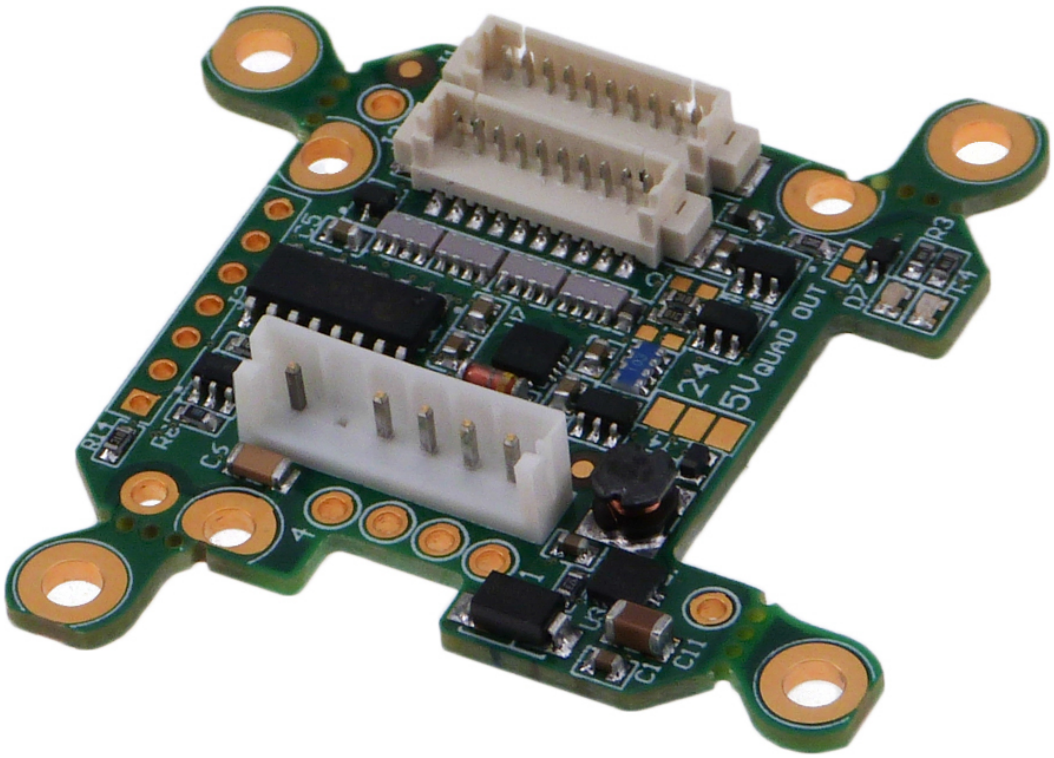
PA0260

Magnetic absolute encoder

User Manual

Including MST/MSW/MSL guide



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1. General

The PA0260 is a general purpose encoder PCB that can be mounted on most types of stepper or servomotor. Incremental or absolute multiturn encoder with incremental ABZ signals and SSI or BiSS interface. Resolution from 512 to 65536 cnt/rev. Suitable with JVL stepper motor controller SMC66 or SMC85.
The PA0260 magnetic absolute encoder is available as a singleturn or multiturn version. Optional absolute multiturn encoder with internal or external battery up to 10+ years lifetime. Special features Dynamic Angle Error Compensation.

Nomenclature for the PA0260 product family:

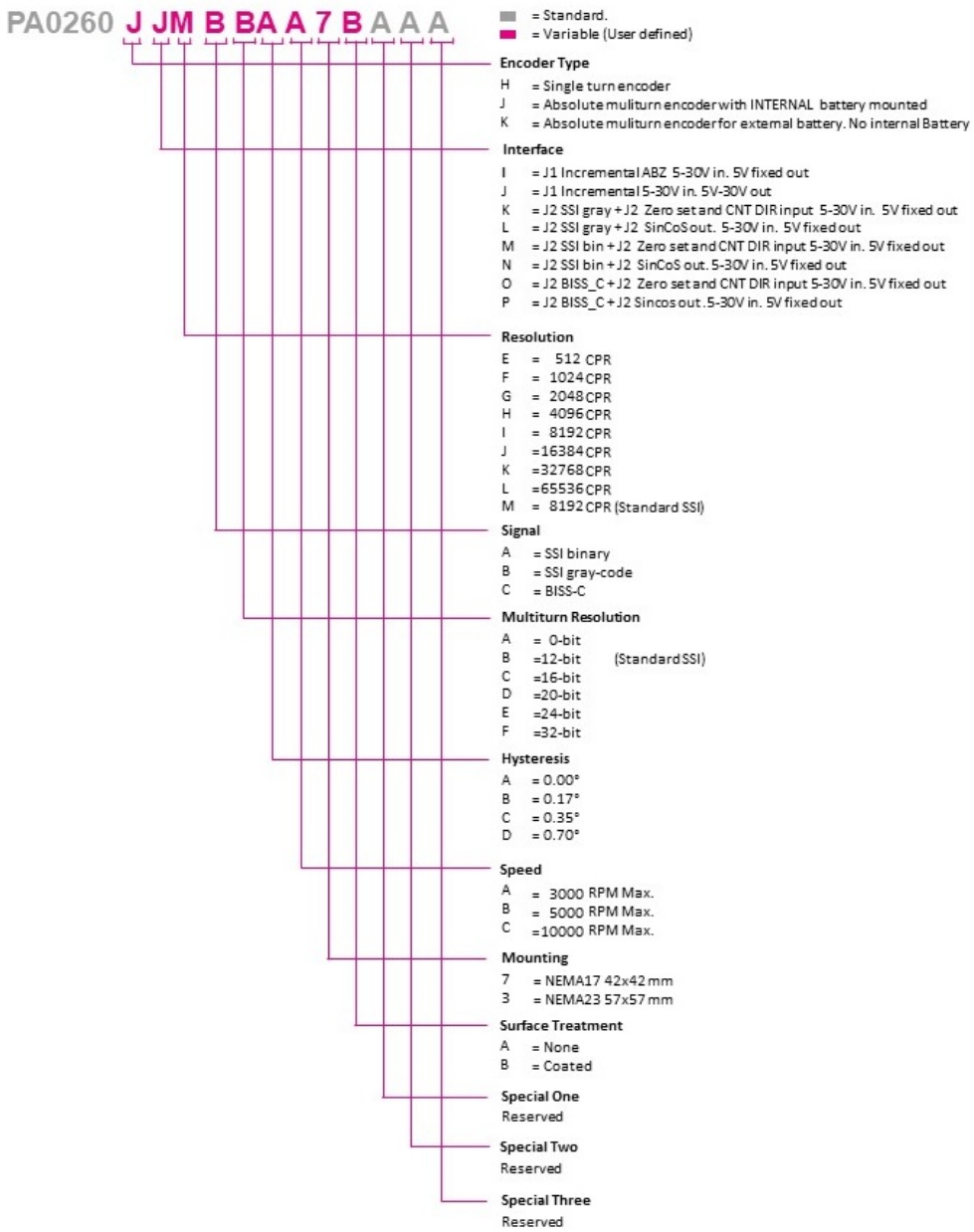


Figure 1 Product partnumber for the PA0260 product family.

Info: When choosing Encodertype configuration option “H” singleturn encoder, this setting is also a hardware setting, meaning multiturn is not possible.

1.1. Intrinsic current consumption

Without load.
Singleturn: at DC 24 V typical less than 35 mA.
Multiturn: at DC 24 V typical less than 38 mA

1.2. Resolution and Accuracy

Absolute Angular Accuracy (optimal signal conditioning) ± 0.35 degree.
Relative Angular Accuracy with reference to one output period at A,B, with 10-bit resolution ± 15 % (see Figure 14)

1.3. Expected battery lifetime[1]

A special high temperature "Poly-carbon mono fluoride" lithium cell is used as backup for the absolute multi-turn encoder. Compared to standard cells the lithium cell used in the PA0260 has extremely good performance at high temperatures up to 85 degrees Celsius (for extended temperature range contact JVL support).
Normal lithium cells self-discharge very rapidly just being exposed to a temperature of 60 degree celsius.
The retention time of the position when the motor is not supplied is better than 10 years.This depends of how long time the motor is in use and the temperature (see Figure 2 Expected battery lifetime).
The self-discharge at 85 degrees celsius (185 degrees Fahrenheit) is 6% per year, and 2% per year at 40 degrees celsius (104 degrees Fahrenheit). Concerning the retention time, there is no big difference if the motor is in use at a high temperature or it is powered down (low temperature).
The absolute multi-turn encoder's current consumption from the battery when the motor is not externally powered, is approx. 7µA
Expected battery lifetime +10 years.

Hints to optimize the battery lifetime:

- Avoid to place the motor in an environment with high temperatures.
- Set the running and especially the standby motor current as low as possible in order not to heat up the motor unnecessarily.
- Keep the external power applied as much as possible.

[1] if present ” J-Option”

Capacity Calculation

Cell: SL-350
Size of cell(s): 1/2 AA
No. of cells in series: 1
No. of cells in parallel: 1
Voltage / Capacity (nominal): 3,6 V / 1,2 Ah

Temp. (Batt.)	Fraction	Max. net DOD	Available net capacity per cell	Application Current per cell	Self discharge current per cell	System Life	Operation Time (electrical)	Battery Life	
°C	%	%	Ah	µA	µA	yr	yr	yr	
25	65	95%	1,13	6,7	1,6	526,1	10,2		
80	35	95%	1,13	6,7	6,0	36,3	3,6		
eff. 53	avg. 44 °C		1,13	avg. 6,7	avg. 3,1	avg. 34,0	13,8	13,8	typ.
								11,1	min.

Figure 2 Expected battery lifetime.

2. General Hardware description

This section contains general PA0260 hardware description, interface, battery replacement and mounting procedure.

2.1. Indicators

1 LED (D3 - green) for power and 1 LED (D2-red) for error/Warning, located bottom right on Figure 3.

2.2. Physical dimensions

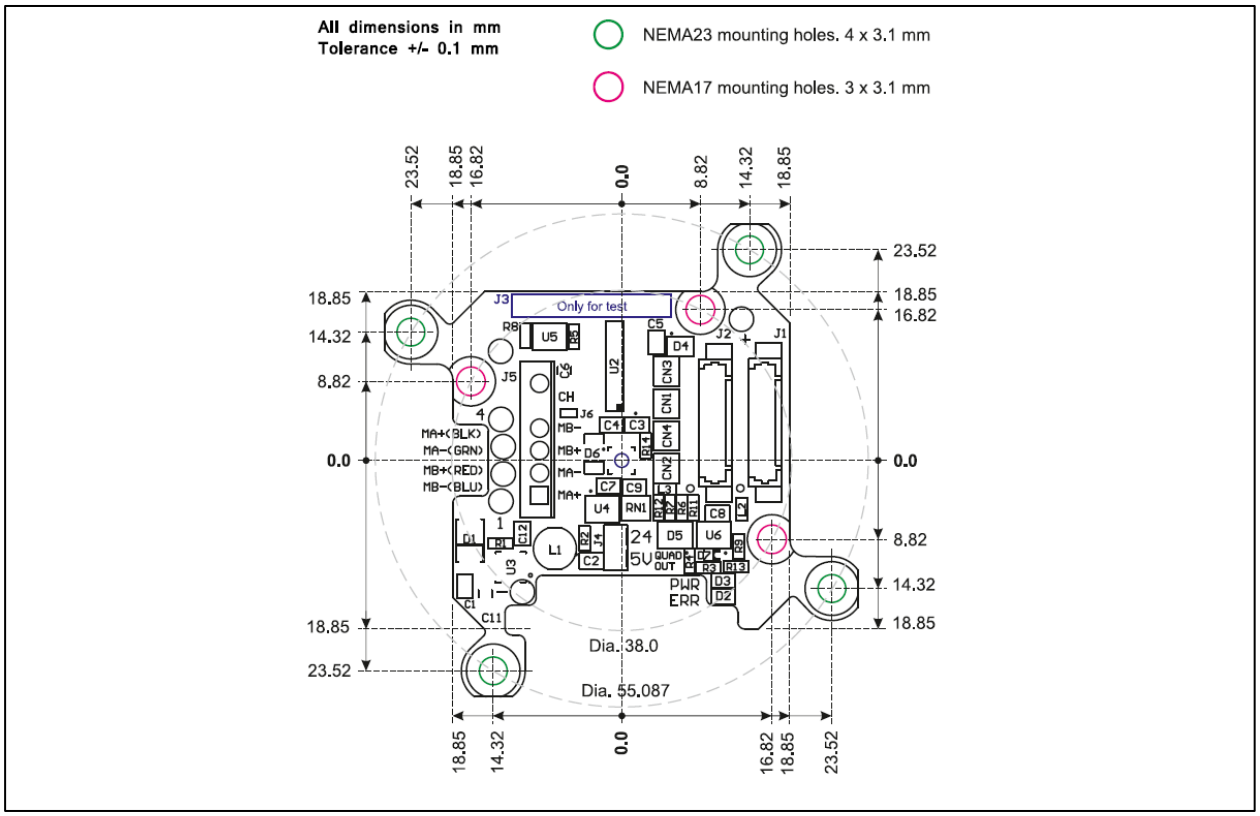


Figure 3: PA0260 Physical dimensions.

