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Absolute Rotary Encoder

“GMI-ROTARY” Series

based on the

Giant Magneto Impedance (GMI) principle

Technical Datasheet

2023-02 - rev01

www.flux.gmbh

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1. GMI-ROTARY Encoders

The **GMI-ROTARY** series of encoders from FLUX GmbH offers motor feedback solutions for a broad array of applications, especially in designs that require precise positioning and exact control of velocity and torque.

Through the use of the FLUX patented GMI (Giant Magneto Impedance) sensor technology, the **GMI-ROTARY** series provides high-performance feedback as part of the closed loop motion control process.

The GMI position sensor technology and encoder architecture, developed and manufactured by FLUX, are the result of 40+ years experience in encoder development and manufacturing. It addresses in a purposeful and compact manner motion control feedback design requirements calling for:

- Precise position feedback
- Axial scanning of the measuring ring
- Hollow shaft implementation
- High positioning accuracy
- High position stability / low noise
- Zero backlash / hysteresis
- Insensitivity to external electrical noise
- Insensitivity to environmental pollution (IP67)
- Low signal latency
- Versatile mounting with fasteners or servo clamps

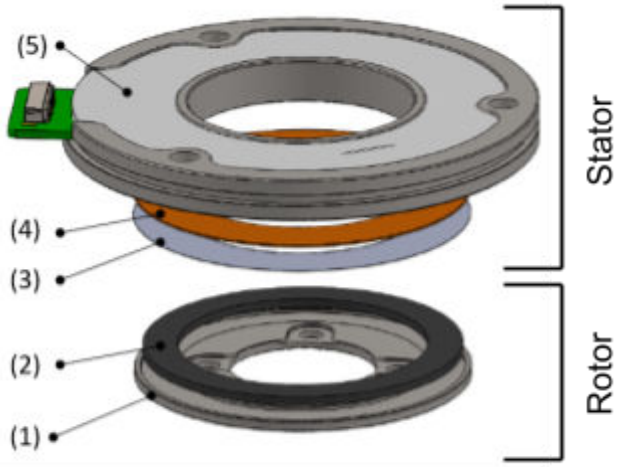
GMI-ROTARY encoder performance achievements:

- Resolution up to 22 bits / revolution
- Accuracy to ± 0.005° (± 18 arc seconds)
- Liberal mounting tolerance: axial ± 0.40 mm and radial ± 0.20 mm
- Axial stack-up as small as 8 mm including air-gap
- High ratio of inner diameter (through hole) to outer diameter

GMI-ROTARY series is the ideal choice for a wide range of applications including:

- machine tools
- semiconductor manufacturing
- cobots and robotics
- satcomm
- medical
- gimbals
- motors (torque, direct drive, servo, dc brushless)
- automated guided vehicles (AGV)

1.1. Giant Magneto Impedance principle (simplified)



Encoder rotor
(1) Metal carrier
(2) Absolute magnetic ring

Encoder stator
(3) GMI layer
(4) Absolute GMI sensor
(5) Metal housing and evaluation electronic

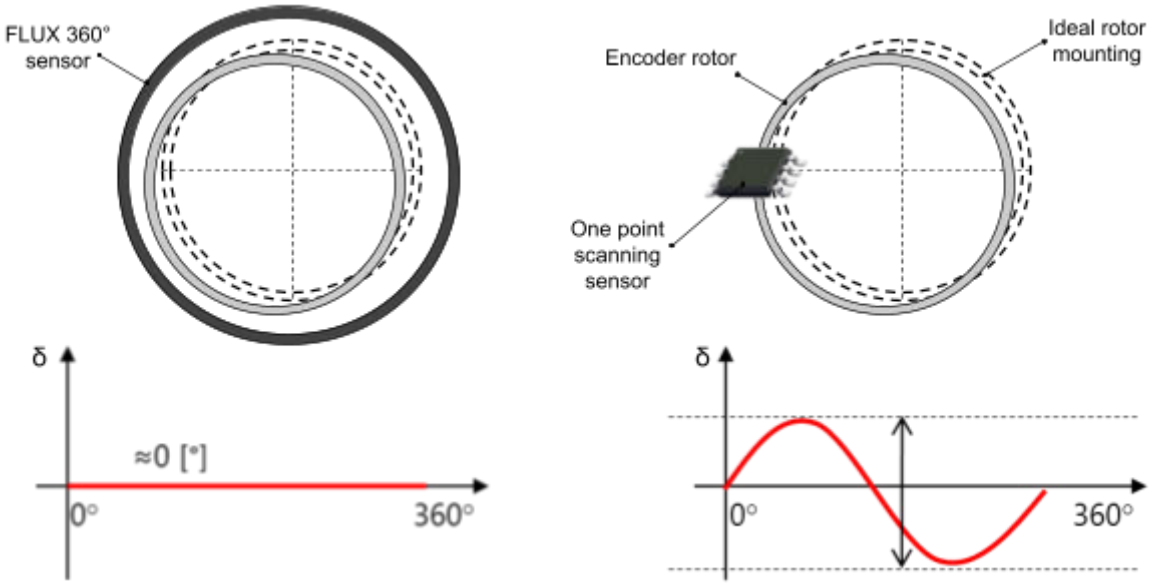
HOW IT WORKS

The magnetic field of the grating ring (2) generates in the thin metal foil (3) areas with variable electrical a.c. impedance. The variation of the generated a.c. impedance is converted to an electrical signal by the GMI sensor (4). The GMI sensor (4) is connected to the evaluation electronic (5) which converts the electrical signal in digital position.

