

# LA11 absolute magnetic encoder system



**LA11 is an absolute magnetic linear encoder system designed for motion control applications as a position and velocity control loop element.**

**The encoder system is highly reliable due to contactless absolute measuring principle, built-in safety algorithms and high quality materials/components used.**

The measuring standard is a magnetic scale which consists of a stainless steel substrate with an elasto-ferrite layer. The elasto-ferrite layer is magnetised with two tracks. The incremental track is magnetised with 2 mm long (alternating south and north) poles and the absolute track is magnetised with a pseudo random binary sequence (PRBS) absolute code with 13 bit length.

The elasto-ferrite layer is immune to chemicals commonly found in industrial environment.

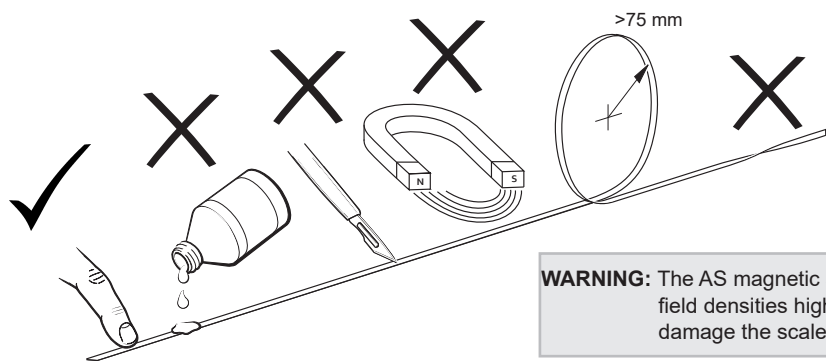
The readhead includes Hall sensor arrays for PRBS track reading, an AMR sensor for incremental track reading, interpolation electronics and custom logic circuitry. The data from the Hall arrays and interpolator are processed in the internal MCU using special algorithms to determine the absolute position.

The electronics design provides short response and recovery times.

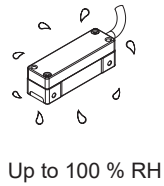
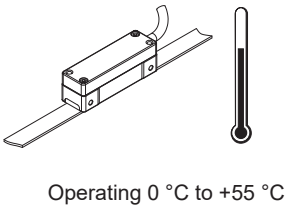
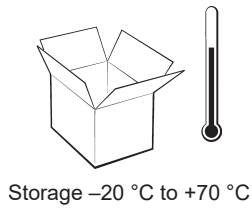
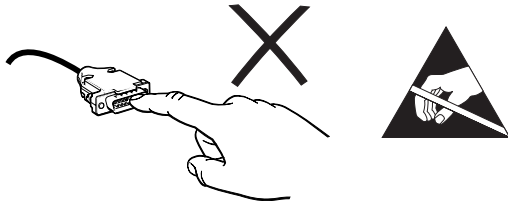
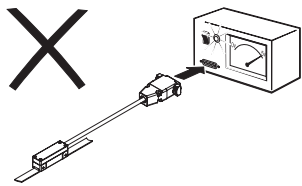
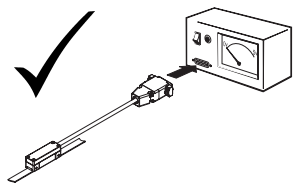
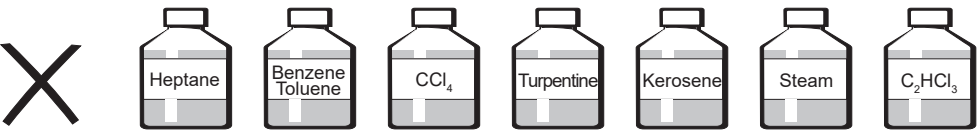
Diagnostic information is available through a serial communication channel and status LED.

- True absolute system
- Suitable for highly dynamic control loops
- Small footprint
- High accuracy
- Resolutions up to 0.244  $\mu\text{m}$
- Axis lengths up to 16.3 m
- Speeds up to 7 m/s at 0.976  $\mu\text{m}$  resolution
- Integral status LED
- Synchronous (SSI, SPI, BiSS) communication protocols available
- Parallel incremental output (analogue  $\sim$  or digital  $\square$ )
- Double shielded, drag-chain compatible cable
- Simple and fast installation
- Robust measuring principle
- Excellent degree of protection to IP68

Storage and handling

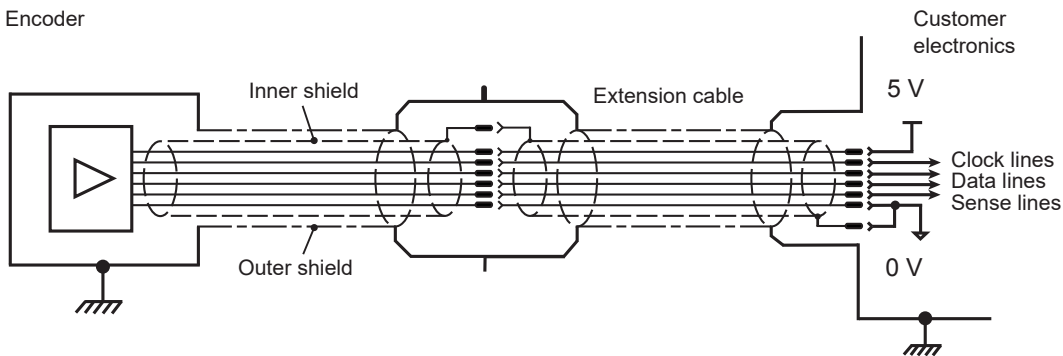


**WARNING:** The AS magnetic scale should not be exposed to magnetic field densities higher than 50 mT on its surface, as it can damage the scale.



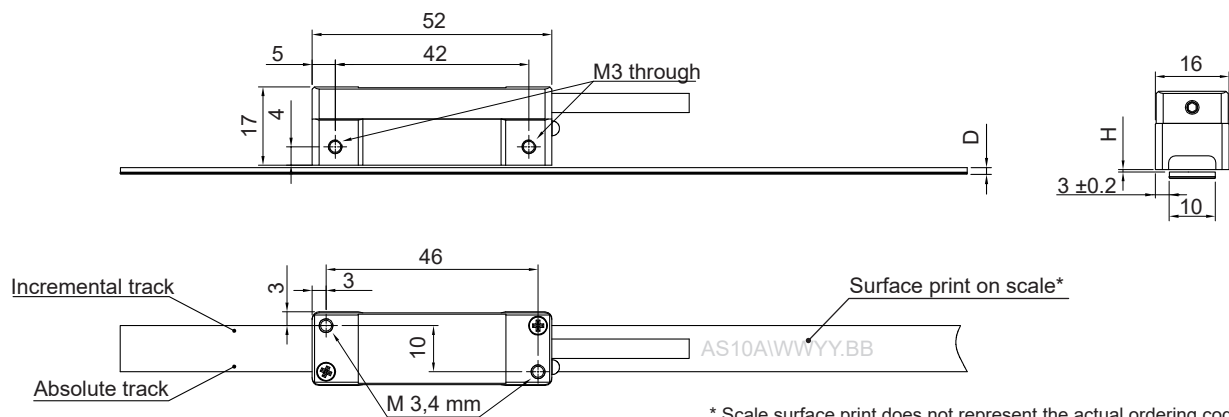
## Shield connection

Encoder



## Dimensions

Dimensions and tolerance in mm.

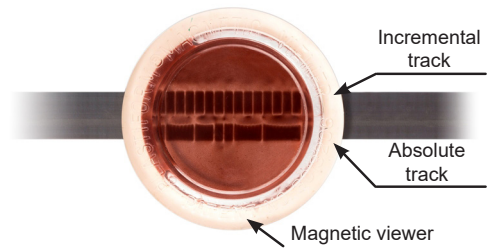


\* Scale surface print does not represent the actual ordering code.  
For orientation purpose only.

