LA11 and Artos absolute encoders

Connection to different controllers

Abstract: Setting the controller parameters to correctly process the data received from the encoder system is essential for correct operation. This document describes the most common controllers and their parameters in order to correctly interpret the data frames of the LA11 and ARTOS systems. The document also contains examples based on the part numbering of the encoder system.

The LA11 and Artos are linear absolute systems and are often used as the primary feedback device in closed loop systems. Artos also supports a partial arc reading where the scale is installed on the shaft with a partial arc movement.

Related products

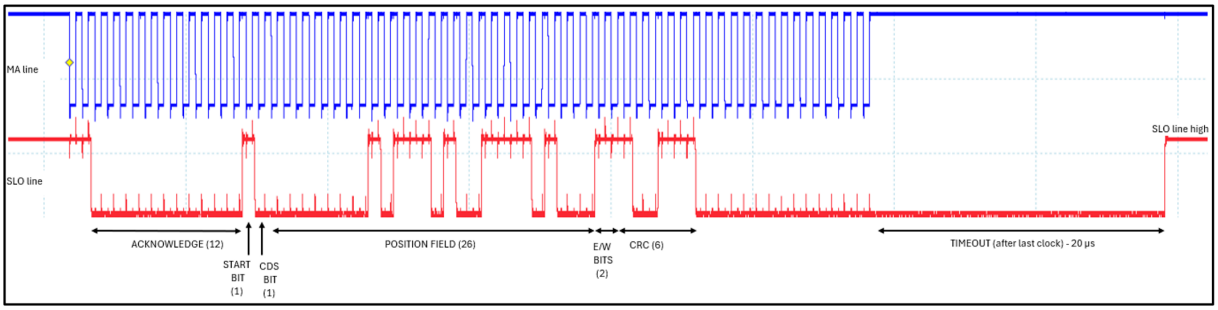
LA11 off-axis absolute magnetic encoder

Artos linear or rotary magnetic encoder system

LA11 data frame

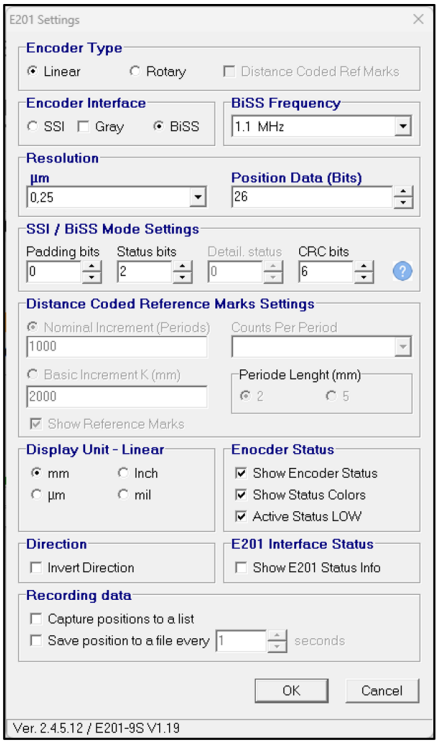
BiSS-C

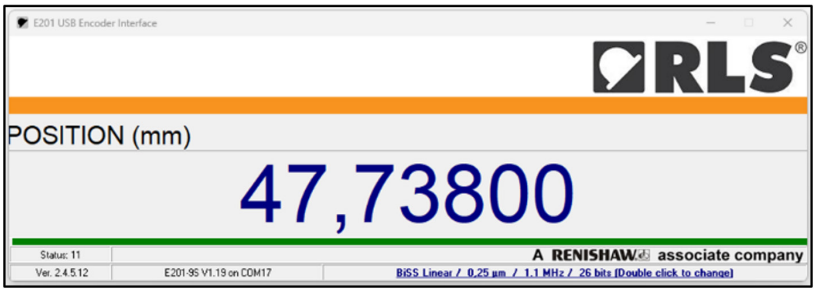
Below, you can see a BiSS C data frame recorded with the oscilloscope. The master communicating with the LA11 is the E201-9S interface. The PN of the LA11 read head is LA11DCA2D0KA10DA00 (BiSS C, 1 µm resolution). The absolute position read by the encoder is 47.738 mm.



Communication settings

The resolution is set to 0.25 µm due to the fixed position of the position field. Only 24 position bits are active for the 1 µm resolution, thus 2 bits are unused and set to zero. To simplify the setup, the length of the position field is set to 26 bits and the resolution of the LSB is reduced accordingly to 0.25 µm.

