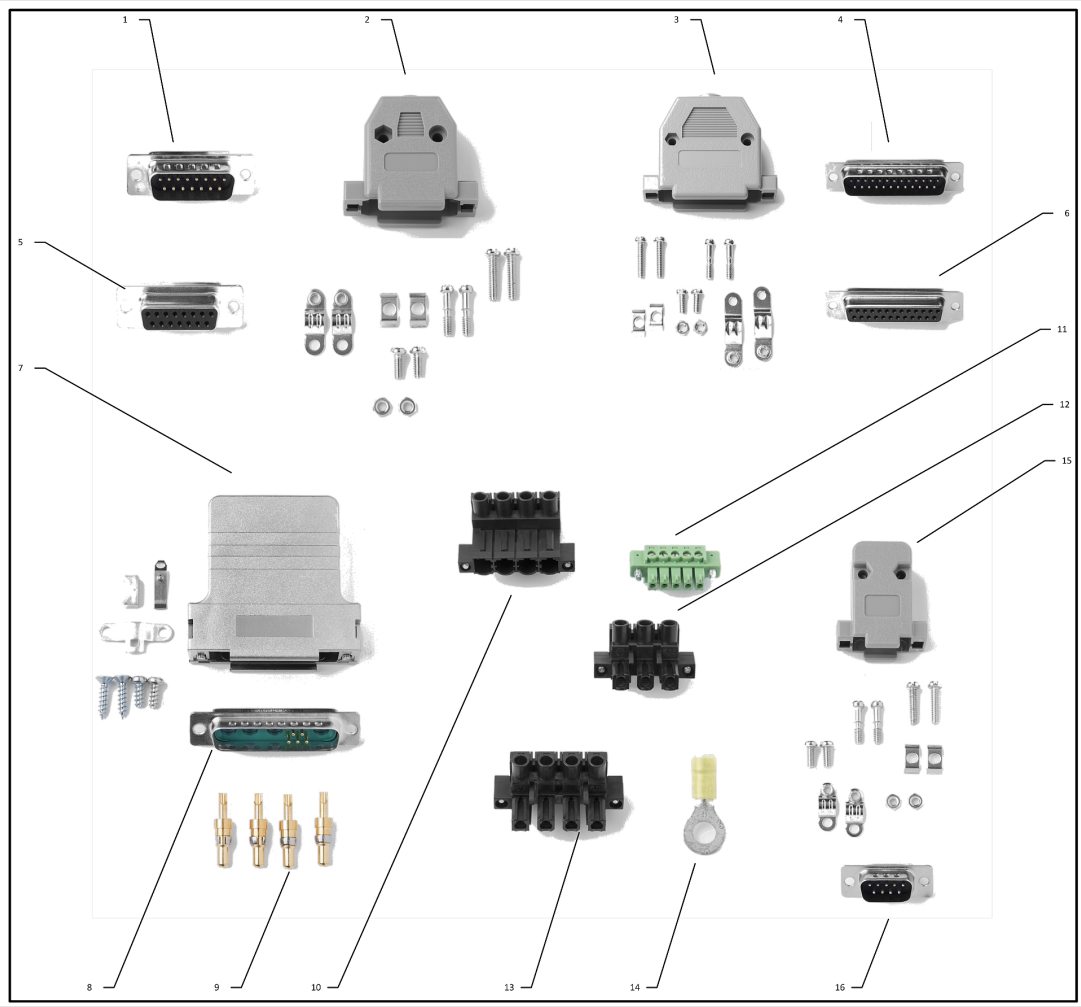


Figure 2-2. Mating connector kit

Table 2-5. Mating connector kit

Reference	Four-axis quantity	Eight-axis quantity	Part Description	Connector	Manufacturer	P/N
1	1	1	INHIBIT IN	J2	AMPHENOL	G17S-1510-110EU
2	2	2	Cover for D-type 15-pin	NA	CHANT SINCERE CO., LTD.	216AE-15P0AB004
3	5	10	Cover for D-type 25-pin	NA	Many	
4	1	2	Motor current monitor 0, 1, 2, 3 Motor current monitor 4, 5, 6, 7	J19 J14	AMPHENOL	G17S-2510-110-EU
5	1	1	INHIBIT OUT	J3	AMPHENOL	G17S-1500-110EU
6	4	8	Drive 0, 1, 2, 3 Drive 4, 5, 6, 7	J20, J15, J21, J16 J22, J17, J23, J18	Many	
7	4	8	Cover for 9W4 PWR D-Sub	NA	FCT Electronics	FKC3GAE/FKT 3-4
8	4	8	MOTOR 0, 1, 2, 3 MOTOR 4, 5, 6, 7	J4, J5, J6, J7 J8, J9, J10, J11	FCT Electronics	FM9W4P-K120
9	16	32	Solder Pin 20A for PWR D-Sub plug NPB	NA	FCT Electronics	FMP006P103

Reference	Four-axis quantity	Eight-axis quantity	Part Description	Connector	Manufacturer	P/N
10	1	1	AC-XPS (Controller supply output)	J27	WEIDMULLER	1043450000
11	1	1	STO	J24	PHOENIX CONTACT	MC 1,5/5-STF-3,81
12	1	1	AC-IN (Control supply)	J25	WEIDMULLER	1095690000
13	1	1	PWR-IN (Drive supply)	J13	WEIDMULLER	1095700000
14	1	1	PE	J26	MOLEX	193240014
15	2	2	Cover for D-type 9-pin	NA	Many	
16	2	2	EMERGENCY, MOTOR BRAKING	J1, J12	Many	

2.3.3 Spare Parts

The following replacement parts are available.

Table 2-6. Spare Parts List

Item	Part Number
Drive	
1 axis, 3.3/10A, Single phase motor	NPA3u-1AS
1 axis, 6.6/20A, Single phase motor	NPA3u-1BS
1 axis, 10/30A, Single phase motor	NPA3u-1CS
1 axis, 13.3/40A, Single phase motor	NPA3u-1DS
2 axis, 3.3/10A, Single phase motor	NPA3u-2AS
2 axis, 6.6/20A, Single phase motor	NPA3u-2BS
2 axis, 10/30A, Single phase motor	NPA3u-2CS
2 axis, 13.3/40A, Single phase motor	NPA3u-2DS
1 axis, 3.3/10A, Three phase motor	NPA3u-1AT
1 axis, 6.6/20A, Three phase motor	NPA3u-1BT
1 axis, 10/30A, Three phase motor	NPA3u-1CT
1 axis, 13.3/40A, Three phase motor	NPA3u-1DT
2 axis, 3.3/10A, Three phase motor	NPA3u-2AT
2 axis, 6.6/20A, Three phase motor	NPA3u-2BT
2 axis, 10/30A, Three phase motor	NPA3u-2CT
2 axis, 13.3/40A, Three phase motor	NPA3u-2DT
Plug-in Module	
Power supply (48Vdc, 32A)	NPArm-PS4832
Regeneration module	NPArm-Reg
Power Management module	NPArm-PwrM

2.4 Power management plug-in module

The Power management plug-in module routes the two 100-240Vac inputs to the drive supplies (48Vdc, 96Vdc) and to the 24Vdc control supply. The following figure and table shows and describes the power management plug-in module.

Figure 2-3. Power management plug-in module front view

Table 2-7. Power management plug-in module

Reference	Descripton	Protection	Switch	Note
PWR-IN	Drive supply AC input	2 Fuses	2-pole	
AC-IN	Control supply AC input	2 Fuses	2-pole	Also controls power for J27 AC-XPS (see "Power management plug-in module connections" on page 27)

The two AC inputs pass through fuses as shown in Figure 1-3. To replace the fuses, remove the power management plug-in module from the NPARM enclosure. The fuse specifications are listed in Table 2-8

Table 2-8. Fuse specifications

Reference	Description	Type	Ampere Rating	Voltage Rating	Size
F1	PWR-IN AC input phase1	fast acting	20A	500V	6.3 x 32mm
F2	PWR-IN AC input phase2	fast acting	20A	500V	6.3 x 32mm
F3	AC-IN AC input phase	fast acting	16A	500V	6.3 x 32mm
F4	AC-IN AC input phase	fast acting	16A	500V	6.3 x 32mm

2.4.1 Safety modes of operation

The power management plug-in module supports three safety modes of operation:

- No power mode
- Emergency mode
- Motor braking mode
- Normal mode

When the emergency input becomes active, the power to the drive supply is cut off by a two-pole normally open (NO) power relay. Table 2-9 describes the safety modes of operation.

Table 2-9. Safe Modes

Item	No power mode	Emergency mode	Motor braking mode	Normal mode
Control supply AC input	Cut off physically from AC-IN connector just after Control supply fuses via AC-XPS unplugged connector (pins #2 and #3)	Connected to AC-IN connector	Connected to AC-IN connector	Connected to AC-IN connector
Drive supply AC input	Cut off physically from PWR-IN connector just after Drive supply fuses by 2 form A (NO) relay contacts	Cut off physically from PWR-IN connector just after Drive supply fuses by 2 form A (NO) relay contacts	Connected to PWR-IN connector	Connected to PWR-IN connector

Item	No power mode	Emergency mode	Motor braking mode	Normal mode
Motors outputs	Disconnected from the driver outputs and short-circuited to a "rolling" resistance by 3 NO + 3 NC safety relay contacts	Disconnected from the driver outputs and short-circuited to a "rolling" resistance by 3 NO + 3 NC safety relay contacts	Disconnected from the driver outputs and short-circuited to a "rolling" resistance by 3 NO + 3 NC safety relay contacts	Connected to driver outputs by 3 NO + 3 NC safety relay contacts
Inhibit OUT (pin 1)	Inhibit OUT (pin #1) is disconnected from Inhibit IN (pin #1) by the internal dry contact	Inhibit OUT (pin #1) is disconnected from Inhibit IN (pin #1) by the internal dry contact	Inhibit OUT (pin #1) is disconnected from Inhibit IN (pin #1) by the internal dry contact	Inhibit OUT (pin #1) is connected to Inhibit IN (pin #1) by the internal dry contact
Motor braking output	MOTOR BRAKING connector pins #1 and #2 (output) are open-circuited by the internal dry contact	MOTOR BRAKING connector pins #1 and #2 (output) are shorted by the internal dry contact	MOTOR BRAKING connector pins #1 and #2 (output) are open-circuited by the internal dry contact	MOTOR BRAKING connector pins #1 and #2 (output) are shorted by the internal dry contact

2.4.2 Power management plug-in module connections

All connections to the power management plug-in module are made from the rear. The following figure and table shows the connector locations and lists their assignments.

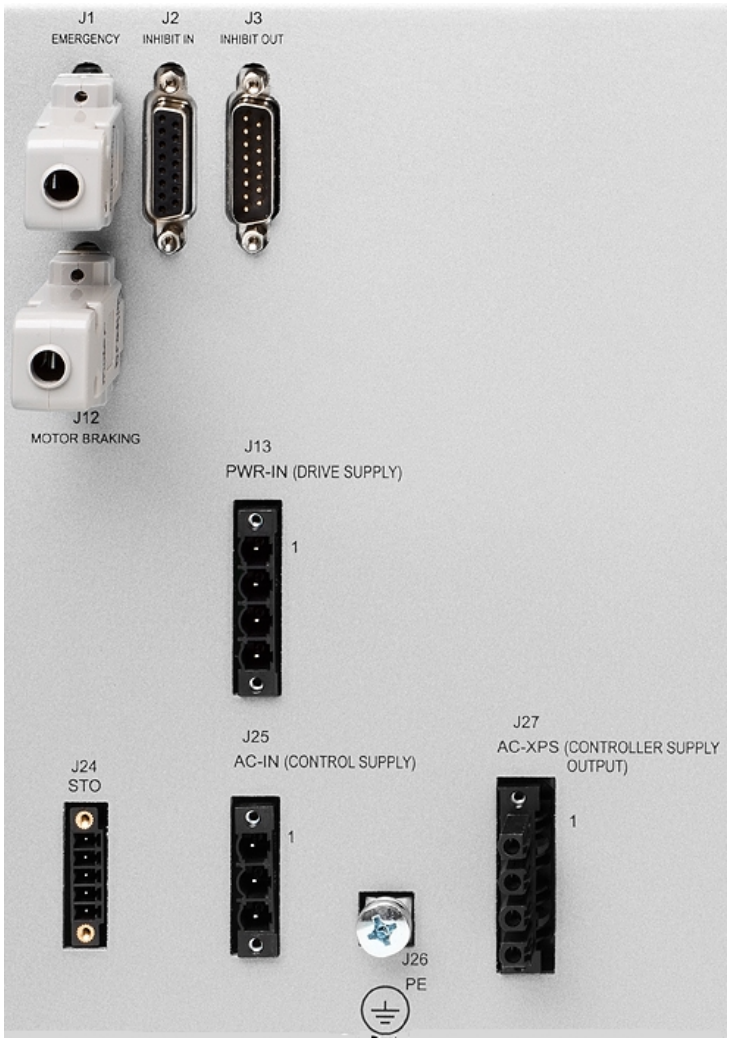


Figure 2-4. Power management plug-in module rear view

Table 2-10. Power management plug-in module connection table

Connector Assignment	Connector label	Description
J1*	EMERGENCY	Emergency input is used to switch NPARM unit into "Emergency mode". The external dry contact can be connected to Emergency input connector pins #1 and #2. The NPARM unit will switch into "Emergency mode" when the external dry contact is open circuit. The external dry contact electrical rating requirement: > Contact current: 1A

Connector Assignment	Connector label	Description
		> Contact voltage: 24Vdc  If not used, then create a short circuit between pins #1 and #2 on the mating connector.
J2*	INHIBIT-IN	See INHIBIT-OUT description.
J3*	INHIBIT-OUT	Inhibit output can be used for the external circuits interlocking when NPARM unit is in one of the three Safety modes of operation: > No power mode > Emergency mode > Motor braking mode The internal dry contact is connected between pin #1 of INHIBIT-IN and pin 1 #of INHIBIT-OUT connectors. The internal dry contact is open when NPARM unit is in one of the three Safety modes of operation. The internal dry contact is closed when NPARM unit is in "Nominal mode" of operation The internal dry contact electrical rating: > Contact current: 2A > Contact voltage: 30Vdc Pins #4, #9, #11, #12, #13, and #2 of J2-INHIBIT-IN connector are internally shorted with the corespondent pins #4, #9, #11, #12, #13, and #2 of J3-INHIBIT-OUT connector.
J12*	MOTOR BRAKING	Motor braking input is used to switch NPARM unit into “Motor braking mode”. The external dry contact can be connected to J12 MOTOR BRAKING connector pins #3 and #4. The NPARM unit will switch in “Motor braking mode” when the external dry contact is open circuit. The external dry contact electrical rating requirement: > Contact current: 1A > Contact voltage: 24Vdc

Connector Assignment	Connector label	Description
		When motor braking is used, do not switch the relay on/off while the axis is enabled. If the relay is switched on/off while the axis is enabled, then damage to the drive can occur. > The propagation delay for the internal brake relay is approximately 200mS. Take the following extra measures when enabling/disabling the motor.  > When enabling the motor, switch on the relays (by creating a short circuit between pin #3 and #4 on connector J12) 200mS before the ENABLE command is issued. When disabling the motor, the brake relays must remain on (that is pin #3 and #4 short circuited) for 200mS after the DISABLE command was issued. If the internal brake relays are not used, then create a permanent short circuit between pin #3 and pin #4 on connector J12. Motor braking output can be used for the external circuits interlocking when NPARM unit is in “motor braking mode” or in “No power mode” The internal dry contact is connected between pins #1 and #2 ofJ12 MOTOR BRAKING connector. The internal dry contact is open when NPARM unit is in “Motor braking mode” or in “No power mode” of operation The internal dry contact is closed when NPARM unit is in “Emergency mode” or in "Nominal mode"of operation The internal dry contact electrical rating: > Contact current: 2A > Contact voltage: 30Vdc.
J13	PWR-IN (DRIVE SUPPLY)	48V/96V Drive supply AC input connector Rating: 100/240Vac, 16A, 50/60Hz.
J25	AC-IN (CONTROL SUPPLY)	24V Control supply AC input connector.

Connector Assignment	Connector label	Description
		Additional function linking the AC input voltage via AC-IN connector and power management plug-in module with J27 (AC-XPS) AC output connector.
J26	PE	Protected earth connection terminal
J27	AC-XPS (CONTROLLER SUPPLY OUTPUT)	Output connector for an external control device supplying: 100/240Vac, 11/5.5A, 60/50Hz If not used, then create a short circuit between pins #1 and #2 on the mating connector.

*See Figure 1-3 for an interconnection diagram.

2.5 Regeneration plug-in module

The Regeneration plug-in module dissipates the energy that the motors produce when they decelerate and thus ensures that the supply voltage does not raise above its allowed maximum value. It can dissipate up to 2KW peak and 100W continuously. The shunt resistor value is 12Ω.

If the regeneration circuit provided is insufficient , contact ACS customer support.

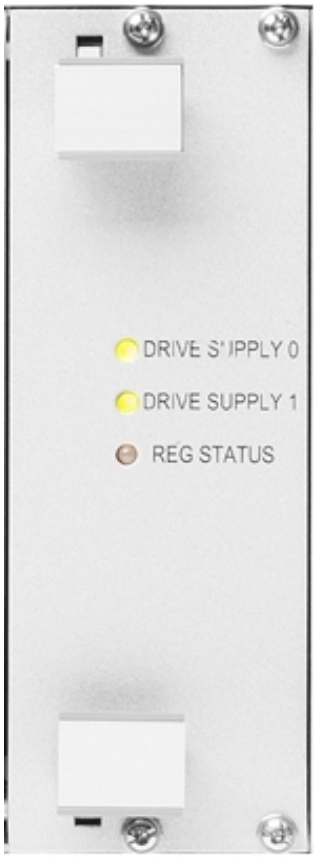


Figure 2-5. Regeneration plug-in module front view

Status LEDs for the drive supply and regeneration circuit are located on the front of the regeneration plug-in module. The following table describes the LED indicators.

