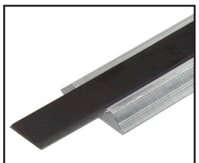
Data sheet
LA11D01_01
Issue 1, 25th January 2016

LA11 absolute magnetic encoder system


Track system

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

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 µm**
- **Axis lengths up to 16.3 m**
- **Speeds up to 7 m/s at 0.977 µm resolution**
- **Integral status LED**
- **Synchronous (SSI, SPI, BiSS) communication protocols available**
- **Parallel incremental output (analogue or digital)**
- **Double shielded, drag-chain compatible cable**
- **Simple and fast installation**
- **Robust measuring principle**
- **Excellent degree of protection to IP68**

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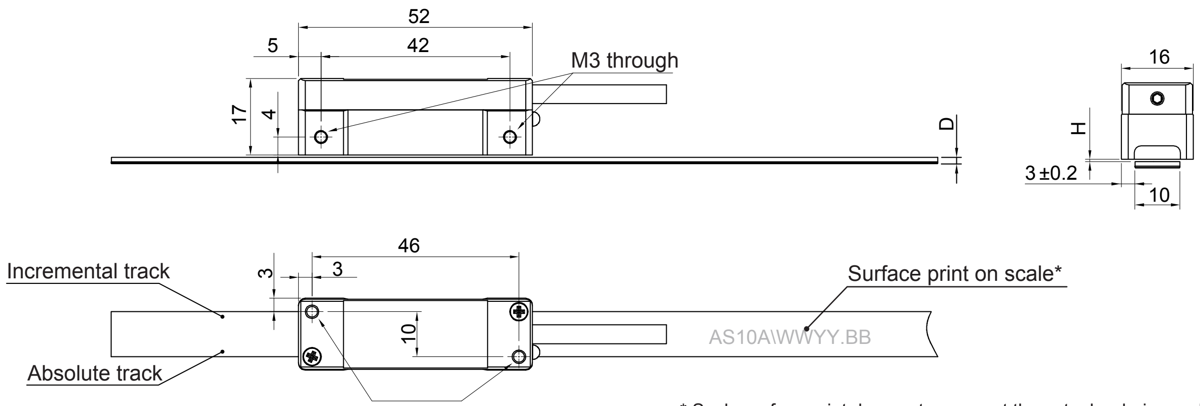
LA11 dimensions

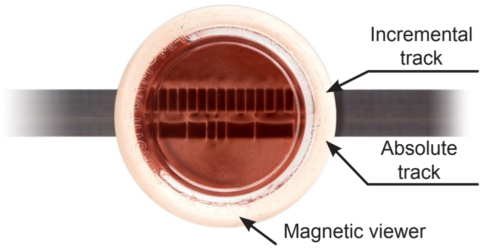
Dimensions and tolerance in mm.



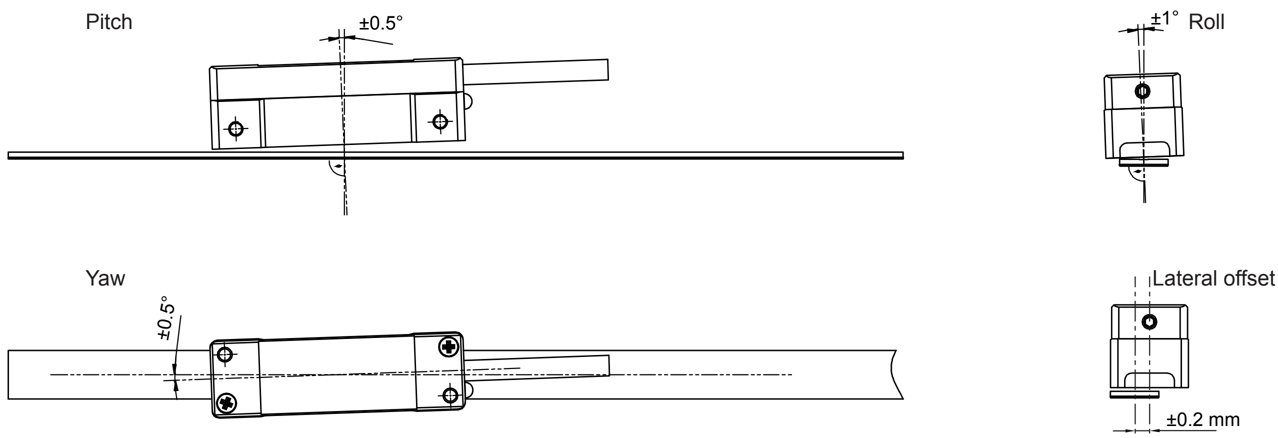
* Scale surface print does not represent the actual ordering code.
For orientation purpose only.

	Magnetic scale thickness (D)		Ride height (H)
	Standard option	Option 01	
With back-adhesion tape	1.5 ±0.15	1.8 ±0.15	0.1 – 0.6
With back-adhesion tape, with cover foil	1.6 ±0.15	1.9 ±0.15	0.1 – 0.5
No back-adhesion tape	1.3 ±0.15	1.6 ±0.15	0.1 – 0.6
No back-adhesion tape, with cover foil	1.4 ±0.15	1.7 ±0.15	0.1 – 0.5

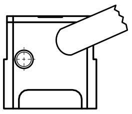
NOTE: Orientation of the readhead relative to AS10 magnetic scale should be according to the drawing. For reference use the surface print on AS scale or magnet viewer (see image below).



