Motor and Encoder Connections and Assignment

MACS5-AMPx

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1 Introduction

The MACS5-AMPx device series combines MACS5 motion control and programability with integrated power amplifiers. The device's power connectors are designed to operate a specific number and type of motors. However the hard- and software always supports DC, BLDC, PMSM[1] and stepper[2] motors. Simultaneous operation of different motor types is possible. This document shows the motor and encoder pin layout and how to setup the device for non default motor combinations.

2 Aposs Axis Assignment

The MACS5-AMP1 and AMP2 devices can operate six DC, four BLDC or three stepper motors. The MACS5-AMP3 can operate three DC, two BLDC or one stepper motor. While DC motors can be operated by any axis, BLDC, PMSM and stepper motors are restricted to certain axes. Table 1 shows pairwise whether an intended combination of motors is permitted.

Aposs Axis No.		1			2	3		3	4		5		6	
	Type	DC	BLDC	Stepper	DC	DC	BLDC	Stepper	DC	BLDC	DC	Stepper	DC	BLDC
1	DC	✓			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	BLDC		✓		×	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Stepper			✓	×	✓	✓	✓	✓	✓	✓	✓	✓	✓
2	DC				✓	✓	×	✓	✓	✓	✓	✓	✓	✓
3	DC					✓			✓	✓	✓	✓	✓	✓
	BLDC						✓		✓	✓	✓	✓	✓	✓
3	Stepper							✓	×	×	✓	✓	✓	✓
4	DC								✓		✓	✓	✓	✓
	BLDC									✓	×	×	✓	✓
5	DC										✓		✓	×
	Stepper											✓	×	×
6	DC												✓	
	BLDC													✓

AMP3

AMP1/2

Table 1: possible motor combinations

1 Often no clear distinction between BLDC and PMSM motors is made. Both are brushless three phase motors with permanent magnet rotor. The difference is made by the current control and commutation. In this document, for readability reasons, term “PMSM” is ommited and “BLDC” stands for both types.

2 The term “Stepper” and “stepper motor” in this document stands for one type of stepper motors only, a two phases bi-directional stepper motor. All other types are not supported

3 Motor Power Connections

3.1 MACS5-AMP1

The MACS5-AMP1 is designed to operate six DC, alternatively four BLDC or three stepper motors can be operated. DC motors can be operated by any of the six axes, BLDC motors by axes 1, 3, 4, 6 and Stepper motors by axes 1, 3, 5. Table 2 shows the pin layout of the power outputs.

Pin		DC	BLDC	Stepper
X31	1 M1+	Axis1 +	Axis1 U	Axis1 A+
	2 M1-	Axis1 -	Axis1 W	Axis1 A-
X32	1 M2+	Axis2 +	Axis1 V	Axis1 B+
	2 M2-	Axis2 -	Axis3 V	Axis1 B-
X33	1 M3+	Axis3 +	Axis3 U	Axis3 A+
	2 M3-	Axis3 -	Axis3 W	Axis3 A-
X34	1 M4+	Axis4 +	Axis4 U	Axis3 B+
	2 M4-	Axis4 -	Axis4 W	Axis3 B-
X35	1 M5+	Axis5 +	Axis4 V	Axis5 A+
	2 M5-	Axis5 -	Axis6 V	Axis5 A-
X36	1 M6+	Axis6 +	Axis6 U	Axis5 B+
	2 M6-	Axis6 -	Axis6 W	Axis5 B-