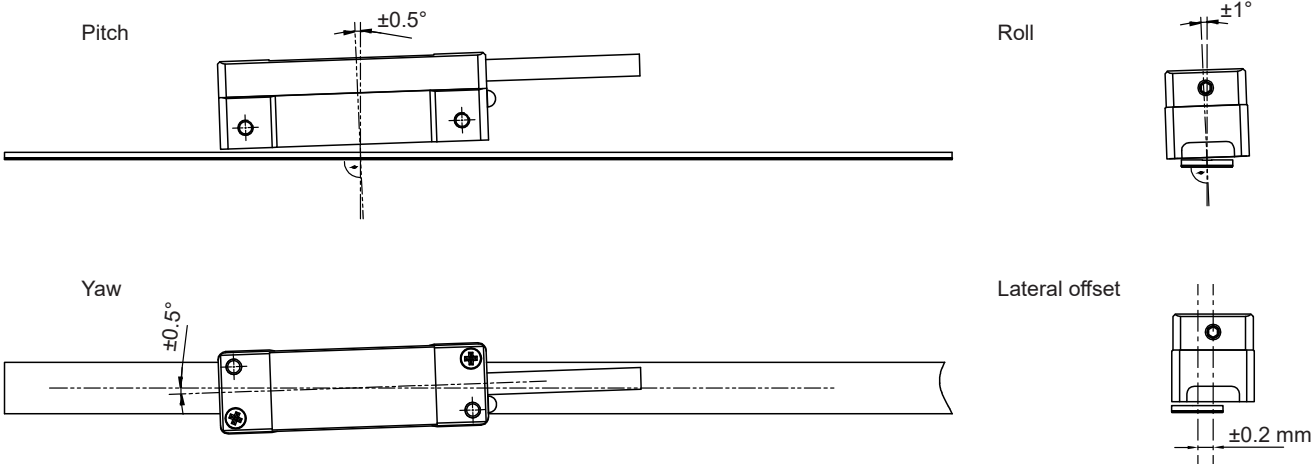
	Magnetic scale thickness (D)	Ride height (H)
With back-adhesion tape	1.5 ± 0.15	0.1–0.6
With back-adhesion tape, with cover foil	1.6 ± 0.15	0.1–0.5
No back-adhesion tape	1.3 ± 0.15	0.1–0.6
No back-adhesion tape, with cover foil	1.4 ± 0.15	0.1–0.5
No back-adhesion tape, sides prepared for track system	1.3 ± 0.15	0.1–0.4
No back-adhesion tape, sides prepared for track system, with cover foil	1.4 ± 0.15	0.1–0.3

Readhead orientation

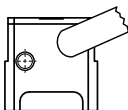
Orientation of the readhead relative to AS10 magnetic scale should be according to the dimensions drawing on page 3. For reference use the surface print on AS scale or magnet viewer (see image on the right).



Installation tolerances



Status LEDs




LED	Communication	Status
Green	Yes	Valid position data
Green flashing	No	Valid position data
Orange	Yes	Valid position data, >80 % of max. temperature
Orange flashing	No	Valid position data, >80 % of max. temperature
Red	Yes	Invalid position data
Red flashing	No	Invalid position data

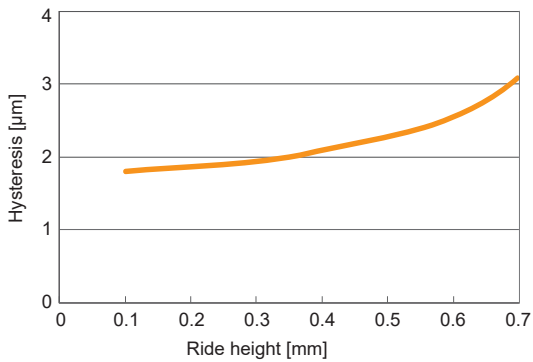
By special request the status LEDs can be turned off. Please contact [sales@rls.si](mailto:sales@rls.si).

For readheads with BiSS communication interface:  
When there is no communication between controller and encoder the alarm status on LED is not updated, with the exception of temperature alarm. LED shows the alarm status of the last communication request.

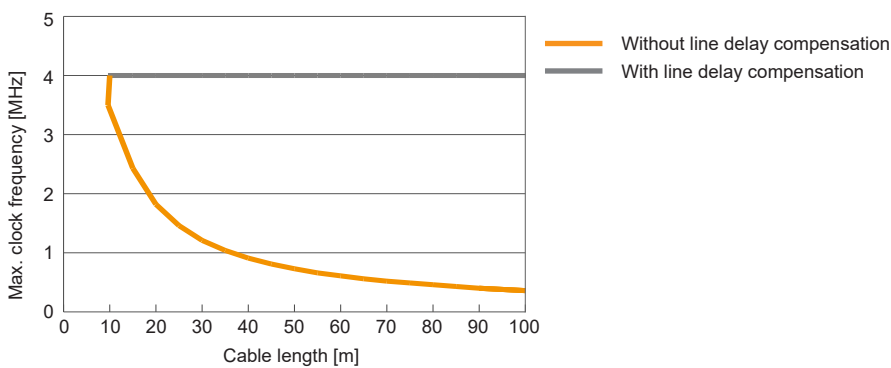
## Technical specifications

System data											
Maximum length for AS scale			16.3 m								
Incremental pole length			2 mm								
Maximum speed for parallel incremental signals											
Ordering code	Resolution (µm)	Interpolation factor	Maximum speed (m/s)								
13B	~0.244	8,192	1.82	0.91	0.23	0.11	0.06	0.03	0.02	0.01	0.01
12B	~0.488	4,096	3.65	1.82	0.46	0.23	0.12	0.06	0.05	0.02	0.01
11B	~0.976	2,048	7	3.65	0.91	0.46	0.24	0.12	0.10	0.05	0.02
2D0	1	2,000	7	3.73	0.93	0.47	0.24	0.12	0.10	0.05	0.02
10B	~1.953	1,024	7	7	1.82	0.91	0.48	0.24	0.19	0.10	0.05
09B	~3.906	512	7	7	3.65	1.82	0.95	0.49	0.38	0.19	0.10
08B	~7.812	256	7	7	7	3.65	1.90	0.97	0.77	0.39	0.19
07B	15.625	128	7	7	7	7	3.81	1.94	1.53	0.77	0.39
06B	31.25	64	7	7	7	7	7	3.89	3.07	1.55	0.78
05B	62.5	32	7	7	7	7	7	7	6.14	3.10	1.56
04B	125	16	7	7	7	7	7	7	7	6.19	3.11
Edge separation (µs)			0.07	0.12	0.50	1	2	4	5	10	20
Maximum count frequency (MHz)			15	8	2	1	0.50	0.25	0.20	0.10	0.05
Ordering code			K	A	B	C	D	E	F	G	H
System accuracy			±40 µm/m								
Short range accuracy			<±10 µm/10 mm (see diagram 9)								
Coefficient of thermal expansion (CTE)			17 ± 1 µm/(m K)								
Repeatability			Unit of resolution								
Hysteresis			<2 µm at 0.1 mm ride height (see diagram 1)								
Electrical data											
Power supply			Option A: From 4.75 V to 5.75 V - Voltage on readhead, consider voltage drop over cable (see diagrams 3, 4, 5, 6 ) Option B: From 8 V to 30 V (see diagram 7)								
Reverse polarity protection			For option A only								
Set-up time after switch-on			<350 ms								
Power consumption (without load)			Option A: < 150 mA at 5 V power supply Option B: see diagram 7								
Voltage drop over cable			~80 mV/m (without load)								
Mechanical data											
Mass			Readhead (with 1 m cable, no connector) 41 g, magnetic scale 60 g/m								
Environmental data											
Temperature			Operating 0 °C to +55 °C Storage -20 °C to +70 °C								
Vibrations (55 Hz to 2000 Hz)			300 m/s² (IEC 60068-2-6)								
Shocks (11 ms)			300 m/s² (IEC 60068-2-27)								
Humidity			100 % (condensation permitted)								
EMC Immunity			IEC 61000-6-2 (particularly: ESD: IEC 61000-4-2; EM fields: IEC 61000-4-3; Burst: IEC 61000-4-4; Surge: IEC 61000-4-5; Conducted disturbances: IEC 61000-4-6; Power frequency magnetic fields: IEC 61000-4-8; Pulse magnetic fields: IEC 61000-4-9)								
EMC Emission			IEC 61000-6-4 (for industrial, scientific and medical equipment: IEC 55011)								
Environmental sealing			Readhead only: IP68 (according to IEC 60529)								