LA11 installation tolerances



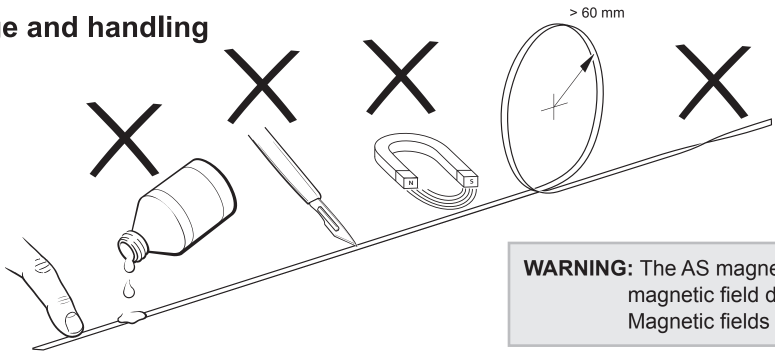
Status LEDs



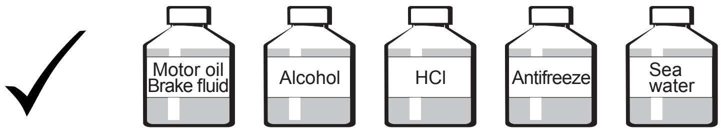
LED	Communication	Status
Green	Yes	Valid position data
Green flashing	No	Valid position data
Orange	Yes	Valid position data, > 80 % of max. temperature
Orange flashing	No	Valid position data, > 80 % of max. temperature
Red	Yes	Invalid position data
Red flashing	No	Invalid position data

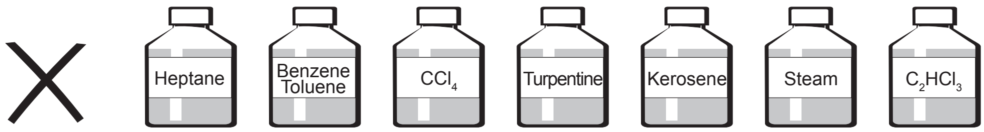
By special request the status LEDs can be turned off. Please contact sales@rls.si.

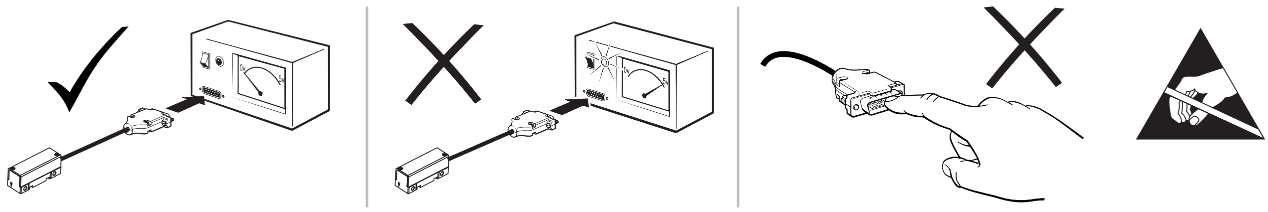
Storage and handling

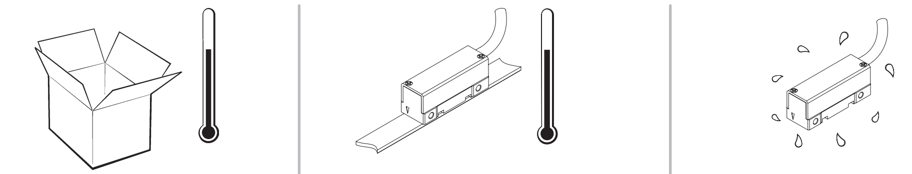


WARNING: The AS magnetic scale should not be exposed to magnetic field densities higher than 50 mT on its surface. Magnetic fields higher than 50 mT can damage the scale.







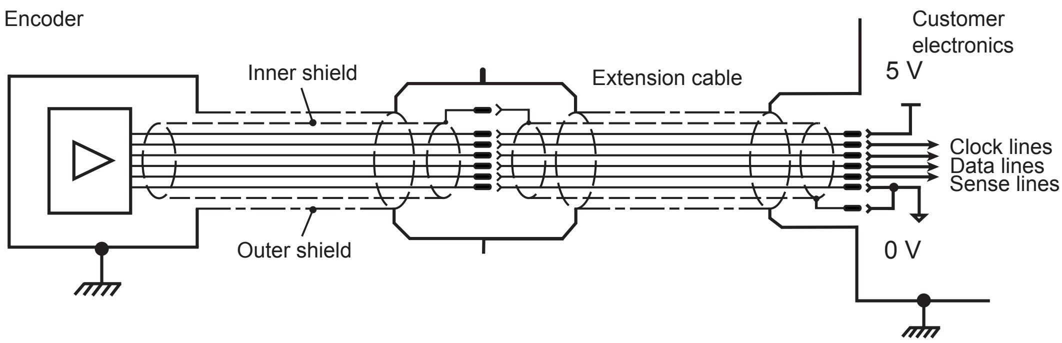


Storage –20 °C to +70 °C

Operating 0 °C to +55 °C
(cable under non-dynamic conditions: –20 °C to +55 °C)

Up to 100 % RH

Shield connection



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Data sheet
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LA11 technical specifications

System data	
Incremental pole length	2 mm
Maximum scale measuring length	16.3 m
System accuracy	±40 μm/m
Short range accuracy	< ±10 μm/10 mm (see diagram 3)
Coefficient of thermal expansion (CTE)	11 ±1 μm/m/K
Hysteresis	< 2 μm at 0.1 mm ride height (see diagram 1)
Repeatability	Unit of resolution

Available resolutions [μm]	~0.244	~0.488	~0.976	~1.953	~3.906	~7.812	15.625	31.25	62.5	125
Maximum speed [m/s]	1.82	3.65	7	7	7	7	7	7	7	7

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
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
		Minimum count frequency (MHz)	15	8	2	1	0.5	0.25	0.2	0.1	0.05
		Ordering code	**K**	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**

Electrical data	
Power supply	5 V ± 5 % (voltage on readhead) and from 8 V to 30 V Consider voltage drop over cable (see diagram 2)
Reverse polarity protection	Only for 5 V
Set-up time after switch-on	< 350 ms
Power consumption (without load)	< 170 mA at 5 V power supply
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
Cable	PUR high flexible cable, drag-chain compatible, double-shielded. Durability: 20 million cycles at 20 mm bend radius at whole temperature range

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	IP68 (according to IEC 60529)	