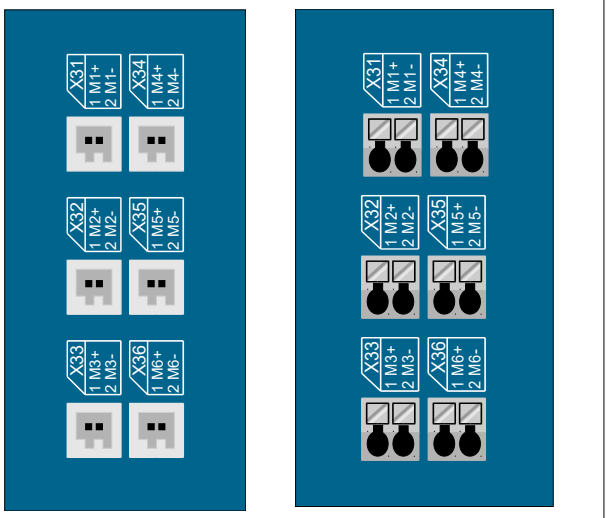


Table 2: AMP1 power outputs

3.2 MACS5-AMP2

The MACS5-AMP2 is designed to operate six DC or four BLDC motors, alternatively three stepper motors can be operated. DC motors can be operated by any of the six axes, BLDC motors by axes 1, 3, 4, 6 and Stepper motors by axes 1, 3, 5. Table 2 shows the pin layout of the power outputs. See Table 1, The pin layout of the power outputs is shown in Table 3.

	Pin	DC	BLDC	Stepper
X31	1 U/+	Axis1 +	Axis1 U	Axis1 A+
	2 V		Axis1 V	
	3 W/-	Axis1 -	Axis1 W	Axis1 A-
X32	1 +	Axis2 +		Axis1 B+
	2			
	3 -	Axis2 -		Axis1 B-
X33	1 U/+	Axis3 +	Axis3 U	Axis3 A+
	2 V		Axis3 V	
	3 W/-	Axis3 -	Axis3 W	Axis3 A-
X34	1 U/+	Axis4 +	Axis4 U	Axis3 B+
	2 V		Axis4 V	
	3 W/-	Axis4 -	Axis4 W	Axis3 B-
X35	1 +	Axis5 +		Axis5 A+
	2			
	3 -	Axis5 -		Axis5 A-
X36	1 U/+	Axis6 +	Axis6 U	Axis5 B+
	2 V		Axis6 V	
	3 W/-	Axis6 -	Axis6 W	Axis5 B-

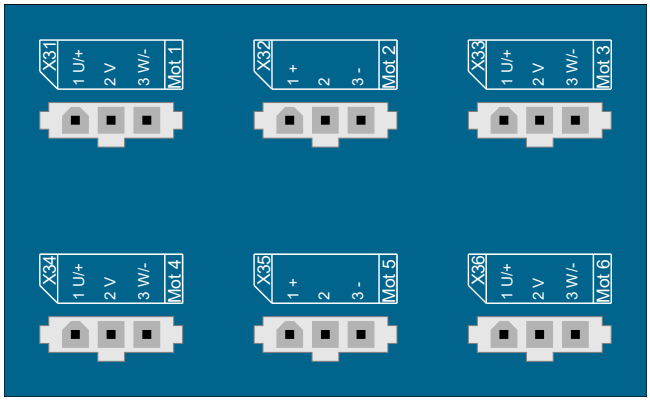


Table 3: AMP2 motor power outputs

3.3 MACS5-AMP3

The MACS5-AMP3 is designed to operate three DC motors, alternatively two BLDC or one stepper motor can be operated. Table 4 shows the pin layout of the power outputs.

	Pin	DC	BLDC	Stepper
X21	MOT 1 +	Axis1 +	Axis1 U	Axis1 A+
	MOT 1 -	Axis1 -	Axis1 W	Axis1 A-
X22	MOT 2 +	Axis2 +	Axis1 V	Axis1 B+
	MOT 2 -	Axis2 -	Axis3 V	Axis1 B-
X23	MOT 3 +	Axis3 +	Axis3 U	
	MOT 3 -	Axis3 -	Axis3 W	