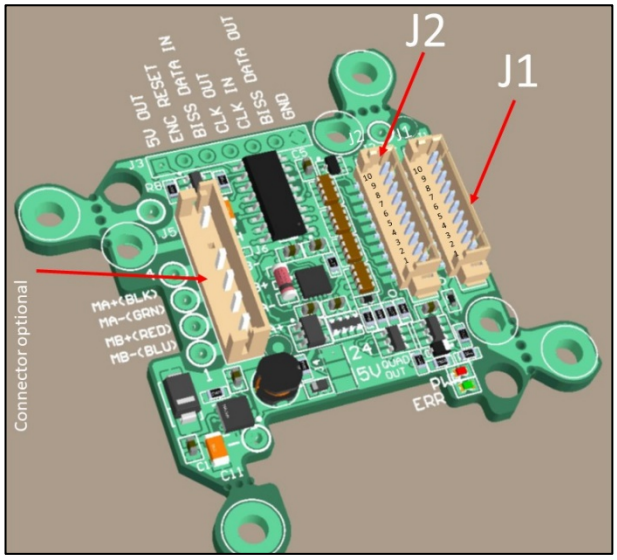


Figure 4 PA0260 Physical overview front with multiturn.

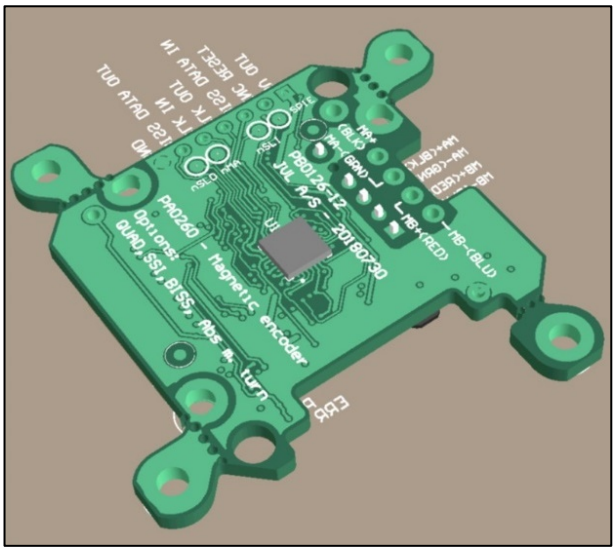


Figure 5 PA0260 Physical overview back.

2.3. Mounting

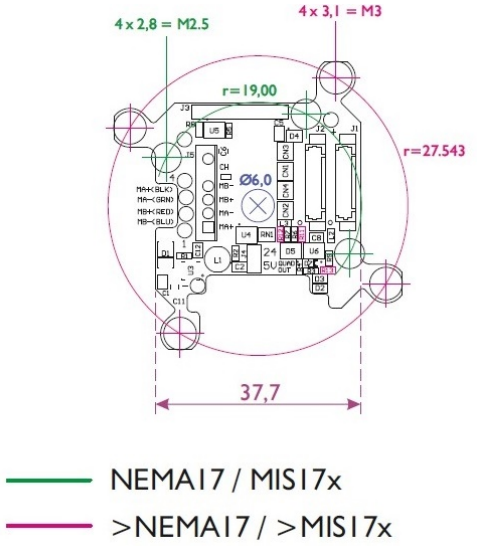


Figure 6 Mounting PA0260.

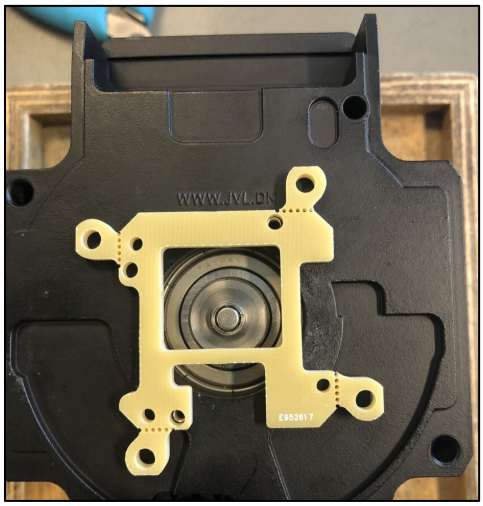


Figure 7 Spacer PB0154-01 mounted on MST34.

1) On NEMA17 drill and cut internal thread in mounting holes according to Figure 6 NEMA17.
On NEMA23 drill and cut internal thread in mounting holes according to Figure 6 >NEMA17.

2) Place the PA0260 on top off spacer, mount and tighten screws.

3) When first mounting or remounting PA0260 on a motor with suitable magnetic target.
Apply power on VIN.

If diode D3 lights red, then preset multiturn encoder, by setting J3 pin 2 high.
This is easily done by briefly connecting J3 pin 1 and 2, and then powercyle PA0260.
D3 should turn green.
If diode D3 lights green, the PA0260 are in sync, no errors and no Warnings.

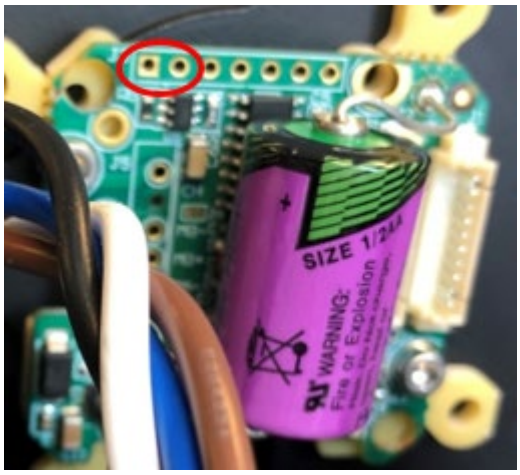


Figure 8 Connect J3 pin 1 and 2 in order to preset.

2.4. Battery replacement

When replacing the battery, be sure to check details like battery type, its chemistry, dimensions, capacity, max. drain current, max. pulse current, shelf life, self-discharge rate etc.
When replacing the battery, follow guidance 2.3 3)

Important note: If not done properly, the battery current draw will be significantly larger, and will drain the battery faster.

2.5. Magnet

Ø4x4 mm (ME0048) and Ø6x4 mm (ME0050) magnets.
Recommended distance from magnet to chip 0.5 to 1.5mm.

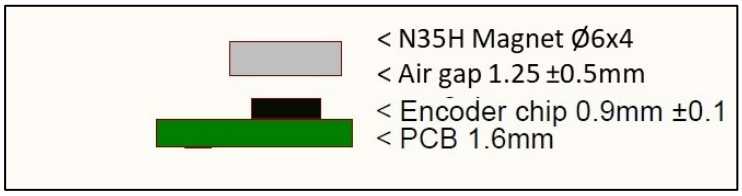


Figure 9 Recommended distance magnet to chip.

2.6. Pinout PCB – Connector

2 pcs 10-Pin Molex connector CI14410M1V00.
Counterpart: Crimp 50079-8000 x 8 Housing 10pin 51021-1000 x 1.

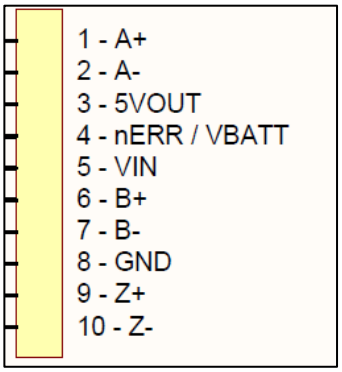


Figure 10 J1 Pinout PCB Connector.

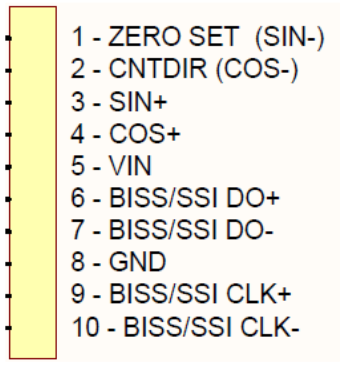


Figure 11 J2 Pinout PCB Connector.

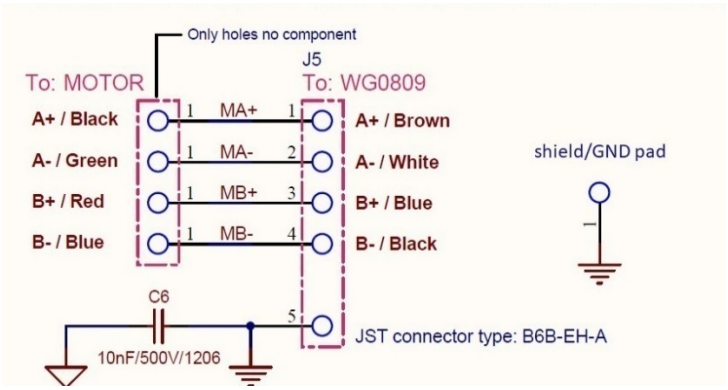


Figure 12 Motor connections that bypasses PCB

3. Interface- Zero set and CNT DIR input

This section describes the interface option << Zero set and CNT direction >>.

Zero set Pa0260 by setting J2 Pin 1 high and then low. The Zero set happens on falling edge.
If Zero set is not set low, a Warning bit will be active, until Zero set gets low.
Only activate CNT DIR and Zero set at stationary in the first program lines before motor movement is executed.
Count direction: Change count direction by setting J2 Pin 2 high. PA0260 must be preset, when changing count direction. If preset is not toggled, a warning bit will be active, until preset.
After executing a zero set, the position data will be invalid for a period of time corresponding to "Power up Time After Preset" time. Please see Table 16.

CNTDIR	Rotation
0	Clockwise
1	Counterclockwise

Table 1 Direction

3.1. Physical interface

Number of wires 2 unidirectional:

- ZEROSET: 5V-30 V In
- CNTDIR: 5V-30 V In

3.2. Pinout PCB – Connector

See Figure 11 J2 Pinout PCB Connector.

4. Interface - Incremental Signals A, B

Channel B leads channel A for negative rotation as defined by CNTDIR-input
The Z output is centered around the PA0260's zero position and is two quadrature states (180°) wide.

- If the multiturn is used (Mutiturn resolution **not** equals 0-bit / option "A").
  The Z output is active at the zero position only when the PA0260's internal multiturn counter overflows or underflows.
- If the multiturn is not used (Mutiturn resolution equals 0-bit / option "A").
  The Z output is active at the zero position during every revolution of the magnet.

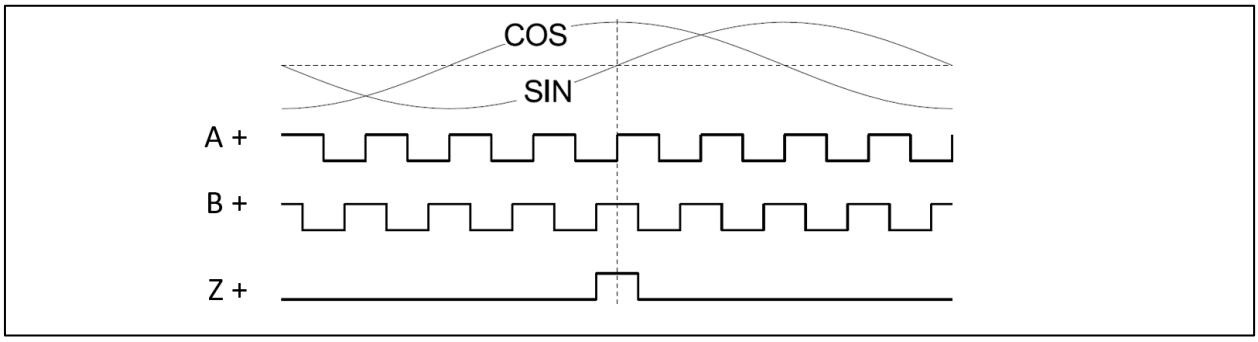


Figure 13 shows the incremental quadrature outputs for negative code direction (iC-Haus, 2021).