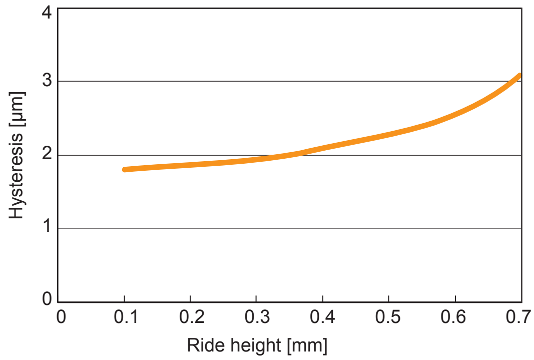


Diagram 1: Hysteresis vs. ride height

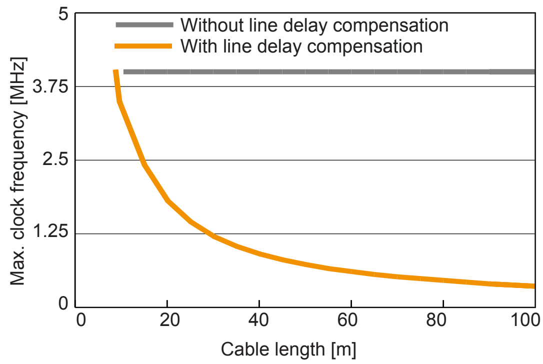


Diagram 2: Maximum clock frequency vs. cable length

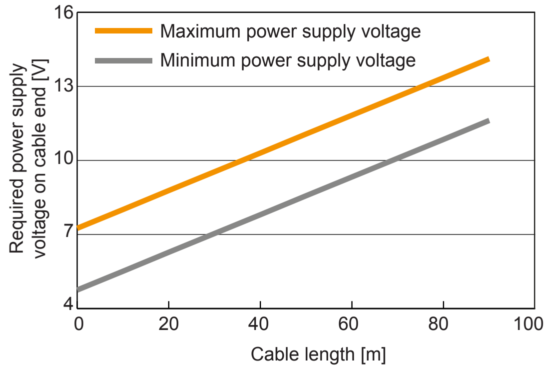


Diagram 3: Required power supply voltage on cable end vs. overall cable length

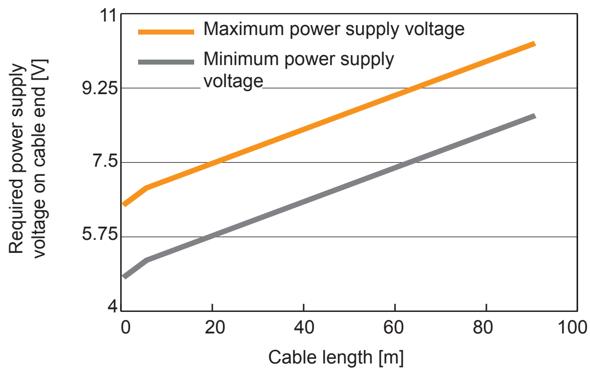


Diagram 4: Required power supply voltage on cable end vs. overall cable length with sense lines connected parallel to power supply lines

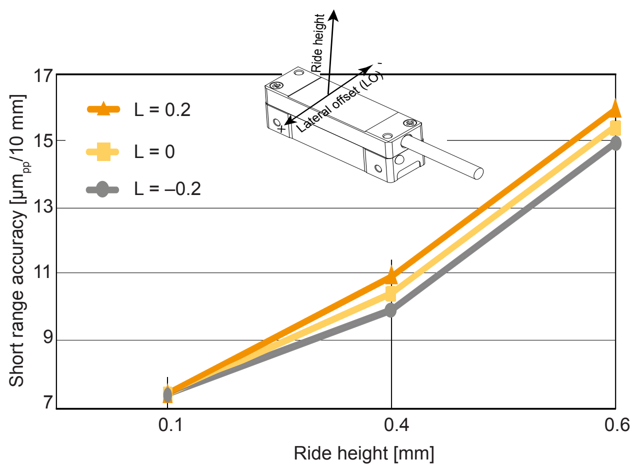


Diagram 5: Short range accuracy vs. ride height-lateral offset (LO) as a parameter - typical

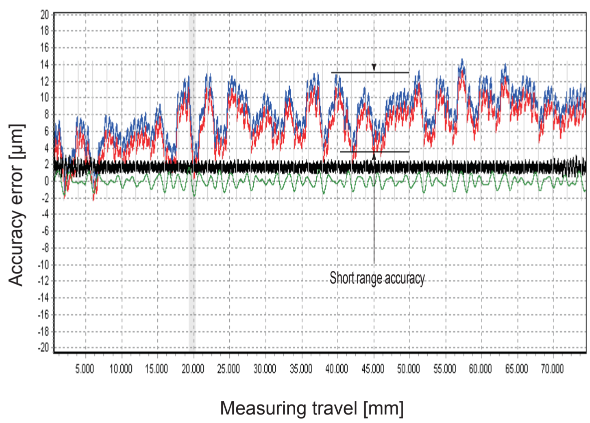
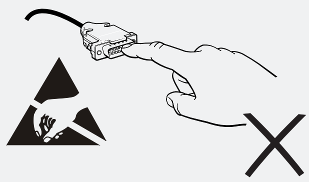


Diagram 6: Definition of short range accuracy

Electrical connections

Cable specifications

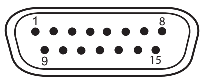
Number of wires	8	12
Communication interface	DC, SP, SC	DA, DI, SB, SI, SQ, SR
Outer diameter	4.2 mm ±0.2 mm	4.5 mm ±0.2 mm
Jacket material	Extruded polyurethane (PUR)	
White wire	0.14 mm^2, 26 AWG, 0.13 Ω/m	0.08 mm^2, 28 AWG, 0.23 Ω/m
Other wires	0.05 mm^2, 30 AWG, 0.35 Ω/m	0.08 mm^2, 28 AWG, 0.23 Ω/m
Durability	20 million cycles at 20 mm bend radius	
Bend radius	Dynamic 25 mm, static 10 mm (internal radius)	
Weight	34 g/m nominal	38 g/m nominal



WARNING!