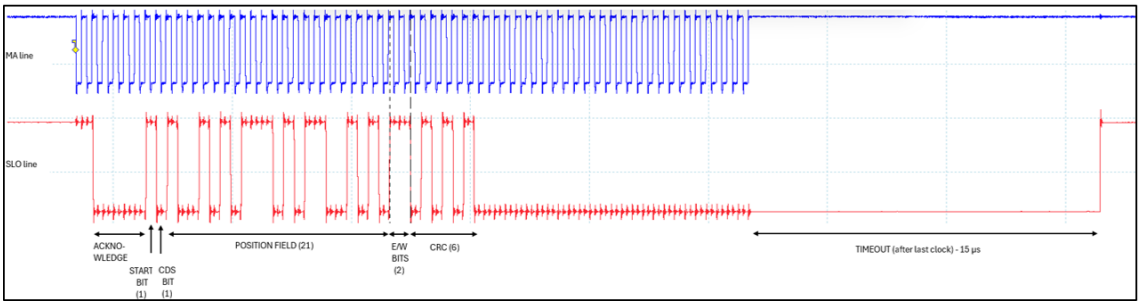




Artos data frame (DHR, DHL, DBR, DBL)

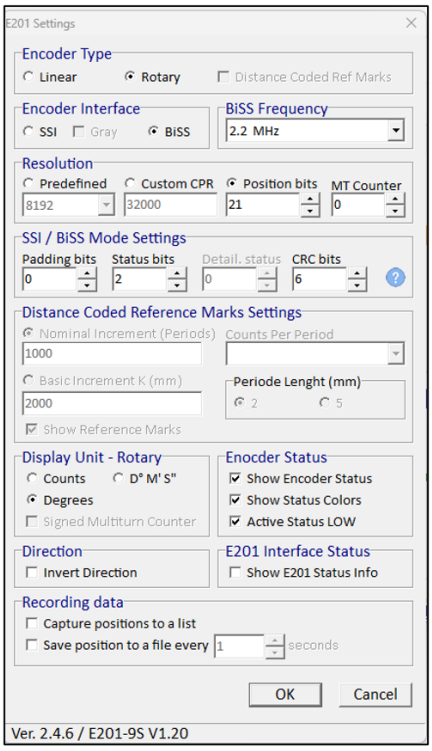
BiSS C (DHR - Rotary absolute system)

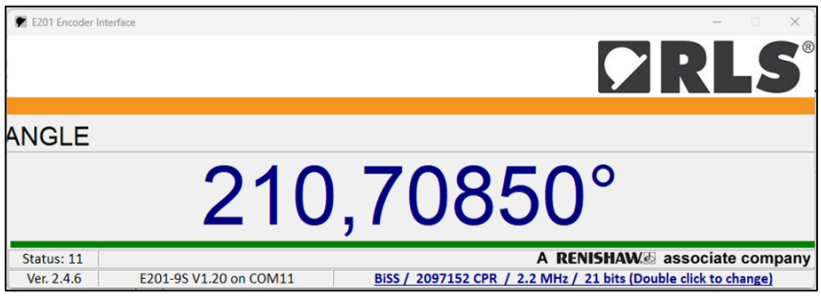
Below you can see a BiSS C data frame recorded with the oscilloscope. The master that communicates with the Artos (DHR read head) is the E201-9S interface. The PN of the Artos read head is DHR114DC21BAAS10DA00 (BiSS C, 21-bit resolution, compatible with SAR114 ring). The absolute position read by the encoder is 210.70850°.



Communication settings

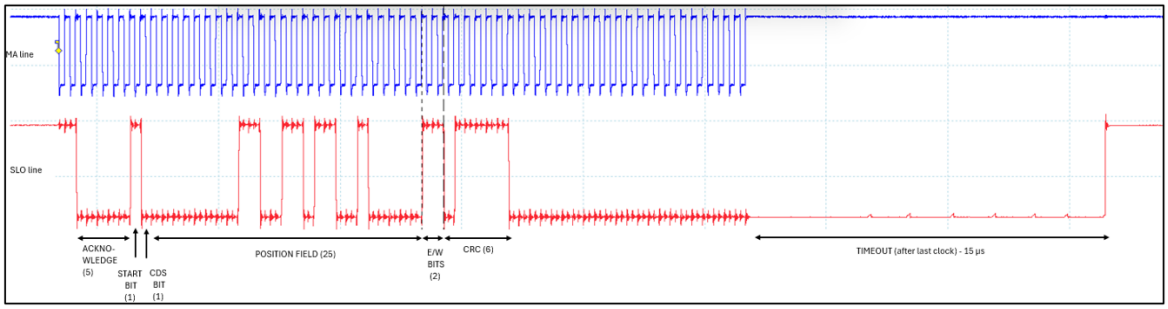
The resolution is set to 21 bits. BiSS C always has 2 status bits and a 6-bit CRC (0x43 – set by default). The status bits are active low, i.e. if an error or a warning is triggered, the bits switch to the logical zero.