**Diagram 1:** Hysteresis vs. ride height

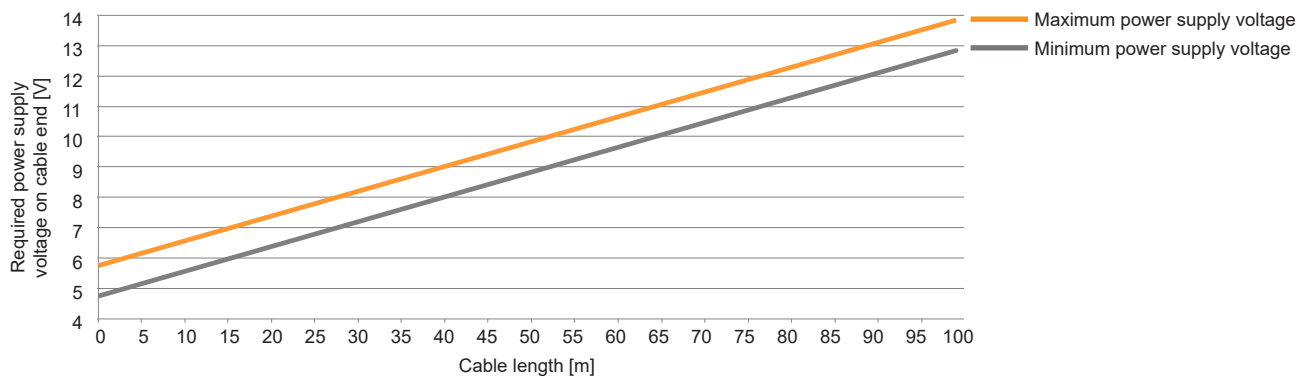


**Diagram 2:** Maximum clock frequency vs. cable length

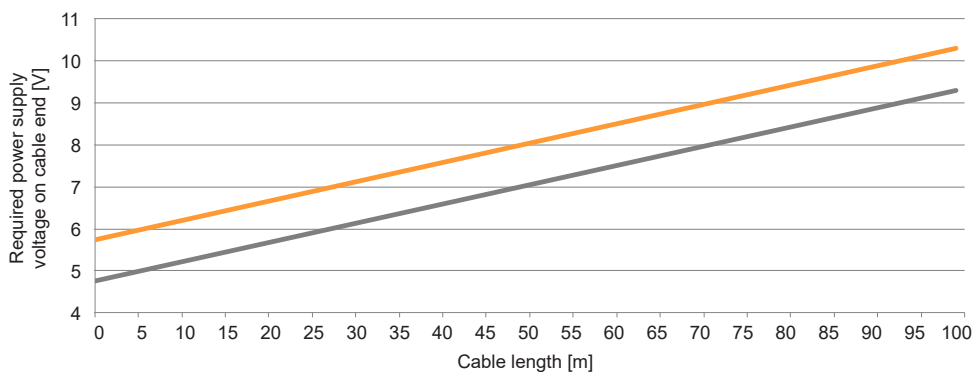


## Required power supply voltage on cable end vs. overall cable length

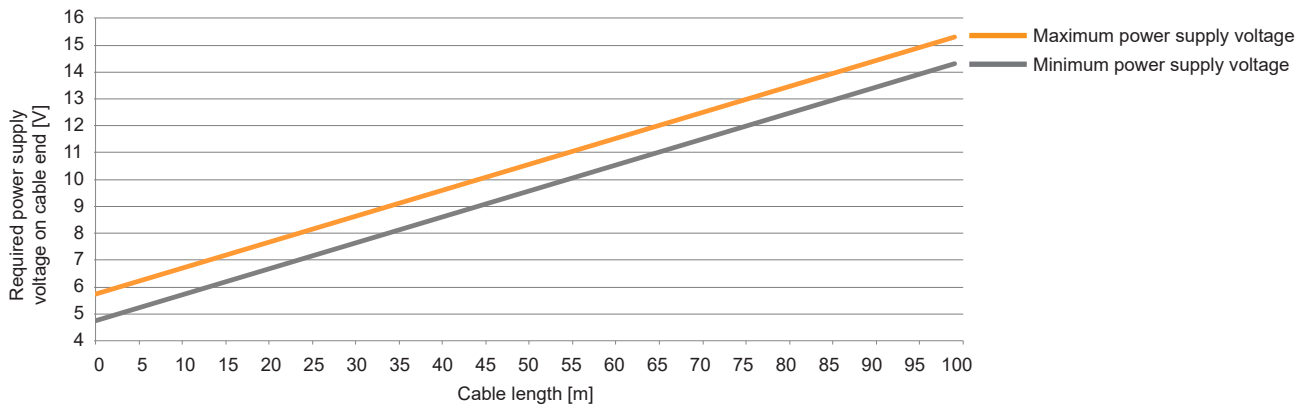
**Diagram 3:** for DC, SC, SP (with 150 Ω termination)



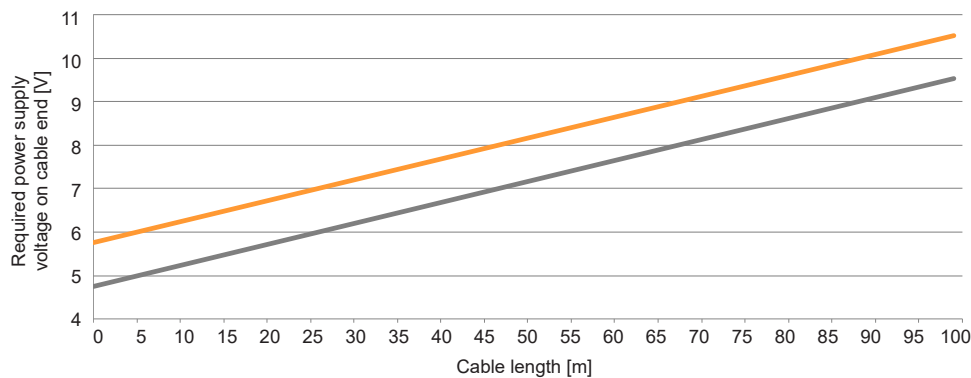
**Diagram 4:** for DC, SC, SP (with 150 Ω termination) with sense lines connected parallel to power supply lines



**Diagram 5:** for DA, DI, SB, SI, SQ, SR (with 150  $\Omega$  termination)



**Diagram 6:** for DA, DI, SB, SI, SQ, SR (with 150  $\Omega$  termination) with sense lines connected parallel to power supply lines



## Current consumption vs. voltage on cable end

**Diagram 7:** Current consumption vs. voltage on cable end (power supply 8 V to 30 V, option B)

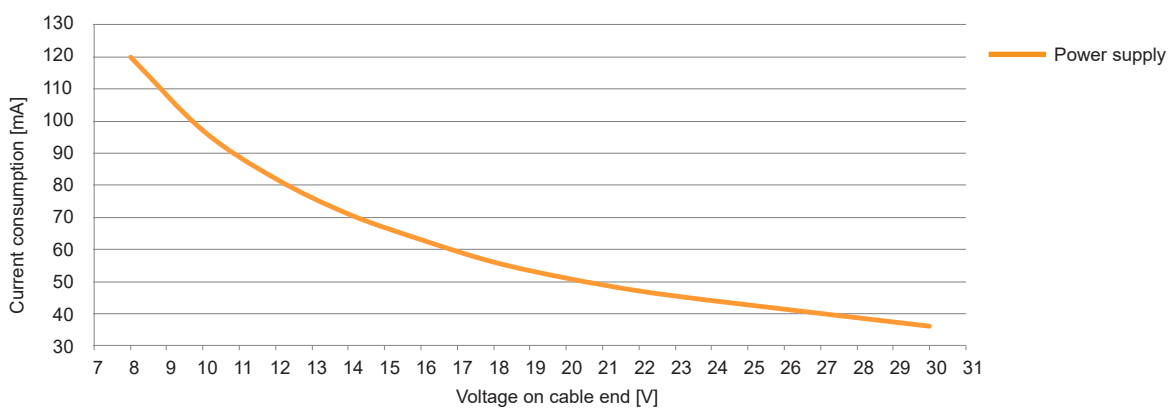


Diagram 8: Short range accuracy vs. ride height-lateral offset (LO) as a parameter - typical

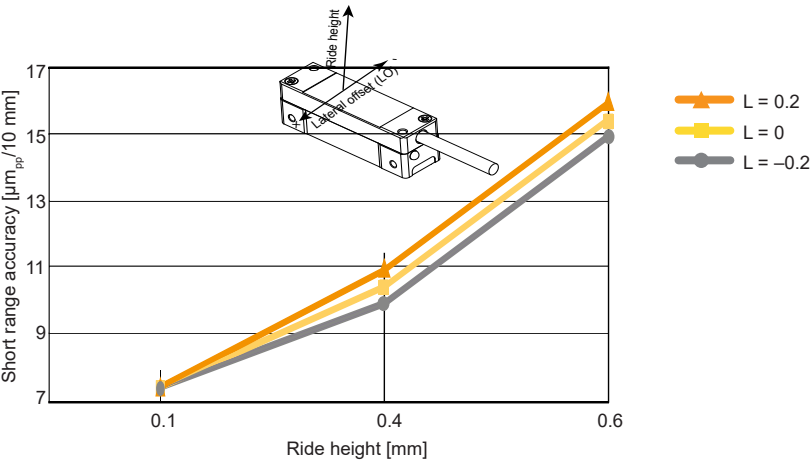
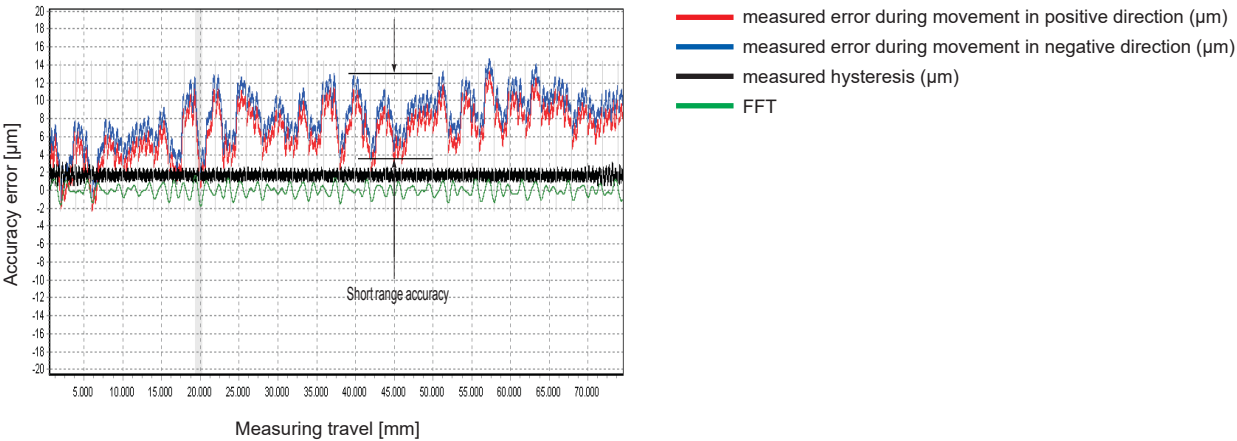