Table 2-11. Drive supply power and regeneration circuit LED status indicators

Indicator	Description
DRIVE SUPPLY 0 DRIVE SUPPLY 1	One bicolor LED for each drive supply > Off- 48Vdc power supply is off > Green- 48Vdc power supply is on > Red- 48Vdc power supply fault
REG	One bicolor LED

Indicator	Description
STATUS	> Off- drive supply is below limit > Green blinking - regeneration circuit is intermittently activate when drive supply voltage exceeds the limit > Red- regeneration circuit is in the fault condition due to over temperature or short circuit, see below for instructions

Possible causes for a 48Vdc power supply fault:

1. Over temperature shutdown - when ambient temperature is more than 45° and the power supply is overloaded
2. Fan Failure - when supply fan fails
3. AC failure - when supply AC input voltage exceeds 320Vac
4. Output short circuit - when supply output is shorted
5. Output under voltage - when supply output voltage is below 36V
6. Output over voltage - when supply output voltage is above 59.5V

Instructions in case of a 48V power supply failure:

1. Check that the ambient temperature does not exceed 45°.
2. Check that the internal NPARM fans are working.

Check for air flow at NPARM upper panel holes.

3. Check that fan power supply is working.

Check for air flow at power supply front panel holes.

4. Replace power supply plug-in module.

Switch "OFF" the AC input voltage before servicing.

- If, after replacing the power supply plug-in module, the DRIVE SUPPLY status LED lights "GREEN", then send the power supply plug-in module, that was replaced, to ACS for repair.
- If, after replacing the power supply plug-in module, the DRIVE SUPPLY status LED still lights "RED", then one of the Drive plug-in modules or Regeneration plug-in module has failed and needs to be replaced.

Instructions in case of regeneration plug-in module failure:

1. Check that the ambient temperature does not exceed 45°
2. Check that the internal NPARM fans are working.

Check for air flow at NPARM air supply panel holes.

3. Replace Regeneration plug-in module

Switch "OFF" the AC input voltage before servicing.

- If after replacing the regeneration plug-in module, the "REG STATUS" LED is "Green blinking" during motor operation, then send the regeneration plug-in module, that was replaced, to ACS for repair.

2.6 Drive plug-in module

The Drive plug-in module includes one or two identical drives. Each drive is fed by one or two (sinusoidal current commutation) +/-10V commands from an external motion NanoPWM™ controller. The current loop filter is programmable. The filter can be selected from a group of 16 different set of gains using the four dip-switches. DS0 for drive 0 and DS1 for drive 1.The current loop can also be tuned using the SPiiPlusMMI Application Studio and one of ACS' Motion controllers and EtherCAT Masters, such as the SPiiPlusEC connected to the drive plug-in module via the EtherCAT connector. A seven-segment display and LED indicators provide the status of the drive and faults.

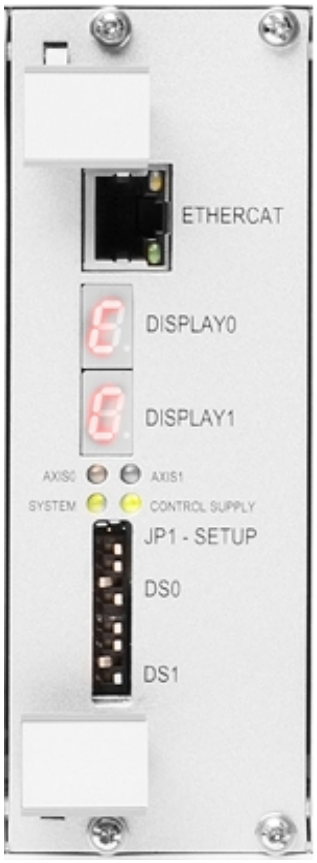


Figure 2-6. Drive plug-in module front view

2.6.1 Dip swtiches - DS0 and DS1

The current loop filter gains are set by DS0 (Drive 0) and DS1 (Drive 1) DIP switches, see Current loop filter tuning in normal operation mode.

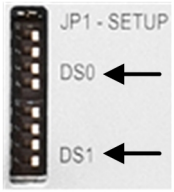


Figure 2-7. DIP switches and jumper

The drive index corresponding to DS0 and DS1 for each plug-in module is shown below.

Table 2-12. Drive relationship between DS0 and DS1 and plug-in module

Plug-in module	DS0	DS1
1	To select current loop filter gains for drive 0	To select current loop filter gains for drive 1
2	To select current loop filter gains for drive 2	To select current loop filter gains for drive 3
3	To select current loop filter gains for drive 4	To select current loop filter gains for drive 5
4	To select current loop filter gains for drive 6	To select current loop filter gains for drive 7

2.6.2 Operation mode jumper - JP1

JP1, see Figure 2-7, defines the operation mode of the (two) drives. The choices are normal operational mode or setup mode, see Operation modes for more details. The operational mode corresponding to jumper settings is shown below.

Table 2-13. JP1 settings and operational mode

Jumper setting	Description
Open	Normal operational mode
Closed / installed	Setup mode

2.6.3 LED Indicators

Each plug-in module has a four LED indicators.

Figure 2-8. LED indicators

The drive index corresponding to AXIS0 and AXIS1 for each plug-in module is shown below.

Table 2-14. Drive relationship between AXIS0 and AXIS1 and plug-in module

Plug-in module	AXIS0	AXIS1
1	Drive 0	Drive 1
2	Drive 2	Drive 3
3	Drive 4	Drive 5
4	Drive 6	Drive 7

The description for each LED indicator is below.

Table 2-15. LED indicators description table

Indicator	Description
AXIS0 AXIS1	One bicolor LED for each drive: > Green - Drive is enabled > Red - Drive fault > Off - Drive is disabled
System	One bicolor LED: > Red - System Fault > Green - System OK > Blinking - Communication with master (during Setup mode only)
Control Supply	One green LED: > On - Control supply is On - voltage applied > Off - Control supply is Off - voltage not applied

2.6.4 Drive status display

Each plug-in module has a two drive status displays.

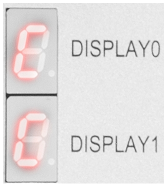


Figure 2-9. Drive status display

The drive index corresponding to DISPLAY0 and DISPLAY1 for each plug-in module is shown below.

Table 2-16. Drive relationship between DISPLAY0 and DISPLAY1 and plug-in module

Plug-in module	DISPLAY0	DISPLAY1
1	Drive 0	Drive 1
2	Drive 2	Drive 3
3	Drive 4	Drive 5
4	Drive 6	Drive 7

The description for each code in the display is below.

Table 2-17. Drive status display description table

Code	Status	Description
C	Powered up	Drive power up executed Lit after power-on when the drive initialization ends. Turned off when an error occurs
• (dot character)	Setup mode	Drive is in setup mode
0	Drive is enabled	No fault detected.
1	Over voltage	Drive over-voltage protection is activated. The drive is disabled. Check that the regeneration plug-in module is functioning properly > If "REG STATUS" LED is "Green blinking" during motor operation, then replace the drive plug-in module > If "REG STATUS" LED is "RED" during the motor operation, then see Regeneration plug-in module to proceed in accordance with the "Instructions in

Code	Status	Description
		case of regeneration plug-in module failure".
4	STO	A 24Vdc is not connected to one or two of the STO inputs. The drive is disabled.
5	Short circuit	Drive short- circuit protection is activated. The drive is disabled.
H	Over temperature	Drive over-temperature protection is activated. The drive is disabled Ensure ambient temperaturedoes not exceed 45°C
h	Motor over temperature	Motor over temperature protection is activated. The motor temperature sensor (PTC) impedance is above 10KΩ or not connected. The drive is disabled. When motor over temperature sensor is not used connect the $_OVER pin to DGND
U	Under voltage	Drive under-voltage protection is activated. The drive supply is under 9Vdc or not connected. The drive is disabled.
2	Drive Over current (SW)	Drive over-current protection is activated. The drive exceeded the specified motor continuous RMS current. The drive is disabled.
L	Drive saturation	Drive saturation The drive is disabled.
F	Fatal error	Contact ACS Motion Control customer service to return unit for repair.

2.6.5 Motor and drive command connections

The connectors for the motors, drive command interface, and current monitoring are located on the rear of the NPARM. The following figure and table shows and describes these connectors for an eight drive NPARM.

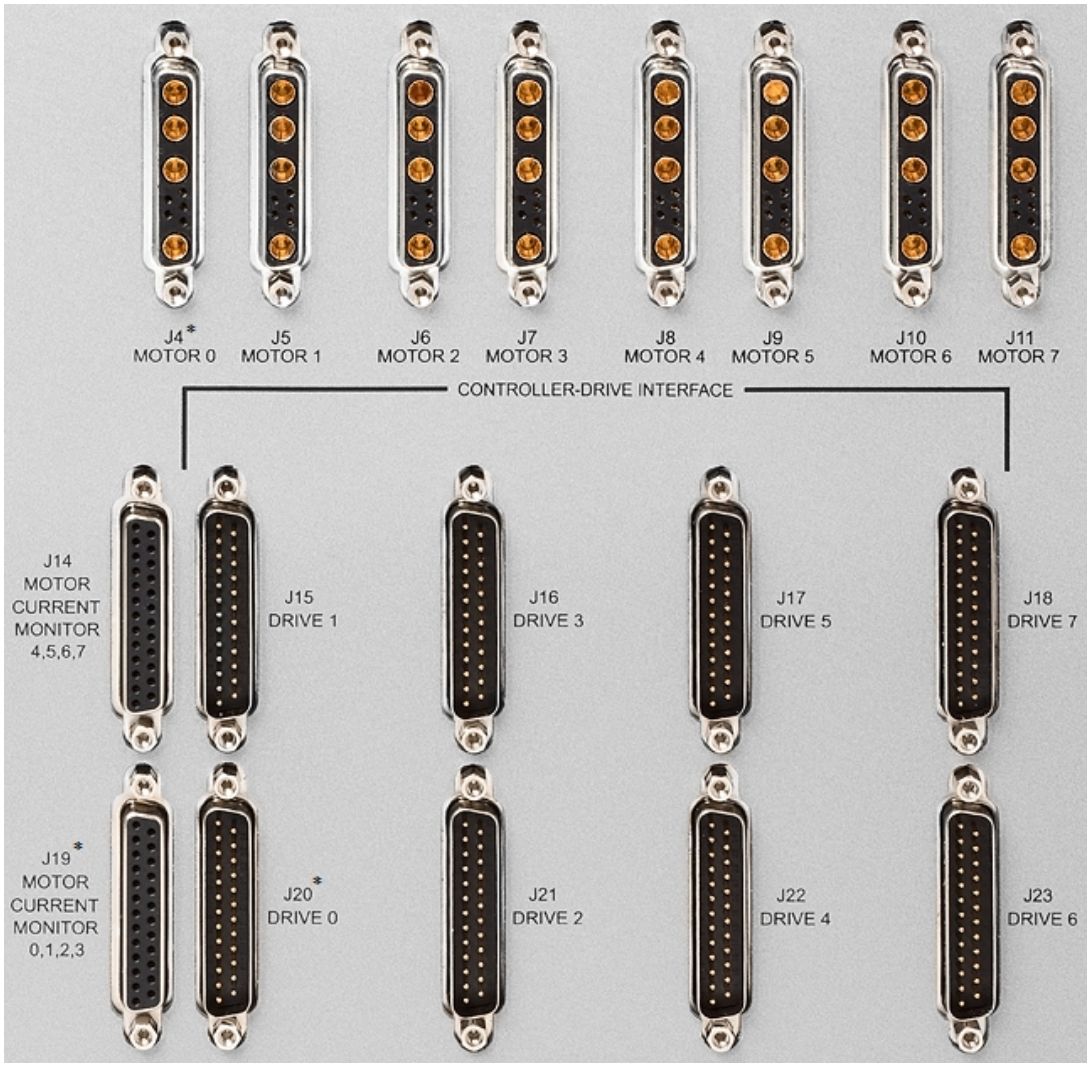


Figure 2-10. NPARM rear view

*Included in the basic configuration (single drive)- J4, J19, J20.

Table 2-18. NPARM connection table

Connector	Connector label	Description
J4	MOTOR0	Drive plug-in module 0 - drive 0

Connector	Connector label	Description
J5	MOTOR1	Drive plug-in module 0 - drive 1
J6	MOTOR2	Drive plug-in module 1 - drive 0
J7	MOTOR3	Drive plug-in module 1 - drive 1
J8	MOTOR4	Drive plug-in module 2 - drive 0
J9	MOTOR5	Drive plug-in module 2 - drive 1
J10	MOTOR6	Drive plug-in module 3 - drive 0
J11	MOTOR7	Drive plug-in module 3 - drive 1
J14	MOTOR CURRENT MONITOR 4,5,6,7	Current monitor for motor 4 - drive plug-in module 2 - drive 0 Current monitor for motor 5, -drive plug-in module 2 - drive 1 Current monitor for motor 6 - drive plug-in module 3 - drive 0 Current monitor for motor 7 - drive plug-in module 3 - drive 1
J15	DRIVE1	Drive plug-in module 0 - drive 1
J16	DRIVE3	Drive plug-in moduel 1 - drive 1
J17	DRIVE5	Drive plug-in module 2 - drive 1
J18	DRIVE7	Drive plug-in module 3 - drive 1
J19	MOTOT CURRENT MONITOR 0,1,2,3	Current monitor for motor 0 - drive plug-in module 0 - drive 0 Current monitor for motor 1, -drive plug-in module 0 - drive 1 Current monitor for motor 2 - drive plug-in module 1 - drive 0 Current monitor for motor 3 - drive plug-in module 1- drive 1
J20	DRIVE0	Drive plug-in module 0 - drive 0
J21	DRIVE2	Drive plug-in module 1 - drive 0
J22	DRIVE4	Drive plug-in module 2 - drive 0
J23	DRIVE6	Drive plug-in module 3 - drive 0

3. Mounting

The NPARM can be mounted in a 19 inch rack.

The NPARM cooling is self-contained. The direction of airflow is from the front side of the rack to the rear side.

Keep the area in front and in the back of the NPARM free of any obstructions.

4. Connections

This section describes how to interface with the NPARM using proper safety, EMC and wiring guidelines. Figure 1-4Figure 1-4 shows the entire chain from controller to motor including connectors for each drive.

4.1 Safety, EMC, and Wiring Guidelines

Read this section carefully before beginning the installation process.

Make sure that the following guidelines and procedures are addressed and observed prior to powering up.

An STO module (Safe Torque Off) is an optional feature of the unit. Additional information can be found in J24 STO.

Installation and maintenance must be performed only by qualified personnel who have been trained and certified to install and maintain high power electrical and electro-mechanical equipment, servo systems, power conversion equipment and distributed networks.

Further ensure that all of the attached power and signal cables are in good operating condition. Maintenance should be performed only after the relevant network devices have been powered down, and all associated and surrounding moving parts have settled in their safe mode of operation. Certain drives require a longer time to fully discharge.

To avoid electric arcing and hazards to personnel and electrical contacts, avoid connecting and disconnecting the NPARM while the power source is on.

The NPARM is not intended for use in safety-critical applications (such as life supporting devices) where a failure of the NPARM can reasonably be expected to cause severe personal injury or death.

Perform the following instructions to ensure safe and proper wiring:

- Whenever possible, use shielded cables with braided shield of at least 80%-95% coverage.
- Follow the guidance of below, based on the current rating of your NPARM.
- Proper wiring, grounding and shielding are essential for ensuring safe, immune and optimal servo performance. After completing the wiring, carefully inspect all wires to ensure tightness, good solder joints and general safety.

Table 4-1. Wiring Guidelines

Item	Gauge	Twisted pair
Control supply AC input	16-18AWG	No
Drive supply AC input	12-16AWG	No
Motor	14-16AWG	No
Motor Brake	18AWG	No

ACS recommends using the ÖLFLEX® SERVO 9YSLCY-JB motor supply cables from Lapp Group.

4.2 J1 Emergency

Label: J1 EMERGENCY

Connector	
Manufacturer	Any - industry standard connector
Type	D-sub
Version	DB-9 female, threaded inserts, 4-40 UNC
P/N	NA

Mating Connector	
Manufacturer	Any - industry standard connector
Type	D-sub
Version	DB-9 male, screw locks, 4-40 UNC
P/N	NA

Table 4-2. J1 emergency connector pinout table

Pin	Signal	Description
1	EMRG1	Dry contact intput 1 (Must be connected to 2 for nominal mode)
2	EMRG2	Dry contact input 2 (Must be connected to 1 for nominal mode)

Pin	Signal	Description
3	NC	Not connected
4	NC	Not connected
5	NC	Not connected
6	NC	Not connected
7	NC	Not connected
8	NC	Not connected
9	NC	Not connected

4.3 J2 INHIBIT IN

Label: J2 INHIBIT-IN

For a description of the functionality of INHIBIT-IN see Table 2-10.

Connector	
Manufacturer	Any - industry standard connector
Type	D-sub
Version	DB-15 female, threaded inserts, 4-40 UNC
P/N	NA

Mating Connector	
Manufacturer	Any - industry standard connector
Type	D-sub
Version	DB-15 male, screw locks, 4-40 UNC
P/N	NA

Connector


Table 4-3. J2 INHIBIT IN supply connector pinout table

Pin	Signal	Description
1	INHIB1_IN	Inhibition (Must be connected to GND for normal mode)
2	DGND	GND
3	NC	Not connected
4	INHIB4	Inhib pin 4
5	NC	Not connected
6	NC	Not connected
7	NC	Not connected
8	NC	Not connected
9	INHIB9	Inhibit pin 9
10	NC	Not connected
11	INHIB11	Inhib pin 11
12	INHIB12	Inhib pin 12
13	INHIB13	Inhib pin 13
14	NC	Not connected
15	NC	Not connected

4.4 J3 INHIBIT OUT

For a description of the functionality of INHIBIT-OUT see Table 2-10.