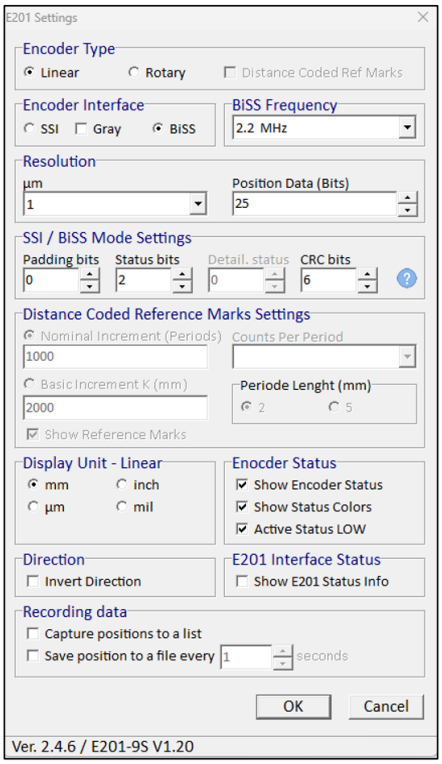
BiSS C (DHL - Linear absolute system)

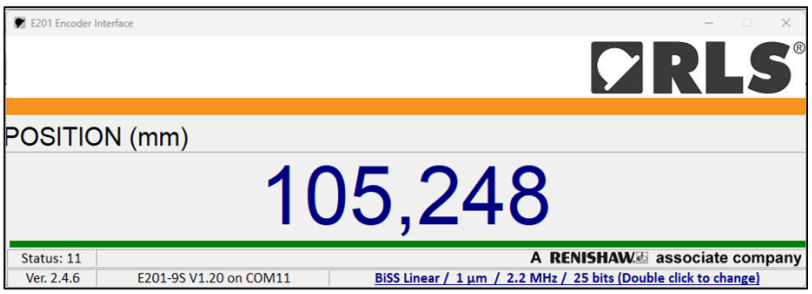
Below you can see a BiSS C data frame recorded with the oscilloscope. The master communicating with the Artos (DHL read head) is the E201-9S interface. The PN of the Artos read head is DHL001DC001AAS10DA00 (BiSS C, 1 µm resolution, compatible with the linear magnetic absolute scale DS19). The absolute position read by the encoder is 105.248 mm.



Communication settings

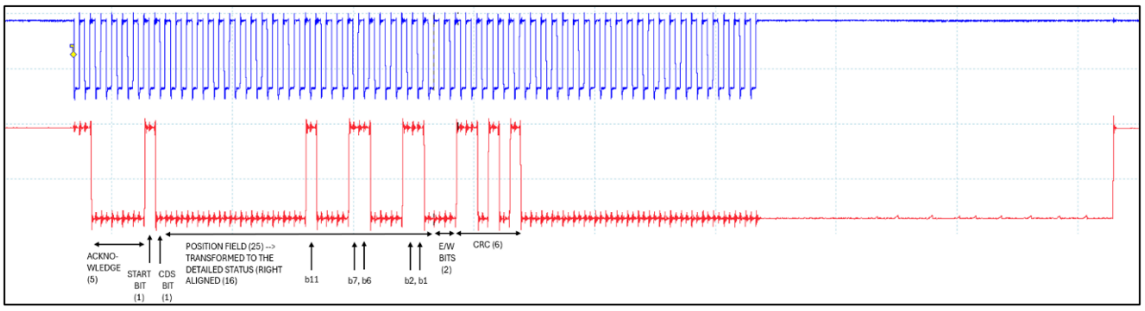
The resolution is set to 1 µm. In contrast to the LA11 BiSS C data frame, the Artos data frame is always shifted to the right so that there are no padding bits. BiSS C always has 2 status bits and a 6-bit CRC (0x43 – set by default). The status bits are active low, i.e. if an error or a warning is triggered, the bits switch to the logical zero.





General note on BiSS-C and SSI communication (valid for Artos system)

In case of an error, the position field is replaced by the detailed status field described in the table on pages 13 and 14 of the **Artos data sheet (DRD01)**.
The plot below shows the detailed status in the position field. The read head is in an error state. The detailed status shows that bits b1, b2, b6, b7 and b11 are active. The table shows that these are decoding and signal lost errors. They indicate the misalignment between the magnetic scale and the read head.