1.2. Holistic, 360° scanning principle

FLUX encoders have a holistic scanning principle, meaning that they scan and read 360° around the encoder rotor. By comparison, many other rotary encoder technologies (magnetic xMR, Hall, optical, etc.) use segment or “one point” scanning.

360° scanning has many advantages, including improved signal quality, error averaging, and, most importantly, the reduction of the eccentricity error.
Eccentricity [e] is the displacement between the geometrical center of an encoder rotor and the rotation axis. The dotted disk in the figure below is the ideal position, and the gray disk shows the eccentric location of the encoder rotor.



Sensor geometry causes FLUX encoders to inherently average out eccentricity across the circumference of the rotor, resulting in significant reduction in eccentricity error. However, a sensor with a "one-point" scanning capability will exhibit eccentricity errors [δ] over a complete rotation in the form of a sinusoidal wave.

The eccentricity error [δ] for an “one-point” encoder can be calculated using the following formula:

$$\delta['] = \pm 412 \times \frac{e\ [\mu m]}{D\ [mm]}$$

with:

- δ … encoder eccentricity error in arcseconds
- e … eccentricity (half of the runout) in µm
- D … encoder diameter in mm

The eccentricity may occur both statically as a result of manufacturing or mounting tolerances as well as dynamically as the result of external forces acting on the mechanical parts during operation.

A "one-point" scanning approach could partially correct the statical eccentricity with additional effort and expensive calibration procedures, but there is no possibility of correcting the dynamical eccentricity.
As a result of the 360° scanning approach of the FLUX encoders, they inherently compensate for both statically and dynamically eccentricities .

Eccentricity error is a significant source of additional error in applications that require accuracy. Using an "one-point" encoder can reduce the overall performance of the machine even for eccentricities under 20 µm. Using different sizes of encoder, a comparison of additional errors to the positioning system is presented in the following tables for both 10 and 20 µm eccentricities.

Additional error δ for e = 10 µm		
Diameter *D*	**FLUX GMI-ROT**	**One-Point**
55 mm	<± 4”	± 75”
69 mm	<± 3”	± 60”
80 mm	<± 3”	± 52”
96 mm	<± 2”	± 43”

Additional error δ for e = 20 µm		
Diameter *D*	**FLUX GMI-ROT**	**One-Point**
55 mm	<± 6”	± 150”
69 mm	<± 4”	± 119”
80 mm	<± 4”	± 103”
96 mm	<± 3”	± 86”

1.3. Environmental and EMC immunity

FLUX rotary encoders based on Giant Magnetic Impedance (GMI) offer exceptional immunity to environmental and electromagnetic perturbations.

GMI-ROTARY encoders come standard with an IP67 rating. Moreover, the rotary encoder can work in extreme environmental conditions, and its performance is not compromised by dust, condensation or solvents.

2. Encoder Specification

**GMI-ROTARY-055 (size 55mm) with radial mounting rotor version (-C11)*

GMI-ROTARY size (OD)	**55 mm**	**69 mm**	**80 mm**	**96 mm**
System data				
Type	Axial, frameless, true absolute **Giant Magneto Impedance encoder** **GMI Technology** - FLUX GmbH proprietary			
Standard resolution	20 bits	20 bits	21 bits	22 bits
Standard accuracy *(no calibration required)*	± 0.014°	± 0.010°	± 0.007°	± 0.005°
	± 50”	± 36”	± 25”	± 18”
	± 250 µrad	± 180 µrad	± 120 µrad	± 90 µrad
Hysteresis	none			
Repeatability	1 resolution count			
Position update rate and signal latency	Real-time			
Standard maximum speed	6’000 rpm *(higher on request)*			

Electrical data	
Supply voltage *(at encoder connector)*	**Option 5V:** typ. 5 Vdc Min. 4.35 Vdc. Max. 6 Vdc
Reverse polarity protection	Yes
Current Consumption *(w/o output terminations)*	max. 150 mA @ 5 Vdc (**Option 5V**)

GMI-ROT size (OD)	55 mm	69 mm	80 mm	96 mm
Mechanical Data				
Stator base material	Stainless steel (option ***-ST***) CTE ~ 10 ppm/°C Aluminum (option ***-AL***) CTE ~ 24 ppm/°C			
Stator weight (ST)[(1)]	45 g	65 g	85 g	115 g
Stator weight (AL)[(1)]	22 g	30 g	35 g	45 g
Rotor base material	Stainless steel (option ***-ST***) CTE ~ 10 ppm/°C Aluminum (option ***-AL***) CTE ~ 24 ppm/°C			
Rotor weight (ST)[(1)]	15 g	22 g	28 g	36 g
Rotor weight (AL)[(1)]	8 g	9 g	14 g	17 g
Vibration	EN 60068-2-6, 20 g, 55 .. 2000 Hz			
Shock	EN 60068-2-27, 200 g, 6 ms			