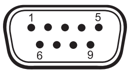
ESD protection
Readhead is ESD sensitive - handle with care. Do not touch wires or sensor area without proper ESD protection or outside of ESD controlled environment.

15 pin D type plug



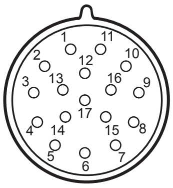
Pin	Wire colour	BiSS	SSI	SPI
Case	Outer shield	Encoder/machine case (Earth connection)	Encoder/machine case (Earth connection)	Encoder/machine case (Earth connection)
1	Inner shield			
2	White	0 V (GND) supply		
3	Green	MA +	CLK +	CLK
4	Yellow	MA –	CLK –	CS (chip select)
5	Violet	Sin + / A+		
6	Grey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

9 pin D type plug



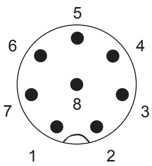
Pin	Wire colour	BiSS	SSI	SPI
Case	Outer shield	Encoder/machine case (Earth connection)	Encoder/machine case (Earth connection)	Encoder/machine case (Earth connection)
1	Inner shield			
2	Green	MA +	CLK +	CLK
3	Yellow	MA –	CLK –	CS (chip select)
4	Grey	+ Vin sense		
5	Brown	+ Vin supply		
6	Blue	SLO +	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 + analog sinusodial
1	Brown	+ Vin supply
2	-	-
3	-	-
4	White	0 V (GND) supply
5	-	-
6	-	-
7	-	-
8	Green	CLK +
9	Yellow	CLK –
10	-	-
11	Outer shield	Encoder/machine case (Earth connection)
12	Grey	COS +
13	Pink	COS –
14	Blue	DATA +
15	Purple	SIN +
16	Black	SIN –
17	Red	DATA –

Phoenix contact M12 8 pole



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

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. In case sense lines are not used and/or connected, they should be isolated in order to prevent possible shorts between power supply lines.

LA11 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		
	Maximum clock frequency	3.5 MHz
	Read repetition rate	30 kHz
	Resolution	See table below
	Latency	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).

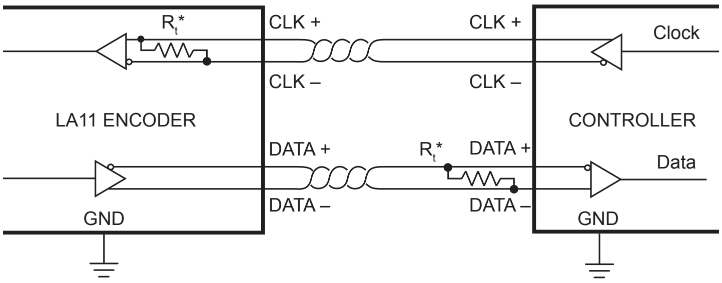
Available resolutions

Resolution
13B - $2/2^{13}$ mm (~0.244 µm)
12B - $2/2^{12}$ mm (~0.488 µm)
11B - $2/2^{11}$ mm (~0.976 µm)
10B - $2/2^{10}$ mm (~1.953 µm)
09B - $2/2^{9}$ mm (~3.906 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)

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 internaly captured every 10 µs (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.

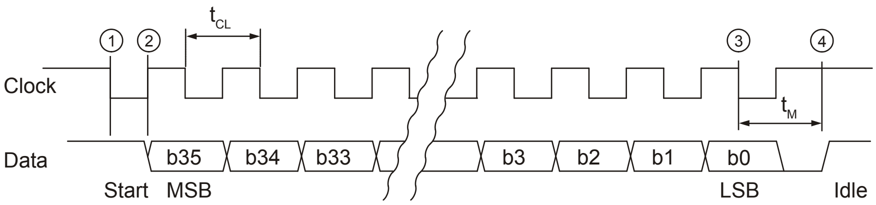
Electrical connection



Line signals	
CLK+	Receiver, + input
CLK-	Receiver, - input
DATA+	Transmitter, + output
DATA-	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.
The termination on the end of the Data line at the controller end is required if the total cable length is longer than 5 m.
The nominal impedance of cable is 120 Ω.

SSI timing diagram

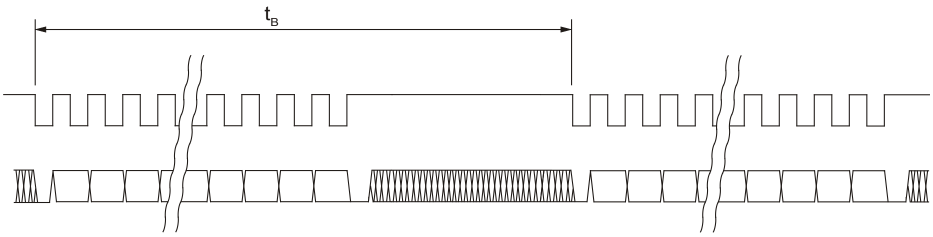


The controller interrogates the readhead for its position and status data by sending a pulse train to the Clock input. The Clock signal always starts from high. The first falling edge ① latches the last position data available and on the first rising edge ② the most significant bit (MSB) of the position 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 µs 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 µs (400 ns*)		10 µs
Clock frequency	f_{CL}	100 kHz		0.8 MHz (2.5 MHz*)
Monoflop time	t_M	10 µs		
Update time	t_B	65 µs (34.4 µs*)		

* 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 demagnetized. - Incorrect orientation of readhead and magnetic scale. - Distance between the readhead and the magnetic scale is too high. - 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 +75 °C) . The position is still valid.