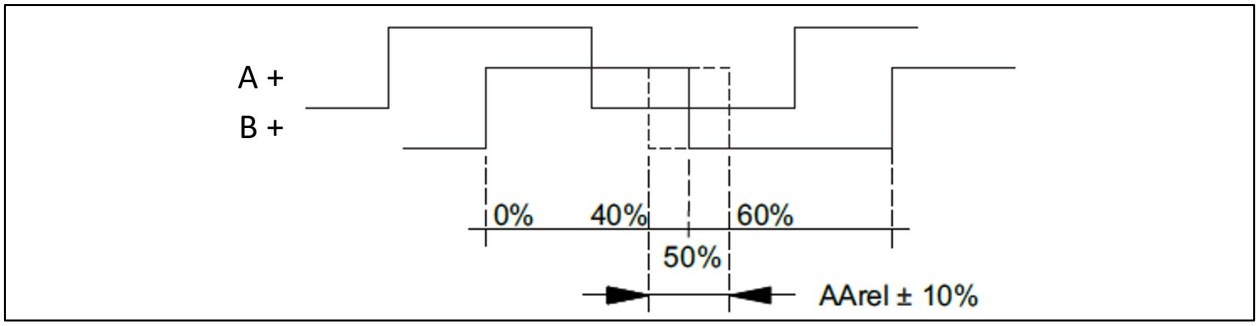


Figure 14 Definition of Relative Angular Accuracy. (iC-Haus, 2021)

4.1. Physical interface

Number of wires 6 unidirectional

- A+ and A-: 5V fixed out or 5V-30 V out[2].
- B+ and B-: 5V fixed out or 5V-30 V out[2].
- Z+ and Z-: 5V fixed out or 5V-30 V out[2].

4.2. Pinout PCB – Connector

See Figure 10 J1 Pinout PCB Connector.

[2] depending on interface configuration see Figure 1

5. Interface - SSI

When choosing SSI as an option in Interface configuration selection, please refer to Figure 1.

The SSI data transmission of an absolute encoder position value is based on a shift register, where the shift clock is provided by the external control. The encoder provides its position data and depending on configuration (Standard SSI or extended SSI) also status information synchronous to the external clock on the data line.
This SSI interface has a frequency of data transmission ranging between 100 kHz and 2 MHz. The clock frequency (baud rate) depends on the length of the cable and must comply with the technical information reported in the following table:

Max. cable length m	400	200	100	75	60	30	15
Max. cable length feet	1310	655	330	245	200	100	50
Clock frequency kHz	100	200	300	400	500	900	1800

Table 2 Frequency of data transmission ranging-frequency and data transmission range.: At ambient temperature (23°C).

Recommend SSI frequency 200 kHz.
The PA0260 protocol will always be MSB ALIGNED protocol. LSB and TREE FORMAT protocol are not possible.
The singleturn position bit length depends on the interpolator resolution as set by parameter ”Resolution” see Figure 1 but is always fixed at 12 or 16 bits. If the singleturn resolution (in bits) is less than one of these values, the singleturn position value is left-justified in the singleturn position field and the unused LSBs are set to zero.
For example, if the singleturn position (angle) is a 10-bit value in a 12-bit field. In this case, bits 11:2 contain the singleturn position while bits 1:0 are zero.

5.1. Physical interface

Number of wires 4 unidirectional

- *Data:* BISS/SSI DO+ and / BISS/SSI DO- : RS485-Level
- *Clk:* BISS/SSI CLK+ and / BISS/SSI CLK-: RS485-Level

Driver Short-circuit Current ±450 mA

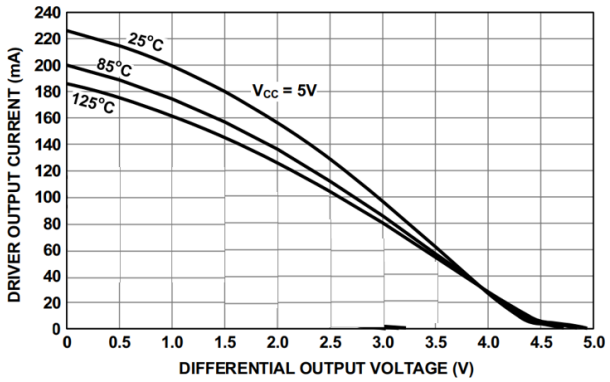


Figure 15 DRIVER OUTPUT CURRENT vs DIFFERENTIAL OUTPUT VOLTAGE.

RS-422 is a subset of RS-485, so this RS-485 transmitter and receiver are also RS-422 compliant.

5.2. Pinout PCB – Connector

See Figure 11 J2 Pinout PCB Connector.
Cable for clock and data should be twisted in pairs and shielded.

5.3. Protocol standard SSI

By choosing configuration option “M” in the “Resolution” selection, PA0260 configuration is Standard SSI.
Standard SSI protocol provides selectable multiturn bit lengths and fixed 13-bit singleturn bit length, no errror bit, no warning bit. Selectable MT according see Figure 16 and Figure 1.

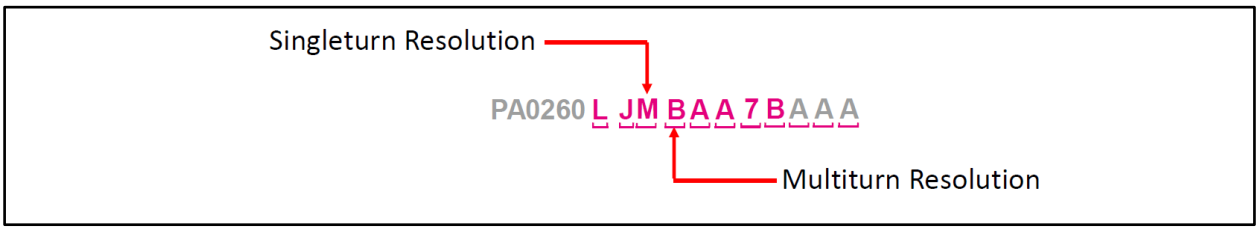


Figure 16: Selectable Multiturn resolution.

Many controllers use standard SSI with 25-bit.
Select this configuration by choosing option “M” in “Resolution”, and option “B” in “Multiturn resolution” (See Figure 1 and Figure 16)

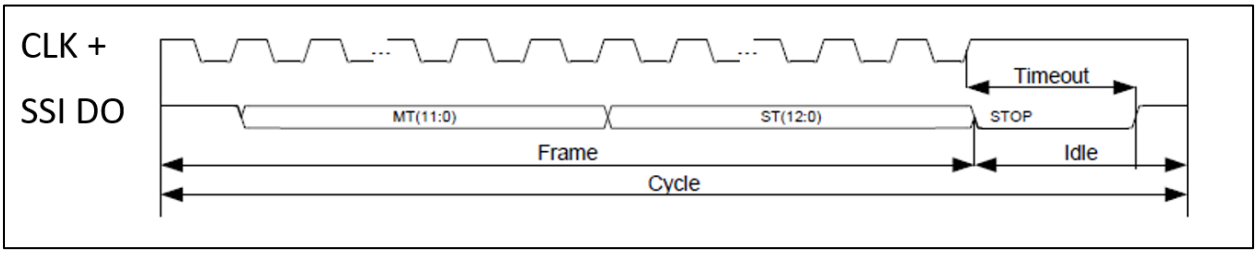


Figure 17 Standard SSI Protocol show with 13-bit singleturn and 12-bitmultiturn.

Interface - SSI

For correct transfer of the data a defined number of impulses (clock pulse brush), must be applied to the clock input of the absolute encoder.
Next, a pause must be observed.
As soon as a clock pulse brush is applied to the clock pulse input, the actual angle information will be latched.
At each change of the clock signal and at each subsequent rising edge one bit is clocked out at a time, up to LSB, so completing the data word transmission. The cycle ends at the last rising edge of the clock signal. This means that up to n + 1 rising edges of the clock signals are required for each data word transmission (where n is the bit resolution); for instance, a 13-bit Standard SSI + 12- multiturn encoder needs minimum 26 clock edges. Since start and stop bits are not present, this allows better use of data transmission bandwidth for more message bits and makes the whole transmission process simpler and easier
If the number of clocks is greater than the number of bits of the data word, then the system will send a zero (low logic level signal) at each additional clock, zeros will follow MSB ALIGNED protocol.

After the period Timeout, having a typical duration of XX µsec (See Table 15), calculated from the end of the clock signal transmission, the encoder is ready for the next transmission and therefore the data signal is switched high.

Data format Standard SSI

- Data format MSB – Binary/Gray Code
- Multiturn 12 - Bit
- Singleturn 13 - Bit

5.4. Protocol SSI Extended

Extented SSI provides selectable multiturn bit lengths and selectable singleturn bit length, and always end with errror bit nE (active low) ,warning bit nW (active low).
Scalable Resolution and Multiturn resolution see Figure 18 and Figure 1.

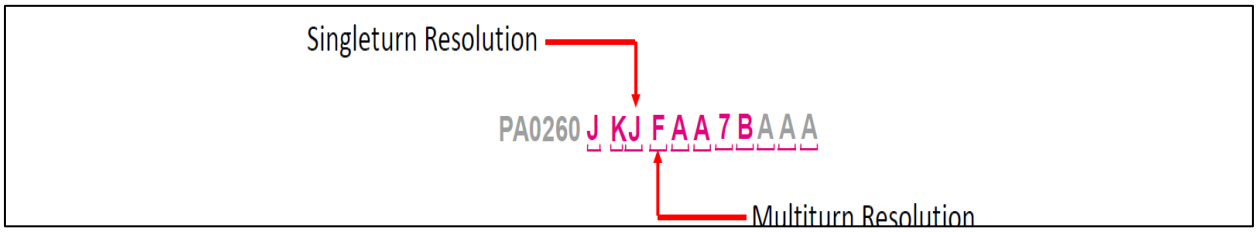


Figure 18 Singleturn resolution and Multiturn resolution.

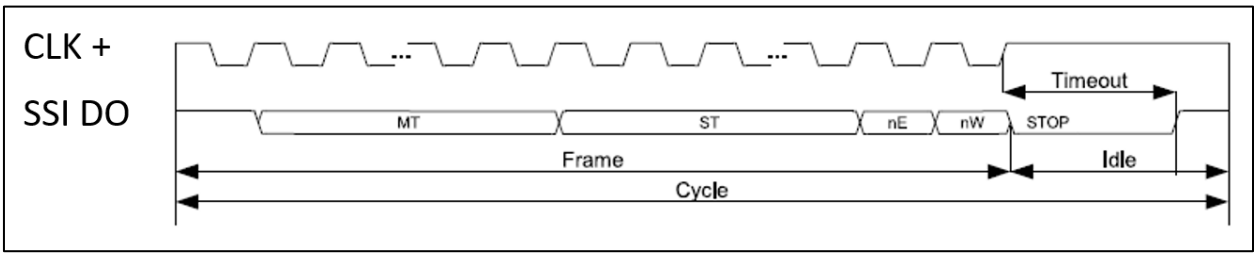


Figure 19 Extended SSI Protocol. (iC-Haus, 2021)

The multiturn count (MT) is transmitted first, followed by the singleturn position (ST), an error bit and a warning bit.
The active-low warning bit, nWARN, is activated if magnet rotation speed is excessive. Refer to Figure 1 Product part number –Speed, maximum rotation speed.

The active-low error bit, nERROR is activated if distance to magnet are either too little or too big, if there is mounted are wrong magnet, or not magnet are mounted. Refer to section 2.5.