[(1)] Guiding values, without cable. Values can vary with the rotor mounting option

Mounting tolerances	
Nominal Axial Air-Gap	0.3 mm
Axial tolerances	-0.2 mm; +0.5 mm
Radial Tolerance	±0.2 mm

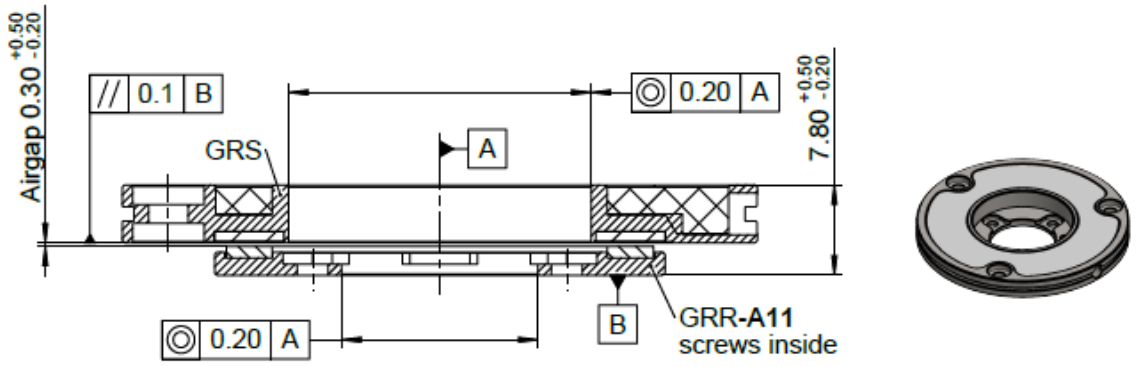
Environmental data	
Temperature range - Standard (*no additional option in order code***)**	
Operating	-20°C .. +85°C
Storage	-20°C .. +85°C
Temperature range - Extended (*contact FLUX for more details***)**	
Operating	-40°C .. +105°C
Storage	-55°C .. +125°C
Ingress Protection	IP67 (*only for Options: K01, K02 - cable output*)
EMC immunity	complies with EN IEC 61000-6-2
EMC emission	complies with EN IEC 61000-6-4

Output interfaces (See Chap.5)	
Absolute: **SSI**	SSI00, SSI01, SSI02
Absolute: **BiSS/C**	BIS00, BIS10 *(recommended for new designs)*
Incremental: **A/B/Z**	INCxx
Absolute: **SPI**	*contact FLUX for more details*
Other synchronous or asynchronous	*contact FLUX for more details*

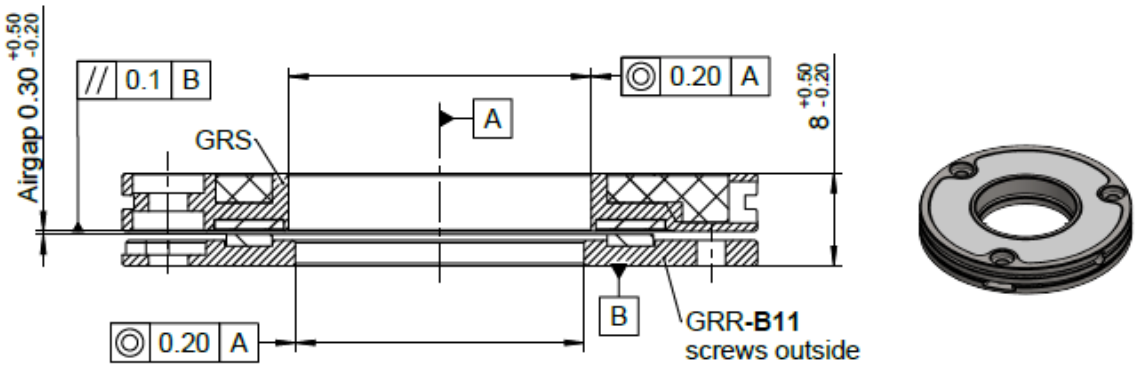
3. Mechanical dimensions and mounting tolerances