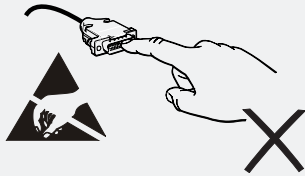
Diagram 9: Definition of short range accuracy



## Electrical connections

### Cable specifications

<b>Cable type</b>	PUR high flexible cable, drag-chain compatible, double-shielded	
<b>Number of wires</b>	8	12
<b>Communication interface</b>	DC, SC, SP	DA, DI, SB, SI, SQ, SR
<b>Outer diameter</b>	4.2 mm $\pm$ 0.2 mm	4.5 mm $\pm$ 0.2 mm
<b>Jacket material</b>	Extruded polyurethane (PUR)	
<b>White wire</b>	0.14 mm <sup>2</sup> , 26 AWG, 0.13 $\Omega$ /m	0.08 mm <sup>2</sup> , 28 AWG, 0.23 $\Omega$ /m
<b>Other wires</b>	0.05 mm <sup>2</sup> , 30 AWG, 0.35 $\Omega$ /m	
<b>Durability</b>	20 million cycles at 25 mm bend radius	20 million cycles at 50 mm bend radius
<b>Weight</b>	34 g/m nominal	38 g/m nominal
<b>Bend (internal) radius</b>	Dynamic 25 mm, static 10 mm	Dynamic 50 mm, static 10 mm

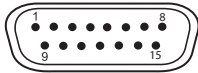


#### WARNING!

##### ESD protection

Readhead is ESD sensitive - handle with care. Do not touch wires or connector pins without proper ESD protection or outside of ESD controlled environment.

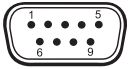
### 15 pin D type plug



Pin	Wire colour (for SC, DC, SP)	Wire colour	BiSS	SSI	SPI
Case	Outer shield	Outer shield	Encoder/machine case (Earth connection)	Encoder/machine case (Earth connection)	Encoder/machine case (Earth connection)
1	Inner shield				
2	White	White	0 V (GND) supply		
3	Green	Green	MA+	Clock+	Clock
4	Yellow	Yellow	MA-	Clock-	CS (chip select)
5	-	Purple	Sin+ / A+		
6	-	Grey	Cos+ / B+		
7	Brown	Brown	+Vin supply		
8	Grey	Orange	+Vin sense		
9	-	-	-	-	-
10	-	Black	Sin- / A-		
11	-	Pink	Cos- / B-		
12	-	-	-	-	-
13	Blue	Blue	SLO+	Data+	MISO (data)
14	Red	Red	SLO-	Data-	-
15	Pink	Transparent	0 V (GND) sense		

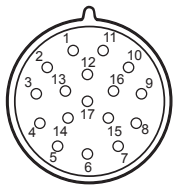
Data sheet  
**LA11D01\_09**

**9 pin D type plug**



Pin	Wire colour	BiSS	SSI	SPI
Case	Outer shield	Encoder/machine case (Earth connection)	Encoder/machine case (Earth connection)	Encoder/machine case (Earth connection)
1	Inner shield			
2	Green	MA+	Clock+	Clock
3	Yellow	MA–	Clock–	CS (chip select)
4	Grey	+Vin sense		
5	Brown	+Vin supply		
6	Blue	SLO+	DATA +	MISO
7	Red	SLO–	DATA –	-
8	Pink	0 V (GND) sense		
9	White	0 V (GND) supply		

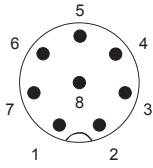
**Siemens 6FX2003-0SA17**



Pin	Wire colour	SSI + analogue sinusoidal
1	Brown	+Vin supply
2	-	-
3	-	-
4	White	0 V (GND) supply
5	-	-
6	-	-
7	-	-
8	Green	Clock+
9	Yellow	Clock–
10	-	-
11	Outer shield	Encoder/machine case (Earth connection)
12	Grey	B (Cos+)
13	Pink	B* (Cos–)
14	Blue	Data+
15	Purple	A (Sin+)
16	Black	A* (Sin–)
17	Red	Data–

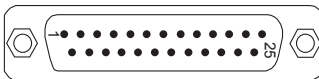
**NOTE:** If controller does not support voltage sense functionality, we recommend connecting sense lines parallel to power supply lines in order to decrease voltage drop over cable. If sense lines are not used and/or connected, they should be isolated in order to prevent possible shorts between power supply lines.

## Phoenix contact M12 8 pole



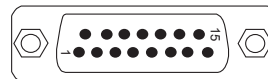
Pin	Wire colour	BiSS	SSI	SPI
Case	Outer shield	Encoder/machine case (Earth connection)	Encoder/machine case (Earth connection)	Encoder/machine case (Earth connection)
1	White	0 V (GND) supply	0 V (GND) supply	0 V (GND) supply
2	Brown	+Vin supply	+Vin supply	+Vin supply
3	Blue	SLO+	Data+	MISO
4	Red	SLO-	Data -	-
5	-	-	-	-
6	Yellow	MA-	Clock -	CS
7	Green	MA+	Clock+	CLOCK
8	-	-	-	-

## Siemens SMC20



Pin	Wire colour	SSI +
Case	Outer shield	Outer shield
1	Brown	P encoder
2	White	M encoder
3	Purple	A (Sin+)
4	Black	A- (Sin-)
5	Inner shield	Ground
6	Grey	B (Cos+)
7	Pink	B- (Cos-)
8	-	-
9	-	-
10	Green	Clock
11	-	-
12	Yellow	Clock-
13	-	-
14	Orange	P Sense
15	Blue	Data
16	Transparent	M sense
17	-	-
18	-	-
19	-	-
20	-	-
21	-	-
22	-	-
23	Red	Data-
23	-	-
25	-	-

## Siemens SMC30



Pin	Wire colour	SSI + analogue sinusoidal
Case	Outer shield	Outer shield
1	-	-
2	Green	Clock
3	Yellow	Clock-
4	Brown	P encoder 5 V / 24 V
5	-	-
6	Grey	P sense
7	White	M encoder
8	-	-
9	Pink	M sense
10	-	-
11	-	-
12	-	-
13	-	-
14	Red	Data-
15	Blue	Data

## Communication interfaces

SSI	
Maximum clock frequency	0.8 MHz standard 2.5 MHz with Delay First Clock option on the controller
Read repetition rate	15 kHz 30 kHz with Delay First Clock option on the controller
Resolution	See table below
Refresh rate*	100 kHz
Timeout (monoflop time)	10 µs
BiSS-C	
Maximum clock frequency	2.2 MHz or 3.5 MHz
Read repetition rate (3.5 MHz)	27 kHz
Resolution	See table below
Latency	7.5 µs
Timeout (monoflop time)	20 µs
SPI slave	
Maximum clock frequency	4 MHz
Read repetition rate	90 kHz
Resolution	See table below
Refresh rate*	100 kHz
Timeout (monoflop time)	10 µs

\* The position is captured internally every 10 µs (for SSI and SPI only).