Data format Extended SSI

- Data format MSB – Binary/Gray Code
- Multiturn 0 or 12 or 16 or 20 or 24 or 32-Bit
- Singleturn 12 or 16–Bit (left aligned)
- 1-bit Error Bit nE (Active Low)
- 1-bit Warning Bit nW (Active Low)

5.5. Timing SSI

See Figure 20 and read timing specifications in Table 16.

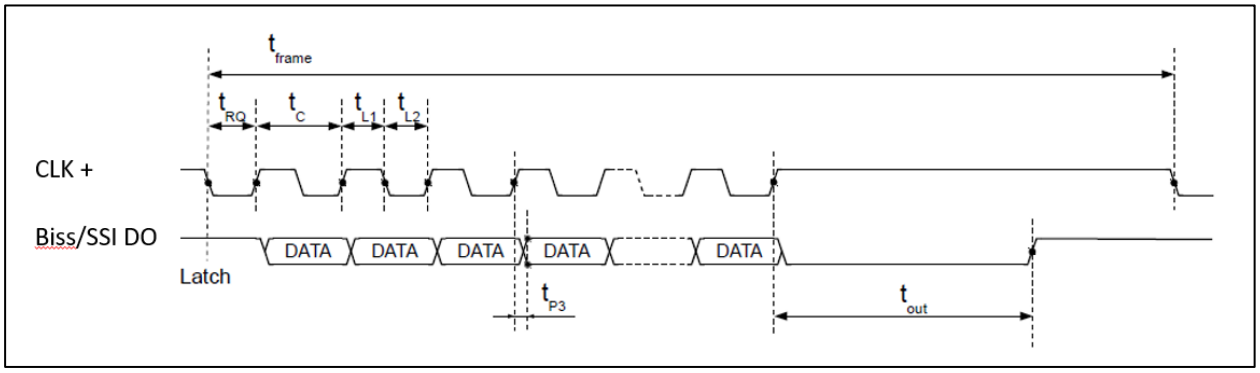


Figure 20 SSI Protocol Timing. (iC-Haus, 2021)

In SSI mode the PA0260 has a fixed nominal timeout of 18.5 µs.

6. Interface - BiSS-C

When choosing BiSS-C as an option in Interface configuration selection see Figure 1.

This BiSS interface is an open-source differential, serial, unidirectional communications interface used for absolute Position data transmission.
In BiSS mode, the PA0260 is a BiSS slave and must be connected to a BiSS master for proper operation. For a detailed description of the BiSS Interface, please refer to www.biss-interface.com.
After every BiSS cycle, the integrity of the data is verified using a CRC. If CRC fails, the BiSS error bit is activated (nERR = 0).
The singleturn position bit length depends on the interpolator resolution as set by parameter ”Resolution” see Figure 1, but is always fixed at 12 or 16 bits. If the singleturn resolution (in bits) is less than one of these values, the singleturn position value is left-justified in the singleturn position field and the unused LSBs are set to zero.
For example, if the singleturn position (angle) is a 10-bit value in a 12-bit field. In this case, bits 11:2 contain the singleturn position while bits 1:0 are zero.

6.1. Physical interface

BiSS-C uses 4 unidirectional wires

- *Data:* BISS/SSI DO+ and / BISS/SSI DO- : RS485-Level 5V
- *Clk:* BISS/SSI CLK+ and / BISS/SSI CLK-: RS485-Level 5V

RS-422 is a subset of RS-485, so RS-485 transmitters and receivers are also RS-422 compliant.

6.2. Pinout PCB – Connector

See Figure 11 J2 Pinout PCB Connector.
Cable for clock and data should be twisted in pairs and shielded

6.3. BiSS-C Protocol

The BiSS protocol is a unidirectional BiSS-C protocol using BiSS Encoder Profile BP3.
The Single Cycle Data (SCD) produced by the PA0260 shown in blue in Figure 21, contains the multiturn position (Revolution count / number of revolutions) followed by the singleturn position (magnet angle), an error bit, a warning bit, and a CRC value. All values are transmitted MSB first.

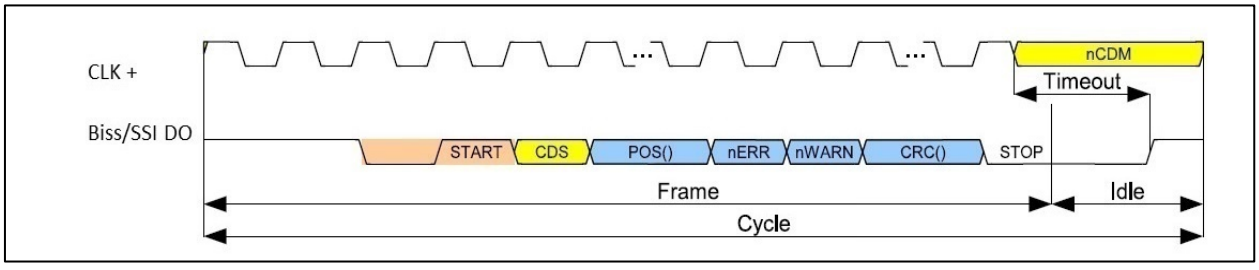


Figure 21 BiSS Protocol. (iC-Haus, 2021)

Data format BiSS-C

- Data format MSB – Binary/Gray Code
- Multiturn 0 or 12 or 16 or 24 or 32-Bit
- Singleturn 12 or 16-Bit (left aligned)
- 1-bit Error Bit nE (Active Low)
- 1-bit Warning Bit nW (Active Low)
- 6-bit CRC

6.4. Timing BiSS

See Figure 22 and read timing specifications in Table 16.

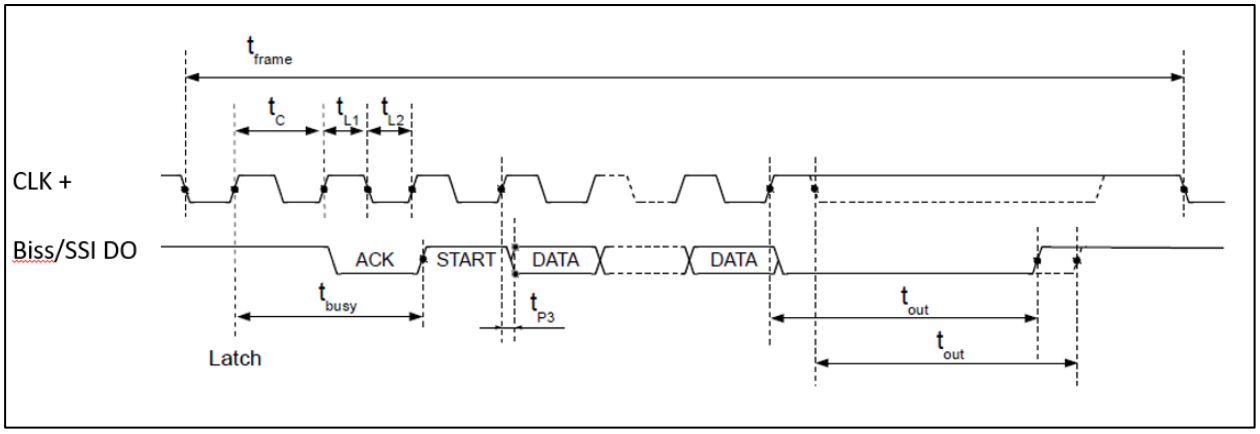


Figure 22 BiSS Protocol Timing. (iC-Haus, 2021)

The PA0260 uses adaptive timeout with BiSS communication.
PA0260 adapts the BiSS timeout length based on the period of the BiSS clock, TMA, and its internal sampling frequency, 1/TCLK, to ensure fastest communication. In operation, the PA0260 measures 1.5 periods of T_{MA} (from the first falling to the second rising edge) of each BiSS frame and calculates an adaptive timeout value of

$$T_{CLK}\frac{4}{3 \cdot 14}$$

Timeout	Condition	Min	Max
t_{out}	$T_{CLK} \leq 1.5 \cdot T_{MA}$	$1.5 \cdot T_{MA}$	$1.5 \cdot T_{MA} + 3.0 \cdot T_{CLK}$
t_{out}	$T_{CLK} \geq 1.5 \cdot T_{MA}$	$1.0 \cdot T_{MA}$	$1.5 \cdot T_{MA} + 3.0 \cdot T_{CLK}$

Table 3 Adaptive Timeout Calculations.

For more information on the BiSS adaptive timeout, refer to BiSS application note AN23 at https://biss-interface.com/.

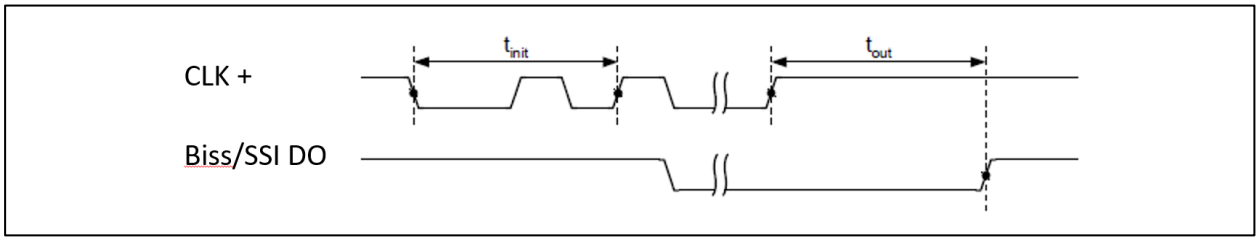


Figure 23 Adaptive Slave Timeout for BiSS only. (iC-Haus, 2021)

6.5. CRC

The Cyclic Redundancy Check value (CRC) is transmitted in its inverted state last in the SCD.
A 6-bit CRC code is transmitted.
CRC HEX Code: 0x43
CRC start value : 0x00
CRC Polynomial: X6 + X1 + X0

7. Interface - Sin/Cos

When choosing SinCOS Out as an option in interface configuration selection see Figure 1.

Accurate sine wave rotary encoders by JVL, a preferred choice in drives with high dynamics thanks to their low harmonic distortion. They have excellent immunity to interference and high functional dependability due to control and system monitoring. The broad working temperature range means the motor can be used to capacity more effectively.

The magnet should be centered on the iC-MHM for lowest angular error and jitter.
If it is possible to adjust the magnet position relative to the iC-MHM, the centering can be optimized by equalizing the amplitudes of the four analog outputs SIN+, SIN-, COS+, and COS-. With the magnet rotating, move it (or the PA0260) along the SIN+/SIN- diagonal of the iC-MHM (refer to Figure 24) until the amplitudes of SIN+ (J2 pin 3) and SIN- (J2 pin 1) are equal.
Then, move the magnet or The PA0260 along the PCOS/NCOS diagonal until the amplitudes of COS+ (J2 pin 4) and COS- (J2 pin 2) are equal. Several iterations may be required for optimum results.

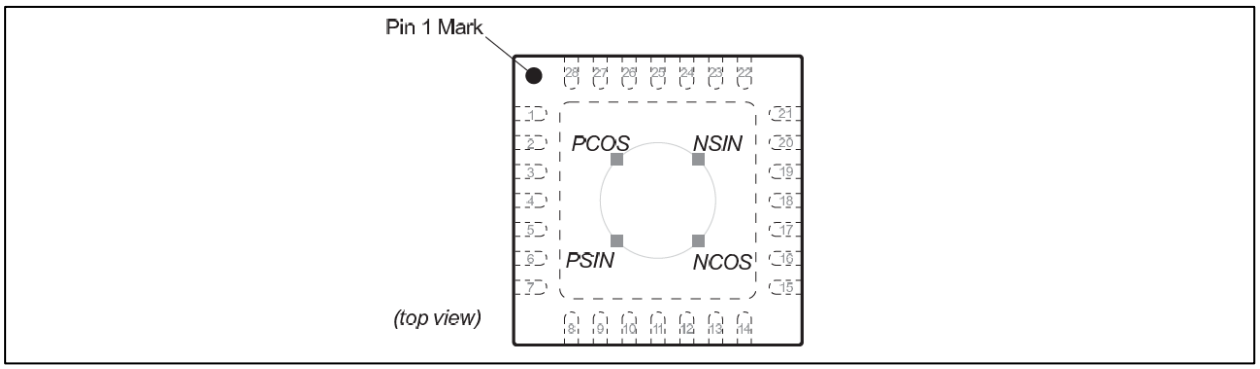


Figure 24 Location of Hall sensor iC-MHM.