Controller's specific (general)

Binary and decimal resolutions

Some controllers cannot set the binary resolution sufficiently. In many cases, the field in which the resolution is set only supports 3 decimal digits. If the binary resolution of the encoder is 0.244140625, for example, the controller can only accept the value 0.244. This means that we make an error of 0.000140625 µm (or 0.14 nm) with each count. The error accumulates over the linear travel distance.

Here is an example of a linear travel of 1 m where the error accumulates due to the insufficient resolution setting in the controller. The selected resolution is 10 bits (1.953125 µm).

The acceptable resolution for the controller is 1.953 µm. The controller cannot accept more than 3 digits after the dot, therefore 0.000125 µm per count is missing (0.125 nm).

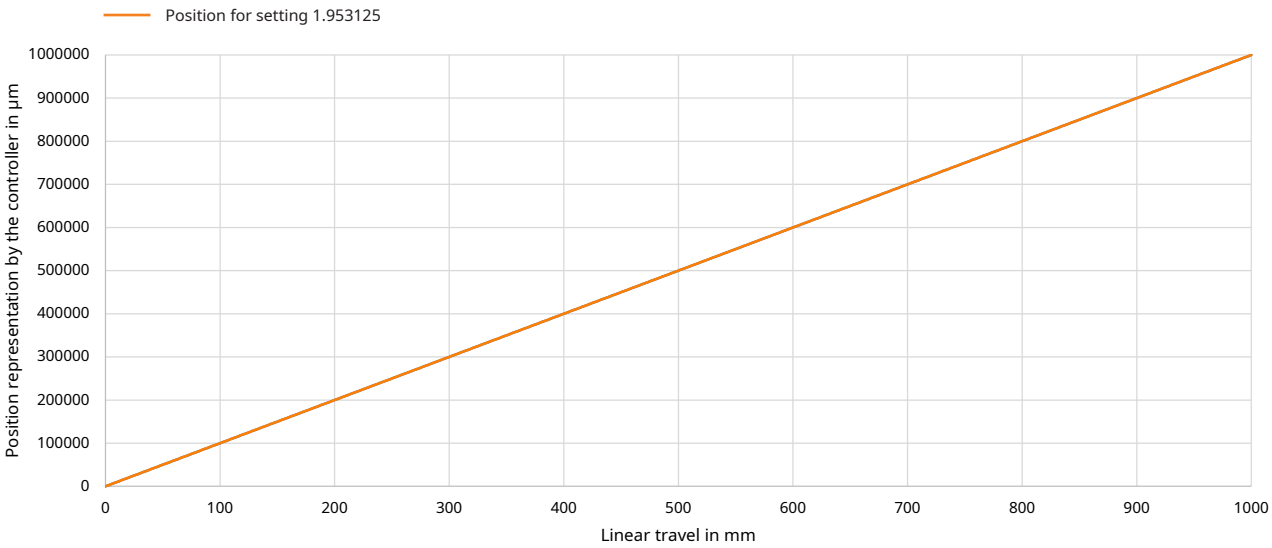
Plot 1
Shows the interpretation of the position over the linear travel from 0 to 1,000 mm.

Plot 2
Shows the absolute difference between the full resolution and the insufficient resolution setting for the last 5 mm (zoomed in). The accumulated difference is ~64 µm.

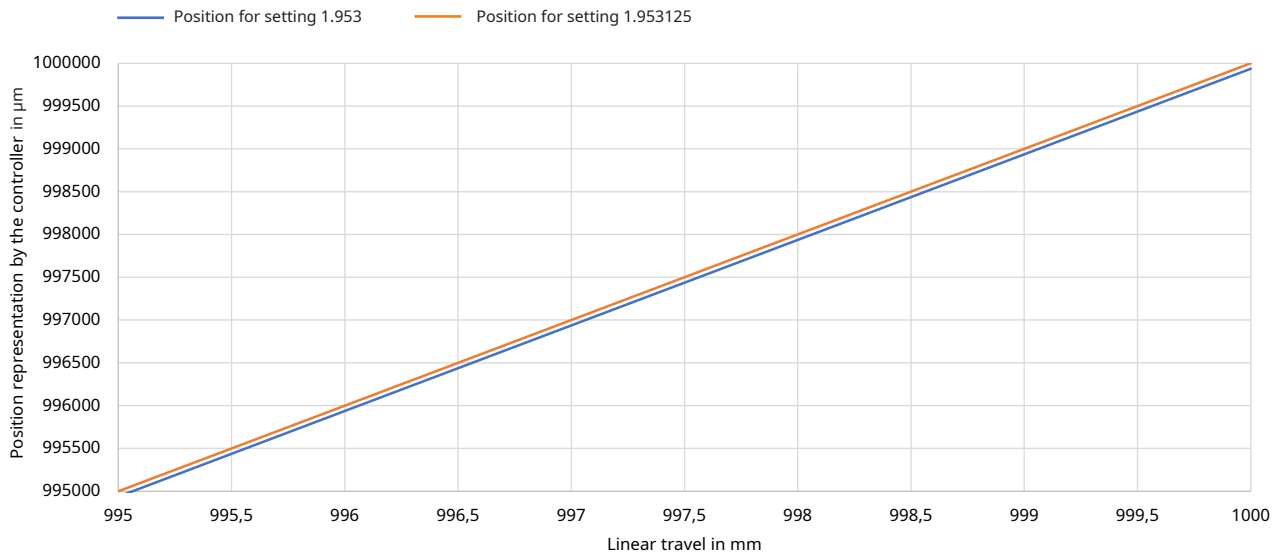
Plot 3
Shows the absolute difference between the full resolution and the insufficient resolution over the entire linear movement of 1 metre. The position difference is close to zero at the beginning, but then accumulates over the course of the linear movement. At the end of the movement, the difference amounts to ~64 µm.

