

BiSS® Safety for RESOLUTE™ and FORTiS™ encoders



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About Renishaw encoders with BiSS® interface

- RESOLUTE rotary encoders are single-turn (with 2ⁿ counts per revolution and no revolution counting).
- RESOLUTE and FORTiS linear encoders are available with a range of different resolutions (and maximum measuring lengths) as specified on the product data sheet.

Description of the BiSS Safety interface

BiSS Safety is a fast synchronous serial interface for acquiring position data from an encoder in applications requiring Functional Safety. RESOLUTE FS and FORTiS FS use BiSS Safety communications and are certified to the following Functional Safety standards:

- ISO 13849 Category 3 PLd
- IEC 61508 SIL2
- IEC 61800-5-2 SIL2

BiSS Safety is a master-slave interface. The master controls the timing of position acquisition and the data transmission speed, and the encoder is the slave. The interface consists of two unidirectional differential pairs of lines:

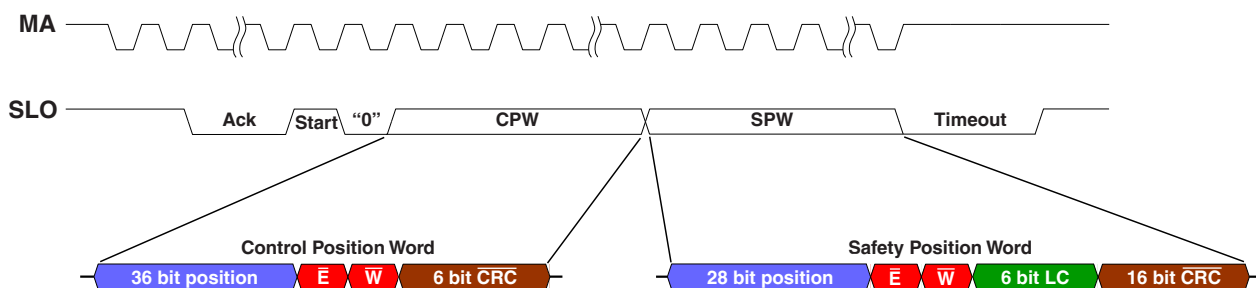
- MA transmits position acquisition requests and timing information (clock) from master to encoder.
- SLO transfers position data from encoder to master, synchronised to MA.

The diagram below shows the data transmitted.

The master-slave signal communication format is RS485/RS422 differential line-driven.

Data format

Example shown for 36 bit control position word (CPW):



A typical request cycle proceeds as follows:

1. When idle, the master holds MA high. The encoder indicates it is ready by holding SLO high.
2. The master requests position acquisition by starting to transmit clock pulses on MA.
3. The encoder responds by setting SLO low on the second rising edge on MA.
4. After the Ack period is complete, the encoder transmits data to the master synchronised with the clock as shown on page 2.
5. When all data has been transferred, the master stops the clock and sets MA high.
6. If the encoder is not yet ready for the next request cycle, it sets SLO low (the Timeout period).
7. When the encoder is ready for the next request cycle, it indicates this to the master by setting SLO high.

Description of data

Ack

This is the period during which the readhead calculates the absolute position. See the timing information table on page 5.

Start and “0” (1 bit each)

The encoder transmits the start bit to signal to the master that it is starting to transmit data. The start bit is always high and the “0” bit is always low.

Control position word (CPW)

The control position word (CPW) is used for motor control, has high resolution and is protected against transmission errors with a standard 6 bit CRC (HD = 3). The control position word comprises:

- **Position (28, 32 or 36 bits)**

The absolute position data is sent MSB first in binary format. For linear encoders, the LSB is equivalent to one unit of resolution of the encoder, as specified in the data sheet. Lower resolutions may be achieved by ignoring the least significant bit(s) of the position data.

- **Error (1 bit)**

The error bit is active low: “1” indicates that the transmitted position information has been verified by the readhead’s internal safety checking algorithm and is correct; “0” indicates that the internal check has failed and the position information should not be trusted. The error bit is also set to “0” if the temperature exceeds the maximum specified for the product. The operating temperature limits of Renishaw encoders are specified in the product data sheets.

- **Warning (1 bit)**

The warning bit is active low: “0” indicates that the encoder scale (and/or reading window) should be cleaned.

NOTE: The warning bit is not an indication of the trustworthiness of the position data. Only the error bit should be used for this purpose.

- **CRC for position data (6 bit)**

The CRC polynomial for position, error and warning data is: 0x43. The CRC start value is 0x00. It is transmitted MSB first and inverted. The start bit and “0” bit are omitted from the CRC calculation.

Safety position word (SPW)

The safety position word (SPW) is strongly protected with a safety capable 16 bit CRC (HD = 6). The SPW brings an additional integrated 6 bit sign-of-life counter to detect missing or reordered position values. The SPW may have lower resolution than the control word. The purpose of the SPW is to ensure the validity of the control word. The safety position word comprises:

- **Position (24, 28 or 32 bits)**

The absolute position data is sent MSB first in binary format. The position data in SPW in linear applications is shorter than the position data in CPW, so the resolution of the SPW is also lower (for 28 bit CPW and 24 bit SPW, it is 16 times lower; for 36 bit CPW and 28 bit SPW, it is 256 times lower).