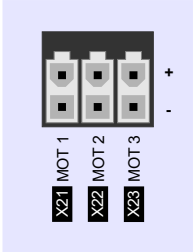


Table 4: AMP3 power outputs

3.4 Aposs Axis Assignment

After power up and a program download the device starts with its default configuration. MACS5-AMP1 is set up to operate six DC motors. This default axis assignment can be changed using the following command in the application program:

```
SET AMPCOMMTYPE X(AxisNo) AxisType

AxisNo =    [1...6]
AxisType = [0=disabled, 1=DC, 2=BLDC, 3=Stepper, 7=PMSM]
```

BLDC and stepper motor operation requires the hardware resources of two Aposs axes. The second axis can no longer be operated. Be sure that it is disabled before the axis type is changed.

4 Encoder Inputs

4.1 MACS5 AMP1 and AMP2

The MACS5-AMP1 and AMP2 devices have the same layout of the encoder inputs and the same internal signal processing. The input received from the six terminal blocks can be processed by different type of decoding units. There are six units to decode incremental encoder and four units to decode hall sensor input. Table 5 shows the pin layout in these two cases.

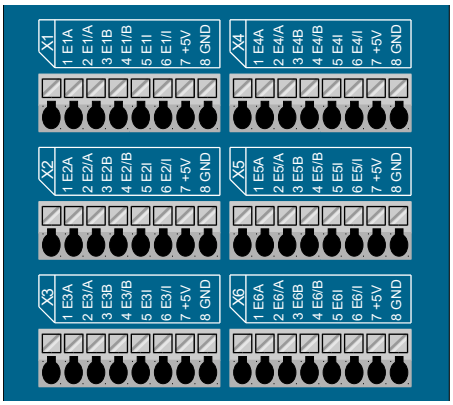
Pin		Incremental	Hall	
X1-X6	1 E1A	Channel A +	Sensor U +	
	2 E1/A	Channel A -	Sensor U -	
	3 E1B	Channel B +	Sensor V +	
	4 E1/B	Channel B -	Sensor V -	
	5 E1I	Index +	Sensor W +	
	6 E1/I	Index -	Sensor W -	
	7 +5V	5V Supply	5V Supply	
	8 GND	GND	GND	

Table 5: AMP1 and AMP2 encoder inputs

4.2 MACS5 AMP3

Pin		Incremental	Hall
X1-X3	1	Index -	Sensor W -
	2	Channel A -	Sensor U -
	3	Channel B -	Sensor V -
	4	Index +	Sensor W +
	5	5V Supply	5V Supply
	6	Channel A +	Sensor U +
	7	Channel B +	Sensor V +
	8	GND	GND
X4-X6	1	Channel A +	Sensor U +
	2	NC	NC
	3	Channel B +	Sensor V +
	4	5V Supply	5V Supply
	5	NC	NC
	6	NC	NC
	7	Index -	Sensor W -
	8	NC	NC
	9	Channel A -	Sensor U -
	10	GND	GND
	11	Channel B -	Sensor V -
	12	5V Supply	5V Supply
	13	NC	NC
	14	Index +	Sensor W -
	15	NC	NC