SSI - position with two general and detailed status bits

Structure of the 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 µm / 2^{13}
General status		
	b9	Error. If bit is “L”, position is not valid.
	b8	Warning. If bit is “L”, encoder is near operation limits. Position is valid.
	Error and Warning bits can be set at the same time; in this case Error bit has priority. Those two bits are synchronized to the LED indicator on the housing of the encoder: Red = Error, Orange = Warning, Green = Normal operation. Red or Orange or Green indicator flashing = no communication running between controller and encoder. Colour of indicator corresponds the current error/warning status of the 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 high.
	b5	Error - Signal lost. The readhead is out of alignment with the magnetic scale or the magnetic scale is demagnetization, incorrect orientation of readhead and magnetic scale.
	b4	Warning - Temperature. The readhead temperature is close to operational limits [> 80% of +75 °C].
	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 the data packet

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

Encoder position	
b27 : b2	Encoder position, left aligned, MSB first. Unused lower bits are set to 0. LSB bit = 2000 µm / 2^{13}
General status	
b1	Error. If bit is “L”, position is not valid.
b0	Warning. If bit is “L”, encoder is near operation limits. Position is valid.
	Error and Warning bits can be set at the same time; in this case Error bit has priority. Those two bits are synchronized to the LED indicator on the housing of the encoder: Red = Error, Orange = Warning, Green = Normal operation. Red or Orange or Green indicator flashing = no communication running between controller and encoder. Colour of indicator corresponds the current error/warning status of the 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 the data packet

Bit	b25 : b0
Data length	26 bits
Meaning	Encoder position

Encoder position	
b25 : b0	Encoder position, left aligned, MSB first. Unused lower bits are set to 0. LSB bit = 2000 µm / 2^{13}

SSI - position only in Gray code

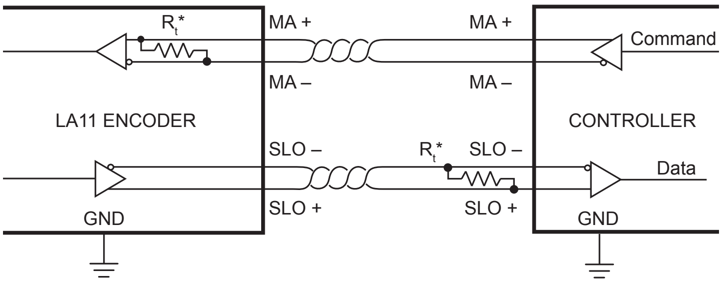
This mode provides position only in the reflected binary code, also known as Gray code.

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 max 25,000 times per second. If higher, the same position data will be reported. Note that 25 kHz is not achievable for all MA clock frequencies (because data transmission takes too long).

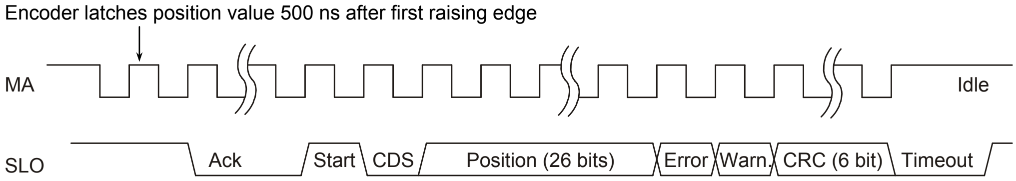
Electrical connection



Signals	
MA	Master clock. Max clock frequency is 3.5 MHz.
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.
The termination on the end of the SLO line at the controller side is recommended end is required if the total cable length is longer than 5 m.
The nominal impedance of the cable is 120 Ω.

BiSS-C timing diagram



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 fixed to 12 MA clock cycles and is not variable.
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	-	3.5 MHz	Master clock frequency
Timeout	-	-	20 µs	Communication timeout

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 demagnetized. - Incorrect orientation of readhead and magnetic scale. - Distance between the readhead and the magnetic scale is too high. - 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 +75 °C) . The position is still valid.

Data packet description

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 Appendix 2 of this document.

For more information regarding BiSS protocol see **www.biss-interface.com**.

SPI - Serial peripheral interface – slave mode

The SPI interface is designed for communication with nearby devices. The position is internaly captured every 10 µs (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 LVTTL 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 µs			
Time after last CLK falling edge to $\overline{CS}$ high		t_H	1 µs			
$\overline{CS}$ high time		t_R	1 µs			Time to complete SPI reset
Read repetition rate*	Simple mode	f_{REP}			90 kHz	
	Advance mode				60 kHz	

*Note that max 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 (option 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 (option 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 demagnetized. - Incorrect orientation of readhead and magnetic scale. - Distance between the readhead and the magnetic scale is too high. - 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 +75 °C) . The position is still valid.

SPI slave simple mode

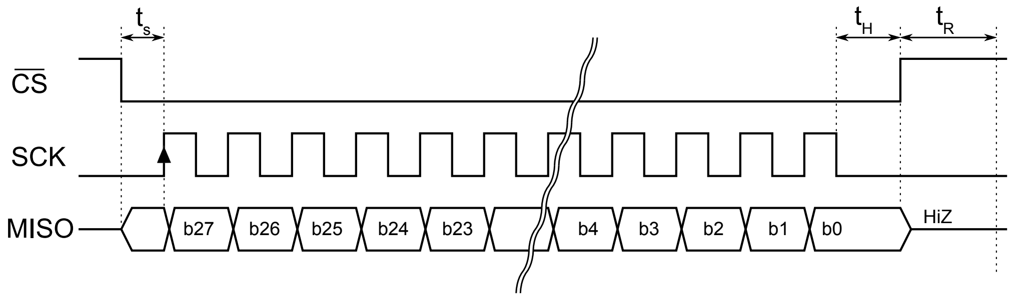
Structure of the data packet

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

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

Encoder position		
	b27 : b2	Encoder position, left aligned, MSB first. Unused lower bits are set to 0. LSB bit = 2000 µm / 2^{13}
General status		
	b1	Error. If bit is “L”, position is not valid.
	b0	Warning. If bit is “L”, encoder is near operation limits. Position is valid.
	Error and Warning bits can be set at the same time; in this case Error bit has priority. Those two bits are synchronized to the LED indicator on the housing of the encoder: Red = Error, Orange = Warning, Green = Normal operation. Red or Orange or Green indicator flashing = no communication running between controller and encoder. Colour of indicator corresponds the current error/warning status of the encoder. No light = no power supply or general failure.	