Label: J3 INHIBIT-OUT

Connector	
Manufacturer	Any - industry standard connector
Type	D-sub
Version	DB-15 male, threaded inserts, 4-40 UNC
P/N	NA

Mating Connector	
Manufacturer	Any - industry standard connector
Type	D-sub
Version	DB-15 female, screw locks, 4-40 UNC
P/N	NA

Table 4-4. J3 INHIBIT OUT connector pinout table

Pin	Signal	Description
1	INHIB1_OUT	Inhibition (Must be connected to GND for normal mode)
2	DGND	GND
3	NC	Not connected
4	INHIB4	Inhib pin 4
5	NC	Not connected
6	NC	Not connected

Pin	Signal	Description
7	NC	Not connected
8	NC	Not connected
9	INHIB9	Inhibit pin 9
10	NC	Not connected
11	INHIB11	Inhib pin 11
12	INHIB12	Inhib pin 12
13	INHIB13	Inhib pin 13
14	NC	Not connected
15	NC	Not connected

4.5 J4 - J11 Motors

Each drive supports three-phase AC synchronous motors or single phase, such as DC brush motors or voice coil actuators. The type of motor is specified for each drive plug-in module. The two drives of a module support the same motor type. The connector assignment and motor index is shown below.

Table 4-5. Motor connector assignment

Connector assignment	Motor
J4	Motor 0
J5	Motor 1
J6	Motor 2
J7	Motor 3
J8	Motor 4
J9	Motor 5
J10	Motor 6
J11	Motor 7

Each drive provides motor over temperature protection.

4.5.1 Description

Label: J4 - J11, MOTOR#

Connector	
Manufacturer	Any - industry standard connector
Type	D sub connector with power pins
Version	9W4 mixed with threaded insert UNC 4-40, female
P/N	NA

Mating Connector	
Manufacturer	Any - industry standard connector
Type	
Version	9W4 mixed with UNC 4-40 lockers, male
P/N	NA

Table 4-6. J4 - J11 motor connector pinout

Pin	Signal	Description
A1	R_#	Motor R phase for three-phase motor, # is 0..7
A2	S_#	Motor S phase for three-phase motor or single-phase motor, # is 0..7

Pin	Signal	Description
A3	T_#	Motor T phase for three-phase motor or single-phase motor, # is 0..7
A4	SHIELD/PE	Motor shield / protected earth
1	MTMP_#	Motor temperature sensor, # i s0..7
2	MTMP_#_ RTN	Return supply for motor temperature sensor, # is 0..7
3	SHIELD	Temperature sensor shield
4	NC	Not connected
5	NC	Not connected

4.5.2 Connection instructions

1. Use a shielded cable with a minimum gauge of 16 AWG. It should be less than 20 meters long.
2. Route the motors' cable (and the drive supply cable) as far as possible from all other noise sensitive cables.
3. Connect the motor as shown below.

The motor connector assignment is listed in Table 4-5.

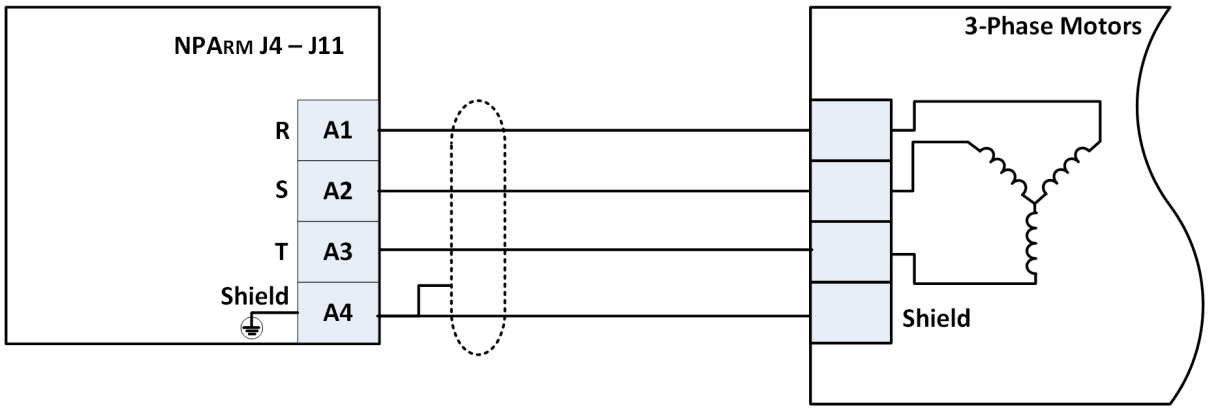


Figure 4-1. Three-phase motor

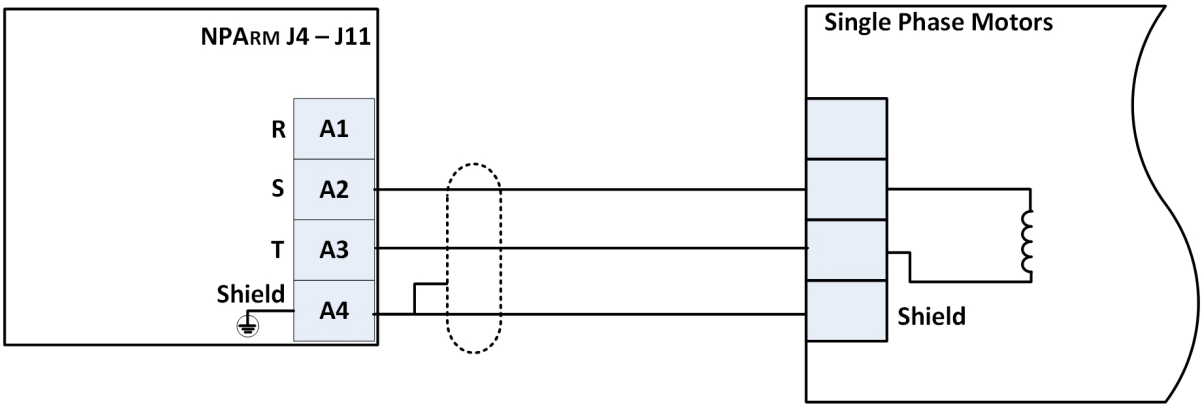


Figure 4-2. DC brush motor or DC voice coil actuator

The connection diagram of motor over temperature input is shown below.

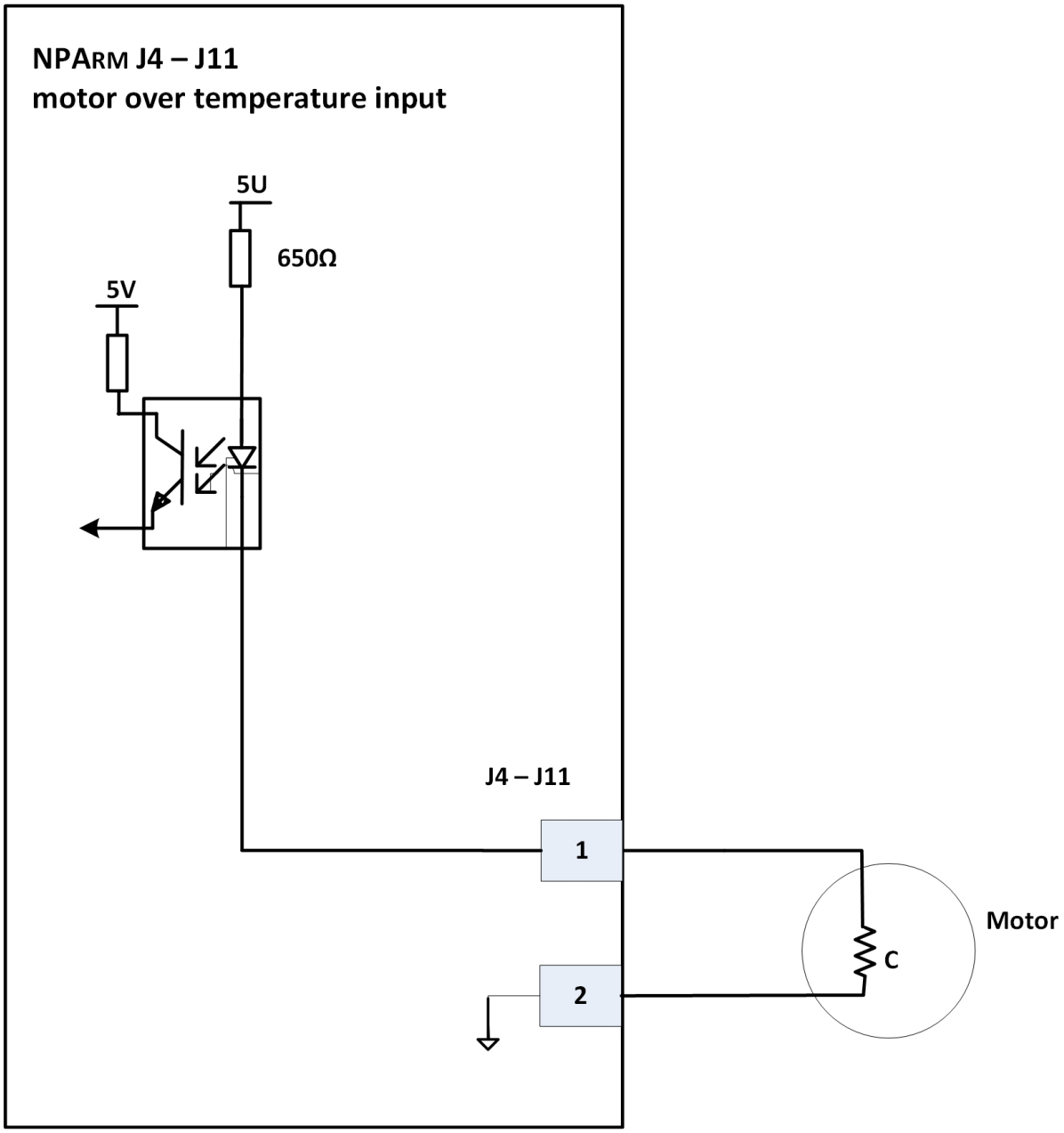


Figure 4-3. Motor over temperature input

If the motor over temperature protection is not used, then connect input pin 1 to input pin 2.

4.6 J12 Motor Braking

For a description of the motor braking functionality see 2.4.

Label: J12 MOTOR BRAKING

One connector is common to all eight motors.

Connector	
Manufacturer	Any - industry standard connector
Type	D-sub
Version	DB-9 female, threaded inserts, 4-40 UNC
P/N	NA

Mating Connector	
Manufacturer	Any - industry standard connector
Type	D-sub
Version	DB-9 male, screw locks, 4-40 UNC
P/N	NA

Table 4-7. J12 motor braking connector pinout table

Pin	Signal	Description
1	BRK_OUT1	Dry contact output 1
2	BRK_OUT2	Dry contact output 2

Pin	Signal	Description
3	BRK_IN1	Dry contact input 1
4	BRK_IN2	Dry contact input 2
5	NC	Not connected
6	NC	Not connected
7	NC	Not connected
8	NC	Not connected
9	NC	Not connected

4.7 J13, J25, J27 Power Supplies

The NPARM has a drive supply and a control supply. Both are fed by 100 – 240Vac input.

4.7.1 PWR-IN (J13) - Drive supply AC input

Label: J13 PWR-IN (DRIVE SUPPLY)

Connector	
Manufacturer	Weidmüller
Type	SL 7.62HP/04/180F 3.2 SN BK BX
Version	male header, 7.62 mm, 4 pin
P/N	1140890000

Mating Connector	
Manufacturer	Weidmüller
Type	BLZ 7.62HP/04/180F SN BK BX

Connector	
Version	female plug, 7.62 mm, 4 pin
P/N	1095700000

Table 4-8. J13 drive supply connector pinout table

Pin	Signal	Description
1	L1	AC input phase 1 (for 100V 3-phase supply) or AC input Line (for 100 -240Vac single phase supply)
2	L2(N)	AC input phase 2 (for 100V 3-phase supply) or AC input Neutral (for 100 - 240Vac single phase supply)
3	NC	Not connected
4	PE	EGND, protected earth

4.7.2 AC-IN (J25) - Control supply AC input

Label: J25 AC-IN (CONTROL SUPPLY)

Connector	
Manufacturer	Weidmüller
Type	SL 7.62HP/03/180F 3.2 SN BK BX
Version	male header, 7.62 mm, 3 pin
P/N	1140880000

Connector


Mating Connector	
Manufacturer	Weidmüller
Type	BLZ 7.62HP/03/180F SN BK BX
Version	female plug, 7.62 mm, 3 pin
P/N	1095690000
	

Table 4-9. J25 AC IN connector pinout table

Pin	Signal	Description
1	L	AC input line
2	N	AC input neutral
3	PE	EGND, protected earth

4.7.3 AC-XPS (J27)

Connector J27 is an optional AC power output for an external device. It provides:

> 100/240Vac

- 11/5.5A (max current)
- 60/50Hz

AC-XPS is used to feed the user controller.

The supply is the same Ac supply that is connected to J25 AC-IN.

If the AC-XPS is not used, make a short between J27 pin #1 to J27 pin #2. a 16AWG wire should be used.

Or instal short wire 16 AWG between pins 1 and 2 on the mating connector

4.7.3.1 Description

Label: J27 AC-XPS (CONTROLLER SUPPLY OUTPUT)

Connector	
Manufacturer	Weidmüller
Type	BLL 7.62HP/04/180F 3.2SN BK BX
Version	female header, 7.62mm, 4 pin
P/N	1122130000

Mating Connector	
Manufacturer	Weidmüller
Type	SLZ 7.62HP/04/180F SN BK BX
Version	male plug, 7.62 mm, 4 pin
P/N	1043450000

Mating Connector

Table 4-10. J27 AC-XPS connector pinout table

Pin	Signal	Description
1	L_XPS	AC line output to the external device
2	L_XPS_RTN	AC line return from the external device
3	N_XPS	Neutral output to the external device
4	PE	EGND, protected earth

4.8 J14, J19 Motor current monitoring analog outputs

There are two, ±10V differential and 16 bit resolution, motor current monitoring outputs per drive. 8V represents the maximum current and 0.8V represent 2A.

The motor current monitoring analog output connections are located on the back of the NPARM, see Figure 2-10.

4.8.1 J14 Motor current monitor

Label: J14 MOTOR CURRENT MONITOR 4,5,6,7

Connector	
Manufacturer	Any - industry standard connector
Type	D-sub
Version	DB-25 female, threaded inserts, 4-40 UNC
P/N	NA

Mating Connector	
Manufacturer	Any - industry standard connector
Type	D-sub
Version	DB-25, male, screw locks, 4-40 UNC
P/N	NA

Table 4-11. J14 motor current monitoring connector pinout table

Pin	Signal	Description
1	IS_ MONITOR_ 0+	Phase S current monitor for drive plug-in module 0 - drive 0 non inverted analog output

Pin	Signal	Description
2	IT_ MONITOR_ 0+	Phase T current monitor for drive plug-in module 0 - drive 0 non inverted analog output
3	AGND_0_1	Analog ground for drive plug-in module 0 - drive 0 and drive plug-in module 0 - drive 1
4	IS_ MONITOR_ 1+	Phase S current monitor for drive plug-in module 0 - drive 1 non inverted analog output
5	IT_ MONITOR_ 1+	Phase T current monitor for drive plug-in module 0 - drive 1 non inverted analog output
6	NC	Not connected
7	IS_ MONITOR_ 2+	Phase S current monitor for drive plug-in module 1 - drive 0 non inverted analog output
8	IT_ MONITOR_ 2+	Phase T current monitor for drive plug-in module 1 - drive 0 non inverted analog output
9	AGND_2_3	Analog ground for drive plug-in module 1 - drive 0 and drive plug-in module 1 - drive 1
10	IS_ MONITOR_ 3+	Phase S current monitor for drive plug-in module 1 - drive 1 non inverted analog output
11	IT_ MONITOR_ 3+	Phase T current monitor for drive plug-in module 1 - drive 1 non inverted analog output
12	NC	Not connected
13	NC	Not connected
14	IS_ MONITOR_ 0-	Phase S current monitor for drive plug-in module 0 - drive 0 inverted analog output
15	IT_ MONITOR_ 0-	Phase T current monitor for drive plug-in module 0 - drive 0 inverted analog output

Pin	Signal	Description
16	AGND_0_1	Analog ground for drive plug-in module 0 - drive 0 and drive plug-in module 0 - drive 1
17	IS_ MONITOR_ 1-	Phase S current monitor for drive plug-in module 0 - drive 1 inverted analog output
18	IT_ MONITOR_ 1-	Phase T current monitor for drive plug-in module 0 - drive 1 inverted analog output
19	NC	Not connected
20	IS_ MONITOR_ 2-	Phase S current monitor for drive plug-in module 1 - drive 0 inverted analog output
21	IT_ MONITOR_ 2-	Phase T current monitor for drive plug-in module 1 - drive 0 inverted analog output
22	AGND_2_3	Analog ground for drive plug-in module 1 - drive 0 and drive plug-in module 1 - drive 1
23	IS_ MONITOR_ 3-	Phase S current monitor for drive plug-in module 1 - drive 1 inverted analog output
24	IT_ MONITOR_ 3-	Phase T current monitor for drive plug-in module 1 - drive 1 inverted analog output
25	NC	Not connected

4.8.2 J19 Motor current monitor

Label: J19 MOTOR CURRENT MONITOR 0,1,2,3

Connector	
Manufacturer	Any - industry standard connector
Type	D-sub
Version	DB-25 female, threaded inserts, 4-40 UNC
P/N	NA