- **Error (1 bit)**

The error bit is active low: “1” indicates that the transmitted position information has been verified by the readhead’s internal safety checking algorithm and is correct; “0” indicates that the internal check has failed and the position information should not be trusted. The error bit is also set to “0” if the temperature exceeds the maximum specified for the product. The operating temperature limits of Renishaw encoders are specified in the product data sheets.

- **Warning (1 bit)**

The warning bit is active low: “0” indicates that the encoder scale (and/or reading window) should be cleaned.

NOTE: The warning bit is not an indication of the trustworthiness of the position data. Only the error bit should be used for this purpose.

- **LC Sign-of-Life (6 bit)**

The sign-of-life counter represents a uniquely consecutive number within 63 SCD frames. The sign-of-life counter with its consecutive number can be used to detect unwanted repetition, wrong sequencing, loss and insertion.

- **CRC for position data (16 bit)**

The SPW CRC polynomial is: 0x190D9. The CRC start value is 0x00. It is transmitted MSB first and inverted.

Encoder type	BiSS Safety configuration type ¹	Control position word (CPW)				Safety position word (SPW)			
		Resolution of position	Number of position bits	CRC length	CRC polynomial	Resolution of position	Number of position bits	CRC length	CRC polynomial
RESOLUTE rotary	LMM	0.0003 arc seconds	32	6 bits	0x43	0.0003 arc seconds	32	16 bits	0x190D9
RESOLUTE linear	RSM	50 nm	28	6 bits	0x43	800 nm	24	16 bits	0x190D9
RESOLUTE linear	RSH	1 nm	36	6 bits	0x43	256 nm	28	16 bits	0x190D9
FORTiS linear	RSH	10 nm	36	6 bits	0x43	2560 nm	28	16 bits	0x190D9
FORTiS linear	RSH	1 nm	36	6 bits	0x43	256 nm	28	16 bits	0x190D9

¹ BiSS Safety configuration types are defined in the BiSS Safety concept document from iC-Haus.

Timeout

RESOLUTE and FORTiS encoders are capable of acquiring a new position reading every 31.25 µs (a maximum request cycle rate of 32 kHz). Therefore 31.25 µs must elapse between the start of one request cycle and the start of the next. However, it is possible for data transmission to be complete before 31.25 µs have elapsed. In this case, the encoder signals this to the master by holding the SLO line low until 31.25 µs have elapsed. This is the timeout period.

Line-delay compensation

Signals travelling between master and encoder experience a time delay due to the cable length and signal propagation delays within the master and encoder. The time delay has no effect at low clock speeds (where the time delay is much shorter than the clock period). However, for high clock speeds, it is necessary for the master to implement line-delay compensation.

The master determines the round-trip time delay by measuring the time between transmitting the second rising edge on MA and receiving the falling edge of Ack on SLO.

MA clock speed	Maximum cable length	
	Without line-delay compensation	With line-delay compensation
250 kHz	95 m	100 m
1 MHz	20 m	100 m
2 MHz	8 m	100 m
5 MHz	0.5 m	100 m
10 MHz	-	50 m

NOTES: All figures relate to installations using original Renishaw readhead and extension cables. See the relevant product data sheet for details of options and limitations.

Care should be taken to ensure supply voltage is maintained within 5 V \pm 10% at the readhead connector.

Great care should be taken with cables to ensure signal integrity. For cable lengths greater than 50 m, contact Renishaw for recommendations.

This table makes no allowance for propagation delays within the master.

Timing information

	Minimum	Typical	Maximum	Units	Notes
Ack time	-	-	16	μ s	The Ack period always ends on a rising edge of MA. Therefore at low MA clock frequencies, the Ack time may exceed 16 μ s.
MA clock frequency	0.25	-	10	MHz	Within any one request cycle, the MA clock frequency must be constant. The duty cycle should be 1:1.
Request cycle rate	-	-	32	kHz	32 kHz is not achievable for all MA clock frequencies (because data transmission takes too long).
Sampling moment	3.225	3.250	3.275	μ s	Timed from the first rising edge on MA.
RESOLUTE/FORTiS internal line-delay	-	-	42.5	ns	This is the internal propagation delay (MA-SLO) within RESOLUTE/FORTiS encoders.
Line-delay due to cable length	-	10	-	ns/m	This is the round-trip delay experienced by signal travelling through the cable (that is, from master to encoder and back to master again).

For information on the actions required for safe integration of the RESOLUTE or FORTiS Functional Safety encoder with BiSS Safety into a functionally safe system, refer to the product installation guide and safety manual.

IMPORTANT: Failure to follow the correct use instructions and heed the limitations may result in SIL2 and/or PLd not being achieved and will invalidate the Functional Safety certification.

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