3.1. GMI-ROTARY Series - Mounting tolerances

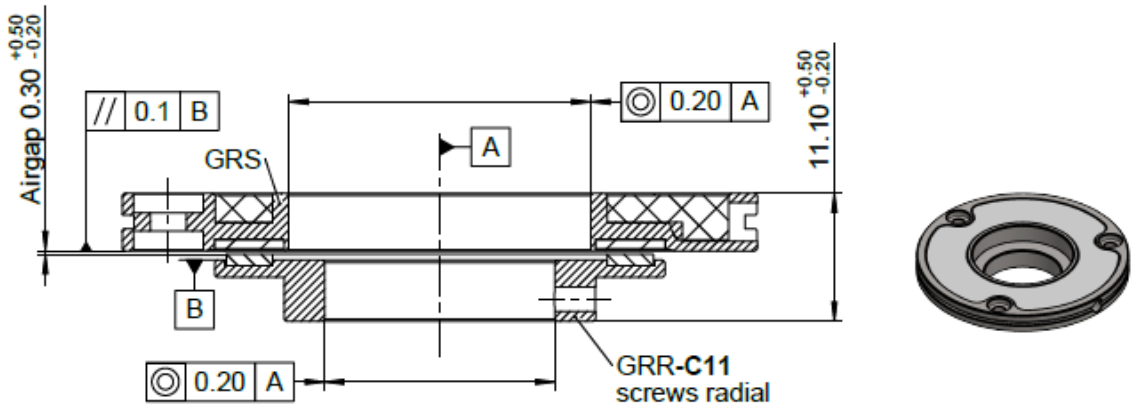
Rotor mounting with screws inside grating (Rotor option "**-A11**"):



Rotor mounting with screws outside grating (Rotor option "**-B11**"):



Rotor mounting with screws radial (Rotor option "**-C11**"):



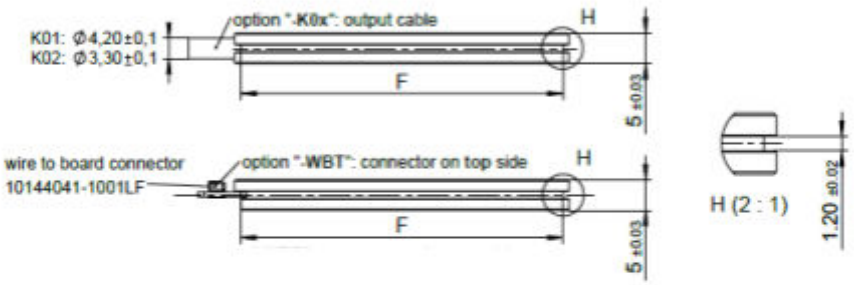
A ... axis of rotation

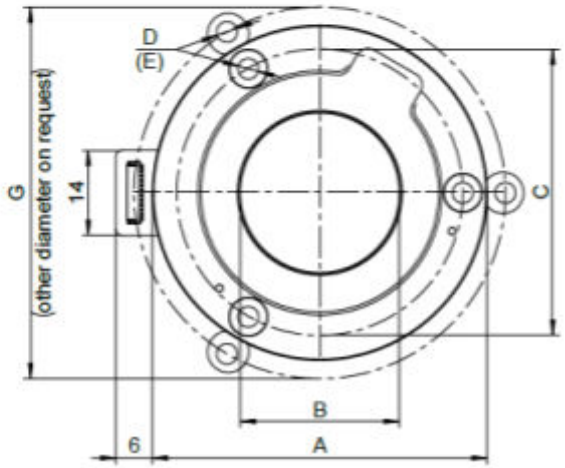
max. total runout GRS + GRR = 0.20mm | / | GRS + GRR | 0.20 | A |

Dimensions are mm.

3.2. **G**MI **R**otary Encoder - **S**tator: **GRS**

3.2.1. Stator for GMI-ROT-055: **GRS-055**





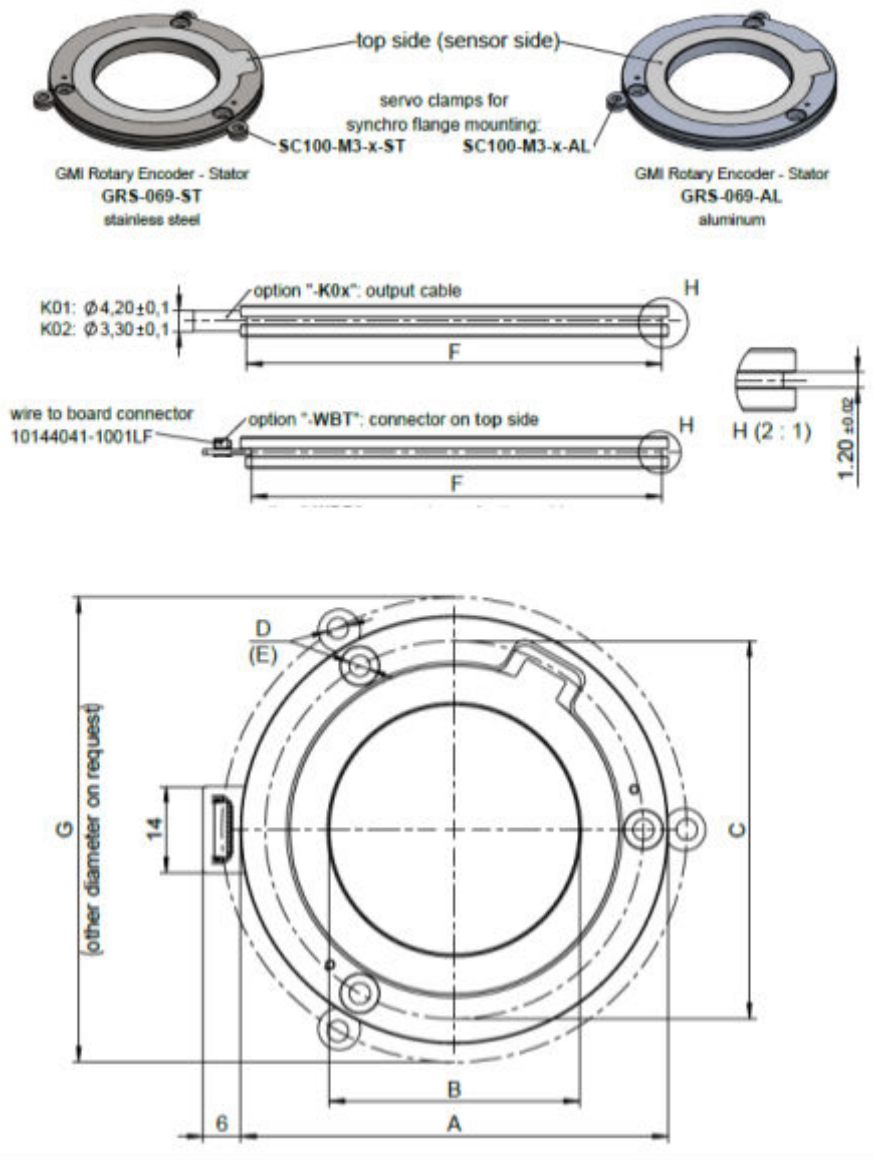
Size comparison table. The 055 mm size is highlighted.