SPI slave simple mode timing diagram



SPI slave - advanced mode

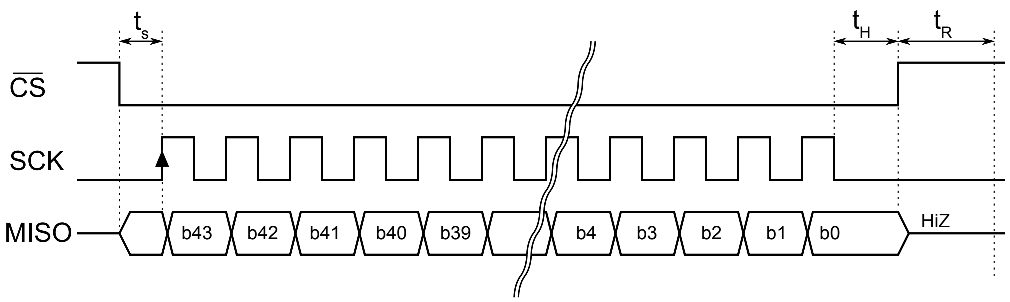
Structure of the data packet

Data packet is 44 bits long. In every particular word (position, CRC) MSB is first. Repetition of reading max 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		
	b43 : b18	Encoder position, left aligned, MSB first. Unused lower bits are set to 0. LSB bit = 2000 µm / 2^{13}
General status		
	b17	Error. If bit is “L”, position is not valid.
	b16	Warning. If bit is “L”, encoder is near operation limits. Position is valid.
	Error and Warning bits can be set at the same time; in this case Error bit has priority. Those two bits are synchronized to the LED indicator on the housing of the encoder: Red = Error, Orange = Warning, Green = Normal operation. Red or Orange or Green indicator flashing = no communication running between controller and encoder. Colour of indicator corresponds the current error/warning status of the 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		
	b15	Not used.
	b14	Error - The distance between the readhead and the magnetic scale is too high.
	b13	Error - Signal lost. The readhead is out of alignment with the magnetic scale or the magnetic scale is demagnetization, incorrect orientation of readhead and magnetic scale.
	b12	Warning - Temperature. The readhead temperature is close to operational limits [> 80 % of +75 °C].
	b11	Not used - always 0.
	b10	Not used - always 0.
	b9	Not used - always 0.
	b8	Error - Frequency. Speed of movement too high.
CRC		
	b7 : b0	CRC check with polynomial 0x97

SPI slave advanced mode timing diagram

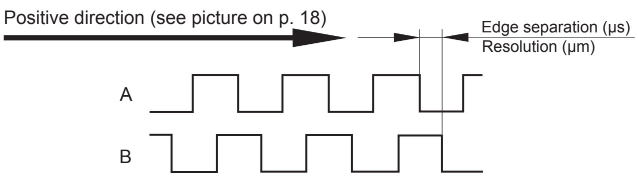


Incremental output signals, RS422

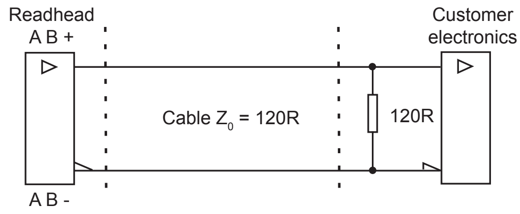
Square wave differential line driver to EIA RS422

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

Timing diagram
Complementary signals not shown



Recommended signal termination

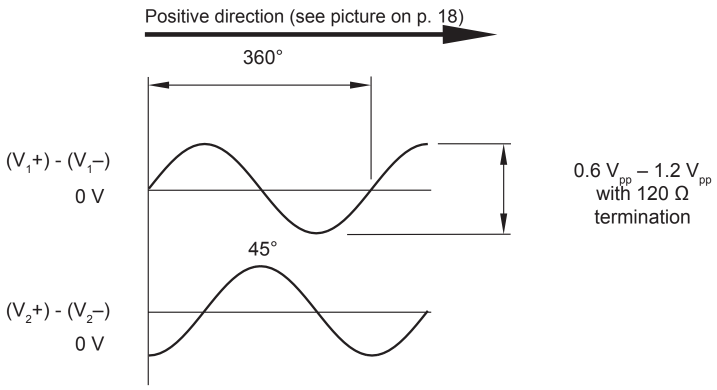


Analogue sinusoidal output signals (1 V_{pp})

The sinusoidal incremental signals A and B are phase-shifted by 90° elec. and have an amplitude of typically 1 V_{pp}.

Output signals	V_1, V_2	
Sine / cosine signals	**Amplitude** (with 120 Ω termination)	0.6 V_{pp} to 1.2 V_{pp}
Termination	$Z_0 = 120\ \Omega$ between associated outputs	

Timing diagram



LA11 readhead part numbering

LA11 SP A 13B A A 10C A 00

Communication interface
DA - BISS-C (RS422) + Analogue sinusoidal
DC - BISS-C (RS422)
DI - BISS-C + Incremental (both RS422)
SB - SSI (RS422) + Analogue sinusoidal
SC - Binary synchro-serial SSI (RS422)
SI - 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
For **DA, DC** and **DI:**
A - N/A
For **SP, SQ** and **SR**:
A - Simple mode 3.3 V LVTTL
B - Advanced mode 3.3 V LVTTL
C - Simple mode 5 V TTL
D - Advanced mode 5 V TTL

Resolution
13B - $2/2^{13}$ mm (~ 0.244 µm)
12B - $2/2^{12}$ mm (~ 0.488 µm)
11B - $2/2^{11}$ mm (~ 0.976 µm)
10B - $2/2^{10}$ mm (~ 1.953 µm)
09B - $2/2^{9}$ mm (~ 3.906 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)

Special requirements
00 - No special requirements (standard)

Connector option
A - 9 pin D type plug
B - Belden Lumberg RSCW 8/9
D - 15 pin D type plug
F - Flying lead (no connector)
K - Siemens 6FX2003-0SA17
P - Phoenix contact M12 8 pole

Cable length*
xxC - Any cable length from 1 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

Minimum edge separation
For **DA, DC, SB, SC,SP** and **SR**: **K** - 0.07 µs (15 MHz)
For **DI**, **SI** and **SQ**:
K - 0.07 µs (15 MHz)
A - 0.12 µs (8 MHz)
B - 0.5 µs (2 MHz)
C - 1 µs (1 MHz)
D - 2 µs (0.5 MHz)
E - 4 µs (0.25 MHz)
F - 5 µs (0.2 MHz)
G - 10 µs (0.1 MHz)
H - 20 µs (0.05 MHz)

* xx stands for any number between 01 to 99.