Connector	
	
Mating Connector	
Manufacturer	Any - industry standard connector
Type	D-sub
Version	DB-25, male, screw locks, 4-40 UNC
P/N	NA
	

Table 4-12. J19 motor current monitoring connector pinout table

Pin	Signal	Description
1	IS_ MONITOR_ 4+	Phase S current monitor for drive plug-in module 2 - drive 0 non inverted analog output
2	IT_ MONITOR_ 4+	Phase T current monitor for drive plug-in module 2 - drive 0 non inverted analog output
3	AGND_4_5	Analog ground for drive plug-in module 2 - drive 0 and drive plug-in module 2 - drive 1
4	IS_ MONITOR_ 5+	Phase S current monitor for drive plug-in module 2 - drive 1 non inverted analog output
5	IT_ MONITOR_ 5+	Phase T current monitor for drive plug-in module 2 - drive 1 non inverted analog output
6	NC	Not connected
7	IS_ MONITOR_ 6+	Phase S current monitor for drive plug-in module 3 - drive 0 non inverted analog output

Pin	Signal	Description
8	IT_ MONITOR_ 6+	Phase T current monitor for drive plug-in module 3 - drive 0 non inverted analog output
9	AGND_6_7	Analog ground for drive plug-in module 3 - drive 0 and drive plug-in module 3 - drive 1
10	IS_ MONITOR_ 7+	Phase S current monitor for drive plug-in module 3 - drive 1 non inverted analog output
11	IT_ MONITOR_ 7+	Phase T current monitor for drive plug-in module 3 - drive 1 non inverted analog output
12	NC	Not connected
13	NC	Not connected
14	IS_ MONITOR_ 4-	Phase S current monitor for drive plug-in module 2 - drive 0 inverted analog output
15	IT_ MONITOR_ 4-	Phase T current monitor for drive plug-in module 2 - drive 0 inverted analog output
16	AGND_4_5	Analog ground fordrive plug-in module 2 - drive 0 and drive plug-in module 2 - drive 1
17	IS_ MONITOR_ 5-	Phase S current monitor for drive plug-in module 2 - drive 1 inverted analog output
18	IT_ MONITOR_ 5-	Phase T current monitor for drive plug-in module 2 - drive 1 inverted analog output
19	NC	Not connected
20	IS_ MONITOR_ 6-	Phase S current monitor for drive plug-in module 3 - drive 0 inverted analog output
21	IT_ MONITOR_ 6-	Phase T current monitor for drive plug-in module 3 - drive 0 inverted analog output

Pin	Signal	Description
22	AGND_6_7	Analog ground fordrive plug-in module 3 - drive 0 and drive plug-in module 3 - drive 1
23	IS_ MONITOR_ 7-	Phase S current monitor for drive plug-in module 3 - drive 1 inverted analog output
24	IT_ MONITOR_ 7-	Phase T current monitor for drive plug-in module 3 - drive 1 inverted analog output
25	NC	Not connected

4.9 J15 - J18, J20 - J23 Drive-Controller interface

A controller that supports sinusoidal commutation of the current of the motor should be used. It should provide

current commands for phases S (CMD0) and T (CMD 1).

Table 2-18 lists the relationship between the connector index and motor command.

4.9.1 Description

Label: J15 - J18 DRIVE#

Connector	
Manufacturer	Any - Industry standard connector.
Type	D-sub
Version	DB-25 male, threaded inserts, 4-40 UNC
P/N	NA

Mating Connector	
Manufacturer	Any - Industry standard connector.
Type	D-sub

Connector	
Version	DB-25, screw locks, 4-40 UNC
P/N	NA

Table 4-13. J15 - J18, J20 - J25 connector pinout table

Pin	Signal	Description
1	CMD0_#-	Current command 0 for drive # inverted, # is 0..7
2	CMD0_#+	Current command 0 for drive # non-inverted, # is 0..7
3	CMD1_#-	Current command 1 for drive # inverted, # is 0..7
4	CMD1_#+	Current command 1 for drive # non-inverted, # is 0..7
5	AGND	Analog ground
6	ENABLE_#	Drive # enable input, # is 0..7
7	FLT_#	Drive # fault ouput, # is 0..7
8	DR_IN_#	Dynamic range drive # input, # is 0..7
9	DRV_#+ON	Drive # ON status output, # is 0..7
10	DGND	Digital ground
11	5U	5V outpur for general purpose
12	NC	Not connected
13	NC	Not connected
14	NC	Not connected
15	NC	Not connected
16	NC	Not connected
17	NC	Not connected

Pin	Signal	Description
18	NC	Not connected
19	NC	Not connected
20	NC	Not connected
21	NC	Not connected
22	NC	Not connected
23	NC	Not connected
24	NC	Not connected
25	NC	Not connected

4.9.2 Connection diagrams

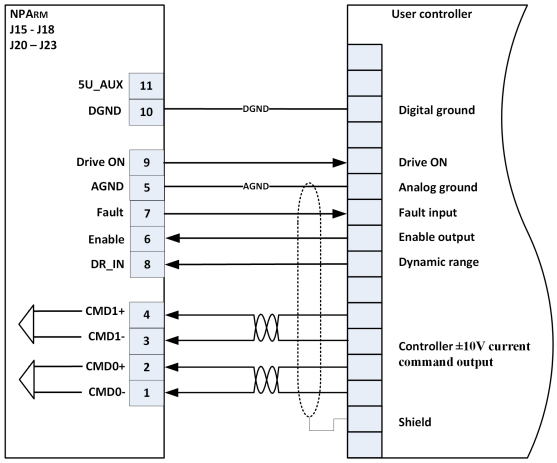


Figure 4-4. Drive connections

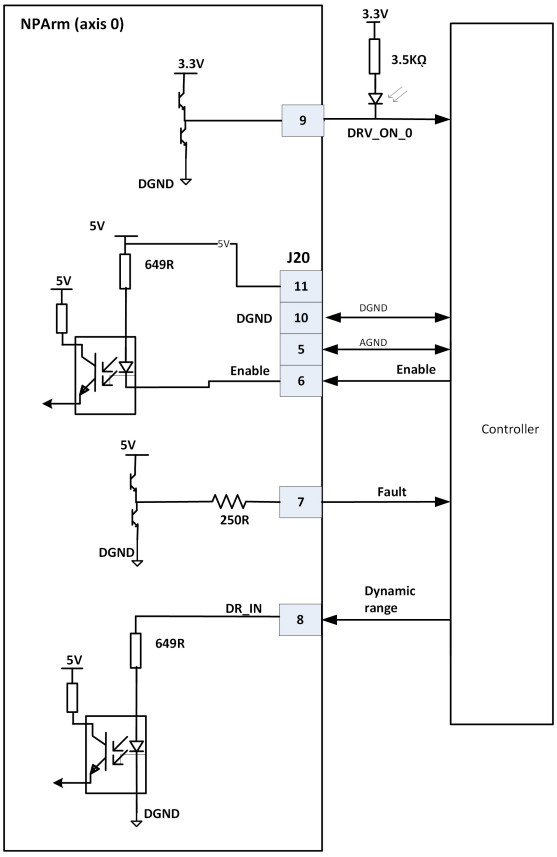


Figure 4-5. Drive connections and grounding

4.10 J24 STO

STO is optional. The STO circuit functionality is designed and tested by ACS to comply with the requirements of EN ISO 13849-1, EN 62061 and IEC 61800-5-2 standards.

The STO (Safe Torque Off) inputs should be connected to a 24V (18Vdc to 33Vdc) source to enable the drives to generate current and feed the motors. When the 24V is removed from one or both STO inputs, current to the motor is blocked within 200msec.

4.10.1 Description

Label: J24 STO

Connector	
Manufacturer	Phoenix
Type	MCV 1,5/5-GF-3,81
Version	5-pin header, pitch 3.81mm
P/N	

Mating Connector	
Manufacturer	Phoenix
Type	MC 1,5/ 5-STF-3,81
Version	5-pin plug, pitch 3.81mm
P/N	

Table 4-14. STO connector pinout table

Pin	Signal	Description
1	STO1-	Safety torque 24V inverted (return) input
2	STO1+	Safety torque 24V non inverted (positive) input
3	EGND	Electrical ground
4	STO2+	Safety torque 24V non inverted (positive) input
5	STO2-	Safety torque 24V inverted (return) input

4.10.2 Connection instructions

The STO1 and STO2 are typically connected to a 24V source via an industry standard safety switch. This device disconnects the 24V upon opening a door, a light current tripping, or other safety related event. Details for handling STO are provided in the *Safe Torque Off Function Application Note*.

The STO circuit in each drive module draws up to 50mA per STO input, with an inrush current of less than 500mA.

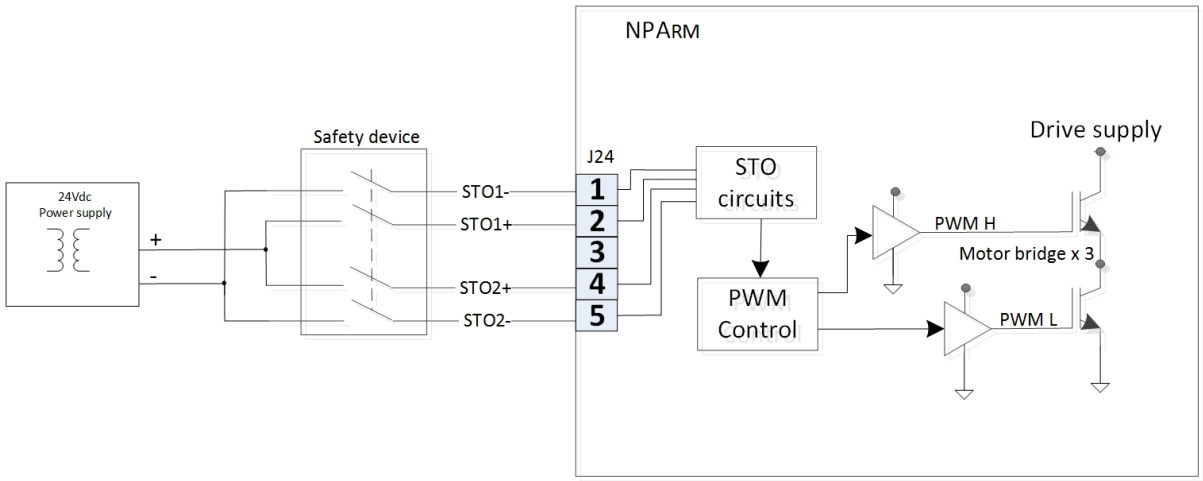


Figure 4-6. STO connections

4.11 J26 PE (Protected Earth)

The system (that includes the NPARM) must be connected to PE (J26) ground terminal.

Connector	
Manufacturer	Erni
Type	PE ground terminal
Version	PCB bush with threaded hole M6

Connector	
P/N	225684

Mating Connector	
Manufacturer	Molex
Type	Ring terminal
Version	Insulated ring terminal for M6 screw
P/N	193240014

For wire assembly use Molex Hand Crimp Tool: 64001-0100

4.12 EtherCAT interface

To fine tune the current loop of each drive, the drive should be connected to any ACS motion controller and EtherCAT Master, such as SPiiPlusEC or SPiiPlusCMba. The tuning process is provided by the SPiiPlusMMI Application Studio is running on a PC.

Each plug-in drive module has an EtherCAT connector, see Calibration in setup mode.

For the motion controller to communicate with the drive, the drive should be set to setup mode by installing a shorting jumper on JP1, see Initial system setup.

4.12.1 Description

Label: EtherCAT

Connector	
Manufacturer	Wurth Electronic
Type	Socket
Version	RJ-45 type 8 pin, socket
P/N	NA

Connector	
Manufacturer	Any - industry standard connection
Type	Plug
Version	RJ-45 type, 8 pin, plug
P/N	NA

Table 4-15. J27 EtherCAT connector pinout table

Pin	Signal	Description
1	TD+	Positive transmit signal
2	TD-	Negative transmit signal
3	RD+	Positive receive signal
4	NC	Not connected
5	NC	Not connected
6	RD-	Negative receive signal
7	NC	Not connected
8	NC	Not connected

4.12.2 Connection instructions

Use Ethernet cables CAT5e or better. ACS offers standard cables in different lengths, see "Ethernet Cables" on page 18.

5. Product Specifications

Feature	Specifications
Drives	**TYPE**: three-phase bridge NanoPWM™ technology **PWM FREQUENCY**: 20kHz **SWITCHING METHOD**: Advanced unipolar PWM **CONTROL:** PI digital filter. PI gains are selected by a four position DIP-switch or programmed when connected to a PC. Current loop sampling rate and update rate: 20 kHz Programmable current loop bandwidth: up to 4 kHz. Will vary with tuning and load parameters. Built-in motor phases shortening relays. **PROTECTION:** Over voltage, Phase to phase and phase to ground short, over current, over-temperature, drive saturation, STO, motor over temperature protection Type: Single ended, opto-isolated **BUILT-IN MOTOR PHASES SHORTENING RELAYS (OPTIONAL)**: disconnect the motor from the drive and shorten the phases of the motor.
Supplies	The module is fed by two AC power sources. PWR-IN drive supply and AC-IN control supply. **PWR-IN:** 100-240Vac feeds the internal drive supply that generates the 48/96Vdc to the plug-in drive modules. Input Current rating should be calculated based on actual load, up to 16A. **AC-IN:** 100-240Vac feeds the internal control supply that generates the 24Vdc ± 10% Maximum input current 1.7A @100Vac (0.7A@ 240Vac)
Motor Type	Two and three 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 INPUT** Type: Sine wave current commutation commands, ±10V differential, 16 bit resolution, Offset: <20mV, Bandwidth < 5 KHZ. **DYNAMIC RANGE CONTROL INPUT** 5V, opto-isolated, source. Input current < 7mA. When 0V (DGND), a 10V command will generate the specified maximum current. When 5V, a 10V command will generate 1/8 of the specified maximum current.

Feature	Specifications
	DRIVE ON/OFF OUTPUT: TTL. active low, upon enable this signal is low (DGND), upon drive disable this signal is high. Output current 1mA. **DRIVE ENABLE INPUT:** TTL, active low (DGND). Input current: <7mA. **DRIVE FAULT OUTPUT:** TTL, active high. Output current 1mA.
Drive status display	One per drive, 7 segment display. Fault Indications: Over voltage, STO, short current, drive over temperature, motor over temperature, drive over current, drive saturation .
Current monitoring analog outputs	Two per drive, for motor phases S and T. Type: ±10V, differential, 16 bit resolution. Offset: ±50mV, Max. output load: 10kΩ.
EtherCAT Communication	Used to connect to an ACS motion controller for current loop setup and fine tuning purposes. One EtherCAT ports per module: type RJ45 connector
Environment	> Operating range: 0 to + 45°C > Storage and transportation range: -25 to +60°C > Humidity (operating range): 5% to 90% non-condensing
Accessories	NPArm-ACC1: Four-axis mating connectors kit NPArm-ACC2: Eight-axis mating connectors kit Ethernet cables

Drive Power Specifications

Feature	Specifications			
Per Drive	A	B	C	D
Continuous/peak current sine amplitude [A]	3.3/10	6.6/20	10/30	13.3/40
Continuous/peak current [Arms]	2.3/7	4.6/14.1	7/21.2	9.4/28.2
Maximum cont/peak output power @ 96Vdc [W]	229/675	459/1350	695/2025	924/2700
Peak current time [sec]	1			

Feature	Specifications			
Maximum load inductance @96Vdc [mH] Can be derated linearly for lower voltages	0.05			
Per Module				
Control supply input [Vac]	100-240			
Drive supply input range [Vac]	100-240			
Drive supply output(s) [Vdc]	48Vdc, 64A 96Vdc, 32A Both 96Vdc and 48Vdc			
Maximum cont. input current [A] per plug-in drive module (i=1 or 2 ; number of drives)*	i x 2.5	i x 4.9	1 x 7.5	i x 10.0
Maximum heat dissipation per plug-in drive module [W] (i = 1 or 2 ; number of drives)**	7 + i x 0.9	7 + i x 2.1	7 + i x 3.7	7 + i x 5.6
Maximum heat dissipation on drive supply for plug-in drive module [W] (i = 1 or 2 ; number of drives)**	i x 12	i x 24	i x 37	i x 49

* The total current consumption from the Drive supply is the sum of the input currents of each plug-in drive module.

** The total heat dissipation is the sum of the heat dissipation of each plug-in drive module and heat dissipation of the power supply for each plug-in drive module.

Table 5-1. Motor over temperature specifications

Item	Description	Remarks
Designation	Motor over temperature: #_OVER_T	Per drive, # is 0..7
Quantity	One per drive	
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	When this protection is not used, the Motor_OVER pin should be shorted to ground.

Item	Description	Remarks
	ground is below 1kΩ	
Default state	Over temperature off = Low impedance <1kΩ	

5.1 STO

STO Specifications

Item	Description	Remarks
Designation	STO1± STO2±	
Quantity	2 inputs	
Interface	24V isolated, two terminal for each input	
Input current (per input pin)	<200mA.	
Operation	No current = drive off.	All drives are disabled within 200mS.

5.2 Controller-Drive Interface

The controller-drive interface includes the following:

- Two current command inputs per drive
- One drive enable input per drive
- One drive fault output per drive
- one drive ON/OFF output per drive
- One dynamic range control input per drive

5.2.1 Current Command

Table 5-2. Current Command

Item	Description	Remarks
Designation	CMD0_#± CMD1_#±	Per drive, # is 0..7
Quantity	Two per drive	
Interface	±10V±10% differential input	

Item	Description	Remarks
Command input filter bandwidth	<5KHz	
Resolution	16-bit	
Offset	<20mV	
SNR	≥14 usable bits	

5.2.2 Drive Enable Input

Drive Enable Input

Item	Description	Remarks
Designation	ENA_#	Per drive, # is 0..7
Quantity	One per drive	
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.	