GRS-xxx	A	B	C	D	E	F	G1	G2
055	**ø55 h7**	**ø26,20 H7**	**ø47**	**3 x ø3,40 (120°)**	**M3**	**ø53**	**ø61**	**ø63**
069	ø69 h7	ø40,20 H7	ø61	3 x ø3,40 (120°)	M3	ø67	ø75	ø77
080	ø80 h7	ø51,20 H7	ø72	3 x ø3,40 (120°)	M3	ø78	ø86	ø88
096	ø96 h7	ø67,20 H7	ø88	6 x ø3,40 (60°)	M3	ø94	ø102	ø104

Dimensions are in mm.
Screw hole dimensions for fastener according ISO 7380-1.

E ... screw size
F/G … synchro flange mounting (see Chapter 9.2.)
G1 … synchro flange mounting option with accessory: SC100-M3-6
G2 … synchro flange mounting option with accessory: SC100-M3-8

3.2.2. Stator for GMI-ROT-069: **GRS-069**



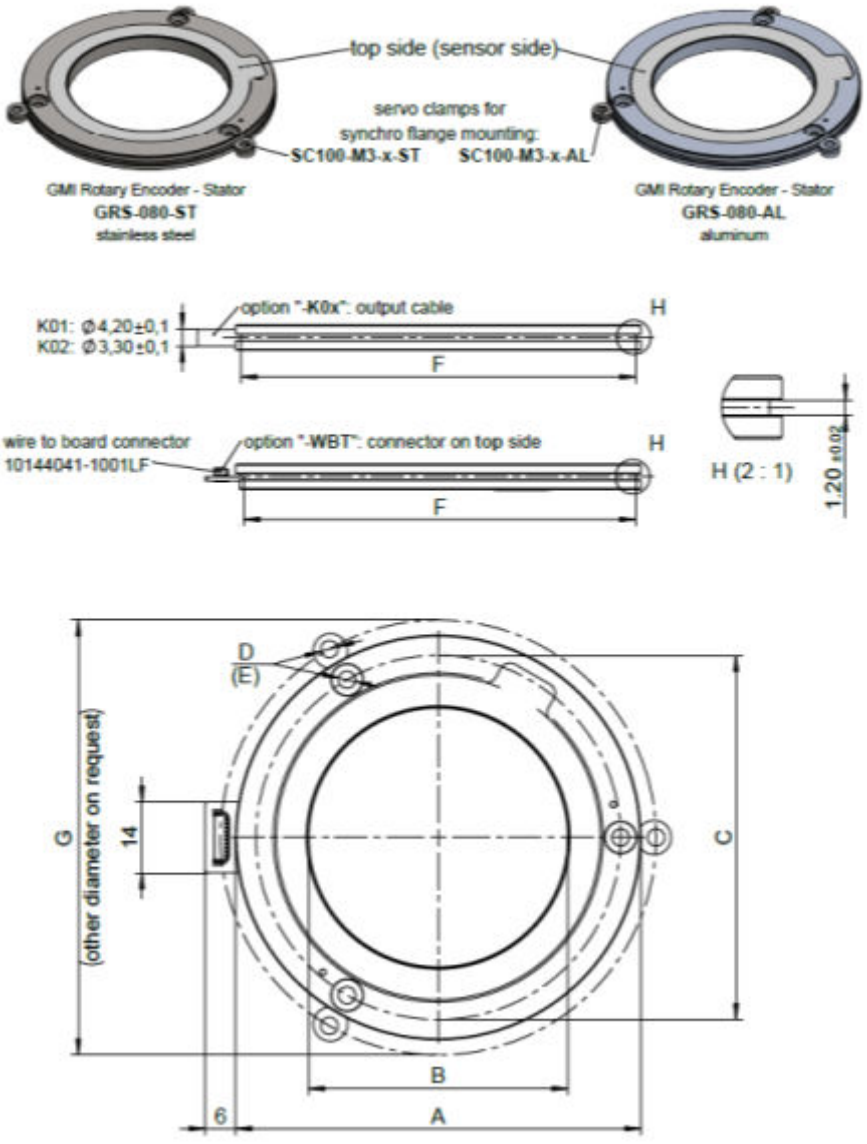
Size comparison table. The 069 mm size is highlighted.