7.1. Physical interface

Number of wires 4 unidirectional

- SIN+ and SIN-
- COS+ and COS-

7.2. Pinout PCB – Connector

See Figure 11 J2 Pinout PCB Connector.

7.3. Output

The build in automatic amplitude control maintains the amplitude of the differential sine and cosine signals at 1 Vpp.
The sine and cosine signals can be monitored at the SIN+(PSIN), SIN-(NSIN), COS+(PCOS) and COS- (NCOS) outputs as shown in Figure 25.

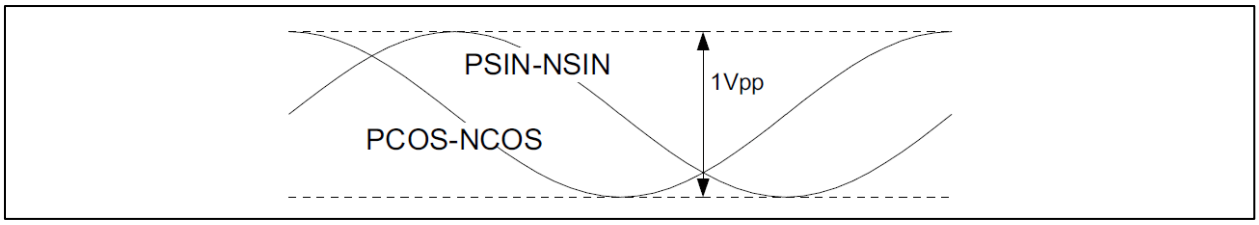


Figure 25 Hall Signal Amplitudes with Automatic gain control.

8. Recommended configurations

8.1. PA0260

This section contains the PA0260 product number recommend by JVL.

8.1.1. Multiturn SSI Standard with Incremental signals 13-bit ST/12-bit MT

PA0260JJMBAA7BAAA :

J:	**Encoder Type**	Absolute muliturn encoder with INTERNAL battery mounted
J:	**Interface**	J2 SSI binary + J1 Incremental 5-30V in. 5V-30V out.
M:	**Resolution**	8192 CPR (Standard SSI)
B:	**Multiturn Resolution**	12-bit (Standard SSI)
A:	**Hysteresis**	0.00°
A:	**Speed**	3000 RPM Max
7:	**Mounting**	NEMA17 42x42mm
B:	**Surface Treatment**	Coated
A:	**Special One**	Reserved
A:	**Special Two**	Reserved
A:	**Special Three**	Reserved

With this configuration delivers a setup, which is compatible with many SSI controllers.
At start-up, use the SSI absolute multiturn position to set start position. When running motor use incremental A,B,and Z to adjust position.
You will get:

- SSI binary-code protocol.
- 13-bit singleturn resolution (Standard SSI).
- 12-bit multiturn resolution (Standard SSI).
- 5-30 V Incremental output
- Internal battery mounted (see expected battery lifetime in section 1.3).
- Low hysteresis.
- Error and warnings.

The MacTalk feature >>**Position "Auto correction"<<** is supported with this PA0260 configuration. Please consult the JVL MIS Manual for more information.

8.1.2. Multiturn Extended SSI 14-bit ST/12-bit MT

PA0260JKJBAA7BAAA :

J:	**Encoder Type**	Absolute muliturn encoder with INTERNAL battery mounted
K:	**Interface**	J2 SSI gray + J2 Zero set and CNT DIR input 5-30V in. 5V fixed out. M12=J2. J1 Do not use
J:	**Resolution**	16384 CPR
B:	**Multiturn Resolution**	12-bit
A:	**Hysteresis**	0.00°
A:	**Speed**	3000 RPM Max
7:	**Mounting**	NEMA17 42x42mm
B:	**Surface Treatment**	Coated
A:	**Special One**	Reserved
A:	**Special Two**	Reserved
A:	**Special Three**	Reserved

With this configuration, you will get high resolution, preset and ability to change count direction.
You will get error and warnings if they occurs.
You will get:

- SSI binary-code protocol.
- 14-bit singleturn resolution.
- 12-bit multiturn resolution.
- Preset function.
- Ability to change count direction.
- Internal battery mounted (see expected battery lifetime in section 1.3).
- Low hysteresis.
- Error and warnings.

The MacTalk feature >>**Position "Auto correction"<<** is supported with this PA0260 configuration. Please consult the JVL MIS Manual for more information.

8.1.3. Singleturn Extended SSI with Incremental signals 14-ST/ 0-bit MT

PA0260HJJAAA7BAAA :

H:	**Encoder Type**	Singleturn encoder
J:	**Interface**	J2 SSI binary + J1 Incremental 5-30V in. 5V-30V out.
J:	**Resolution**	16384 CPR
A:	**Multiturn Resolution**	0
A:	**Hysteresis**	0.00°
A:	**Speed**	3000 RPM Max
7:	**Mounting**	NEMA17 42x42mm
B:	**Surface Treatment**	Coated
A:	**Special One**	Reserved
A:	**Special Two**	Reserved
A:	**Special Three**	Reserved

This configuration delivers a setup, which is compatible with many SSI controllers.
Note: The singleturn encoder does not need a battery, so none will be provided[3].

You will get:

- SSI binary-code protocol.
- 14-bit singleturn resolution.
- No multiturn.
- 5-30 V Incremental output
- Low hysteresis.
- Error and warnings.

[3] No battery

8.2. MST/MSL/MSW

This section contains the MST/MSL/MSW product number recommend by JVL.

8.2.1. Singleturn Extended SSI with Incremental signals 14-bit ST/ 0-bit MT

MST/MSL/MSW 233B087WBH I.60JUL

H:	**Encoder Type**	Single turn encoder PA0260 Hys 0° MAX3000 RPM M12=J1 Incremental, M12=J2 SSI/BISS
I:	**Interface**	J1 Incremental ABZ 5-30V in. 5V fixed out. M12=J1
J:	**Resolution**	16384 CPR

With this configuration, you will be able to use the J2 singleturn SSI gray output, with 14-bit resolution, and J1 with 5V Incremental output.
To get full benefit for both J1 and J2 simultaneously use this setup. See Table 6.
If MST232 are chosen with this configuration, only J1 will be available on M12.
You will get:

- SSI gray-code protocol.
- 14-bit singleturn resolution.
- No multiturn.
- 5V Incremental output
- No battery.
- Low hysteresis.
- Error and warnings.

8.2.2. Multiturn Extended SSI 14-bit ST/16-bit MT

MST/MSL/MSW 340C49BT2SK9.0JAA

S:	**Encoder Type**	Absolute muliturn encoder 16bit, hys 0, Max 3000 RPM with INTERNAL battery mounted PA0260
K:	**Interface**	J2 SSI gray + J2 Zero set and CNT DIR input 5-30V in. M12=J2. J1 Do not use
J:	**Resolution**	16384 CPR

With this configuration, you will get:

- SSI gray-code protocol.
- 14-bit singleturn resolution.
- High multiturn resolution (16-bit).
- Preset function.
- Ability to change count direction.
- Internal battery mounted (see expected battery lifetime in section 1.3).
- Low hysteresis.
- Error and warnings.

The MacTalk feature >>**Position "Auto correction"<<** is supported with this PA0260 configuration up to 13-bit MT. Please consult the JVL MIS Manual for more information.

8.2.3. Multiturn Extended SSI14-bit ST/32-bit MT

MST/MSL/MSW 340C49BT2JK9.0JAA

J:	**Encoder Type**	Absolute muliturn encoder 32bit Hys 0° Max3000RPM for External battery PA0260. No Internal battery. M12=J2
K:	**Interface**	J2 SSI gray + J2 Zero set and CNT DIR input 5-30V in. 5V fixed out. M12=J2. J1 Do not use
J:	**Resolution**	16384 CPR

With this configuration, you will get:

- SSI gray-code protocol.
- 14-bit singleturn resolution.
- High multiturn resolution (32-bit).
- Preset function.
- Ability to change count direction.
- No internal battery, hence external battery .
- Low hysteresis.
- Error and warnings.

MST232 is not possible with this configuration.
The MacTalk feature >>**Position "Auto correction"<<** is supported with this PA0260 configuration up to 13-bit MT. Please consult the JVL MIS Manual for more information.

8.3. Pros and cons Extended SSI

Pros	Cons
Optional Higher resolution	Do not fit all controllers
Optional Lower resolution	
Warning and Error bits	

Table 4 Pros and cons Extended SSI

9. How to setup PA0260 with JVL MST/MSL/MSW motor & SMC66/85 Controller

This section contains information on how to use PA0260 general purpose encoder PCB with JVL MST/MST/MSW motor.

Choose Encoder type, Interface and Resolution to fit your encoder demands.
If you can't configure the PA0260 after your demands, please do not hesitate to contact JVL Support.

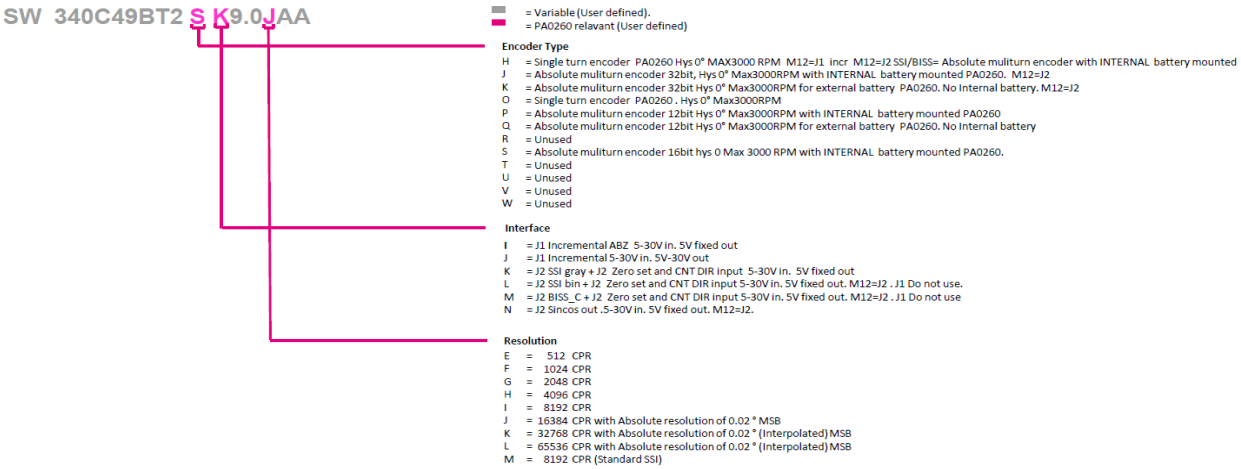


Figure 26 Nomenclature for the MST/MSL/MSW product family.

9.1. Hardware

This section explains some of the different hardware combinations JVL offers, when PA0260 is combined with MST/MSL/MSW.

9.1.1. Power JVL Power Supply Overview

Please read quickstart guide https://www.jvl.dk/files/downloads-1/pr/lb0062.pdf

9.1.2. Different motor, cable and setup opportunities

In the tables below, there are listed some examples on different motor, cable and setup opportunities. Please do not hesitate to contact JVL Support if your combination is not listed.

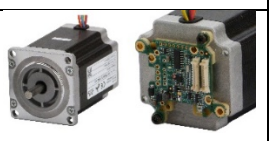
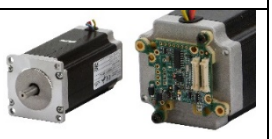
	Torque [Nm]	Length [mm]	Rated Current [A]	Encoder Connections	Encoder Technology	Photo
MST174A403Z0KI3.0J	0.43	69.1	3.0	Cable 8 Wire 1m	Abs. Incremental 16384 CPR	
MST232B087WBKI5.0JUL	2.3	77	5.0	10 pin for SSI and 10 pin for ABZ	Abs. Incremental 16384 CPR*	
MST234B437WBKI5.0JUL	3.2	112	5.0	10 pin for SSI and 10 pin for ABZ	Abs. Incremental 16384 CPR*	
MST340C49BT2SK9.0J	3.0	95	9.0	M12 8 pin female	Abs. SSI 16384 CPR*	
MSW241B234G1SK3.0J	1.3		3.0	M12 8 pin female	Abs. SSI 16384 CPR	
MSW241B234Z1SK3.0J	1.3		3.0	M12 8 pin female	Abs. Incremental 16384 CPR	

Table 5 NEMA23/24/34 with JVL encoder PA0260 with SSI/BISS/COSSIN and quadrature incremental encoder.