AS10 magnetic scale part numbering

AS 10 A 01000 A 00

Scale width
10 - 10 mm width

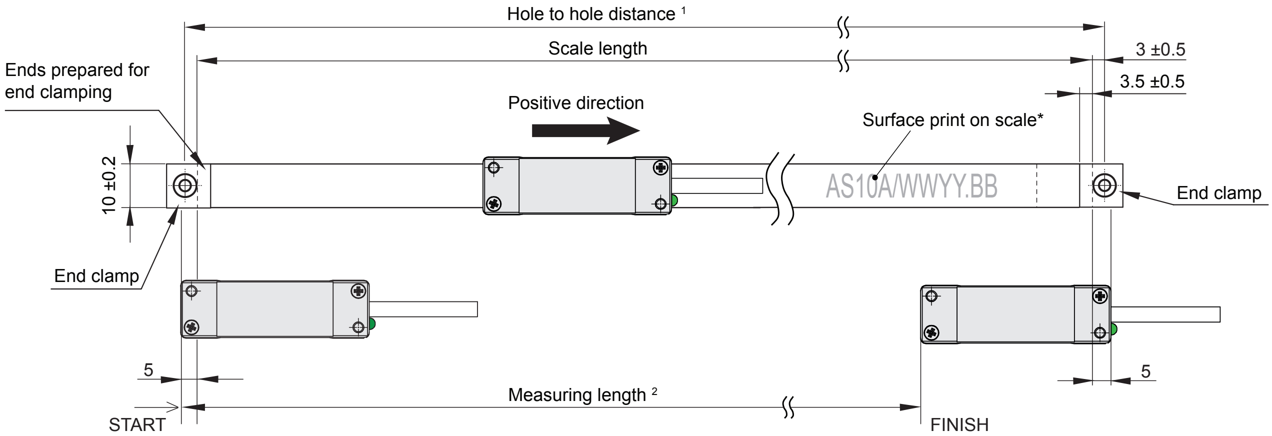
Precision class
A - ±20 µm/m

Scale length
xxxxx - Where xxxxx equals scale length in mm

Special requirements
00 - No special requirements (standard) - Available up to 4 m length
01 - Thickness of scale 1.7 mm. 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
G - No back-adhesion tape, sides prepared for insertion into track system **
H - No back-adhesion tape, sides prepared for insertion into track system with CF08 cover foil*
I - No back-adhesion tape
N - No back-adhesion tape, with CF10 cover foil*
P - No back-adhesion tape, ends prepared for end clamping

* Cover foil supplied separately.
** For details on TRS track system please refer to data sheet LM10D18 on www.rls.si/trs.



[1] Hole to hole distance (for end clamp mounting) = Scale length + (6 mm ±1 mm)
[2] Measuring length = Scale length - 42 mm

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

Accessories part numbering

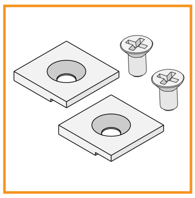
Cover foil

CF 10 1000

Width of cover foil
08 - 08 mm width (for track system option **only**)
10 - 10 mm width

Foil length
xxxx - Where xxxx equals foil length in cm

Accessories part numbering



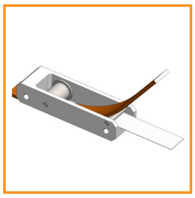
End clamp kit
(2 clamps + 2 screws)

LM10ECL00

USB encoder interface

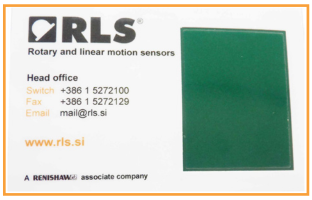
E201-9S or **E201-9Q**

For details on E201 interfaces please refer to data sheet E201 on www.rls.si/e201.



Applicator tool for magnetic scale

LMA10ASC00



Magnet viewer

MM0001

Appendix 1 - 8-bit CRC calculation with 0x97 polynome

Some of the output protocols offer a CRC value to check the correctness of the data read from the encoder. This chapter gives an example of the CRC calculation on the receiver side. The CRC calculation must always be done over the complete set of data including all the reserved bits. The polynomial for the CRC calculation is $P(x) = x^8 + x^7 + x^4 + x^2 + x^1 + 1$, also represented as 0x97.