5.2.3 Drive Fault Output

Table 5-3. Drive Fault Output

Item	Description	Remarks
Designation	FLT_#	Per drive, 0..7
Quantity	One per drive	
Interface	> TTL level > Active high > Reference: DGND	
Output current	1mA	

Item	Description	Remarks
Logic state	In the event of a drive fault, the drive is disabled and the output is set to 1. The drive fault is cleared by enable command. The fault reset propagation delay is 60 µsec.	

5.2.4 Drive On/Off Output

Table 5-4. Drive On/Off Output

Item	Description	Remarks
Designation	DRV_ON_#±	Per drive, # is 0..7
Quantity	1 per drive	
Interface	> TTL level > Reference: DGND	
Output current	1mA	
Logic state	> Drive On = 0 > Drive Off = 1 (3.3V)	

5.2.5 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 drive.

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 3.75A.

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.

Dynamic Range Input

Item	Description
Designation	DR

Item	Description
Quantity	One per drive
Type	TTL level Reference: DGND
Interface	5V, opto-isolated, Source input type.
Input current	< 7mA
Default state	DR=0

5.3 Dimensions

Stardard 19 inch rack mount enclosure.

- Length ≤ 440mm, (483mm with ears)
- Depth ≤ 266mm + 40mm handles
- Height ≤ 260mm (6U)

5.4 Weight

- 11.8 kg for 4-axes
- 13.3kg for 8-axes

5.5 Compliance with standards

5.5.1 Environment

- Operating range: 0 to + 45°C
- Storage and transportation range: -25 to +60°C
- Humidity (operating range): 5% to 90% non-condensing

5.5.2 CE

- EN 61326:2002

5.5.3 Safety

- IEC 61010-1:01
- UL (pending)

5.5.4 RoHS

- Design complies with RoHS requirements.

6. Operation modes

The NPARM drive operates in two modes:

- Normal operation
  - The drive feeds current to the motor relative to current commands provided by an external controller. The unit is shipped from ACS set to this mode.
  - While in normal operation mode, the current loop tuning can be set to 16 different discrete values via four DIP switches, see Current loop filter tuning in normal operation mode.
- Setup
  - Is used for calibration and fine tuning of the drive. All revised parameters are stored in the nonvolatile memory of the unit.
  - Requires an ACS master controller. In this mode the drive acts as an EtherCAT slave.
  - Enables calibration of the command signal offsets for an entire system consisting of the external controller and the drive ("End to End"), see End to End Calibration. It is advisable to perform this action for controllers which do not have an offset compensation option for the command signals.

Calibration of the drive in setup mode is not mandatory. Before shipping, the current command signals are calibrated to have zero offset. The driver should be calibrated only if fine tuning of the current loop and/or "End to End" command offset calibration is required.

6.1 How to set the operation mode

The operation mode is set by jumper JP1. When closed (installed), the unit is in Setup mode. When open, the unit is in Normal operation mode, see Initial system setup for more details.

6.2 Operation in normal mode

Normal operation is the regular operation mode of the driver. The unit is shipped from ACS set to this mode.

6.2.1 Current loop filter tuning in normal operation mode

The current loop filter gains are set by DS0 (Drive 0) and DS1 (Drive 1) DIP switches according to the following table.

Proportional (SLIKP)	Integral (SLIKI)	DIP Switch code
Values saved in the non-volatile memory of the drive		0000

Proportional (SLIKP)	Integral (SLIKI)	DIP Switch code
150	500	0001
300		0010
600		0011
1200		0100
2400		0101
150	4000	0110
300		0111
600		1000
1200		1001
2400		1010
150	8000	1011
300		1100
600		1101
1200		1110
2400		1111

The default factory setting for SLIKP is 100 and SLIKI is 1000 with a DIP switch code 0000.

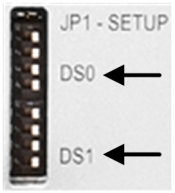


Figure 6-1. DIP Switches DS0 and DS1

6.2.1.1 Initial guess for I and P gains

The initial guess for the I and P gain parameters should be based on motor parameters:

For integral gain:

$$SLIKI = 3.2\frac{R_{p-p}}{L_{p-p}}$$

For proportional gain:

$$SLIKP = 5 \cdot BW_{CUR}\, I_p\, L_{p-p}$$

Where

$I_p[A]$ - peak current of the NPArm unit

$L_{p\text{-}p}[mH]$ - phase to phase inductance of the motor

$R_{p\text{-}p}[\Omega]$ - phase to phase resistance of the motor

$BW_{CUR}[Hz]$ - crossover frequency of the current in "open loop" FRF

The crossover frequency of the current loop can be considered as the current loop bandwidth. Typical values are between 800 - 2000 [Hz].

6.2.1.2 Fine tuning

To fine tune the I and P gains follow one of the methods below.

Using a current probe

1. Connect a current probe to phase "S".
2. Send a square wave command to phase “S” of the NPArm drive.
3. Select a DIP switch combination which results in the fastest current loop response while maintaining stability.

Using a differential voltage probe

1. Measure the following signals:

Signal	Connector	Pin Set
“S” phase current of drive 0	J19	1,14
“T” phase current of drive 0	J19	2,15
“S” phase current of drive 1	J19	4,17
“T” phase current of drive 1	J19	5,18
“S” phase current of drive 2	J19	7,20
“T” phase current of drive 2	J19	8,21
“S” phase current of drive 3	J19	10,23

Signal	Connector	Pin Set
“T” phase current of drive 3	J19	11,24
“S” phase current of drive 4	J14	1,14
“T” phase current of drive 4	J14	2,15
“S” phase current of drive 5	J14	4,17
“T” phase current of drive 5	J14	5,18
“S” phase current of drive 6	J14	7,20
“S” phase current of drive 6	J14	8,21
“S” phase current of drive 7	J14	10,23
“S” phase current of drive 7	J14	11,24

2. Send a square wave command to phase “S” of the NPArm drive.
3. Select a DIP switch combination which results in the fastest current loop response while maintaining stability.

Using single ended voltage probe

1. Measure the following signals:

Signal	Connector	Pin Set
“S” phase current of drive 0	J19	3,1
“T” phase current of drive 0	J19	3,2
“S” phase current of drive 1	J19	3,4
“T” phase current of drive 1	J19	3,5
“S” phase current of drive 2	J19	9,7
“T” phase current of drive 2	J19	9,8
“S” phase current of drive 3	J19	9,10
“T” phase current of drive 3	J19	9,11
“S” phase current of drive 4	J14	3,1
“T” phase current of drive 4	J14	3,2
“S” phase current of drive 5	J14	3,4

Signal	Connector	Pin Set
"T" phase current of drive 5	J14	3,5
"S" phase current of drive6	J14	9,7
"T" phase current of drive 6	J14	9,8
"S" phase current of drive 7	J14	9,10
"T" phase current of drive 7	J14	9,11

2. Send a square wave command to phase "S" of the NPArm drive.
3. Select a DIP switch combination which results in the fastest current loop response while maintaining stability.

6.2.1.3 Example

Motor parameters:

$$R_{(p-p)} = 3[\Omega], L_{(p-p)} = 2.8[mH]$$

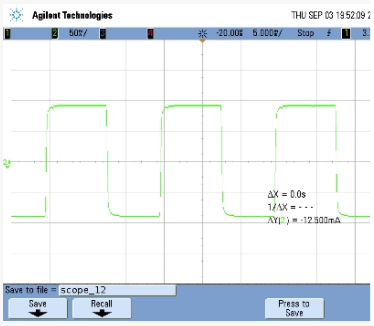
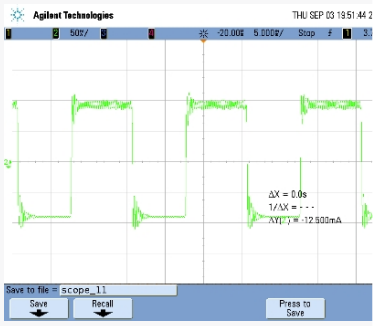
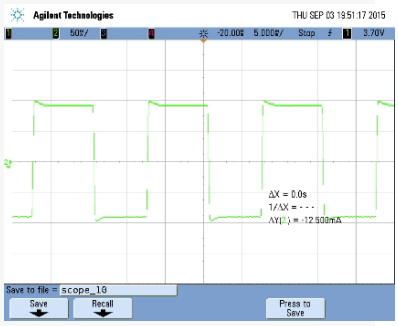
Drive parameters:

$$I_P = 20[A]$$

Initial guess is:

$$SLIKI = 3.2\,\frac{3}{2.8}1000 = 3428$$

$$SLIKP = 5 \text{ x } 1000 \text{ x } 20 \text{ x } 2.8 \div 1000 = 280$$

Initial Guess	First iteration	Second iteration
Good but may be faster	Nearly unstable	Fast and stable
DIP - 0111	DIP - 1000	DIP - 1100
SLIKP = 300, SLIKI = 4000	SLIKP =600, SLIKI = 4000	SLIKP = 300, SLIKI = 8000
		

6.2.2 Current command dynamic range activation

While the motor is at stand still or moving at a constant velocity, the current commands are low. The input commands can be rescaled (scale factor is 1:8) to improve the resolution and the signal to noise ratio (SNR) of the command. Improving the SNR should result in smaller stand still jitter and constant velocity following errors.

The dynamic range is enabled by setting DR_IN to a logic 1 state by providing a 5V command to the a signal pin/ ground pin combination as shown below.

Drive	Connector	Signal Pin	Ground Pin
0	J20	8	10
1	J15	8	10
2	J21	8	10
3	J16	8	10
4	J22	8	10
5	J17	8	10
6	J23	8	10
7	J18	8	10

The motion controller should select the dynamic according to motion state:

1. The dynamic range should be turned OFF during acceleration/deceleration to allow high command to be received.
2. The dynamic range should be turned ON during constant velocity and right after motion to allow smoother velocity and lower stand still following error.

Dynamic Range State	DR_IN Logic State	% of Maximum Current Output from a 10V Command
OFF	0	100
ON	1	12.5

To ensure stability of the entire control loop, the controller should also modify servo gains when modifying the dynamic range.

When the dynamic range is 12.5% (DR_IN = 1), the following two parameters should be updated simultaneously with the dynamic range state.

> Proportional gain of the servo loop - "open loop" should be increased by a factor of 8.

> Acceleration feed-forward should be increased by a factor of 8.

Example:

The following ACSPL+ code illustrates the activation of the dynamic range feature with ACS controller when the motion is completed.

```
GLOBAL INT DR, AXIS ! Define variables
AXIS=0 ! Assign number to AXIS variable


ENABLE(0) ! Enable motor
PTP(0), 10 ! Start Point to point motion
STOP ! Stop program execution

ON ^MST(0).#MOVE ! Upon a state that motor does not move perform the
                        following
       DR.AXIS = 1 ! Set internal variable to 1

RET

ON DR.AXIS ! Upon DR.AXIS is set
       BLOCK ! Block means that all following command will be executed in a
                single controller cycle
              OUT(0).16 = 1 ! Set external output that will send
                              5[V] command to the NPA drive to activate
                              dynamic range
              SLVKP(AXIS) = 1000*8 ! Multiply proportional gain by a factor
                                     of 8
              SLAFF(AXIS) = 0.268*8 ! Multiply acceleration feed forward by
                                      factor of 8
        END
RET

ON ^DR.AXIS ! Upon DR.AXIS is cleared
       BLOCK ! Block means that all following command will be executed in a
                single controller cycle
              SLVKP(AXIS) = 1000 ! Set proportional gain to its original
                                   value
              SLAFF(AXIS) = 0.268 ! Set acceleration feed forward to its
                                    original value
              OUT(0).16 = 0 ! Clear external output that will send 0[V]
                              command to the NPA drive to deactivate dynamic
                              range
       END

RET
```

6.3 Calibration in setup mode

To fine tune and calibrate the drive in Setup mode any ACS EtherCAT master controller and the SPiiPlus MMI application studio are needed. The SPiiPlus MMI application studio is available for download from the ACS website.

6.3.1 Initial system setup

Setting up the system:

1. Turn off the control supply.
2. Turn off the drive supply.
3. Set the NPArm in setup mode by installing a jumper on JP1.
4. Connect the NPArm to an ACS motion controller using an EtherCAT cable.
5. Connect the controller to a PC that runs the *SPiiPlus MMI application studio* using an Ethernet cable.
6. Turn on the control supply.
7. Turn on the drive supply.

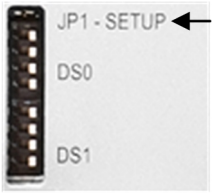
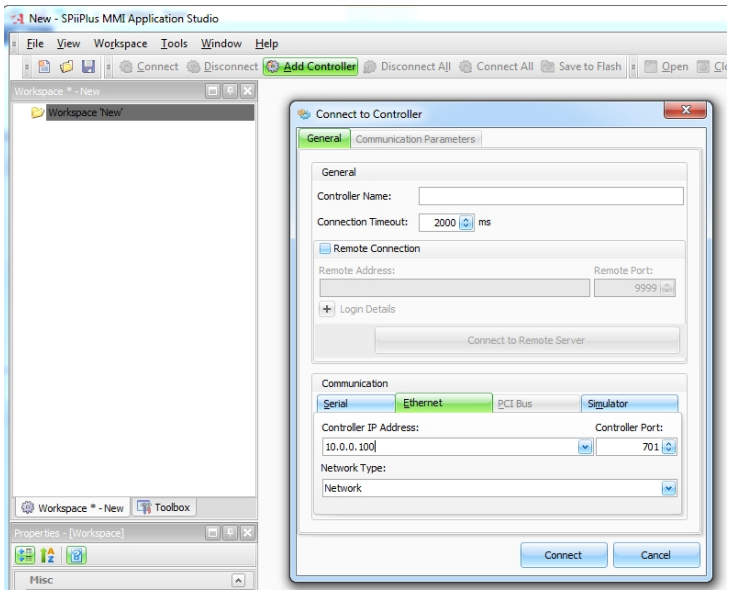


Figure 6-2. Jumper JP1

6.3.2 Establishing communication

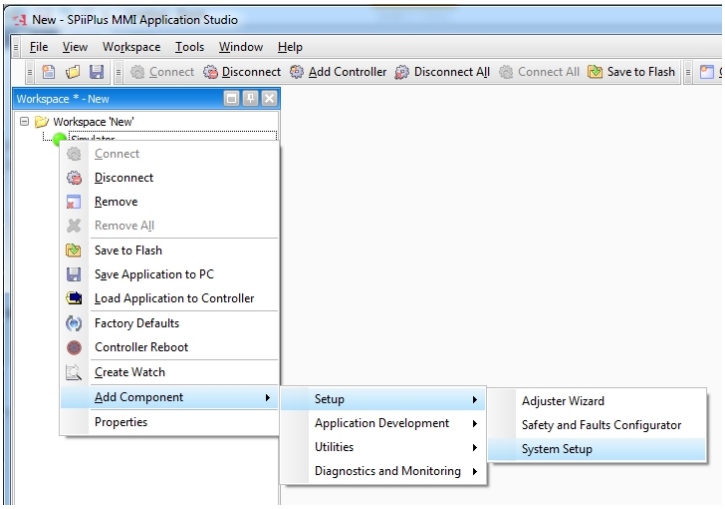
1. Open *SPiiPlus MMI Application Studio*.
2. From the main window, click **Add Controller**, the **Connect to Controller** window appears.



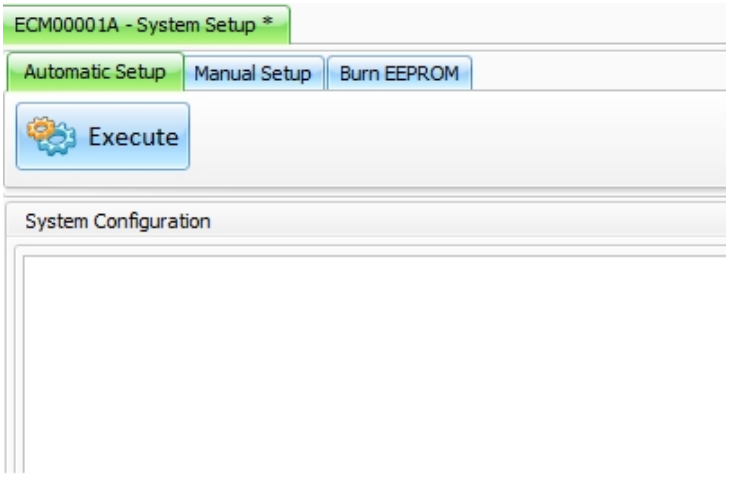
3. Select **Ethernet**.

> The default IP address of the controller is 10.0.0.100.

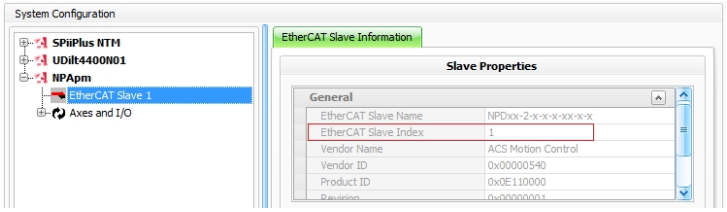
4. Click **Connect**.
5. Right-click the controller in the Workspace Tree, the **Controller Right-Click Options** window appears.