GRS-xxx	A	B	C	D	E	F	G1	G2
055	ø55 h7	ø26,20 H7	ø47	3 x ø3,40 (120°)	M3	ø53	ø61	ø63
069	**ø69 h7**	**ø40,20 H7**	**ø61**	**3 x ø3,40 (120°)**	**M3**	**ø67**	**ø75**	**ø77**
080	ø80 h7	ø51,20 H7	ø72	3 x ø3,40 (120°)	M3	ø78	ø86	ø88
096	ø96 h7	ø67,20 H7	ø88	6 x ø3,40 (60°)	M3	ø94	ø102	ø104

Dimensions are in mm.
Screw hole dimensions for fastener according ISO 7380-1.

E ... screw size
F/G … synchro flange mounting (see Chapter 9.2.)
G1 … synchro flange mounting option with accessory: SC100-M3-6
G2 … synchro flange mounting option with accessory: SC100-M3-8

3.2.3. Stator for GMI-ROT-080: **GRS-080**



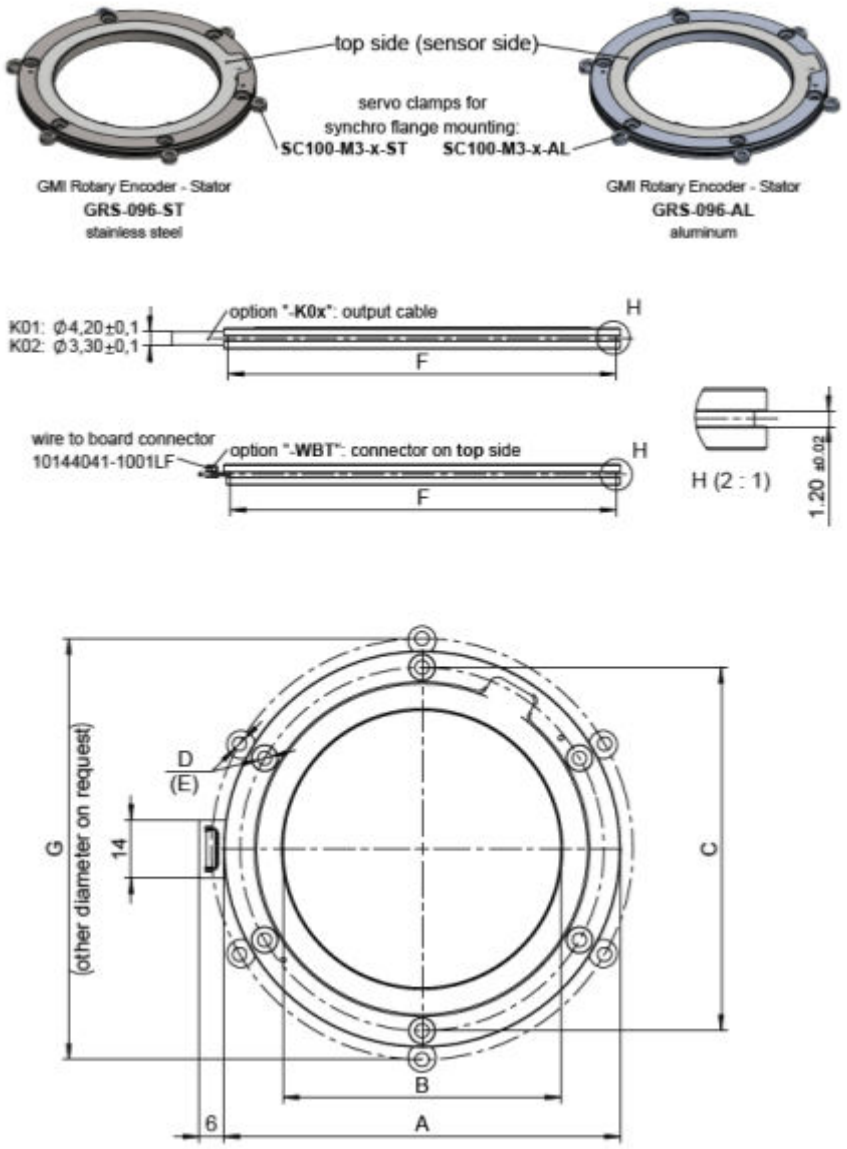
Size comparison table. The 080 mm size is highlighted.