## Available resolutions

Resolution
13B - $2/2^{13}$ mm (0.244140625 µm)
12B - $2/2^{12}$ mm (0.48828125 µm)
11B - $2/2^{11}$ mm (0.9765625 µm)
2D0 - 2/2000 mm (1 µm)
10B - $2/2^{10}$ mm (1.953125 µm)
09B - $2/2^9$ mm (3.90625 µm)
08B - $2/2^8$ mm (7.812 µm)
07B - $2/2^7$ mm (15.625 µm)
06B - $2/2^6$ mm (31.25 µm)
05B - $2/2^5$ mm (62.5 µm)
04B - $2/2^4$ mm (125 µm)

## Communication interface options

Parallel incremental signals	SSI	BiSS	SPI
None	SC	DC	SP
Incremental AB, RS422; 5 V	SI	DI	SQ
Analogue voltage 1 V <sub>pp</sub>	SB	DA	SR

LA11 always reports the position data in 26 bit binary format. Table below shows the bit values in position data for different resolutions:

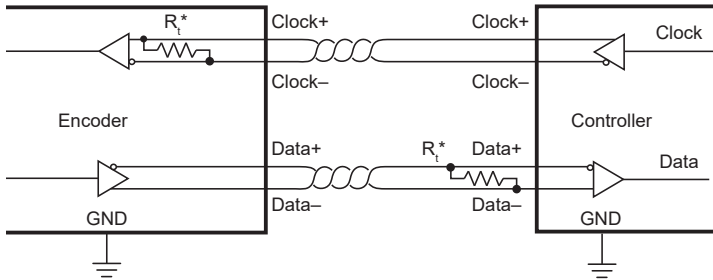
Bits reported position in LA11 output message																										Weight of LSB (µm)	Weight of "last active" bit (µm)	
Resolution	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1			0
13B	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0.244140625	0.244140625
12B	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0	0.244140625	0.48828125
11B	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0	0	0.244140625	0.9765625
2D0	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0	0	0.250	1
10B	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0	0	0	0.244140625	1.953125
09B	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0	0	0	0	0.244140625	3.90625
08B	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0	0	0	0	0	0.244140625	7.8125
07B	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0	0	0	0	0	0	0.244140625	15.625
06B	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0	0	0	0	0	0	0	0.244140625	31.25
05B	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0	0	0	0	0	0	0	0	0.244140625	62.5
04B	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0	0	0	0	0	0	0	0	0	0.244140625	125

Position data on serial interfaces has fixed length of 26 bits. If selected resolution is less than 13 bits, then unused lower bits are set to 0.

## SSI - Synchronous serial interface

The encoder position, in up to 26 bit natural binary code, and the encoder status are available through the SSI protocol. The position is captured internally every 10  $\mu$ s (refresh rate 100 kHz). Output position data is the last captured data before position request trigger. Request trigger is a falling edge of clock signal. The position data is left aligned, MSB first. After the position data there are two general status bits (active status low) followed by the detailed status information.

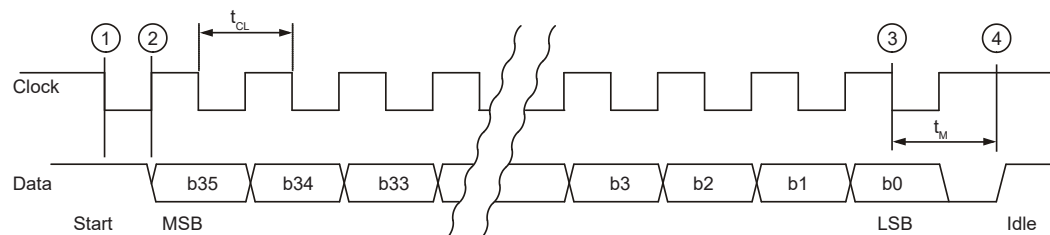
### Electrical connection



Line signals	
<b>Clock+</b>	Receiver, + input
<b>Clock-</b>	Receiver, - input
<b>Data+</b>	Transmitter, + output
<b>Data-</b>	Transmitter, - output

\* The Clock and Data lines are 5 V RS422 compatible differential pairs. The termination resistor on the Clock line is integrated inside the encoder. If the total cable length is longer than 5 m, termination on the end of the Data line at the controller end is required. The nominal impedance of cable is 120  $\Omega$ .

### SSI timing diagram

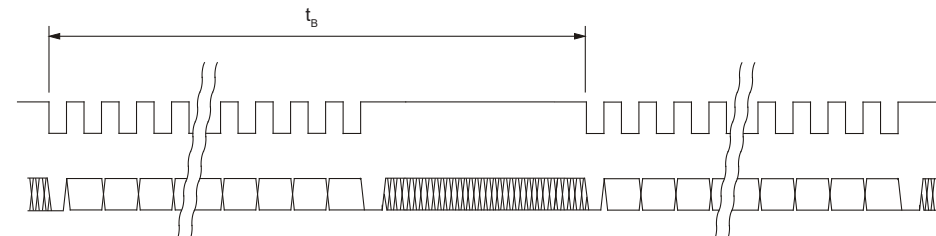


The controller interrogates the readhead for its position and status data by sending a pulse train to the Clock input. The Clock signal always starts from high. The first falling edge ① latches the last position data available and on the first rising edge ② the most significant bit (MSB) of the position is transmitted to the Data output. The Data output should then be latched on the following falling edge. On subsequent rising edges of the Clock signal the next bits are transmitted. If time between ① and ② is extended for additional 1  $\mu$ s then maximum clock frequency limit is 2.5 MHz instead of 0.8 MHz. This function is called "Delay First Clock" and must be supported by the controller the encoder is connected to.

After the transmission of the last bit ③ the Data output goes to low. When the  $t_M$  time expires, the Data output is logical "H" ④. The Clock signal must remain high for at least  $t_M$  before the next reading can take place.

While reading the data, the period  $t_{CL}$  must always be less than  $t_M$ . However, reading the encoder position can be terminated at any time by setting the Clock signal to high for the duration of  $t_M$ .

Maximum reading rate is defined by time  $t_b$ . If the reading request arrives earlier than  $t_b$ , the encoder position will not be updated.



### Communication parameters

Parameter	Symbol	Min	Typ	Max
Clock period	$t_{CL}$	1.25 $\mu$ s (400 ns*)		10 $\mu$ s
Clock frequency	$f_{CL}$	100 kHz		0.8 MHz (2.5 MHz*)
Monoflop time	$t_M$	10 $\mu$ s		
Update time	$t_B$	65 $\mu$ s (34.4 $\mu$ s*)		

\* With Delay First Clock function on the controller.

Type	Value 0	Value 1	Possible reason for failure
Error	Position data is invalid.	OK	Error bit is active low. If low, the position is not valid. Possible reasons: - The readhead is out of alignment with the magnetic scale. - The magnetic scale is demagnetised. - Incorrect orientation of readhead and magnetic scale. - Distance between the readhead and the magnetic scale is too large. - Speed of movement too high.
Warning	Position data is valid.	OK	Warning bit is active low. If low, the encoder operation is close to its limits (> 80% of maximum temperature). The position is still valid.

### SSI - position with two general and detailed status bits

#### Structure of data packet

Bit	b35 : b10	b9 : b8	b7 : b0
Data length	26 bits	2 bits	8 bits
Meaning	Encoder position	General status	Detailed status

#### Encoder position

**b35 : b10** Encoder position, left aligned, MSB first. Unused lower bits are set to 0.  
LSB bit = 2000  $\mu$ m / 2<sup>13</sup>

#### General status

**b9** Error. If bit is "L", position is not valid.

**b8** Warning. If bit is "L", encoder is near operational limits. Position is valid.

Error and Warning bits can be set at the same time; in this case Error bit has priority.

The color of the LED on the readhead housing indicates the value of the General status bits:

**Red** = Error, **Orange** = Warning, **Green** = Normal operation. **Red** or **Orange** or **Green** indicator flashing = no communication running between controller and encoder. No light = no power supply or general failure. The warning or error status is more closely defined by the Detailed status bits.

#### Detailed status

**b7** Not used - always 0.

**b6** Error - The distance between the readhead and the magnetic scale is too large.

**b5** Error - Signal lost. The readhead is out of alignment with the magnetic scale or the magnetic scale is demagnetised. Incorrect orientation of readhead and magnetic scale.

**b4** Warning - Temperature. The readhead temperature is close to operational limits [ > 80% of maximum temperature].

**b3** Not used - always 0.

**b2** Not used - always 0.

**b1** Not used - always 0.

**b0** Error - Frequency. Speed of movement too high.

## SSI - position with two general status bits

Data packet is 28 bits long, MSB first, left aligned. It provides position and two general error warning status bits. All resolutions are available.

### Structure of data packet

<b>Bit</b>	b27 : b2	b1 : b0
<b>Data length</b>	26 bits	2 bits
<b>Meaning</b>	Encoder position	General status

Encoder position	
<b>b27 : b2</b>	Encoder position, left aligned, MSB first. Unused lower bits are set to 0. LSB bit = $2000 \mu\text{m} / 2^{13}$
General status	
<b>b1</b>	Error. If bit is "L", position is not valid.
<b>b0</b>	Warning. If bit is "L", encoder is near operational limits. Position is valid.
Error and Warning bits can be set at the same time; in this case Error bit has priority. The color of the LED on the readhead housing indicates the value of the General status bits: <b>Red</b> = Error, <b>Orange</b> = Warning, <b>Green</b> = Normal operation. <b>Red</b> or <b>Orange</b> or <b>Green</b> indicator flashing = no communication running between controller and encoder. No light = no power supply or general failure.	