The solution: Select a decimal resolution, for example 0.1 µm, 0.2 µm, 0.25 µm, 0.5 µm, 1 µm, 2 µm, 5 µm, 10 µm. Not all resolutions are available for both systems (Artos, LA11).

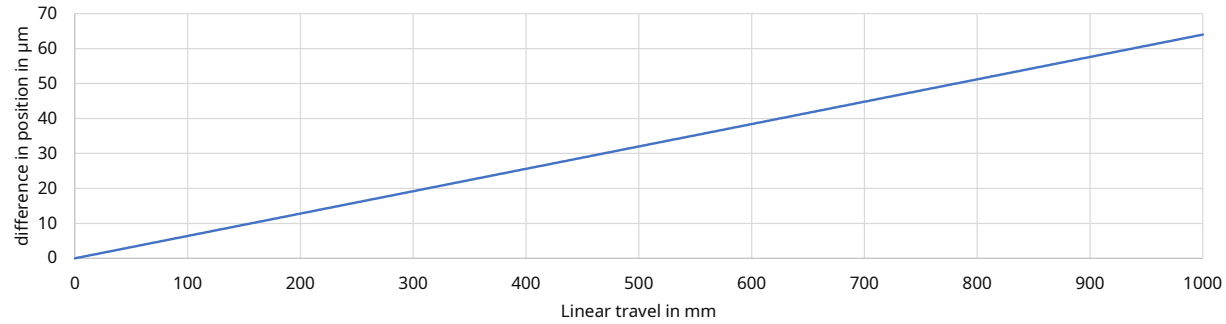
Plot 1 Absolute position (the difference is small and therefore cannot be perceived visually)



Plot 2 Positions on the plot from 995 to 1000 mm



Plot 3 Difference in µm between real movement and captured by the controller over 1 m of travel



Clock frequency setting and ACK timing in BiSS-C

Every encoder system that supports synchronous communication has a specification for the minimum and maximum clock frequency (in BiSS C – MA frequency). For correct operation, it is essential to set this frequency correctly.
The LA11 system has two options for the maximum clock frequency. The maximum clock frequency is determined by the number of ACK bits in the BiSS C protocol.

A - Up to 2.2. MHz CLK (ACK = 12 clock periods)
B - Up to 3.5 MHz CLK (ACK = 20 clock periods)

Artos has only one configuration: Up to 5 MHz with 5 ACK clock periods

ACK value and timing in controller settings

The ACK length is interpreted differently by different controllers. As the ACK value of LA11 and Artos is constant (it does not change during operation), it is easier for the controller to enter a constant value in bits.
However, some controllers require an ACK value to be set in microseconds (µs). This requires a simple calculation.

Input data:

- MA frequency – specified by the user (e.g. 3 MHz)
- ACK length data – specified in the LA11/Artos data sheet (i.e. option B described above – 20 clock periods)

ACK length [µs] = 1/MA frequency * ACK length

Example:

ACK length [µs] = 1/3 MHz × 20 = **6.7 µs**. The 6.7 µs is a value that must be set in the controller under the ACK timing or calculation time. This tells the controller how much time the encoder is given to latch, calculate and start transission of the position. If this value is not set correctly, the controller will not be synchronised with the encoder's BiSS C and the CRC will fail.