GRS-xxx	A	B	C	D	E	F	G1	G2
055	ø55 h7	ø26,20 H7	ø47	3 x ø3,40 (120°)	M3	ø53	ø61	ø63
069	ø69 h7	ø40,20 H7	ø61	3 x ø3,40 (120°)	M3	ø67	ø75	ø77
080	**ø80 h7**	**ø51,20 H7**	**ø72**	**3 x ø3,40 (120°)**	**M3**	**ø78**	**ø86**	**ø88**
096	ø96 h7	ø67,20 H7	ø88	6 x ø3,40 (60°)	M3	ø94	ø102	ø104

Dimensions are in mm.
Screw hole dimensions for fastener according ISO 7380-1.

E ... screw size
F/G … synchro flange mounting (see Chapter 9.2.)
G1 … synchro flange mounting option with accessory: SC100-M3-6
G2 … synchro flange mounting option with accessory: SC100-M3-8

3.2.4. Stator for GMI-ROT-096: **GRS-096**



Size comparison table. The 096 mm size is highlighted.

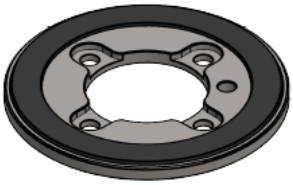
GRS-xxx	A	B	C	D	E	F	G1	G2
055	ø55 h7	ø26,20 H7	ø47	3 x ø3,40 (120°)	M3	ø53	ø61	ø63
069	ø69 h7	ø40,20 H7	ø61	3 x ø3,40 (120°)	M3	ø67	ø75	ø77
080	ø80 h7	ø51,20 H7	ø72	3 x ø3,40 (120°)	M3	ø78	ø86	ø88
096	**ø96 h7**	**ø67,20 H7**	**ø88**	**6 x ø3,40 (60°)**	**M3**	**ø94**	**ø102**	**ø104**

Dimensions are in mm.
Screw hole dimensions for fastener according ISO 7380-1.

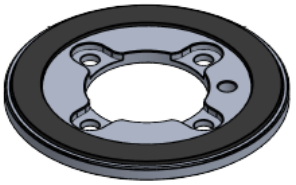
E ... screw size
F/G … synchro flange mounting (see Chapter 9.2.)
G1 … synchro flange mounting option with accessory: SC100-M3-6
G2 … synchro flange mounting option with accessory: SC100-M3-8

3.3. **G**MI **R**otary Encoder - **R**otor: **GRR-A11 screws inside**

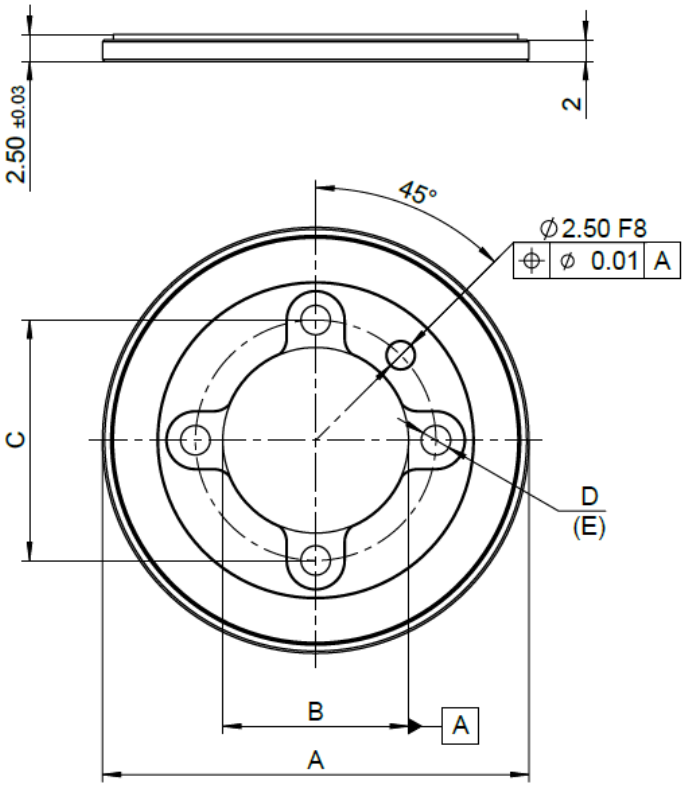
3.3.1. Rotor for GMI-ROT-055: **GRR-055-A11**



GMI Rotary Encoder - Rotor
GRR-055-A11-ST
stainless steel



GMI Rotary Encoder - Rotor
GRR-055-A11-AL
aluminum



Size comparison table. The 055 mm size is highlighted.