*Want to see drawings, go to https://www.jvl.dk/1151/stepper-with-encoder

M12 power / M12 encoder	M12 power / M12 encoder	PG Cable power 1m / M12 encoder
Option:G1	Option:T2	Option: Z1
		
M12 5pin type A Male, motor current max 5 Amp. M12 8 pin Type A encoder female. IP65 Motor+Housing *	M12 5pin type L Male, motor current max 16 Amp. M12 8 pin Type A encoder female.	1m motor cable free end. M12 8 pin Type A encoder female.

Table 6 List of encoder housing and connection options.

BE ADVISED Photo show female 5pin motor connector, in reality the connector is 5pin male

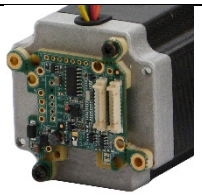
Cable power 1m / Cable encoder 1m	100mm motor 4 wire, Encoder rear mounted without housing
Option: Z0	Option: WB
	
1m motor cable free end. 1m encoder cable free end.	Motor wire free end. See below list for how to connect to this encoder.

Table 7 List of encoder housing and connection options.

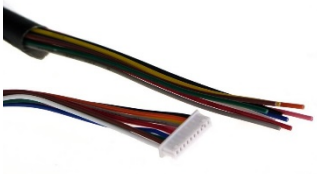
10 pin connector 65mm with M12 8 pin male, for puls/dir	10 pin connector 65mm with M12 8 pin male, for Sin/cos	10 pin connector 0.5m with 10 wire free end
PN: WG0807	PN: WG0801	PN: WG0795
		

Table 8 List of cable accessories for PA0260 encoder.

SMC66 with Housing	SMC85 with Housing	PA0190 Junctionbox
Up to 6A RMS current	Up to 9A RMS current	17 pin M12 connectors
		

Table 9 Controllers and Junctionbox.

Encoder connector M12 Female 8pin	Incremental encoder ABZ Interface Option : I or J (WG0795) J1	PA0260 J1	PA0260 J2	SSI interface option: K,L,M or N (WG0807) J2	BISS Interface option: O or P (WG0807) J2	COS/SIN Interface option: L,N or P (WG0801) J2	Encoder connector M12 Female 8pin WG0801
1	A+ Pair 1	1	1	Zero set IO5	Zero set IO5	SIN+	1
2	A- Pair 1	2	2	CNTDIR IO6	CNTDIR IO6	SIN-	2
3	Z+ Pair 3	9	9	Clock +	Clock +	Clock +	%
4	GND Pair 4	8	8	GND	GND	GND	4
5	B- Pair 2	7	7	Data in -	Data in -	Data in -	5
6	B+ Pair 2	6	6	Data in +	Data in +	Data in +	6
7	Z- Pair 3	10	10	Clock -	Clock -	Clock -	%
8	Vin Pair 4	5 Vin	5 Vin	Vin	Vin	Vin	7
%	5V out PA0260	3	3	SIN+	SIN+	SIN+	3
%	nERR/ VBATT PA0260	4	4	Cos+	Cos+	Cos+	8

Table 10 Encoder connector M12 Female 8pin.

Encoder connector M12 Female 8pin WG0807	Encoder connector M12 (ENC) Male 8 pin SMC66	SSI encoder connector M12 Male 8 pin SMC85
1	1 IO5 Zero Set	1 IO5 Zero Set
2	2 IO6 CNTDIR	2 IO6 CNTDIR
3	3 Clock +	3 Clock +
4	4 GND	4 GND
5	5 Data in -	5 Data in -
6	6 Data in +	6 Data in +
7	7 Clock -	7 Clock -
8	8 Vout	8 Vout

Table 11 Encoder connector M12 Female 8pin SMC66/ SMC85.

9.2. How to connect

This section describes how to choose and connect, controller, encoder cable and motor cable.

9.2.1. Encoder cables

There are two types of encoder cables.

1) Controller with encoder (ENC0) output and SSI output.
   - Use WI1012-M12F8TF8TxxT– 8 pin M12 to 8 pin M12.

2) Controller without encoder (ENC0) output and SSI output.
   - Use WI1012-M12F8TM17TxxT – 8 pin M12 to 17 pin M12.
   - If you want to use MacTalk simultaneously, JVL recommend using PA0190 junction box. The junction box splits the 17 pin connector into 4pcs M12 connectors with different functions. (Read more about PA0190: https://www.jvl.dk/942/mac-motor-mis-motor)

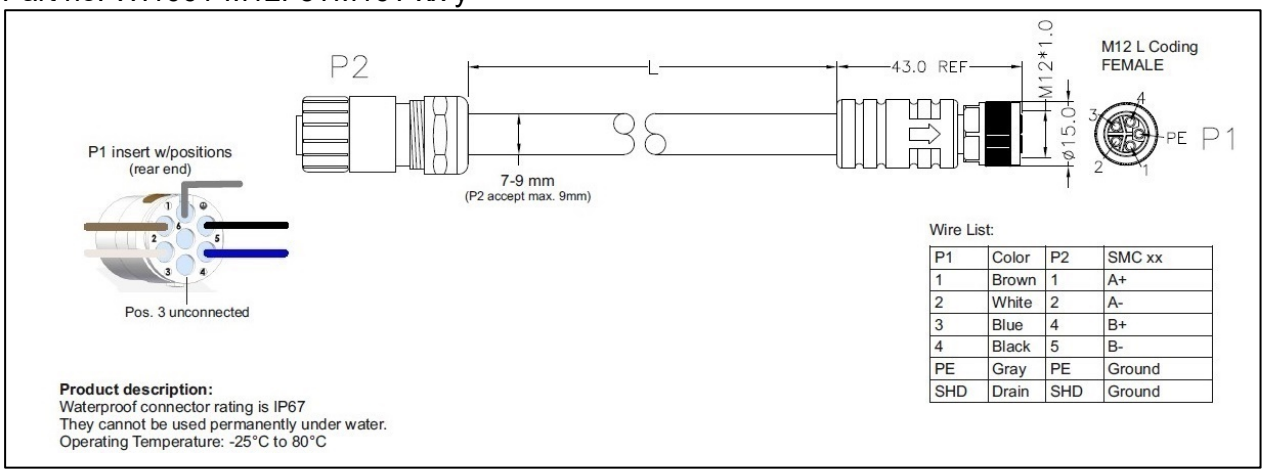
9.2.2. Motor cables

MST with encoder and M12 connector

How to setup PA0260 with JVL MST/MSL/MSW motor & SMC66/85 Controller

Depending on the motor connections on the SMC, JVL offers different opportunities.

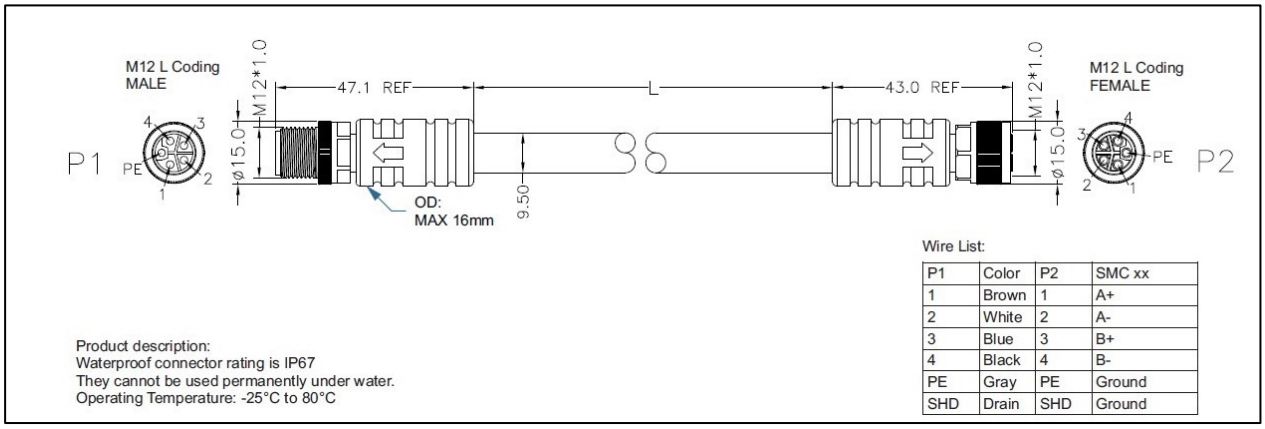
M12 Code L 5pin female shielded, to M16 male IP67.
Part no: WI1061-M12F5TM16T xx y



P1	Color	P2	SMC xx
1	Brown	1	A+
2	White	2	A-
3	Blue	4	B+
4	Black	5	B-
PE	Gray	PE	Ground
SHD	Drain	SHD	Ground

Figure 27 Cable part no: WI1061-M12F5TM16T xx y.

M12 Code L 5pin male to female shielded, IP67.
Part no: WI1061-M12 M5T F5T xx y



P1	Color	P2	SMC xx
1	Brown	1	A+
2	White	2	A-
3	Blue	3	B+
4	Black	4	B-
PE	Gray	PE	Ground
SHD	Drain	SHD	Ground

Figure 28 Cable part no: WI1061-M12 M5T F5T xx y.

Open end standard M12 and M16.

Motor connection M12 or M16	M12(X4)	M12 Angle cable type, WI1000-M12M5VxxN or straight WI1000-M12M5TxxN	M16(X5)	M16 Motor cable type WP2101 (1m), WP2105 (5m), WP2120 (20m)

Motor phase A+	Pin 1	Brown	Pin 1	Black "1"
Motor phase A-	Pin 2	White	Pin 2	Black "2"
Motor phase B+	Pin 3	Blue	Pin 5	Black "3"
Motor phase B-	Pin 4	Black	Pin 4	Black "4"
Ground/Housing	Pin 5	Grey	GND	PE

Table 12 Open end standard M12 and M16. Read more about open end standard here: https://www.jvl.dk/981/stepper-motor-controller

In some rare cases cable color may vary, then you will have to look on the motor drawings. Connect motor cables like illustrated in Figure 29.

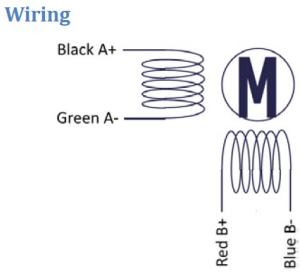


Figure 29 Motor Wiring

MSW/MSL with encoder and M12 connector

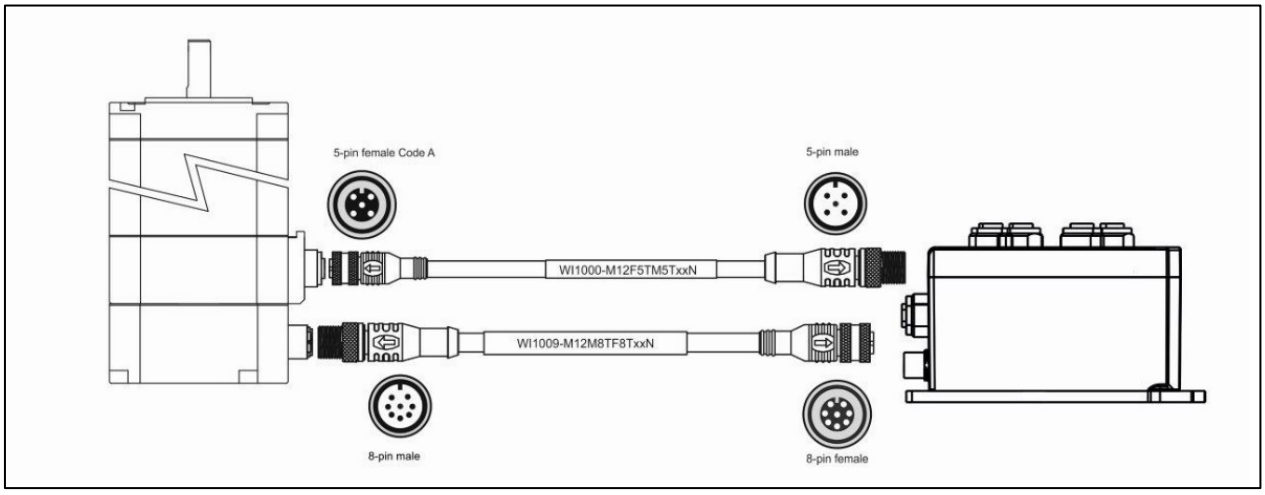


Figure 30 MSW/MSL with encoder and M12 connector.