Error and warning handling

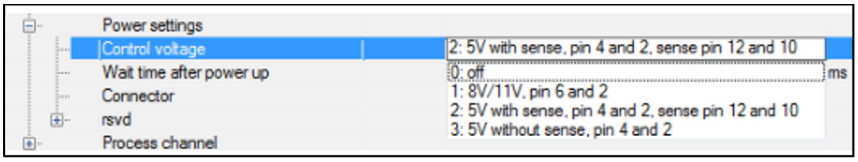
Most absolute encoder systems are able to report the status of the position in the form of error and warning bits. The status bits tell the controller whether the reported position is valid. The cause of an invalid position is, for example, incorrect alignment, demagnetisation of the magnetic scale, encoder failure, etc.

Setting up the error and warning bits in the controller is essential to ensure safety and correct installation.

Power supply for the encoder (valid for LA11 system)

The power supply of the 5V version of the LA11 must be compensated for longer cables. It is essential that the read head is supplied with sufficient voltage in order to work correctly. The LA11 read head has sense lines that allow the controller to automatically recognise the voltage drop. The sense lines are 2 parallel lines that run along the main power supply lines and, if not connected and isolated, can cause a short circuit and irreversible damage to the encoder system. The sense lines have a slightly lower voltage potential (reduced by the voltage drop across the cable), so it is essential to connect them correctly or to insulate them.

An example from the Beckhoff interface for setting up the controller. The LA11 has an option with the sense lines.



Typical encoder settings for most common controllers

Beckhoff AX5206

The controller data can be found here: **Beckhoff-BiSS information**

- Encoder system: LA11DCA2D0KA50DD00
- BiSS-C interface
- Resolution: 1 µm (250 nm when 2 always zero bits are taken into account)

Initial encoder settings in the Beckhoff controller

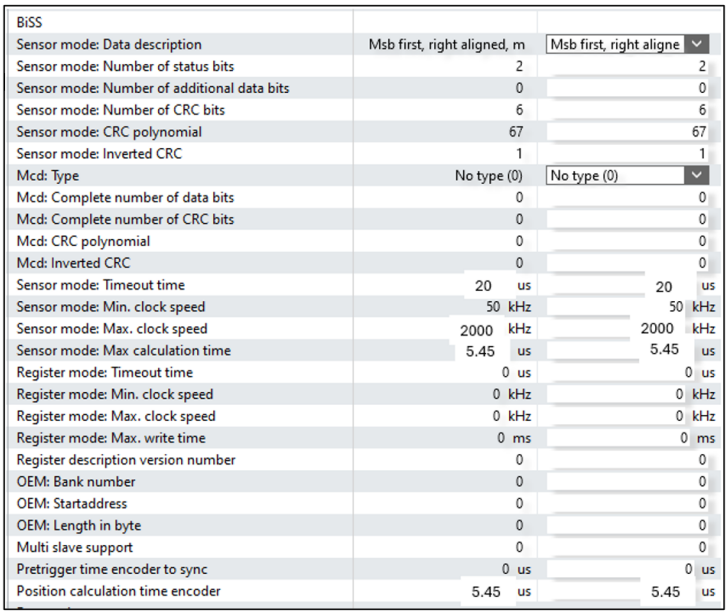
- Parameter interface ⟶ 5; (for BiSS C encoders)
- Bit resolution single turn position ⟶ 26
- Bit resolution multiturn position ⟶ 0
- Number of clock cycles to get a single turn position or absolute position ⟶ 0
- LinearResolutionAboutDigitalInterface_Numerator_nm ⟶ 250 nm

BiS-C mode settings:

- Sensor mode: Data description

Value	Description
0	MSB first, left aligned, multiposition-singleposition-status-crc-mcd
1	MSB first, right aligned, multiposition-singleposition-status-crc-mcd

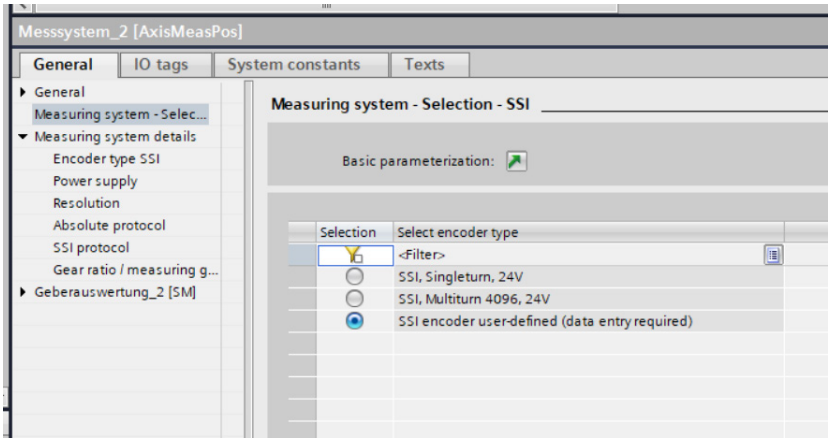
- Sensor mode: Number of status bits ⟶ 2
- Sensor mode: Number of additional data bits ⟶ 0
- Sensor mode: Number of CRC bits ⟶ 67 (decimal); 43 (hexadecimal)
- Sensor mode: Number of CRC polynomials ⟶ 6
- Sensor mode: Inverted CRC ⟶ 1
- Mcd: Not supported by the LA11 system hence the values associated with the Mcd mode are irrelevant and set to zero
- Sensor mode: timeout time in µs ⟶ 20 µs
- Sensor mode: Min clock speed in kHz ⟶ 50
- Sensor mode: Max clock speed in kHz ⟶ 2200; (LA11DCA)
- Sensor mode: Max calculation time in µs ⟶ 5.45 µs; (12 ACK bits, max clock freq. 2200 kHz)
- Register mode: The LA11 system doesn't have access to the register mode hence, the values associated with register mode are set to zero.
- Position calculation time encoder in µs⟶5.45 µs; (12 ACK bits, max clock freq. 2200 kHz)