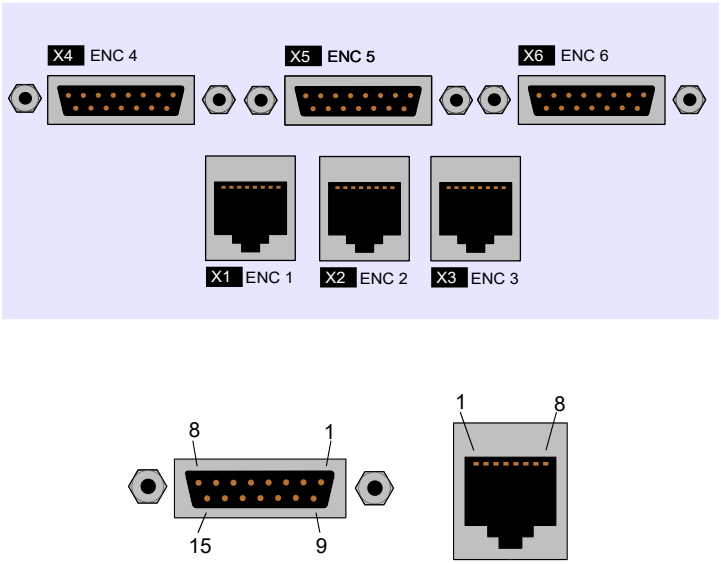


Table 6: AMP3 encoder inputs

4.3 Aposs Encoder Input Assignment

On MACS5-AMP1 and AMP2 devices the inputs signals by default are processed by the incremental decoding unit. Each of the inputs is assigned to its axis (input 1 → axis 1 decoding unit, input 2 → axis 2 decoding unit, etc.) If required an input can be assigned to the decoding unit of another axis as follows:

```
HWCOUNTINC_PARAM((AxisNo - 1), HWCNTINC_PISRC_COUNTER) = (EncNo - 1)

AxisNo = [1...6]
EncNo =  [1...6]
```

4.4 Aposs Hall Sensor Input Assignment

BLDC motor operation requires hall sensor feedback. The hall decoding units are disabled by default. AMP1 and AMP2 devices have four hall decoding units, one for each potential BLDC axis. Please note, that the numbering of the decoding units is not congruent to the axis numbering (decoding unit 1 → axis 1, decoding unit 2 → axis 3, …). Setting up hall sensors requires the following command sequence:

```
HWENC_PARAM ((EncNo - 1),  HWENCODER_MODE) =       EncMode
HWHALL_PARAM((HallNo - 1), HWHALL_MODE) =          HallMode
HWHALL_PARAM((HallNo - 1), HWHALL_PISRC_ENCOUT) = (EncNo - 1)

EncNo =    [1...6]
EncMode =  [0=incremental, 7=hall]
HallNo =   [1...4]
HallMode = [1=enable, 2=disable]
```

5 Examples

5.1 Swap Encoder Inputs

Using AMP1 with two DC motors, axis 1 and 2, are connected at power outputs X31 and X32. The corresponding incremental encoders are swapped resp. connected to encoder inputs X2 and X1. The example shows how to remap the inputs such that the axes run with their encoder.

```
#include "sysdef.mi"

HWCOUNTINC_PARAM(0, HWCNTINC_PISRC_COUNTER) = 1 // axis 1 uses encoder input 2
HWCOUNTINC_PARAM(1, HWCNTINC_PISRC_COUNTER) = 0 // axis 2 uses encoder input 1
```

5.2 Use of BLDC Motors

Using AMP1 with two BLDC motors, axis 1 and 3 are connected at the power outputs X31, X32 and X33. The incremental encoders are connected to encoder inputs X1 and X3. The Hall sensors are connected to encoder inputs X4 and X6. The example shows how to enable and setup the hall decoding.

```
#include "sysdef.mi"

// set motor type
SET AMPCOMMTYPE X(2) 0 // disable axis 2
SET AMPCOMMTYPE X(1) 2 // set up axis 1 for BLDC operation
SET AMPCOMMTYPE X(3) 2 // set up axis 3 for BLDC operation

// setup Hall sensors of axis 1
HWENC_PARAM(3, HWENCODER_MODE) = 7         // set input 4 to mode hall
HWHALL_PARAM(0, HWHALL_MODE) = 1           // enable hall decoder 1
HWHALL_PARAM(0, HWHALL_PISRC_ENCOUT) = 3   // hall decoder 1 uses input 4

// setup Hall sensors of axis 3
HWENC_PARAM(5, HWENCODER_MODE) = 7         // set input 6 to mode hall
HWHALL_PARAM(1, HWHALL_MODE) = 1           // enable hall decoder 2
HWHALL_PARAM(1, HWHALL_PISRC_ENCOUT) = 5   // hall decoder 2 uses input 6
```