When you plan to use less than 5 A RMS

Controller	Encoder cable	Motor cable	Motor
SMC66 encoder connector M12 A code 8pin and MotorConnector A Code 5pin	Female 8pin to Female 8pin	M12 Male A code 5pin to Female 5 A code	M12 Male A Code 5pin, M12 Male 8pin

Eg. SMC66B1-ElAABX1	WI1012-M12F8TF8T02T (2m) WI1012-M12F8TF8T05T (5m) WI1012-M12F8TF8T20T (20m)	WI1000-M12M5TF5T01N (1m) WI1000-M12M5TF5T02N (2m) WI1000-M12M5TF5T03N (3m) WI1000-M12M5TF5T20N (20m)	MST232B013M2KT6.0J

Table 13 When you plan to use less than 5 A RMS.

When you plan to use more than 5 A RMS

Controller	Encoder cable	Motor cable	Motor
SMC66 encoder connector M12 A code 8pin And Motor- connector L Code 5pin	M12 Female 8pin to Female 8pin	M12 Male L code 5pin to Female 5 L code	M12 Male L Code 5pin, M12 Male 8pin
Eg SMC66B1-EIAABX2	WI1012-12F8TF8T02T (2m) WI1012-12F8TF8T05T (5m) WI1012-12F8TF8T20T (20m)	WI1061-M12M5TF5T01N (1m) WI1061-M12M5TF5T05N (5m) WI1061-M12M5TF5T15N (15m)	MST232B013MxKT6 .0J

Table 14When you plan to use more than 5 A RMS.

10. How to operate PA0260

10.1. Connector overview for the MST/MSL/MSW motors

See different connection solutions in section 9 Page 39.

10.2. General information on how to connect the SSI device.

The SSI interface is based on 2 differential lines. Both lines are available in the M12 connectors and are named A1+, A1- and B1+,B1- (4 wires).
In order to see the exact physical location of the signals please consult the section 9.2 page 29.

The function of the signals is as follows:

- Line **A1+** and **A1-** transmit a clock signal to the SSI device.
- Line **B1+** and **B1-** receives the data stream from the SSI device.

10.3. Setup and operation of the SSI function when using MacTalk.

When using the MacTalk Windows program supplied by JVL the following descriptions must be used. In order to setup for SSI support two commands need to be executed in a ePLC program (320 & 321). These two commands configure the RS485 multifunction interface covering the 4 lines to the SSI device for transmitting a clock and receiving data from the SSI device.

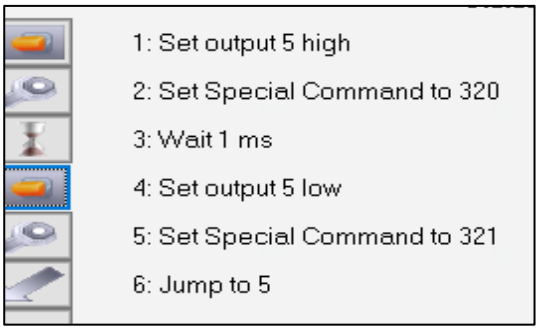


Figure 31 Easy start with sample code.

From MacTalk all configurations and settings are accessible. Choosing the "**Advanced**"-tab gives access to the "SSI encoder value" and the "SSI encoder setup".

MacTalk << Advanced tab >>

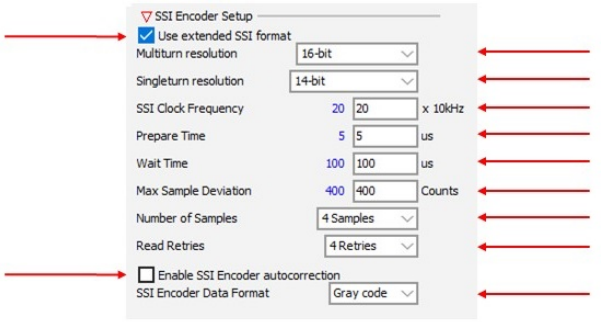


Figure 32 MacTalk << Advanced tab >> extended SSI.

MacTalk << Advanced tab >>

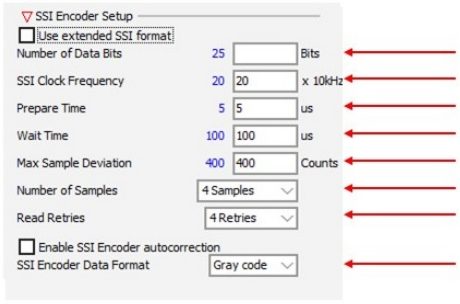


Figure 33 MacTalk << Advanced tab >> standard SSI.

Checkbox: "Use extended SSI format"
It is possible to choose Extended SSI format by ticking the box "Use extended SSI format", else it is operating by standard SSI.
Read product number and extract Multiturn and Singleturn resolution see Figure 1.

Field: "Multiturn resolution"
Type number of multirun bits.[4]

Field: "Singleturn resolution"
Type number of multirun bits.[4]

Field: "Number of Data bits"
Selects the number of data bits in each SSI transfer. The valid range is 13 to 31. Set this value according to the actual SSI device connected.
Read product number and extract Multiturn and Singleturn resolution see Figure 1.
Add the two numbers, type the value in the field.
Example: Using the recommended from section 0: Standard SSI,
Multiturn SSI Standard with Incremental signals, the "Number of Data bits" should be 25.

Field: "Clock frequency"

[4] Note: only used when extended SSI is selected.

Selects the maximum clock speed in units of 10 kHz. The valid range is 1 to 255, corresponding to 10 kHz to 2.55 MHz.
Recommend clock frequency 200 kHz for PA0260, type the value 20 in the field.

Field:"Prepare time"
(Clk to Data) A typical SSI device needs a so called prepare time to sample the position data before transfer. This field is dedicated to type in the prepare time in micro seconds at the start of an SSI transfer. The valid range is 1 to 255, corresponding to 1 to 255 micro seconds.
Recommend Prepare time 5 for PA0260, type the value 5 in the field.

Field "Wait Time"
A typical SSI device have a Timeout after sending position see Table 15, Figure 19 or Figure 20, the wait time must be lager than Timeout (t_{out}).
This field is dedicated to type in the wait time in micro seconds, at the end of an SSI transfer. The valid range is 1 to 255, corresponding to 1 to 255 micro seconds.
Recommend Wait time 100 for PA0260, type the value 100 in the field.

Field "Max. sample deviation"
Selects the maximum allowed deviation between two samples. The valid range is 1 to 8191. This function is ment to be an extra safety to avoid invalid reading of position data caused by noise influencing the signal. Please bear in mind that if the external SSI device is tracking the position of something that moves the value and thereby the deviation from one sample to the next can be significant.

Field: "Number of Samples"
Selects the number of samples in each SSI measurement. If all samples stay below the "Max. sample deviation" value (described earlier in this text), no retry is required. If one pair of samples fails the whole measurement fails and a retry is attempted if allowed according to the "Read Retries" parameter.

Field: "Read Retries"
Selects the number of retries before time out and reporting an error. The MSTxx/MSLxx/MSWxxx / SMC66 and SMC85 has a build in data validation function which automatically compares the current sample with the previous and makes sure that the deviation is within the "Max. sample deviation" limit. "Number of samples" determines how many samples one measurement contains. If the measurement fails, a retry is attempted if number of retries has not exceeded the "Read Retries" value. |Sample(x) – Sample(x+1)| < (Max_sample_deviation) = OK |Sample(x) – Sample(x+1)| > (Max_sample_deviation) = ERROR If the number of retries has exceeded the "Read Retries" value and the measurement still reports an error, the reading will be discarded and "SSI Encoder value" still shows the last correct measurement. An error bit will be set in the ERR_BITS register (35) on position 11. MacTalk will report this error :

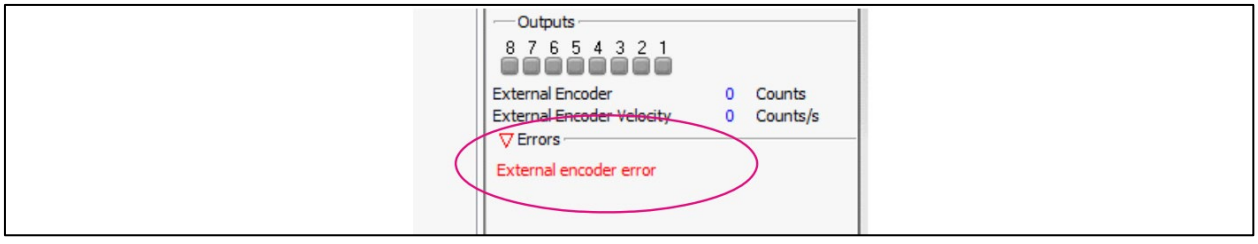


Figure 34 External encoder Error

Checkbox: “Enable SSI encoder Autocorrection”
Please refer to MIS User manual section >>Position "Auto correction"<< and section >>“Auto correction” - basic function<<.

Additional hardware settings: If chosen interface selection contains “Zero set and CNT DIR input” see Figure 1.
These settings can be controlled by having user I/O 5 (CNT DIR) and 6 (Zero set) set as output (see Figure 35).
If counting direction has been changed - the zero set (clearing the position counter) must be done to make sure that position data is valid. We suggest performing the zero set when the encoder is stationary (no rotation)

Figure 35 I/O Setup tab.

10.4. Setup and operation of the SSI function when NOT using MacTalk.

Following lines describe how to access relevant registers when having a SSI device connected. When reading the data from the SSI device the data will be places as a signed 32-bit integer in register 47 shortly after the read command 321 have been executed. The time before data is present can be calculated after following formula:

Total time from the read command 321 is executed until valid data is present is equal:

Time = Prepare time (timer) + (1/ Clock frequency * (Number of Data bits+1))

Example:
Encoder used have following setup:
Prepare time = 100uS (0.0001 sec.)
Clock frequency = 200kHz (200000Hz)
Number of data bits = 25
0.0001+ (1/200000 * (25 + 1) = 0.00023 sec. = 230µs

The position data from the encoder is presented in register 47 as shown below.

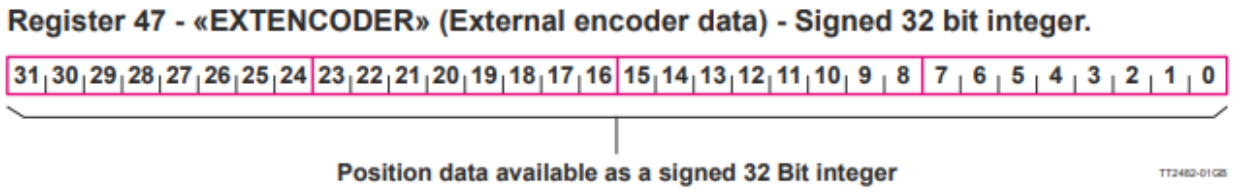


Figure 36: Register 47: External encoder data a signed 32-bit integer.

If the sum of the Multiturn resolution and Singleturn resolution exceed 32-bit, you will not be able to read the MSB above 32-bit.
It is currently NOT recommended to use MacTalk/SMC85/SMC66 with encoder with more than 32-bit position data.
If using the MacTalk feature >>**Position "Auto correction"<<** it is currently NOT recommended to go above 13-bit multiturn. Please consult the JVL MIS Manual for more information.