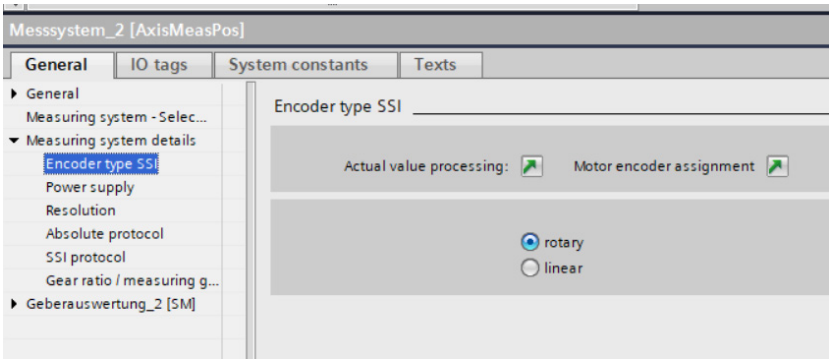
BiSS		
Sensor mode: Data description	Msb first, right aligned, m	Msb first, right aligne
Sensor mode: Number of status bits	2	2
Sensor mode: Number of additional data bits	0	0
Sensor mode: Number of CRC bits	6	6
Sensor mode: CRC polynomial	67	67
Sensor mode: Inverted CRC	1	1
Mcd: Type	No type (0)	No type (0)
Mcd: Complete number of data bits	0	0
Mcd: Complete number of CRC bits	0	0
Mcd: CRC polynomial	0	0
Mcd: Inverted CRC	0	0
Sensor mode: Timeout time	20 us	20 us
Sensor mode: Min. clock speed	50 kHz	50 kHz
Sensor mode: Max. clock speed	2000 kHz	2000 kHz
Sensor mode: Max calculation time	5.45 us	5.45 us
Register mode: Timeout time	0 us	0 us
Register mode: Min. clock speed	0 kHz	0 kHz
Register mode: Max. clock speed	0 kHz	0 kHz
Register mode: Max. write time	0 ms	0 ms
Register description version number	0	0
OEM: Bank number	0	0
OEM: Startaddress	0	0
OEM: Length in byte	0	0
Multi slave support	0	0
Pretrigger time encoder to sync	0 us	0 us
Position calculation time encoder	5.45 us	5.45 us