6. Select **Add Component > Setup > System Setup**, the **System Setup** window appears.



7. Click **Execute**, after the configuration process is complete, the **System Configuration** window appears.



8. The EtherCAT network is identified. Note the EtherCAT Slave Index. It is a required input in the calibration program.

The EtherCAT slave number is also available by:

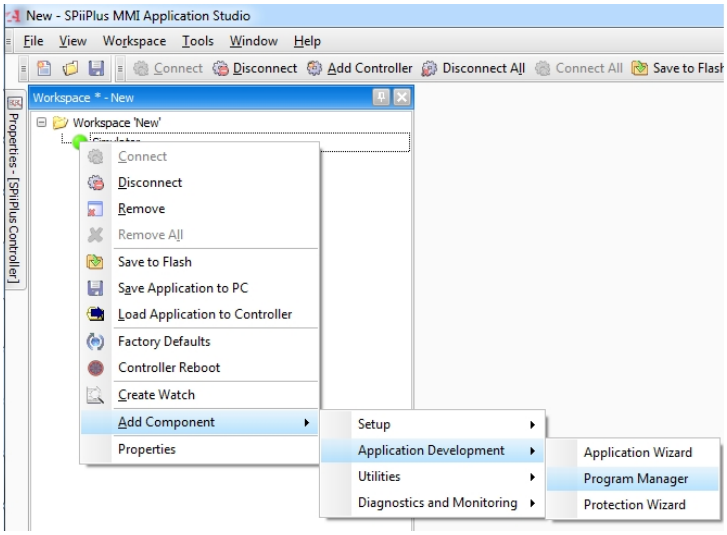
1. Right-click the controller in the Workspace Tree (as in step #5 above), the **Controller Right-Click Options** window appears.
2. Select **Add Component > Diagnostics and Monitoring > System Viewer and Diagnostics**, the **System Viewer and Diagnostics** window appears.
3. Select **Retrieve**, the system configuration stored in the controller is displayed.

Now the current loop can be tuned using the MMI, see Current loop filter calibration and tuning.

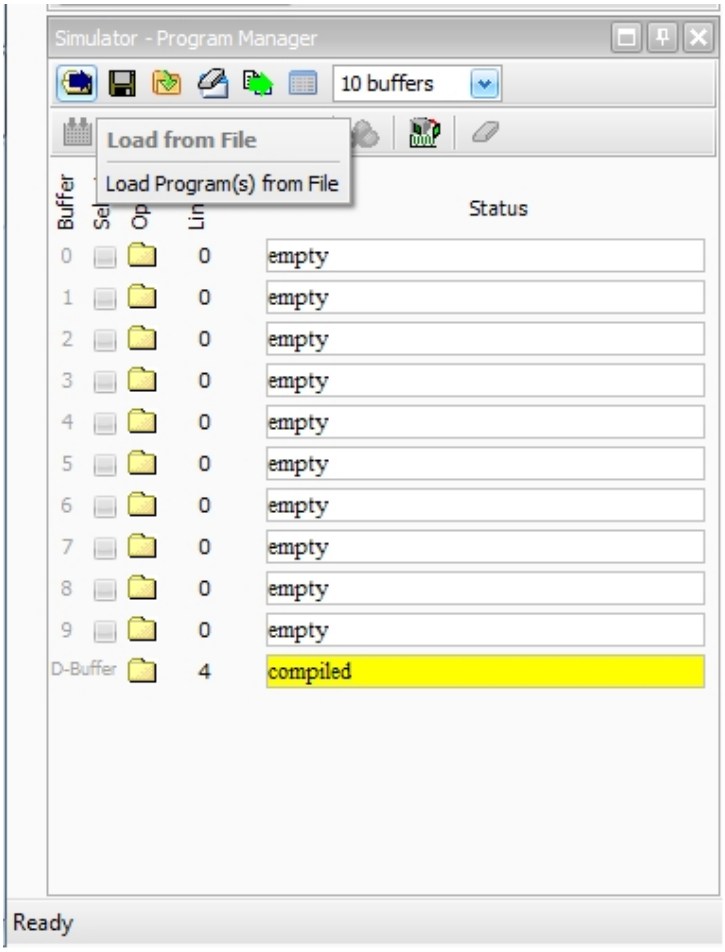
6.3.3 Command offset calibration

ACSPL+ programs are used for command offset calibration, see "How to perform an "End to End" calibration" on page 91, and to save current loop parameters to a controller's non-volatile memory, see Saving parameters to flash memory.

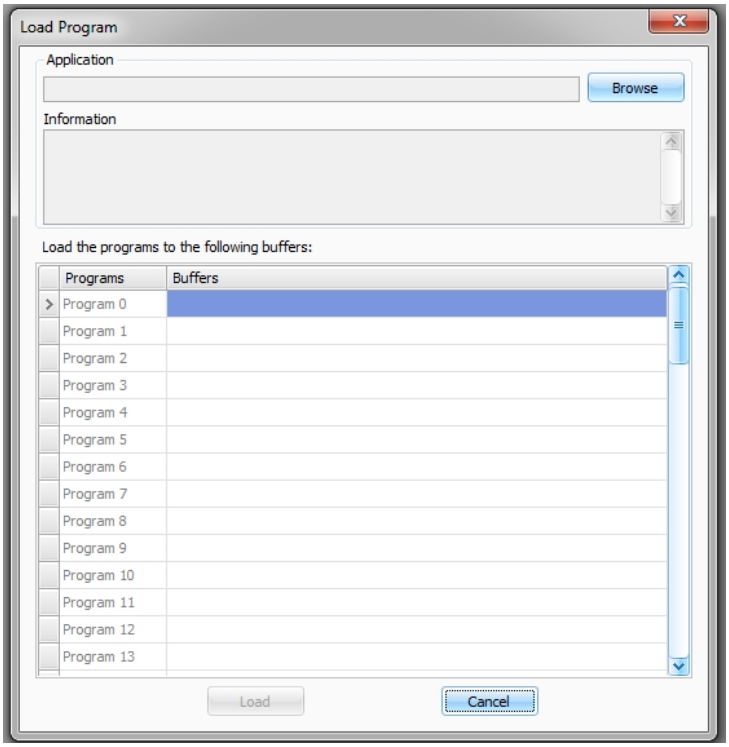
1. Right-click the controller in the Workspace Tree, the **Controller Right-Click Options** window appears.



2. Select **Add Component > Application Development > Program Manager**, the **Program Manager** window appears.



3. Click on **Load from file**, the **Load Program** window appears.



4. Click **Browse** to search for the file (when found, select the file).

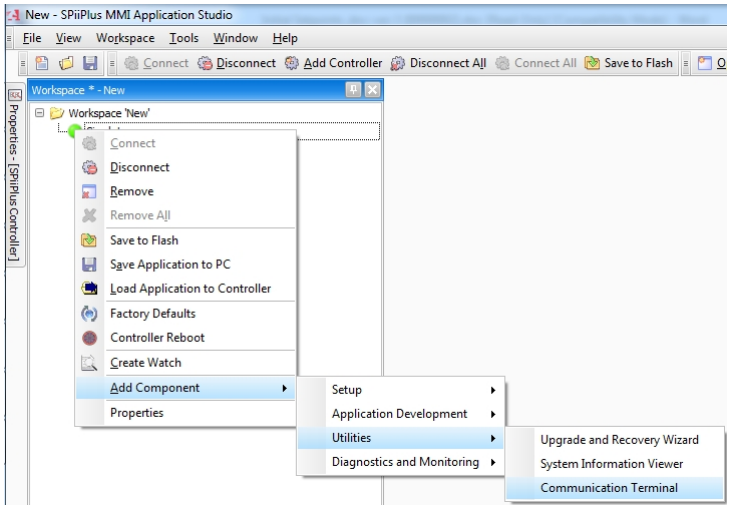
Program files have a **prg** extension.

5. Click **OK**, the file is loaded into the buffer.

6.3.4 Monitoring offset calibration progress

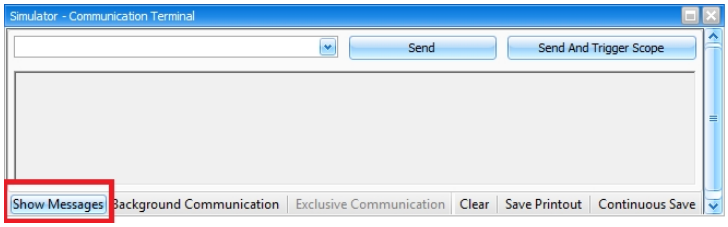
The Communication Terminal is used for communication between a host PC (running the MMI Application Studio) and the controller. The Communication Terminal is used to monitor offset calibration progress, see Saving parameters to flash memory.

1. Right-click the controller in the Workspace Tree, the **Controller Right-Click Options** window appears.



.

2. Select **Add Component > Utilities > Communication Terminal**, the **Communication Terminal** window appears.



3. Click **Show Messages**. Messages sent by a DISP command from any program running in the controller are displayed.

6.3.5 Current command offset calibration

The following current commands are calibrated at the factory to have zero offset.

Current Command	Drive	Connector	Pin Set
0	0	J20	2,1
1	0	J20	4,3
0	1	J15	2,1
1	1	J15	4,3
0	2	J21	2,1
1	2	J21	4,3
0	3	J16	2,1
1	3	J16	4,3

Current Command	Drive	Connector	Pin Set
0	4	J22	2,1
1	4	J22	4,3
0	5	J17	2,1
1	5	J17	4,3
0	6	J23	2,1
1	6	J23	4,3
0	7	J18	2,1
1	7	J18	4,3

After the drive is connected to a controller, the controller command analog outputs should be recalibrated so that a zero command by the controller produces zero current.

Two options are available for recalibration.

> Calibrate the external controller to have zero offset in the corresponding command signals.

> Recalibrate the NPArm offsets "End to End".

6.3.5.1 How to perform an "End to End" calibration

To perform an "End to End" calibration:

1. Configure the NPArm to operate in setup mode, see Calibration in setup mode.
2. Setup the EtherCAT network, see Establishing communication.
3. Connect a controller to the drive connectors.

Drive	Connector
0	J20
1	J15
2	J21
3	J16
4	J22
5	J17
6	J23

Drive	Connector
7	J18

4. Set the controller to output zero commands as command outputs.
5. In **Program Manager**, load the "End2EndCalibrationProgram.prg" program, see EndToEndCalibrationProgram.prg.

When the calibration program runs, the axes are enabled. The BUS voltage should be connected during this process. A motors connection is not required.

6. Open a communication terminal and enable it to show messages, see Monitoring offset calibration progress.
7. In **Program Manager**, click **Select** adjacent to the buffer where the"End2EndCalibrationProgram.prg" is stored.
8. Click, the **Run Buffer(s)** icon.
9. Follow the instructions received in the Communication Terminal.

The buffer status column is green while buffer is running. The color returns to yellow once it stops running.

6.3.6 Current loop filter calibration and tuning

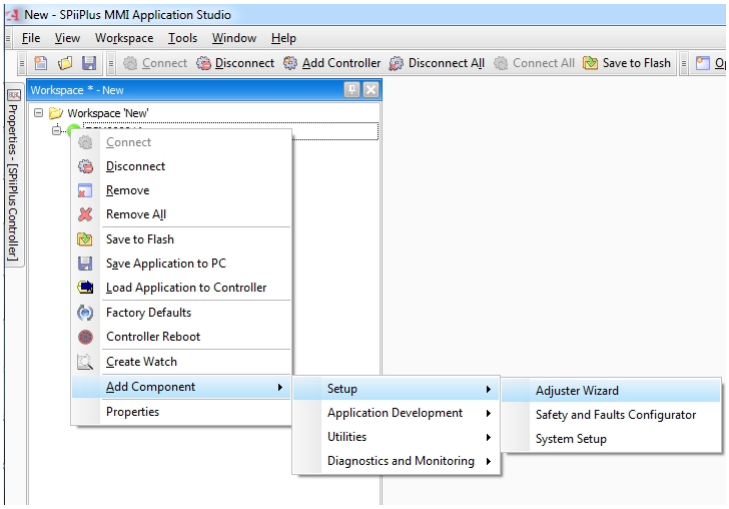
The current loop filter is a PI filter. It has two gains: proportional and integral. Both should be tuned to provide the fastest current loop response while maintaining sufficient stability margin.

The PI filter can be tuned either by selecting a set of PI gains from a pre-set group of 16 different sets of gains using a DIP switch when the unit is in the normal operational mode or by tuning the PI gains using the *SPiiPlus MMI Application Studio* with the unit placed into Setup mode, see Calibration in setup mode.

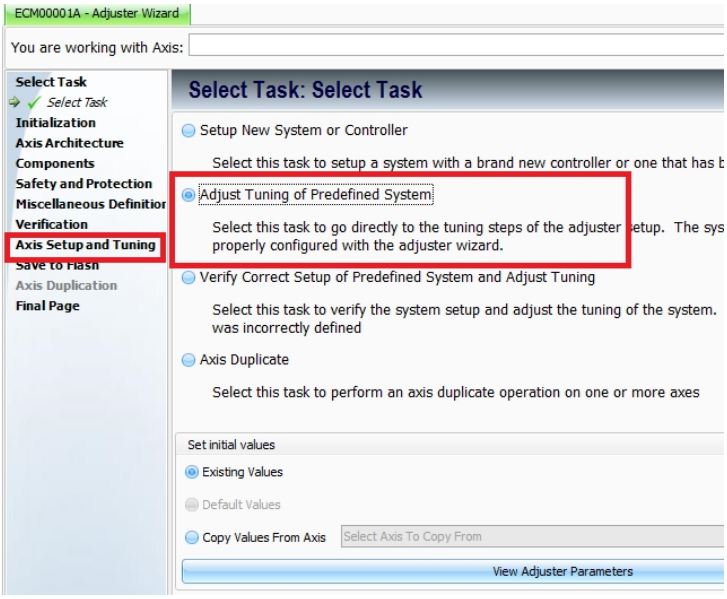
6.3.6.1 Current loop tuning

To tune the current loop:

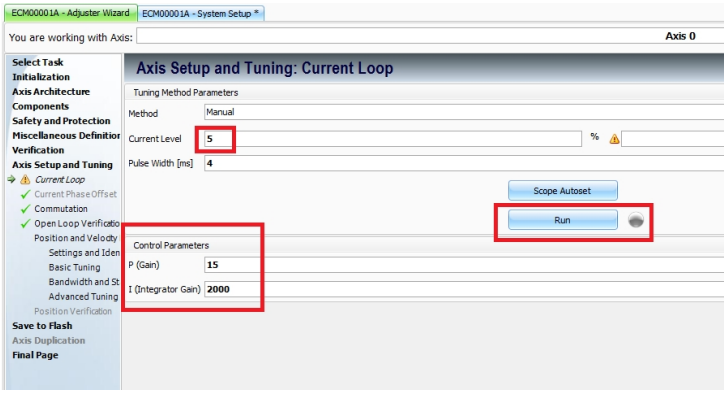
1. Right-click the controller in the Workspace Tree, the **Controller Right-Click Options** window appears.



2. Select **Add Component > Setup > Adjuster Wizard**, the **Adjuster Wizard** window appears.



3. Select **Adjust Tuning of Predefined System** followed by **Axis Setup and Tuning**, the **Axis Setup and Tuning: Current Loop** window appears.



4. Enter appropriate values for the parameters below.

- Current Level [%]
- P (Gain)
- I (Integral Gain)

5. Click **Run**.
6. Click **Scope Autoset**. The scope is displayed.
7. Make adjustments to the P and I gains to achieve the fastest current loop response while maintaining sufficient stability margin.

6.3.6.2 Saving parameters to flash memory

1. Load the program "NPACurrentLoopParametersSaveProgram.prg" into the program manager, see NPACurrentLoopParametersSaveProgram.prg for the program code. For instructions on loading a program, see Command offset calibration.
2. In the **Program Manager** pod, click the **Open Buffer** icon for buffer 0. This opens buffer 0.
3. Open a communication terminal and enable it to show messages, see Monitoring offset calibration progress.
4. In **Program Manager** pod, click **Select** adjacent to the buffer where the "NPACurrentLoopParametersSaveProgram.prg" is stored.
5. Select, **Run Buffer(s)**.
6. Follow the instructions received in the Communication Terminal.
7. In the **Program Manager** pod, select **Run Buffer** for buffer 0. This runs the buffer program.

Once finished all parameters are saved into the non-volatile memory of the drive.

6.3.7 Returning to normal operation mode

To return to normal operation mode:

1. Turn off the control supply.
2. Turn off the drive supply.
3. Set the NPArm to normal operation mode by removing the jumper from JP1.
4. Set the DIP switch to 0000 (to use the saved gains of the PI filter).
5. Turn on the control supply.
6. Turn on the drive supply.

The NPArm should be returned to normal operation mode after performing all calibrations.

Be sure all EtherCAT cables are disconnected.