## SSI - position only mode

Data packet is 26 bits long, MSB first, left aligned. It provides position only without status bits. All resolutions are available.

### Structure of data packet

<b>Bit</b>	b25 : b0
<b>Data length</b>	26 bits
<b>Meaning</b>	Encoder position

Encoder position	
<b>b25 : b0</b>	Encoder position, left aligned, MSB first. Unused lower bits are set to 0. LSB bit = $2000 \mu\text{m} / 2^{13}$

SSI output »position only« with  $1 \mu\text{m}$  resolution has 24 bit long position data word.

## SSI - position only in Gray code

This mode provides position only in the reflected binary code, also known as Gray code.

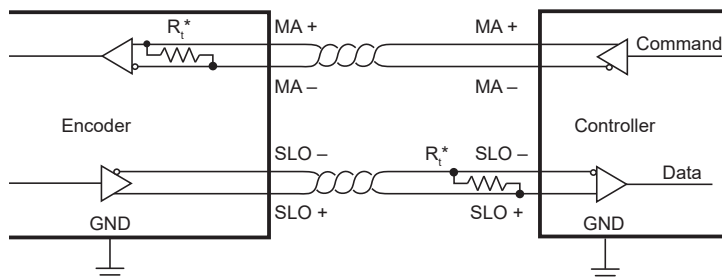
## BiSS-C interface

The encoder position, in up to 26 bit natural binary code, and the encoder status are available through the BiSS-C protocol. The position data is left aligned, MSB first. After the position data there are two status bits (active low) followed by CRC (inverted).

BiSS is implemented for point-to-point operation; multiple slaves are not supported.

Repetition of reading is maximum 27,000 times per second. If higher, the same position data will be reported. Note that 27 kHz is not achievable for all MA clock frequencies (because data transmission takes too long).

### Electrical connection

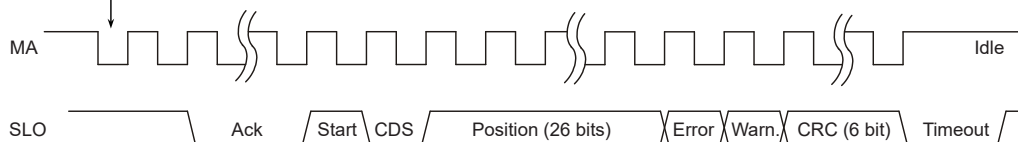


Signals	
MA	Master clock.
SLO	Slave out. Data is output on rising edge on SCK. Data is valid on the falling edge of SCK signal.

\*The MA and SLO lines are 5 V RS422 compatible differential pairs. The termination resistor on the MA line is integrated inside the readhead. If the total cable length is longer than 5 m, termination on the end of the SLO line at the controller side is recommended end is required. The nominal impedance of the cable is 120 Ω.

### BiSS-C timing diagram

Encoder latches position value 500 ns after first falling edge



Encoder responds to the controller commands by saving the position value 500 ns after the falling edge of the MA signal.

MA is idle high. Communication is initiated with first falling edge.

The encoder responds by setting SLO low on the second rising edge on MA.

Ack is the period during which the readhead calculates the absolute position and it is described in ordering code on page 19.

When the encoder is ready for the next request cycle it indicates this to the master by setting SLO high.

The CRC is in binary format and sent MSB first. The absolute position is in binary format and sent MSB first, left aligned, unused lower bits are set to zero. CDS bit is always zero.

### Communication parameters

Parameter	Min	Typ	Max	Description
Clock frequency	50 kHz	-	A / B *	Master clock frequency
Timeout	-	-	20 μs	Communication timeout

\*Please see ordering code on page 19.

### Status bits

Type	Value 0	Value 1	Possible reason for failure
Error	Position data is invalid.	OK	Error bit is active low. If low, the position is not valid. Possible reasons: - The readhead is out of alignment with the magnetic scale. - The magnetic scale is demagnetised. - Incorrect orientation of readhead and magnetic scale. - Distance between the readhead and the magnetic scale is too large. - Speed of movement too high.
Warning	Position data is valid.	OK	Warning bit is active low. If low, the encoder operation is close to its limits (> 80% of maximum temperature). The position is still valid.

### Data packet description

Position data on serial interfaces has fixed length of 26 bits. If selected resolution is less than 13 bits, then unused lower bits are set to 0. See chapter "Available resolutions" on page 9.

Polynomial for CRC calculation of position, error and warning data is:  $x^6 + x^1 + 1$ . Represented also as 0x43. The start bit and CDS bit are omitted from the CRC calculation. It is inverted and transmitted MSB first.

Example of calculation routine for 6-bit CRC can be found in application note CRCD01.

For more information regarding BiSS protocol see [www.biss-interface.com](http://www.biss-interface.com).

## SPI - Serial peripheral interface (slave mode)

The SPI interface is designed for communication with nearby devices. The position is internally captured every 10  $\mu$ s (refresh rate 100 kHz). Output position data is the last valid captured data before position request trigger. Request trigger is a high to low transition of the CS signal.

### Electrical connection

Possible data signals are 3.3 V LVTTTL or 5 V TTL (see part numbering).

Signal	Description
$\overline{CS}$	Active low. $\overline{CS}$ line is used for synchronisation between master and slave devices. During communication it must be held low. Idle is high. Rising edge on $\overline{CS}$ signal resets the SPI interface.
SCK	Clocks out the data on rising edge. Max frequency 4 MHz.
MISO	Data is output on rising edge on SCK after $\overline{CS}$ low. Data is valid on the falling edge of SCK signal. During $\overline{CS}=1$ MISO line is in high-Z mode.

### Communication parameters

Parameter	Symbol	Min	Typ	Max	Note
Clock frequency	$f_{CLK}$	1 Hz		4 MHz	
Time after $\overline{CS}$ low to first CLK rising edge	$t_S$	1 $\mu$ s			
Time after last CLK falling edge to $\overline{CS}$ high	$t_H$	1 $\mu$ s			
$\overline{CS}$ high time	$t_R$	1 $\mu$ s			Time to complete SPI reset
Read repetition rate*	Simple mode	$f_{REP}$		90 kHz	
	Advance mode			60 kHz	

\*Note that maximum read repetition rate is not achievable for all clock frequencies (because data transmission takes too long).

Communication interface variant in the part numbering defines the SPI interface type and all dependent parameters.

Communication interface variant (part numbering)	Description	Parameter	Value
SP (variant A)	SPI slave - simple mode	Resolution	Selectable (see part numbering)
		Status	All status bits are available through the SPI
		Data length	28 bit data packet - position, status
SP (variant B)	SPI slave - advanced mode	Resolution	Selectable (see part numbering)
		Status	All status bits are available through the SPI
		Data length	44 bit data packet - position, status, detailed status, CRC

### Status bits:

Type	Value 0	Value 1	Possible reason for failure
Error	Position data is invalid.	OK	Error bit is active low. If low, the position is not valid. Possible reasons: - The readhead is out of alignment with the magnetic scale. - The magnetic scale is demagnetised. - Incorrect orientation of readhead and magnetic scale. - Distance between the readhead and the magnetic scale is too large. - Speed of movement too high.
Warning	Position data is valid.	OK	Warning bit is active low. If low, the encoder operation is close to its limits (> 80% of maximum temperature). The position is still valid.

## SPI slave - simple mode (variant A)

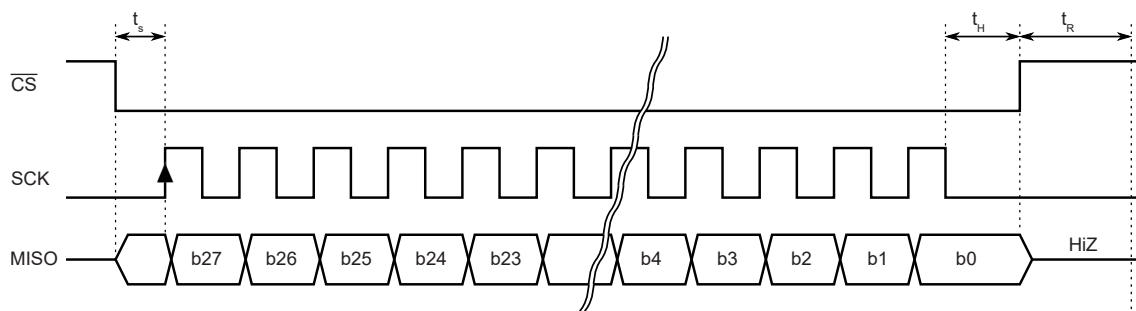
### Structure of data packet

Position is 26 bits long - MSB first, left aligned. After the position data there are two general status bits (active "L"). Repetition of reading is maximum 90,000 times per second.