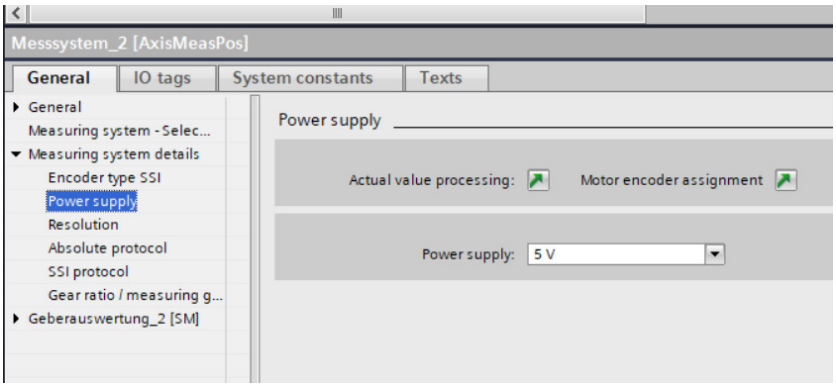
Siemens Sinamics S120 + SME25 module

- Encoder system: HR162SC0IBAAS10DW00
- SSI interface
- Resolution: 512,000 CPR

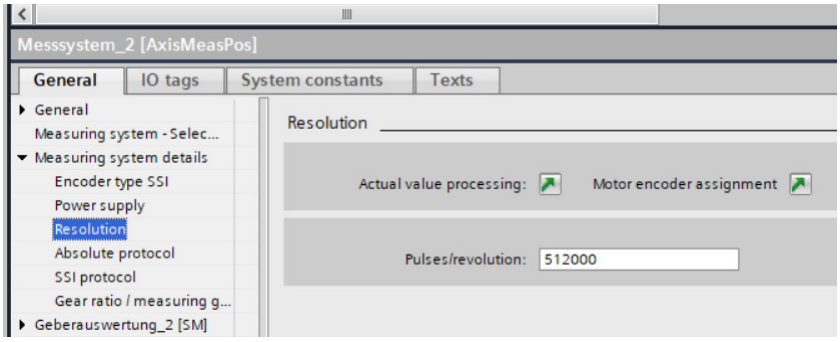


The commisioning will be manual due to specifics in the protocol.



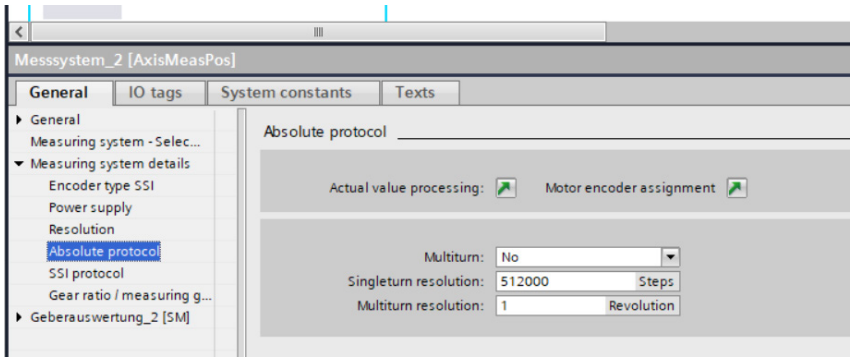


Power supply can be set from 5 to 30 V. Consider a voltage drop over cable. It is recommended to use higher voltages for better EMC imunity and for voltage compensation when longer cable is used.

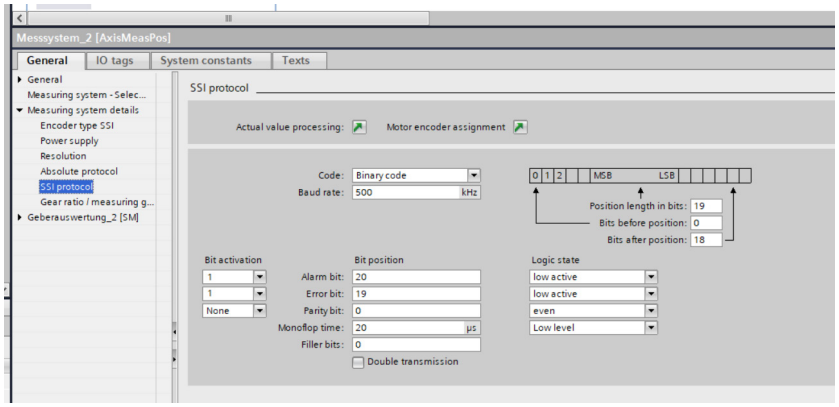


Set the resolution of the encoder system. The resolution is defined with the PN HR162SC0IBAAS10DW00. The data about the resolution can be found in the DRD01 datasheet (Table of available resolutions (DHR readhead with SAR rings). From the same table we can observe the lenght of the position field - in our case 19 bits. This setting will be used in the last setting window.

Readhead	Ring size OD	Pole number	CPR (bits)	Position data length	Resolution PN
DHR	162	256	4,194,304 (22)	22	22B
			2,097,152 (21)	21	21B
			1,048,576 (20)	20	20B
			524,288 (19)	19	19B
			512,000	19	0IB



The encoder configuration does not specify a multiturn counter, hence there a multiturn resolution set to 1.
Singleturn resolution is based on the Siemens configuration the same as the resolution of the encoder - in our case 512,000 CPR.



Based on the structure of the SSI protocol on the DHR162 readhead, the configuration is as above.

The clock frequency is max 500 KHz.
The Position lenght (as described above under setting window 4) is 19 bits, followed by 1 error and 1 warning bit. There is no parity bit present, hence set to “none”.
Bits after position is set to 18 - 1 error, 1 warning and 16 bits of detailed status. The detailed status field is not used in the Siemens configuration.

Logic states of the error and warning bits are - Active low. The monoflop time is 20 us and the line is kept in a low state.

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Issue	Date	Page	Description
1	2. 4. 2025	-	New document