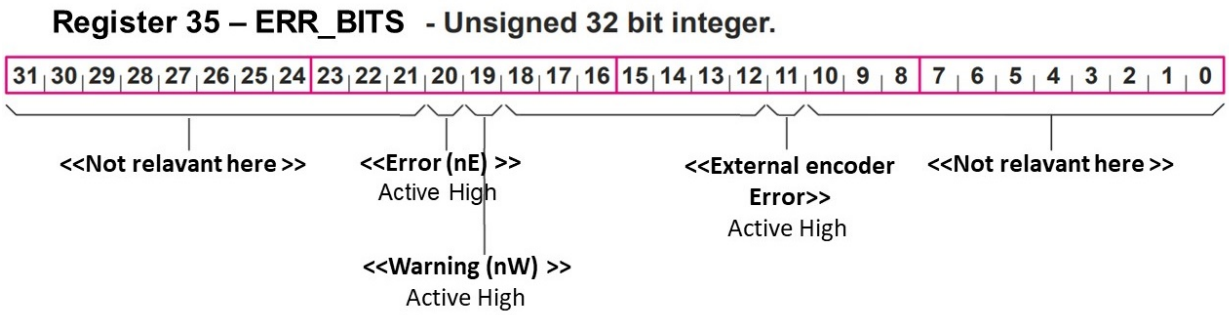


Figure 37 Register 35: ERR_BITS unsigned 32-bit integer.

ERR_BITS register (35) on position 11 see **Field: "Read Retries"** in section 10.3.
Warning (nW) bit will be set in the ERR_BITS register (35) on position 19, is activated if magnet rotation speed is excessive.
Error (nE) bit will be set in the ERR_BITS register (35) on position 20, is activated if sensor distance to magnet do exceed "Recommended distance magnet to chip magnet" Table 15.

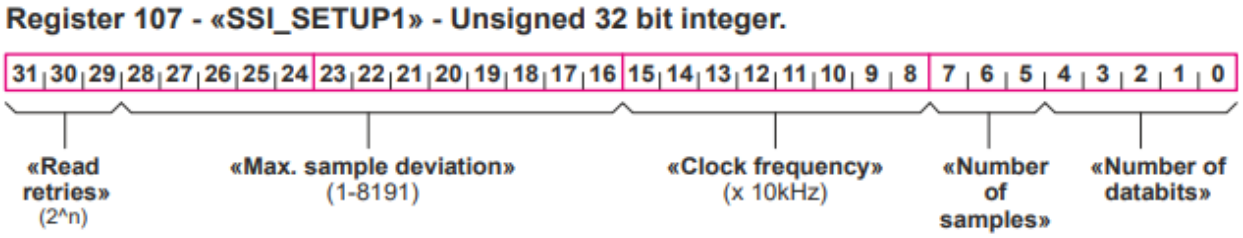


Figure 38 Register 107: SSI_SETUP1 unsigned 32-bit integer.

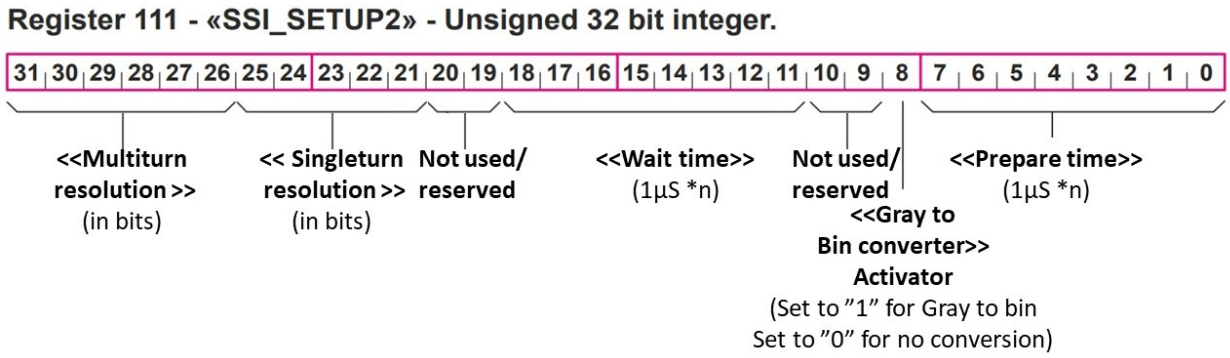


Figure 39 Register 111: SSI_SETUP2 unsigned 32-bit integer.

Prepare time in register (111) on position 0-7.
Gray to bin converter in register (111) on position 8.
Wait time in register (111) on position 11-18.
Singleturn resolution in register (111) on position 21-25.
Multiturn resolution in register (111) on position 26-31.

For more information parameters in register 111, please refer to section 10.3 for more information.

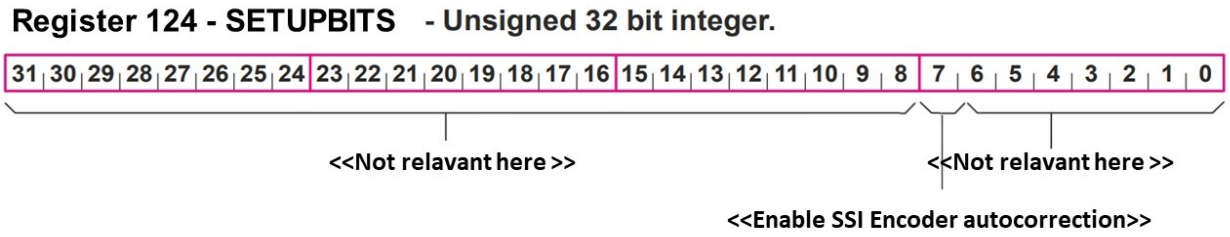


Figure 40 Register 124: SETUPBITS unsigned 32-bit integer.

Enable SSI Encoder autocorrection (**Auto correction**) in register (111) on position 7.
For more information, please refer to section 10.3 for more information.

11. Technical specifications

11.1. Electrical Characteristics

Parameter	Min	Typ	Max	Unit
VDD				
VDD supply voltage	4.85	5.0	30	V
VDDon Turn-on Threshold VDD (Power-Up-Enable) increasing voltage	4.85			V
Turn-off Threshold VDD (Power-Down-Reset) decreasing voltage	3	3.5	3.8	V
Thermal data				
Storage Temperature				°C
Ambient Temperature Range	-25		40	°C
Operating temperature without battery			110	°C
Operating temperature with battery (for extended temperature range with battery, contact JVL)			85	°C
Clock Generation				
MHM clock (fsys)	11.5	14	16	MHz
Power up Time After Preset		33	40	ms
Start up time incremental		35	70	ms
Start up time SSI/BiSS		33	40	ms
Interpolator				
Resolution singleturn	512		65536	CPR
Resolution singleturn absolute			16384 /0.02°	CPR
Resolution		12		Bit
Accuracy	-0,02		0,02	Deg
Absolute Angular Accuracy (optimal signal conditioning)	-0.35		0.35	Deg
Relative Angular Accuracy with with reference to one output period at A,B, with 10-bit resolution see Figure 23	-15		15	%
Max speed			10000	RPM
Digital Input pins				
Voltage input at CNTDIR and Zeroset	5		24	V
Threshold Voltage hi at CNTDIR and Zeroset			3.7	V
Threshold Voltage lo at CNTDIR and Zeroset	3.3			V
Threshold Hysteresis at CNTDIR and Zeroset	150	250		mV
Pull-down Current at CNTDIR and Zeroset	6	30	60	µA

Serial Interface: Outputs				
BiSS/SSI				
(BiSS/SSI Do) Saturation Voltage hi Vs()hi = VDD − V(), I() = -50mA			800	mV
(BiSS/SSI Do) Saturation Voltage lo Vs()lo = GND − V(), I() = 50mA			800	mV
(BiSS/SSI Do) Short-Circuit Current V() = GND	-450		450	mA
Adaptive Slave Timeout at BISS DO tinit measured as first 1.5 ・ T(CLK+) each frame. See Figure 23	2 / fsys	tinit + 4 / fsys	280 / fsys	
Fixed Slave Timeout at SSI DO		280 / fsys		
Sin/Cos				
Optimal Differential Output Voltage			1	Vpp
Differential Output Amplitude	0.8		1.2	Vpp
Amplitude Ratio	0.92		1.09	
Short-Circuit Current hi short-circuit versus VDD	10	30	50	mA
Short-Circuit Current lo short-circuit versus GND	-50	-30	-10	mA
A,B & Z				
Low Level Output1 VDD = 5V		375	500	mV
Low Level Output2 VDD = 30V		370	500	mV
High Level Output1 VDD = 5V	2.4	2.8		V
High Level Output2 VDD = 30V	27.7	28.1		V
Output Rise Time VDD = 24V		50	62	ns
Output Fall Time VDD = 24V		70	84	ns
Incremental interface A+,A-,B+,B-,Z+,Z 5 to 24V			2	MHz
Serial Interface: Inputs				
BiSS/SSI				
Differential Input Threshold Vt(BISS/SSI CLK)diff = V(BISS/SSI CLK+) − V(BISS/SSI CLK-)	-200	-125	-50	mV
SSI interface clock rate			2	MHz
BiSS-C interface clock rate			10	MHz
Hall sensors (MHM)				
Diameter of Hall Sensor Circle		2.42		mm
Permissible Lateral Displacement of Magnet Axis to Center of Hall Sensors			0.2	mm
Magnet				

Compatible magnets	Ø4x4		Ø6x4	mm
Recommended distance magnet to chip magnet Ø4x4	0,5		1	mm
Recommended distance magnet to chip magnet Ø6x4	1		1,5	mm
PCB				
PCB thickness		1.6		mm
Encoder chip thickness	0.8	0.9	1	mm

Table 15 Electrical characteristics, unless otherwise specified, Temperature = 25°C

11.2. Operating requirements

Symbol	Operating requirements: Serial Interface(BiSS, SSI)	Min	Typ	Max	Unit
BiSS Protocol (Figure 22**)**					
t_{frame}	Permissible Frame Repetition		*Indefinite		
t_{busy}	Processing Time w/o Start Bit Delay		$2 \cdot T_C$		
t_{P3}	Output Propagation Delay			70	ns
t_C	Permissible Clock Period	70			ns
t_{L1}	Clock Signal hi Level Duration	25	tout		ns
t_{L2}	Clock Signal lo Level Duration	25	tout		ns
t_{out}	Adaptive Slave Timeout		Refer to Table 3		
SSI Protocol (Figure 20**)**					
t_{frame}	Permissible Frame Repetition		*Indefinite		
t_c	Permissible Clock Period	250			ns
t_{L1}	Clock Signal hi Level Duration	30	tout		ns
t_{L2}	Clock Signal lo Level Duration	30	tout		ns
t_{RQ}	REQ Signal lo Level Duration	30			ns
t_{P3}	Output Propagation Delay	70			ns
t_{out}	Adaptive Slave Timeout		280 / fsys		

Table 16 Operating requirements: Serial Interface (BiSS, SSI), unless otherwise specified, Temperature = 25°C.

* Allow t_{out} to elapse.

11.3. Environmental specifications

Environmental specifications	
Parameter	Value
Shock	100G 6mS
Vibrations	10g, 5-2000Hz
Protection PCB	IP00. Options for coating or potting

Table 17 Environmental specifications.

11.4. Mechanical specifications

Mechanical specifications	
Parameter	Value
Dimension	Made for NEMA17 (38x388mm) and NEMA23 (53x53mm) motor. See Figure 6
Compatible with	NEMA17/23/24/34
Compatible magnets	Ø4 and Ø6. Recommended distance magnet to chip 0,5 to 1,5mm
Connections PCB	2 pcs 10Pin Molex connector CI14410M1V00 Counterpart: Crimp 50079-8000 x 8 , Housing 10pin 51021-1000 x1
Connections Motor	2 pcs M12 for motor and encoder. Optional 1pcs M12 Hybrid.
Weight 38x38mm Nema17	5.7g / 15.2g (with battery)
Weight 53x53mm. Nema23	6.3g /15.8g (with battery)

Table 18 Mechanical specifications.

12. References

iC-Haus. (23. 04 2021). *iC-HAUS.* Hentet fra https://www.ichaus.de/upload/pdf/MHM_datasheet_D2en.pdf: https://www.ichaus.de/upload/pdf/MHM_datasheet_D2en.pdf

13. History of document

Version	Author	Review status	Date
1.0 (draft/released)	KT		20200922
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1.2	KT	Review by MAJ	20210426
1.3	KT	Review by RRA	20210531