Bit	b27 : b2	b1 : b0
Data length	26 bits	2 bits
Meaning	Encoder position	General status

Encoder position	
<b>b27 : b2</b>	Encoder position, left aligned, MSB first. Unused lower bits are set to 0. LSB bit = $2000 \mu\text{m} / 2^{13}$
General status	
<b>b1</b>	Error. If bit is "L", position is not valid.
<b>b0</b>	Warning. If bit is "L", encoder is near operational limits. Position is valid.
Error and Warning bits can be set at the same time; in this case Error bit has priority. The color of the LED on the readhead housing indicates the value of the General status bits: <b>Red</b> = Error, <b>Orange</b> = Warning, <b>Green</b> = Normal operation. <b>Red</b> or <b>Orange</b> or <b>Green</b> indicator flashing = no communication running between controller and encoder. No light = no power supply or general failure.	

### SPI slave timing diagram (variant A)



## SPI slave - advanced mode (variant B)

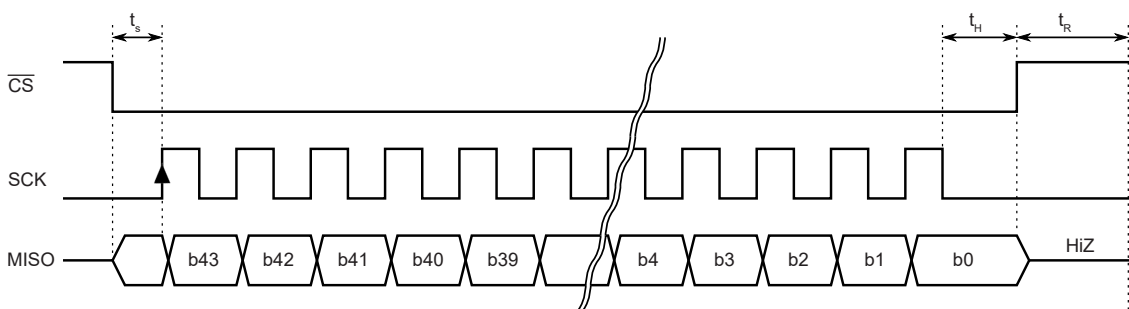
### Structure of data packet

Data packet is 44 bits long. In every particular word (position, CRC) MSB is first. Repetition of reading is maximum 60,000 times per second. Note that 60 kHz is not achievable for all clock frequencies (because data transmission takes too long).

Bit	b43 : b18	b17 : b16	b15 : b8	b7 : b0
Data length	26 bits	2 bits	8 bits	8 bits
Meaning	Encoder position	General status	Detailed status	CRC

Encoder position	
<b>b43 : b18</b>	Encoder position, left aligned, MSB first. Unused lower bits are set to 0. LSB bit = $2000 \mu\text{m} / 2^{13}$
General status	
<b>b17</b>	Error. If bit is "L", position is not valid.
<b>b16</b>	Warning. If bit is "L", encoder is near operational limits. Position is valid.
Error and Warning bits can be set at the same time; in this case Error bit has priority. The color of the LED on the readhead housing indicates the value of the General status bits: <b>Red</b> = Error, <b>Orange</b> = Warning, <b>Green</b> = Normal operation. <b>Red</b> or <b>Orange</b> or <b>Green</b> indicator flashing = no communication running between controller and encoder. The warning or error status is more closely defined by the Detailed status bits.	
Detailed status	
<b>b15</b>	Not used.
<b>b14</b>	Error - The distance between the readhead and the magnetic scale is too large.
<b>b13</b>	Error - Signal lost. The readhead is out of alignment with the magnetic scale or the magnetic scale is demagnetised. Incorrect orientation of readhead and magnetic scale.
<b>b12</b>	Warning - Temperature. The readhead temperature is close to operational limits ( >80 % of maximum temperature).
<b>b11</b>	Not used - always 0.
<b>b10</b>	Not used - always 0.
<b>b9</b>	Not used - always 0.
<b>b8</b>	Error - Frequency. Speed of movement too high.
CRC	
<b>b7 : b0</b>	CRC check with polynomial 0x97

### SPI slave timing diagram (variant B)



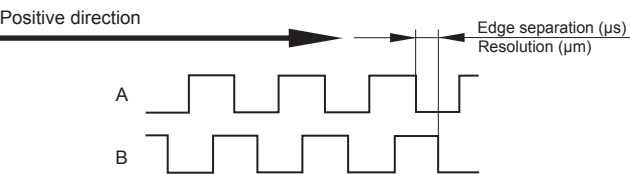
### Incremental output signals, RS422

Square wave differential line driver to EIA RS422

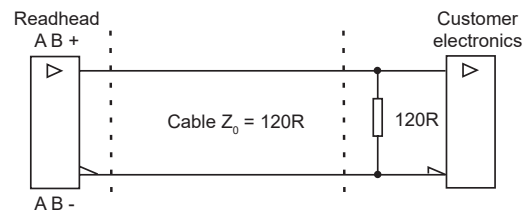
<b>Output signals</b>	2 square-wave signals A, B and their inverted signals A –, B –
<b>Signal level</b>	Differential line driver to EIA standard RS422: $U_H \geq 2 \text{ V}$ at $-I_H = 50 \text{ mA}$ $U_L \leq 0.5 \text{ V}$ at $I_L = 50 \text{ mA}$
<b>Permissible load</b>	$Z_0 \geq 100 \Omega$ between associated outputs $I_L \leq 50 \text{ mA}$ max. load per output Capacitive load $\leq 1000 \text{ pF}$ Outputs are protected against short circuit to 0 V and to +5 V

#### Timing diagram

Complementary signals not shown



#### Recommended signal termination

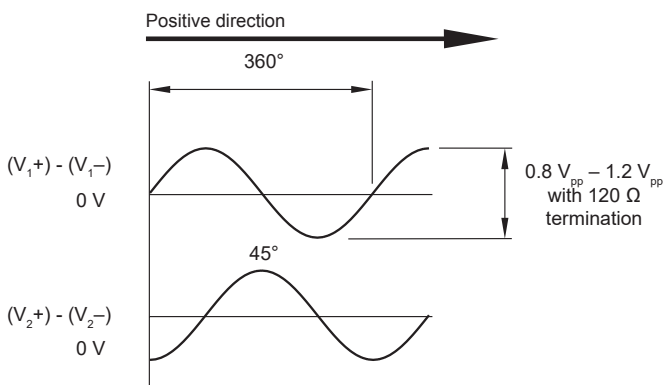


### Analogue sinusoidal output signals (1 V<sub>pp</sub>)

The sinusoidal incremental signals A and B are phase-shifted by 90° elec. and have an amplitude of typically 1 V<sub>pp</sub>.

<b>Output signals</b>	$V_1, V_2$
<b>Sin/cos signals</b>	<b>Amplitude</b> $0.8 V_{pp}$ to $1.2 V_{pp}$ (with 120 $\Omega$ termination)
<b>Termination</b>	$Z_0 = 120 \Omega$ between associated outputs

#### Timing diagram



## Readhead part numbering

**LA11 SP A 13B K A 10C A 00**

### Communication interface

**DA** - BiSS-C, RS422 + Analogue sinusoidal  
**DC** - BiSS-C, RS422  
**DI** - BiSS-C + Incremental (both RS422)  
**SB** - Synchronous serial interface (SSI), RS422 + Analogue sinusoidal  
**SC** - Synchronous serial interface (SSI), RS422  
**SI** - Synchronous serial interface (SSI) + Incremental (both RS422)  
**SP** - SPI slave  
**SQ** - SPI slave + Incremental, RS422  
**SR** - SPI slave + Analogue sinusoidal

### Communication interface variant

For **SB**, **SC** and **SI**:

**A** - Position with general and detailed status  
**B** - Position with general status  
**C** - Position only  
**D** - Position only - Gray code (not available with 2D0 resolution)

For **DA**, **DC** and **DI**:

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

For **SP**, **SQ** and **SR** (not available with 2D0):

**A** - Simple mode 3.3 V LVTTTL  
**B** - Advanced mode 3.3 V LVTTTL  
**C** - Simple mode 5 V TTL  
**D** - Advanced mode 5 V TTL