Code example:

```
//poly = 0x97
static u8 tableCRC [256] = {
                0x00, 0x97, 0xB9, 0x2E, 0xE5, 0x72, 0x5C, 0xCB, 0x5D, 0xCA, 0xE4, 0x73, 0xB8, 0x2F, 0x01, 0x96,
                0xBA, 0x2D, 0x03, 0x94, 0x5F, 0xC8, 0xE6, 0x71, 0xE7, 0x70, 0x5E, 0xC9, 0x02, 0x95, 0xBB, 0x2C,
                0xE3, 0x74, 0x5A, 0xCD, 0x06, 0x91, 0xBF, 0x28, 0xBE, 0x29, 0x07, 0x90, 0x5B, 0xCC, 0xE2, 0x75,
                0x59, 0xCE, 0xE0, 0x77, 0xBC, 0x2B, 0x05, 0x92, 0x04, 0x93, 0xBD, 0x2A, 0xE1, 0x76, 0x58, 0xCF,
                0x51, 0xC6, 0xE8, 0x7F, 0xB4, 0x23, 0x0D, 0x9A, 0x0C, 0x9B, 0xB5, 0x22, 0xE9, 0x7E, 0x50, 0xC7,
                0xEB, 0x7C, 0x52, 0xC5, 0x0E, 0x99, 0xB7, 0x20, 0xB6, 0x21, 0x0F, 0x98, 0x53, 0xC4, 0xEA, 0x7D,
                0xB2, 0x25, 0x0B, 0x9C, 0x57, 0xC0, 0xEE, 0x79, 0xEF, 0x78, 0x56, 0xC1, 0x0A, 0x9D, 0xB3, 0x24,
                0x08, 0x9F, 0xB1, 0x26, 0xED, 0x7A, 0x54, 0xC3, 0x55, 0xC2, 0xEC, 0x7B, 0xB0, 0x27, 0x09, 0x9E,
                0xA2, 0x35, 0x1B, 0x8C, 0x47, 0xD0, 0xFE, 0x69, 0xFF, 0x68, 0x46, 0xD1, 0x1A, 0x8D, 0xA3, 0x34,
                0x18, 0x8F, 0xA1, 0x36, 0xFD, 0x6A, 0x44, 0xD3, 0x45, 0xD2, 0xFC, 0x6B, 0xA0, 0x37, 0x19, 0x8E,
                0x41, 0xD6, 0xF8, 0x6F, 0xA4, 0x33, 0x1D, 0x8A, 0x1C, 0x8B, 0xA5, 0x32, 0xF9, 0x6E, 0x40, 0xD7,
                0xFB, 0x6C, 0x42, 0xD5, 0x1E, 0x89, 0xA7, 0x30, 0xA6, 0x31, 0x1F, 0x88, 0x43, 0xD4, 0xFA, 0x6D,
                0xF3, 0x64, 0x4A, 0xDD, 0x16, 0x81, 0xAF, 0x38, 0xAE, 0x39, 0x17, 0x80, 0x4B, 0xDC, 0xF2, 0x65,
                0x49, 0xDE, 0xF0, 0x67, 0xAC, 0x3B, 0x15, 0x82, 0x14, 0x83, 0xAD, 0x3A, 0xF1, 0x66, 0x48, 0xDF,
                0x10, 0x87, 0xA9, 0x3E, 0xF5, 0x62, 0x4C, 0xDB, 0x4D, 0xDA, 0xF4, 0x63, 0xA8, 0x3F, 0x11, 0x86,
                0xAA, 0x3D, 0x13, 0x84, 0x4F, 0xD8, 0xF6, 0x61, 0xF7, 0x60, 0x4E, 0xD9, 0x12, 0x85, 0xAB, 0x3C};
// use this function to calculate CRC from 32-bit number

u8 crc8_4B(u32 bb)
 {
 u8 crc;
 t = (bb >> 24) & 0x000000FF;
 crc = ((bb >> 16) & 0x000000FF);
 t = crc ^ tableCRC[t];
 crc = ((bb >> 8) & 0x000000FF);
 t = crc ^ tableCRC[t];
 crc = (bb & 0x000000FF);
 t = crc ^ tableCRC[t];
 crc = tableCRC[t];
 return crc;
 }

// use this function to calculate CRC from fixed length buffer
example:

u8 Buffer[BufferLength];

crc_value = u8 CRC_Buffer(BufferLength);

u8 CRC_Buffer(u8 NumOfBytes)  // parameter = how many bytes from buffer to use to calculate CRC
 {
 NumOfBytes -= 1;
 icrc = 1;
 t = Buffer[0];
 while (NumOfBytes--)
   {
   t = Buffer[icrc++] ^ tableCRC[t];
   }
 crc = tableCRC[t];
 return crc;
 }
```

Recommended literature:

- Painless guide to CRC error detection algorithm; Ross N. Williams.
- Cyclic Redundancy Code (CRC) Polynomial Selection For Embedded Networks; P. Koopman, T. Chakravarty

Appendix 2 - 6-bit CRC calculation with 0x43 polynome for BiSS

BiSS communication offers a CRC value to check the correctness of the data read from the encoder. This chapter gives an example of the CRC calculation on the receiver side. The CRC calculation must always be done over the complete set of data. The polynomial for the CRC calculation is $P(x) = x^6 + x^1 + 1$, also represented as 0x43.

Code example:

```
u8 tableCRC6[64] =  {
                0x00, 0x03, 0x06, 0x05, 0x0C, 0x0F, 0x0A, 0x09,
                0x18, 0x1B, 0x1E, 0x1D, 0x14, 0x17, 0x12, 0x11,
                0x30, 0x33, 0x36, 0x35, 0x3C, 0x3F, 0x3A, 0x39,
                0x28, 0x2B, 0x2E, 0x2D, 0x24, 0x27, 0x22, 0x21,
                0x23, 0x20, 0x25, 0x26, 0x2F, 0x2C, 0x29, 0x2A,
                0x3B, 0x38, 0x3D, 0x3E, 0x37, 0x34, 0x31, 0x32,
                0x13, 0x10, 0x15, 0x16, 0x1F, 0x1C, 0x19, 0x1A,
                0x0B, 0x08, 0x0D, 0x0E, 0x07, 0x04, 0x01, 0x02};

u8 crcBiSS(u32 bb)
 {
 u8 crc;
 t = (bb >> 30) & 0x00000003;
 crc = ((bb >> 24) & 0x0000003F);
 t = crc ^ tableCRC6[t];
 crc = ((bb >> 18) & 0x0000003F);
 t = crc ^ tableCRC6[t];
 crc = ((bb >> 12) & 0x0000003F);
 t = crc ^ tableCRC6[t];
 crc = ((bb >> 6) & 0x0000003F);
 t = crc ^ tableCRC6[t];
 crc = (bb & 0x0000003F);
 t = crc ^ tableCRC6[t];
 crc = tableCRC6[t];
 return crc;
 }
```

Recommended literature:

- Painless guide to CRC error detection algorithm; Ross N. Williams.
- Cyclic Redundancy Code (CRC) Polynomial Selection For Embedded Networks; P. Koopman, T. Chakravarty

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Document issues

Issue	Date	Page	Corrections made
1	25. 1. 2016	-	New document