Appendix A. Calibration programs and additional notes

A.1 EndToEndCalibrationProgram.prg

Copy the code below to text editor and save it with .prg extension or copy it as it is to a buffer.

```
#/ Controller version = 2.29.04.00
#/ Date = 22-Dec-15 14:51
#/ User remarks = V6
#0

int  NUMBER_OF_AXES(1), INDEX
GLOBAL INT DSP_INDEX(1), ADDRESS_ERROR, FIRST_AXIS_INDEX(1)
GLOBAL INT OffsetPlugReady(1), START_SAVE(1),SYSTEM_RESTART(1), SaveCurrentCurrentLooopParams(1)
GLOBAL INT SAT_PROTECT(2), SLILI_ORIG(2)
GLOBAL REAL COMMAND_SF(2)
global real CURRENT_LOOP_PARAMETER(1)
GLOBAL REAL DRIVE_RESCALE(1), NEW_SCALE_FACTOR(1)

!********************!

DSP_INDEX_LABEL:
DISP "\n\nEnter EtherCAT Slave index of the NPA as it appears in the System Viewer and Diagnostics."
DSP_INDEX(0) = 0
INPUT (DSP_INDEX)

IF(DSP_INDEX(0) <0 | DSP_INDEX(0)>9)
       DISP "DSP index out of range. Try again in range 0-9."
       GOTO DSP_INDEX_LABEL
END
!********************!

! Under voltage protection
IF(getsp(DSP_INDEX(0),getspa(DSP_INDEX(0),"Vbus")) < 32767*9/200)
       DISP "BUS voltage is too low. Process aborted"
       STOP
END

DISP "Enter number of axes available in the unit. 1 - single axis unit. 2 - dual axis unit."
NUM_OF_AXES_LABEL:


INPUT (NUMBER_OF_AXES)
IF(NUMBER_OF_AXES(0) <1 | NUMBER_OF_AXES(0)>2)
       DISP "DSP index out of range. Try again in range 1-2."
       GOTO NUM_OF_AXES_LABEL
END

!********************!

global real collected_data(20000)

int cs_offset(2)
int ct_offset(2)
int u30(2)
int u40(2)

int cs_offset_read(2)
int ct_offset_read(2)
int u30_read(2)
int u40_read(2)

int sin_data_addr(4)
int cos_data_addr(4)

int cs_offset_addr(2)
int ct_offset_addr(2)
int u30_addr(2)
int u40_addr(2)

! Store parameters
SAT_PROTECT(0) = getsp(DSP_INDEX(0), getspa(DSP_INDEX(0), "axes[0].sat_protect")); wait 10
SLILI_ORIG(0) = getsp(DSP_INDEX(0), getspa(DSP_INDEX(0), "axes[0].voltage_limit")); wait 10
COMMAND_SF(0) = getsp(DSP_INDEX(0), getspa(DSP_INDEX(0), "axes[0].command_sf")); wait 10
! Change parameters to enable the drive with zero command
```

```
setsp(DSP_INDEX(0), getspa(DSP_INDEX(0), "axes[0].sat_protect"), 1e9); wait 10
setsp(DSP_INDEX(0), getspa(DSP_INDEX(0), "axes[0].voltage_limit"), 0); wait 10
setsp(DSP_INDEX(0), getspa(DSP_INDEX(0), "axes[0].command_sf"), 0); wait 10

IF (NUMBER_OF_AXES(0)=2)
       SAT_PROTECT(1) = getsp(DSP_INDEX(0), getspa(DSP_INDEX(0), "axes[1].sat_protect")); wait 10
       SLILI_ORIG(1) = getsp(DSP_INDEX(0), getspa(DSP_INDEX(0), "axes[1].voltage_limit")); wait 10
       COMMAND_SF(1) = getsp(DSP_INDEX(0), getspa(DSP_INDEX(0), "axes[1].command_sf")); wait 10
       ! Change parameters to enable the drive with zero command
       setsp(DSP_INDEX(0), getspa(DSP_INDEX(0), "axes[1].sat_protect"), 1e9); wait 10
       setsp(DSP_INDEX(0), getspa(DSP_INDEX(0), "axes[1].voltage_limit"), 0); wait 10
       setsp(DSP_INDEX(0), getspa(DSP_INDEX(0), "axes[1].command_sf"), 0); wait 10
END

! Enable axes
FIRST_AXIS_INDEX(0) = 0
WHILE(GETCONF(260, FIRST_AXIS_INDEX(0)) <> DSP_INDEX(0))
       FIRST_AXIS_INDEX(0) = FIRST_AXIS_INDEX(0) + 1
END

DISP "Following parameters are available at FW for NPA EtherCAT Slave index is %2i", DSP_INDEX(0)
disp""
DISP "SLIKP(%2i",FIRST_AXIS_INDEX(0),")"  , SLIKP(FIRST_AXIS_INDEX(0))
DISP "SLIKI(%2i",FIRST_AXIS_INDEX(0),")"  , SLIKI(FIRST_AXIS_INDEX(0))
IF (NUMBER_OF_AXES(0)=2)
       DISP "SLIKP(%2i",FIRST_AXIS_INDEX(0)+1,")", SLIKP(FIRST_AXIS_INDEX(0)+1)
       DISP "SLIKI(%2i",FIRST_AXIS_INDEX(0)+1,")", SLIKI(FIRST_AXIS_INDEX(0)+1)
END

DISP ""
DISP" To save these parameters enter 1. To enter new values for current loop parameters enter 2"

SaveCurrentLooopLabel:
INPUT (SaveCurrentCurrentLooopParams)
IF(SaveCurrentCurrentLooopParams(0) <1 | SaveCurrentCurrentLooopParams(0)>2)
       DISP "DSP index out of range. Try again in range 1-2."
       GOTO SaveCurrentLooopLabel
ELSEIF(SaveCurrentCurrentLooopParams(0)=2)
       !********************!
       ENTER_SLIKP0:
       DISP "\n\nEnter value for SLIKP(%2i", FIRST_AXIS_INDEX(0),")"
       INPUT(CURRENT_LOOP_PARAMETER)

       IF(CURRENT_LOOP_PARAMETER(0)<0 | CURRENT_LOOP_PARAMETER(0)>256000)
              DISP "Value out of range (0-256000). Try again"
              GOTO ENTER_SLIKP0
       ELSE
              SLIKP(FIRST_AXIS_INDEX(0)) = CURRENT_LOOP_PARAMETER(0)
       END
       CURRENT_LOOP_PARAMETER(0) = -1

       !********************!
       ENTER_SLIKI0:
       DISP "\n\nEnter value for SLIKI(%2i", FIRST_AXIS_INDEX(0),")"
       INPUT(CURRENT_LOOP_PARAMETER)

       IF(CURRENT_LOOP_PARAMETER(0)<0 | CURRENT_LOOP_PARAMETER(0)>65000)
              DISP "Value out of range (0-65000). Try again"
              GOTO ENTER_SLIKI0
       ELSE
              SLIKI(FIRST_AXIS_INDEX(0)) = CURRENT_LOOP_PARAMETER(0)
       END
       CURRENT_LOOP_PARAMETER(0) = -1

       !********************!
       IF (NUMBER_OF_AXES(0)=2)
              ENTER_SLIKP1:
              DISP "\n\nEnter value for SLIKP(%2i", FIRST_AXIS_INDEX(0)+1,")"
              INPUT(CURRENT_LOOP_PARAMETER)

              IF(CURRENT_LOOP_PARAMETER(0)<0 | CURRENT_LOOP_PARAMETER(0)>256000)
                     DISP "Value out of range (0-256000). Try again"
                     GOTO ENTER_SLIKP1
              ELSE
                     SLIKP(FIRST_AXIS_INDEX(0)+1) = CURRENT_LOOP_PARAMETER(0)
              END
              CURRENT_LOOP_PARAMETER(0) = -1
```

```
		!********************!
		ENTER_SLIKI1:
		DISP "\n\nEnter value for SLIKI(%2i", FIRST_AXIS_INDEX(0)+1,")"
		INPUT(CURRENT_LOOP_PARAMETER)

		IF(CURRENT_LOOP_PARAMETER(0)<0 | CURRENT_LOOP_PARAMETER(0)>65000)
			DISP "Value out of range (0-65000). Try again"
			GOTO ENTER_SLIKI1
		ELSE
			SLIKI(FIRST_AXIS_INDEX(0)+1) = CURRENT_LOOP_PARAMETER(0)
		END
	END

	DISP "Following current loop parameters will be saved"
	disp""
	DISP "SLIKP(%2i",FIRST_AXIS_INDEX(0),")"  , SLIKP(FIRST_AXIS_INDEX(0))
	DISP "SLIKI(%2i",FIRST_AXIS_INDEX(0),")"  , SLIKI(FIRST_AXIS_INDEX(0))
	IF (NUMBER_OF_AXES(0)=2)
		DISP "SLIKP(%2i",FIRST_AXIS_INDEX(0)+1,")", SLIKP(FIRST_AXIS_INDEX(0)+1)
		DISP "SLIKI(%2i",FIRST_AXIS_INDEX(0)+1,")", SLIKI(FIRST_AXIS_INDEX(0)+1)
	END
END

! DISABLE "INVALID EEPROM" PROTECTION
int config(2)
config(0) = getsp(DSP_INDEX(0), getspa(DSP_INDEX(0), "axes[0].flags.state.invalid_eeprom")) & 0xFFFF
setsp(DSP_INDEX(0), getspa(DSP_INDEX(0), "axes[0].flags.state.invalid_eeprom"), (config(0) & 0xFFFB))
config(1) = getsp(DSP_INDEX(0), getspa(DSP_INDEX(0), "axes[1].flags.state.invalid_eeprom")) & 0xFFFF
setsp(DSP_INDEX(0), getspa(DSP_INDEX(0), "axes[1].flags.state.invalid_eeprom"), (config(1) & 0xFFFB))

INDEX = 0
LOOP NUMBER_OF_AXES(0)

	cs_offset(INDEX) = 0
	ct_offset(INDEX) = 0
	u30(INDEX) = 0
	u40(INDEX) = 0

	cs_offset_read(INDEX) = 0
	ct_offset_read(INDEX) = 0
	u30_read(INDEX) = 0
	u40_read(INDEX) = 0

	INDEX = INDEX + 1
END

sin_data_addr(0) = getspa(DSP_INDEX(0), "axes[0].sin")
sin_data_addr(1) = getspa(DSP_INDEX(0), "axes[1].sin")
sin_data_addr(2) = getspa(DSP_INDEX(0), "axes[2].sin")
sin_data_addr(3) = getspa(DSP_INDEX(0), "axes[3].sin")

cos_data_addr(0) = getspa(DSP_INDEX(0), "axes[0].cos")
cos_data_addr(1) = getspa(DSP_INDEX(0), "axes[1].cos")
cos_data_addr(2) = getspa(DSP_INDEX(0), "axes[2].cos")
cos_data_addr(3) = getspa(DSP_INDEX(0), "axes[3].cos")

cs_offset_addr(0) = getspa(DSP_INDEX(0), "axes[0].cs_offset")
cs_offset_addr(1) = getspa(DSP_INDEX(0), "axes[1].cs_offset")

ct_offset_addr(0) = getspa(DSP_INDEX(0), "axes[0].ct_offset")
ct_offset_addr(1) = getspa(DSP_INDEX(0), "axes[1].ct_offset")

u30_addr(0) = getspa(DSP_INDEX(0), "axes[2].u30")
u30_addr(1) = getspa(DSP_INDEX(0), "axes[3].u30")

u40_addr(0) = getspa(DSP_INDEX(0), "axes[2].u40")
u40_addr(1) = getspa(DSP_INDEX(0), "axes[3].u40")

!********************!
LABEL_OFFSET:
OffsetPlugReady(0)=0

DISP "\n\nPlug in command connector. Send zero command to NPA."
DISP "\nPress '1' when done"
INPUT (OffsetPlugReady)
```

```
IF (OffsetPlugReady(0)<>1)
       disp "\n\nUnknown value, please enter again."
       GOTO LABEL_OFFSET
END

DISP "Measuring offsets ..."

ADDRESS_ERROR = 0

INDEX = 0
LOOP NUMBER_OF_AXES(0)
       ENABLE(FIRST_AXIS_INDEX(0) + INDEX)
       if (sin_data_addr(INDEX) > 0)
              spdc/r collected_data, 20000, 0.05, DSP_INDEX(0), sin_data_addr(INDEX)
              wait 1100
              cs_offset(INDEX) = -avg(collected_data)
       ELSE
              ADDRESS_ERROR=1
       end
       if (cos_data_addr(INDEX) > 0)
              spdc/r collected_data, 20000, 0.05, DSP_INDEX(0), cos_data_addr(INDEX)
              wait 1100
              ct_offset(INDEX) = -avg(collected_data)
       ELSE
              ADDRESS_ERROR=1
       end
       if (sin_data_addr(INDEX + 2) > 0)
              spdc/r collected_data, 20000, 0.05, DSP_INDEX(0), sin_data_addr(INDEX + 2)
              wait 1100
              u30(INDEX) = -avg(collected_data)
       ELSE
              ADDRESS_ERROR=1
       end
       if (cos_data_addr(INDEX + 2) > 0)
              spdc/r collected_data, 20000, 0.05, DSP_INDEX(0), cos_data_addr(INDEX + 2)
              wait 1100
              u40(INDEX) = -avg(collected_data)
       ELSE
              ADDRESS_ERROR=1
       end

       if (cs_offset_addr(INDEX) > 0)
              setsp(DSP_INDEX(0), cs_offset_addr(INDEX), cs_offset(INDEX))
       ELSE
              ADDRESS_ERROR=1
       end
       if (ct_offset_addr(INDEX) > 0)
              setsp(DSP_INDEX(0), ct_offset_addr(INDEX), ct_offset(INDEX))
       ELSE
              ADDRESS_ERROR=1
       end
       if (u30_addr(INDEX) > 0)
              setsp(DSP_INDEX(0), u30_addr(INDEX), u30(INDEX))
       ELSE
              ADDRESS_ERROR=1
       end
       if (u40_addr(INDEX) > 0)
              setsp(DSP_INDEX(0), u40_addr(INDEX), u40(INDEX))
       ELSE
              ADDRESS_ERROR=1
       end

       INDEX = INDEX + 1

       IF (ADDRESS_ERROR=1)
              DISP "Parameters address read failed. Process aborted."
              STOPALL
              STOP
       END
END

!********************!



IF(SAT_PROTECT(0)=1e9 | SLILI_ORIG(0)=0 | COMMAND_SF(0)=0)
       DISP " "
```

```
	DISP "One of the following parameters is zero: SAT_PROTECT(0), SLILI_ORIG(0), COMMAND_SF(0)"
	DISP "This may be caused by stopping the calibration program previously"
	DISP "Process aborted"
	DISP "Restart the controller and perform calibration process again"
	STOP
END

! Change drive dynamic range
DISP " "
DISP "Would you like to rescale the drive peak current rating."
DISP "Rescaling peak current will improve dynamic range."
DRIVE_RESCALE:
DISP " "
DISP "To rescale press 1 to skip this step press 2.
DISP "Skipping this step will set dynamic range to 100 percent even if"
DISP "              the drive was calibrated to a different level before."


INPUT(DRIVE_RESCALE)
IF(DRIVE_RESCALE(0) = 1)
	ENTER_NEW_SCALE_FACTOR_0:
	DISP "Enter scale factor [0-100 percent] for axis", FIRST_AXIS_INDEX(0)
	INPUT(NEW_SCALE_FACTOR)
	IF(NEW_SCALE_FACTOR(0)<0 | NEW_SCALE_FACTOR(0)>100)
		DISP "Value out of 0-100 range. Try again"
		GOTO ENTER_NEW_SCALE_FACTOR_0
	END
	COMMAND_SF(0) = NEW_SCALE_FACTOR(0)/100*COMMAND_SF(0)
	IF(NUMBER_OF_AXES(0) = 2)
		ENTER_NEW_SCALE_FACTOR_1:
		DISP "Enter scale factor [0-100 percent] for axis", FIRST_AXIS_INDEX(0)+1
		INPUT(NEW_SCALE_FACTOR)
		IF(NEW_SCALE_FACTOR(0)<0 | NEW_SCALE_FACTOR(0)>100)
			DISP "Value out of 0-100 range. Try again"
			GOTO ENTER_NEW_SCALE_FACTOR_1
		END
		COMMAND_SF(1) = NEW_SCALE_FACTOR(0)/100*COMMAND_SF(1)
	END
ELSEIF(DRIVE_RESCALE(0) = 2)

ELSE
	DISP "Wrong input. Try again"
	GOTO DRIVE_RESCALE
END

ENTER_START_SAVE:
DISP "\n\nOffsets has been measured. Enter 1 to save them to non-volatile memory."
DISP " All axes will be disabled during this process"
INPUT(START_SAVE)
IF(START_SAVE(0) = 1)
	DISP "\n\nSaving to non-volatile memory ..."
ELSEIF(START_SAVE(0) = -1)
	DISP "Process aborted."
	STOPALL
	STOP
ELSE
	DISP "\nWrong input. Try again."
	GOTO ENTER_START_SAVE
END

DISP "\n\nALL axes are being disabled"
DISABLE ALL
wait 1000



! Change parameters to enable the drive with zero command
setsp(DSP_INDEX(0), getspa(DSP_INDEX(0), "axes[0].sat_protect"), SAT_PROTECT(0)); wait 10
setsp(DSP_INDEX(0), getspa(DSP_INDEX(0), "axes[0].voltage_limit"), SLILI_ORIG(0)); wait 10
setsp(DSP_INDEX(0), getspa(DSP_INDEX(0), "axes[0].command_sf"), COMMAND_SF(0)); wait 10


IF (NUMBER_OF_AXES(0)=2)
	IF(SAT_PROTECT(1)=1e9 | SLILI_ORIG(1)=0 | COMMAND_SF(1)=0)
		DISP "One of the following parameters is zero: SAT_PROTECT(0), SLILI_ORIG(0), COMMAND_SF(0)"
		DISP "This may be caused by stopping the calibration program previously"
		DISP "Process aborted"
```

```
              DISP "Restart the controller and perform calibration process again"
              STOP
       END
       ! Change parameters to enable the drive with zero command
       setsp(DSP_INDEX(0), getspa(DSP_INDEX(0), "axes[1].sat_protect"), SAT_PROTECT(1)); wait 10
       setsp(DSP_INDEX(0), getspa(DSP_INDEX(0), "axes[1].voltage_limit"), SLILI_ORIG(1)); wait 10
       setsp(DSP_INDEX(0), getspa(DSP_INDEX(0), "axes[1].command_sf"), COMMAND_SF(1)); wait 10
END

SAVE_PARAMETERS:

IF (DSP_INDEX(0) = 0)
       EXEC "#SAVESPPAR 0"
ELSEIF(DSP_INDEX(0) = 1)
       EXEC "#SAVESPPAR 1"
ELSEIF(DSP_INDEX(0) = 2)
       EXEC "#SAVESPPAR 2"
ELSEIF(DSP_INDEX(0) = 3)
       EXEC "#SAVESPPAR 3"
ELSEIF(DSP_INDEX(0) = 4)
       EXEC "#SAVESPPAR 4"
ELSEIF(DSP_INDEX(0) = 5)
       EXEC "#SAVESPPAR 5"
ELSEIF(DSP_INDEX(0) = 6)
       EXEC "#SAVESPPAR 6"
ELSEIF(DSP_INDEX(0) = 7)
       EXEC "#SAVESPPAR 7"
ELSEIF(DSP_INDEX(0) = 8)
       EXEC "#SAVESPPAR 8"
ELSEIF(DSP_INDEX(0) = 9)
       EXEC "#SAVESPPAR 9"
END

WAIT 5000
ECREPAIR

IF (DSP_INDEX(0) = 0)
       EXEC "#LOADSPPAR 0"
ELSEIF(DSP_INDEX(0) = 1)
       EXEC "#LOADSPPAR 1"
ELSEIF(DSP_INDEX(0) = 2)
       EXEC "#LOADSPPAR 2"
ELSEIF(DSP_INDEX(0) = 3)
       EXEC "#LOADSPPAR 3"
ELSEIF(DSP_INDEX(0) = 4)
       EXEC "#LOADSPPAR 4"
ELSEIF(DSP_INDEX(0) = 5)
       EXEC "#LOADSPPAR 5"
ELSEIF(DSP_INDEX(0) = 6)
       EXEC "#LOADSPPAR 6"
ELSEIF(DSP_INDEX(0) = 7)
       EXEC "#LOADSPPAR 7"
ELSEIF(DSP_INDEX(0) = 8)
       EXEC "#LOADSPPAR 8"
ELSEIF(DSP_INDEX(0) = 9)
       EXEC "#LOADSPPAR 9"
END

WAIT 5000
ECREPAIR



DISP "\n\nProgram finished."
DISP "-----------------------------------------------"

START_RESTART:
DISP "\n\nSystem should be restarted. To restart enter 1"
INPUT(SYSTEM_RESTART)
IF(SYSTEM_RESTART(0) = 1)
       EXEC "#HWRES #HWRES"
ELSE
       GOTO START_RESTART
END

STOP
```