### Resolution

**13B** -  $2/2^{13}$  mm (0.244140625  $\mu$ m)  
**12B** -  $2/2^{12}$  mm (0.48828125  $\mu$ m)  
**11B** -  $2/2^{11}$  mm (0.9765625  $\mu$ m)  
**2D0** -  $2/2000$  mm (1  $\mu$ m) \*\*  
**10B** -  $2/2^{10}$  mm (1.953125  $\mu$ m)  
**09B** -  $2/2^9$  mm (3.90625  $\mu$ m)  
**08B** -  $2/2^8$  mm (7.812  $\mu$ m)  
**07B** -  $2/2^7$  mm (15.625  $\mu$ m)  
**06B** -  $2/2^6$  mm (31.25  $\mu$ m)  
**05B** -  $2/2^5$  mm (62.5  $\mu$ m)  
**04B** -  $2/2^4$  mm (125  $\mu$ m)

### Special requirements

**00** - No special requirements (standard)  
**02** - DB15 connector for SIEMENS SMC30 module (for connector option **D**)

### Connector option

**A** - 9 pin D type plug (for **DC**, **SC** and **SP** only)  
**D** - 15 pin D type plug  
**F** - Flying lead (no connector)  
**G** - DB-25 for SIEMENS SMC20 module (for **SB** only)  
**K** - Siemens 6FX2003-0SA17  
**P** - Phoenix contact M12 8 pole (for **DC**, **SC** and **SP** only)

### Cable length\*

**xxC** - Any cable length from 10 cm to 99 cm  
**xxD** - Any cable length from 10 dm to 99 dm  
**xxM** - Any cable length from 10 m to 99 m

### Power supply

**A** - 5 V  
**B** - From 8 to 30 V (for **DA**, **DC**, **DI**, **SB**, **SC** and **SI** only)

### Minimum edge separation

For **DA**, **DC**, **SB**, **SC**, **SP** and **SR**:

**K** - N/A

For **DI**, **SI** and **SQ**:

**K** - 0.07  $\mu$ s (15 MHz)  
**A** - 0.12  $\mu$ s (8 MHz)  
**B** - 0.5  $\mu$ s (2 MHz)  
**C** - 1  $\mu$ s (1 MHz)  
**D** - 2  $\mu$ s (0.5 MHz)  
**E** - 4  $\mu$ s (0.25 MHz)  
**F** - 5  $\mu$ s (0.2 MHz)  
**G** - 10  $\mu$ s (0.1 MHz)  
**H** - 20  $\mu$ s (0.05 MHz)

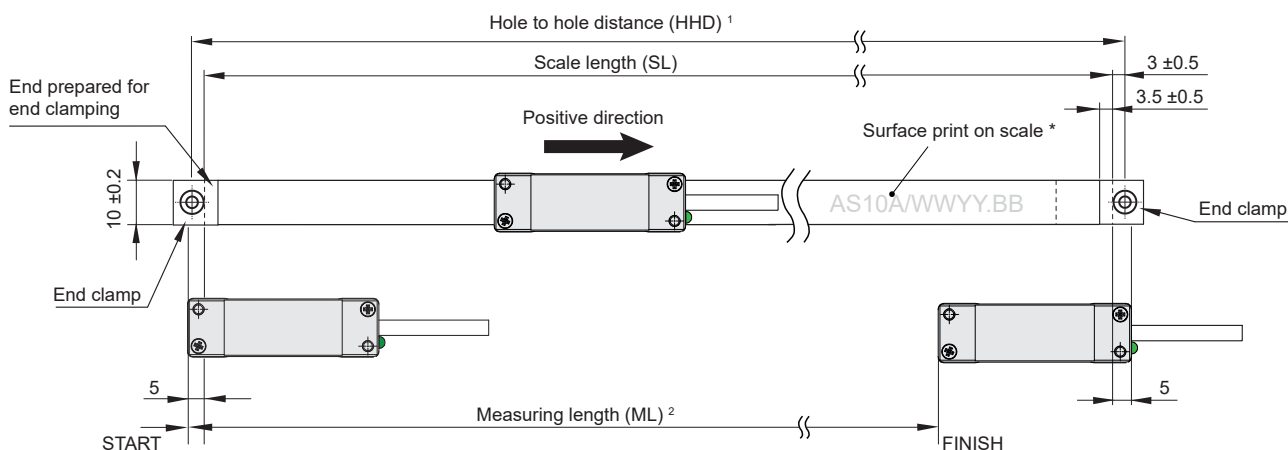
\* xx stands for any number between 10 to 99.

\*\* Available only for SSI and BiSS.

Not available for Gray protocol and SPI.

**NOTE:** Not all combinations are valid. Please check below table for available options.

Series	Communication interface	Communication interface variant	Resolution	Minimum edge separation	Power supply	Cable length	Connector options	Special requirements		
LA11	DA	A / B	13B / 12B / 11B / 2D0 / 10B / 9B / 08B / 07B / 06B / 05B / 04B	K	A / B	xxC / xxD / xxM	D / F / K	00		
	DC			K / A / B / C / D / E / F / G / H			A / D / F / K / P			
	DI						D / F / K			
	SB	A / B / C / D		K			D / F / G / K			
	SC						A / D / F / K / P			
	SI						D / F / K			
	SP		13B / 12B / 11B / 10B / 9B / 08B / 07B / 06B / 05B / 04B	K	A		A / D / F / K / P			
	SQ			K / A / B / C / D / E / F / G / H			D / F / K			
	SR	K								



<sup>1</sup> HHD (for end clamp mounting) = SL + (6 mm ±1 mm)

<sup>2</sup> ML = SL - 42 mm

\* Scale surface print does not represent the actual ordering code. For orientation purpose only.

## AS10 magnetic scale part numbering

**AS 10 A 01000 A 00**

**Precision class**  
A - N/A

**Scale length**  
xxxxx - Where xxxxx equals scale length in mm

### Special requirements

**00** - No special requirements (standard)  
**03** - Absolute code begins with 0. Available up to 16.3 m

### Options

**A** - Back-adhesion tape (standard)  
**B** - Back-adhesion tape, with CF10 cover foil\*  
**C** - Back-adhesion tape, ends prepared for end clamping <sup>2</sup>  
**G** - No back-adhesion tape, sides prepared for insertion into track system <sup>1</sup>  
**H** - No back-adhesion tape, sides prepared for insertion into track system with CF08 cover foil\* <sup>1</sup>  
**I** - No back-adhesion tape  
**N** - No back-adhesion tape, with CF10 cover foil\*  
**P** - No back-adhesion tape, ends prepared for end clamping <sup>2</sup>

\* Cover foil supplied separately.

## Cover foil part numbering

**CF 10 1000**

**Width of cover foil**

**08** - 08 mm width (for track system option only) <sup>2</sup>  
**10** - 10 mm width

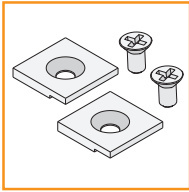
**Foil length**

xxxx - Where xxxx equals foil length in cm

<sup>1</sup> For details on TRS system please refer to data sheet LM10D18 on [www.rls.si/lm10](http://www.rls.si/lm10).

<sup>2</sup> For details on end clamp installation please refer to data sheet LM10D14 on [www.rls.si/lm10](http://www.rls.si/lm10).

## Accessories part numbering

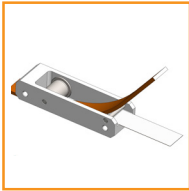


End clamp kit  
(2 clamps + 2 screws)  
**LM10ECL00**

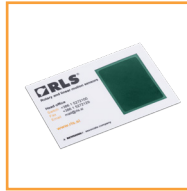


USB encoder interface  
**E201-9S or E201-9Q**

For details on E201 interfaces  
please refer to data sheet E201 on  
[www.rls.si/e201](http://www.rls.si/e201).



Applicator tool for magnetic scale  
**LMA10ASC00**



Magnet viewer  
**MM0001**

## Accessories for MS Track System



Track section, 1.00 m  
**TRS100A00**



Track section, 2.00 m  
**TRS200A00**



Scale clamp, 0.04 m  
**TRE004A00**



Joining element, 0.04 m  
**TRE004A01**



Screw and washer  
**TRC00**

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## Document issues

Issue	Date	Page	Corrections made
6	13. 12. 2017	2	Storage and handling amended
		5	Technical specifications amended
		6, 7, 8	Graphs added and amended
		9	Cable specifications amended, 15-pin amended
		11	Available resolution amended
		21	AS part numbering amended
7	28. 5. 2018	5	Technical specifications amended
		11	New electrical connections added
		22	AS magnetic scale part numbering amended
		23	Accessories part numbering amended
8	3. 2. 2020	3	Ride height for special option 01 removed
		5	CTE value corrected
		11	SPI output for Phoenix connector added
		22	Direction of the readhead explicitly shown, special option 01 removed from AS part numbering
9	15. 7. 2020	12, 16, 21	BiSS-C Maximum clock frequency and latency amended

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