A.2 NPACurrentLoopParametersSaveProgram.prg

Copy the code below to text editor and save it with .prg extension or copy it as it is to a buffer.

```
#/ Controller version = 2.29.04.00
#/ Date = 22-Dec-15 14:51
#/ User remarks = V6
#0

GLOBAL INT DSP_INDEX(1), FIRST_AXIS_INDEX(1), START_SAVE(1), SYSTEM_RESTART(1), NUMBER_OF_AXES(1)
GLOBAL REAL CURRENT_LOOP_PARAMETER(1)
GLOBAL INT SAT_PROTECT(2), SLILI_ORIG(2)
GLOBAL REAL COMMAND_SF(2)
GLOBAL REAL DRIVE_RESCALE(1), NEW_SCALE_FACTOR(1)

!!!!!!!!!!!!!!!!!!!!!!!!!!!!! User definitions !!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
! Change DSP index in accordance with EtherCat network configuration
! Range 0-9
DSP_INDEX(0) = -1

!********************!
ENTER_DSP_INDEX:
DISP "\n\nEnter EtherCAT Slave index of the NPA as it appears in the System Viewer and Diagnostics."
INPUT(DSP_INDEX)
IF(DSP_INDEX(0)<0 | DSP_INDEX(0)>9)
       DISP "DSP index out of 0-9 range. Try again."
       GOTO ENTER_DSP_INDEX
       STOP
END

! Under voltage protection
IF(getsp(DSP_INDEX(0),getspa(DSP_INDEX(0),"Vbus")) < 32767*9/200)
       DISP "BUS voltage is too low. Process aborted"
       STOP
END

!********************!
FIND_FIRST_AXIS_INDEX:
FIRST_AXIS_INDEX(0) = 0
WHILE(GETCONF(260, FIRST_AXIS_INDEX(0)) <> DSP_INDEX(0))
       FIRST_AXIS_INDEX(0) = FIRST_AXIS_INDEX(0) + 1
END

!********************!
ENTER_NUMBER_OF_AXES:
DISP "\n\nEnter number of axes available in the unit. 1 - single axis unit. 2 - dual axis unit."
INPUT(NUMBER_OF_AXES)
IF(NUMBER_OF_AXES(0)<1 | NUMBER_OF_AXES(0)>2)
       DISP "Number of axes should be 1 or 2. Try again."
       GOTO ENTER_NUMBER_OF_AXES
       STOP
END


! Store parameters
SAT_PROTECT(0) = getsp(DSP_INDEX(0), getspa(DSP_INDEX(0), "axes[0].sat_protect")); wait 10
SLILI_ORIG(0) = getsp(DSP_INDEX(0), getspa(DSP_INDEX(0), "axes[0].voltage_limit")); wait 10
COMMAND_SF(0) = getsp(DSP_INDEX(0), getspa(DSP_INDEX(0), "axes[0].command_sf")); wait 10

! Change parameters to enable the drive with zero command
setsp(DSP_INDEX(0), getspa(DSP_INDEX(0), "axes[0].sat_protect"), 1e9); wait 10
setsp(DSP_INDEX(0), getspa(DSP_INDEX(0), "axes[0].voltage_limit"), 0); wait 10
setsp(DSP_INDEX(0), getspa(DSP_INDEX(0), "axes[0].command_sf"), 0); wait 10

enable(FIRST_AXIS_INDEX(0)); wait 300
disable(FIRST_AXIS_INDEX(0))

if(NUMBER_OF_AXES(0) = 2)
       ! Store parameters
       SAT_PROTECT(1) = getsp(DSP_INDEX(0), getspa(DSP_INDEX(0), "axes[1].sat_protect")); wait 10
       SLILI_ORIG(1) = getsp(DSP_INDEX(0), getspa(DSP_INDEX(0), "axes[1].voltage_limit")); wait 10
       COMMAND_SF(1) = getsp(DSP_INDEX(0), getspa(DSP_INDEX(0), "axes[1].command_sf")); wait 10

       ! Change parameters to enable the drive with zero command
       setsp(DSP_INDEX(0), getspa(DSP_INDEX(0), "axes[1].sat_protect"), 1e9); wait 10
       setsp(DSP_INDEX(0), getspa(DSP_INDEX(0), "axes[1].voltage_limit"), 0); wait 10
```

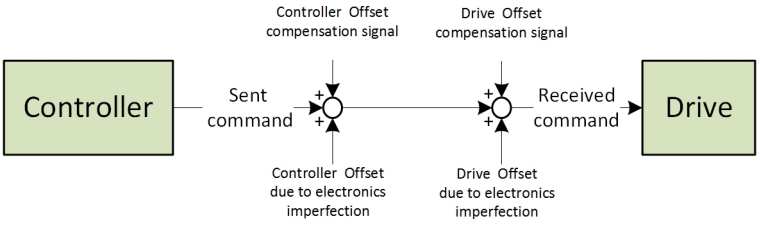
```
	setsp(DSP_INDEX(0), getspa(DSP_INDEX(0), "axes[1].command_sf"), 0); wait 10

	enable(FIRST_AXIS_INDEX(0), FIRST_AXIS_INDEX(0)+1); wait 300
	disable(FIRST_AXIS_INDEX(0), FIRST_AXIS_INDEX(0)+1)
end


!********************!
ENTER_SLIKP0:
DISP "\n\nEnter value for SLIKP(%2i", FIRST_AXIS_INDEX(0),")"
INPUT(CURRENT_LOOP_PARAMETER)

IF(CURRENT_LOOP_PARAMETER(0)<0 | CURRENT_LOOP_PARAMETER(0)>256000)
	DISP "Value out of range (0-256000). Try again"
	GOTO ENTER_SLIKP0
ELSE
	SLIKP(FIRST_AXIS_INDEX(0)) = CURRENT_LOOP_PARAMETER(0)
END
CURRENT_LOOP_PARAMETER(0) = -1

!********************!
ENTER_SLIKI0:
DISP "\n\nEnter value for SLIKI(%2i", FIRST_AXIS_INDEX(0),")"
INPUT(CURRENT_LOOP_PARAMETER)

IF(CURRENT_LOOP_PARAMETER(0)<0 | CURRENT_LOOP_PARAMETER(0)>65000)
	DISP "Value out of range (0-65000). Try again"
	GOTO ENTER_SLIKI0
ELSE
	SLIKI(FIRST_AXIS_INDEX(0)) = CURRENT_LOOP_PARAMETER(0)
END
CURRENT_LOOP_PARAMETER(0) = -1

!********************!
IF (NUMBER_OF_AXES(0)=2)
	ENTER_SLIKP1:
	DISP "\n\nEnter value for SLIKP(%2i", FIRST_AXIS_INDEX(0)+1,")"
	INPUT(CURRENT_LOOP_PARAMETER)

	IF(CURRENT_LOOP_PARAMETER(0)<0 | CURRENT_LOOP_PARAMETER(0)>256000)
		DISP "Value out of range (0-256000). Try again"
		GOTO ENTER_SLIKP1
	ELSE
		SLIKP(FIRST_AXIS_INDEX(0)+1) = CURRENT_LOOP_PARAMETER(0)
	END
	CURRENT_LOOP_PARAMETER(0) = -1

	!********************!
	ENTER_SLIKI1:
	DISP "\n\nEnter value for SLIKI(%2i", FIRST_AXIS_INDEX(0)+1,")"
	INPUT(CURRENT_LOOP_PARAMETER)

	IF(CURRENT_LOOP_PARAMETER(0)<0 | CURRENT_LOOP_PARAMETER(0)>65000)
		DISP "Value out of range (0-65000). Try again"
		GOTO ENTER_SLIKI1
	ELSE
		SLIKI(FIRST_AXIS_INDEX(0)+1) = CURRENT_LOOP_PARAMETER(0)
	END
END
!********************!
DISP "Following parameters will be saved to"
DISP "NPA EtherCAT Slave index is %2i", DSP_INDEX(0)
disp""
DISP "SLIKP(%2i",FIRST_AXIS_INDEX(0),")"  , SLIKP(FIRST_AXIS_INDEX(0))
DISP "SLIKI(%2i",FIRST_AXIS_INDEX(0),")"  , SLIKI(FIRST_AXIS_INDEX(0))
IF (NUMBER_OF_AXES(0)=2)
	DISP "SLIKP(%2i",FIRST_AXIS_INDEX(0)+1,")", SLIKP(FIRST_AXIS_INDEX(0)+1)
	DISP "SLIKI(%2i",FIRST_AXIS_INDEX(0)+1,")", SLIKI(FIRST_AXIS_INDEX(0)+1)
END



IF(SAT_PROTECT(0)=1e9 | SLILI_ORIG(0)=0 | COMMAND_SF(0)=0)
	DISP " "
	DISP "One of the following parameters is zero: SAT_PROTECT(0), SLILI_ORIG(0), COMMAND_SF(0)"
	DISP "This may be caused by stopping the calibration program previously"
	DISP "Process aborted"
```

```
	DISP "Restart the controller and perform calibration process again"
	STOP
END

! Change drive dynamic range
DISP " "
DISP "Would you like to rescale the drive peak current rating."
DISP "Rescaling peak current will improve dynamic range."
DRIVE_RESCALE:
DISP " "
DISP "To rescale press 1 to skip this step press 2.
DISP "Skipping this step will set dynamic range to 100 percent even if"
DISP "              the drive was calibrated to a different level before."


INPUT(DRIVE_RESCALE)
IF(DRIVE_RESCALE(0) = 1)
	ENTER_NEW_SCALE_FACTOR_0:
	DISP "Enter scale factor [0-100 percent] for axis", FIRST_AXIS_INDEX(0)
	INPUT(NEW_SCALE_FACTOR)
	IF(NEW_SCALE_FACTOR(0)<0 | NEW_SCALE_FACTOR(0)>100)
		DISP "Value out of 0-100 range. Try again"
		GOTO ENTER_NEW_SCALE_FACTOR_0
	END
	COMMAND_SF(0) = NEW_SCALE_FACTOR(0)/100*COMMAND_SF(0)
	IF(NUMBER_OF_AXES(0) = 2)
		ENTER_NEW_SCALE_FACTOR_1:
		DISP "Enter scale factor [0-100 percent] for axis", FIRST_AXIS_INDEX(0)+1
		INPUT(NEW_SCALE_FACTOR)
		IF(NEW_SCALE_FACTOR(0)<0 | NEW_SCALE_FACTOR(0)>100)
			DISP "Value out of 0-100 range. Try again"
			GOTO ENTER_NEW_SCALE_FACTOR_1
		END
		COMMAND_SF(1) = NEW_SCALE_FACTOR(0)/100*COMMAND_SF(1)
	END
ELSEIF(DRIVE_RESCALE(0) = 2)

ELSE
	DISP "Wrong input. Try again"
	GOTO DRIVE_RESCALE
END

ENTER_START_SAVE:
DISP "\nEnter 1 to save parameters. All axes will be disabled during this process"
INPUT(START_SAVE)
IF(START_SAVE(0) = 1)
	DISP "\n\nSaving to non-volatile memory ..."
ELSE
	DISP "\nWrong input. Try again."
	GOTO ENTER_START_SAVE
END

DISP "\n\nALL axes are being disabled"
DISABLE ALL
wait 1000
!!!!!!!!!!!!!!!!!!!!!!!!!!!! Automatic save procedure !!!!!!!!!!!!!!!!!!!!!!!!!!!!

! Change parameters to enable the drive with zero command
setsp(DSP_INDEX(0), getspa(DSP_INDEX(0), "axes[0].sat_protect"), SAT_PROTECT(0)); wait 10
setsp(DSP_INDEX(0), getspa(DSP_INDEX(0), "axes[0].voltage_limit"), SLILI_ORIG(0)); wait 10
setsp(DSP_INDEX(0), getspa(DSP_INDEX(0), "axes[0].command_sf"), COMMAND_SF(0)); wait 10


IF (NUMBER_OF_AXES(0)=2)
	IF(SAT_PROTECT(1)=1e9 | SLILI_ORIG(1)=0 | COMMAND_SF(1)=0)
		DISP "One of the following parameters is zero: SAT_PROTECT(0), SLILI_ORIG(0), COMMAND_SF(0)"
		DISP "This may be caused by stopping the calibration program previously"
		DISP "Process aborted"
		DISP "Restart the controller and perform calibration process again"
		STOP
	END
	! Change parameters to enable the drive with zero command
	setsp(DSP_INDEX(0), getspa(DSP_INDEX(0), "axes[1].sat_protect"), SAT_PROTECT(1)); wait 10
	setsp(DSP_INDEX(0), getspa(DSP_INDEX(0), "axes[1].voltage_limit"), SLILI_ORIG(1)); wait 10
	setsp(DSP_INDEX(0), getspa(DSP_INDEX(0), "axes[1].command_sf"), COMMAND_SF(1)); wait 10
END
```

```
IF (DSP_INDEX(0) = 0)
       EXEC "#SAVESPPAR 0"
ELSEIF(DSP_INDEX(0) = 1)
       EXEC "#SAVESPPAR 1"
ELSEIF(DSP_INDEX(0) = 2)
       EXEC "#SAVESPPAR 2"
ELSEIF(DSP_INDEX(0) = 3)
       EXEC "#SAVESPPAR 3"
ELSEIF(DSP_INDEX(0) = 4)
       EXEC "#SAVESPPAR 4"
ELSEIF(DSP_INDEX(0) = 5)
       EXEC "#SAVESPPAR 5"
ELSEIF(DSP_INDEX(0) = 6)
       EXEC "#SAVESPPAR 6"
ELSEIF(DSP_INDEX(0) = 7)
       EXEC "#SAVESPPAR 7"
ELSEIF(DSP_INDEX(0) = 8)
       EXEC "#SAVESPPAR 8"
ELSEIF(DSP_INDEX(0) = 9)
       EXEC "#SAVESPPAR 9"
END

WAIT 5000
ECREPAIR

IF (DSP_INDEX(0) = 0)
       EXEC "#LOADSPPAR 0"
ELSEIF(DSP_INDEX(0) = 1)
       EXEC "#LOADSPPAR 1"
ELSEIF(DSP_INDEX(0) = 2)
       EXEC "#LOADSPPAR 2"
ELSEIF(DSP_INDEX(0) = 3)
       EXEC "#LOADSPPAR 3"
ELSEIF(DSP_INDEX(0) = 4)
       EXEC "#LOADSPPAR 4"
ELSEIF(DSP_INDEX(0) = 5)
       EXEC "#LOADSPPAR 5"
ELSEIF(DSP_INDEX(0) = 6)
       EXEC "#LOADSPPAR 6"
ELSEIF(DSP_INDEX(0) = 7)
       EXEC "#LOADSPPAR 7"
ELSEIF(DSP_INDEX(0) = 8)
       EXEC "#LOADSPPAR 8"
ELSEIF(DSP_INDEX(0) = 9)
       EXEC "#LOADSPPAR 9"
END

WAIT 5000
ECREPAIR


DISP "\n\nProgram finished."
DISP "\n\nStored current loop values will be retrieved wneh the NPA operates in 'Normal' mode"
DISP "                                                          and DIP switch is at 0000 position"
DISP "-----------------------------------------------"

START_RESTART:
DISP "\n\nSystem should be restarted. To restart enter 1"
INPUT(SYSTEM_RESTART)
IF(SYSTEM_RESTART(0) = 1)
       EXEC "#HWRES #HWRES"
ELSE
       GOTO START_RESTART
END

STOP
```

A.3 End to End Calibration

In this section, the calibration of the command signal offsets for an entire system consisting of the external controller and the drive is described. A schematic description of the offsets and their compensation process is shown below.



Do the following:

1. Connect a controller to a drive
2. Send a zero command from the controller (actual command may be non-zero due to offset)
3. Read the signal received by a drive
4. Tune the drive offset compensation signal such that zero command is read
5. The controller offset and the drive offset can be adjusted individually. These procedures are below.

Controller offset calibration:

1. Connect the controller output to scope

> Send a zero command

> Tune the offset compensation signal untill a zero signal is read by scope.

Drive offset calibration:

1. Send a zero command to a drive
2. Read the signal received by a drive
3. Tune the drive offset compensation signal such that zero command is read

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ACS MOTION CONTROL