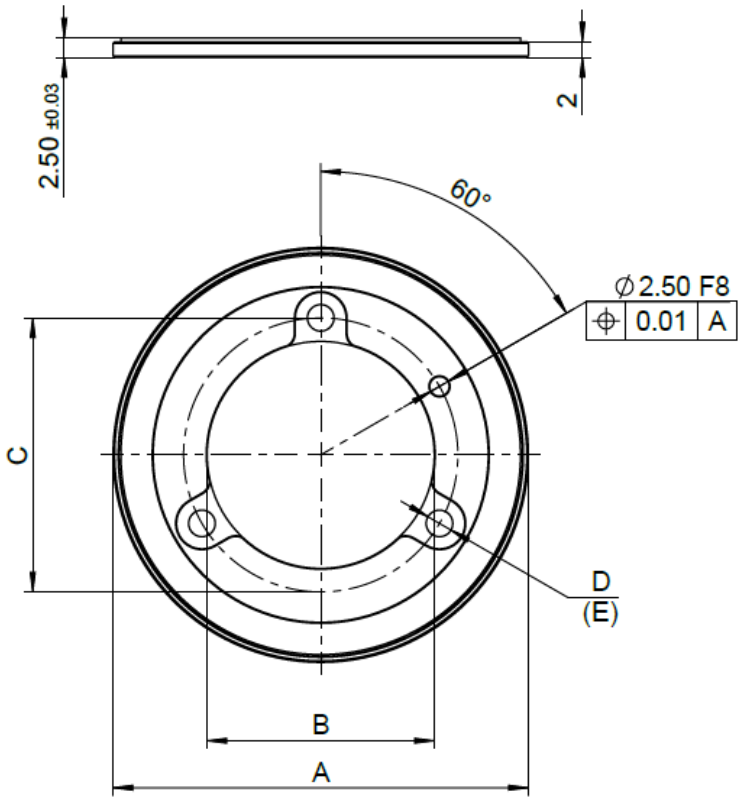
GRR-xxx	A	B	C	D	E
055-A11	**ø39 h7**	**ø17 H7**	**ø22**	**4 x ø2,70 (90°)**	**M2,5**
069-A11	ø53 h7	ø29 H7	ø35	3 x ø3,40 (120°)	M3
080-A11	ø64 h7	ø40 H7	ø46	6 x ø3,40 (60°)	M3
096-A11	ø80 h7	ø56 H7	ø62	6 x ø3,40 (60°)	M3

Dimensions are in mm.
Screw hole dimensions for fastener according ISO 7380-1.
E ... screw size

3.3.2. Rotor for GMI-ROT-069: **GRR-069-A11**

GMI Rotary Encoder - Rotor
GRR-069-A11-ST
stainless steel

GMI Rotary Encoder - Rotor
GRR-069-A11-AL
aluminum



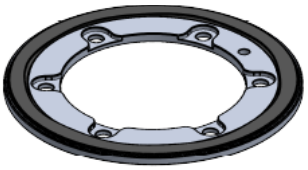
Size comparison table. The 069 mm size is highlighted.

GRR-xxx	A	B	C	D	E
055-A11	ø39 h7	ø17 H7	ø22	4 x ø2,70 (90°)	M2,5
069-A11	**ø53 h7**	**ø29 H7**	**ø35**	**3 x ø3,40 (120°)**	**M3**
080-A11	ø64 h7	ø40 H7	ø46	6 x ø3,40 (60°)	M3
096-A11	ø80 h7	ø56 H7	ø62	6 x ø3,40 (60°)	M3

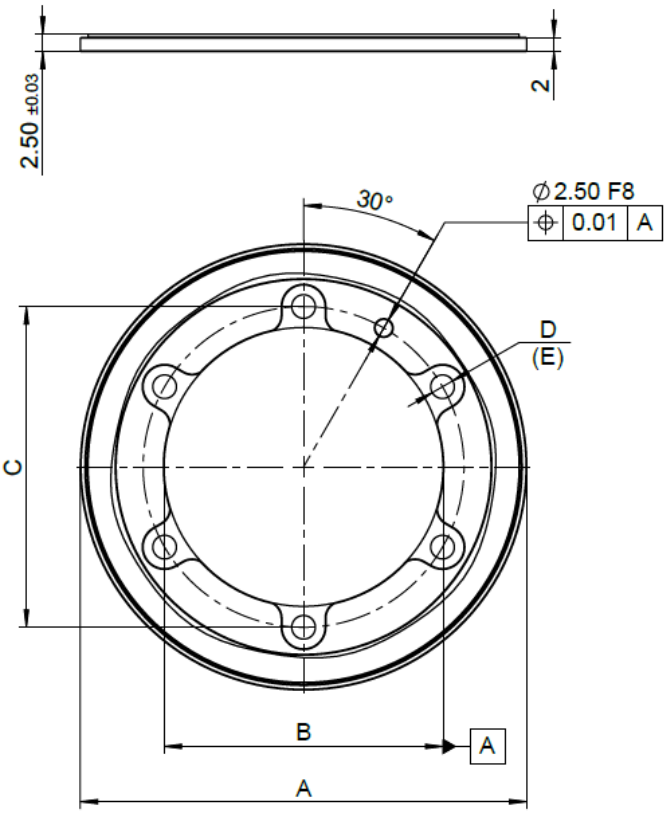
Dimensions are in mm.
Screw hole dimensions for fastener according ISO 7380-1.
E ... screw size

3.3.3. Rotor for GMI-ROT-080: **GRR-080-A11**

GMI Rotary Encoder - Rotor
GRR-080-A11-ST
stainless steel



GMI Rotary Encoder - Rotor
GRR-080-A11-AL
aluminum



Size comparison table. The 080 mm size is highlighted.

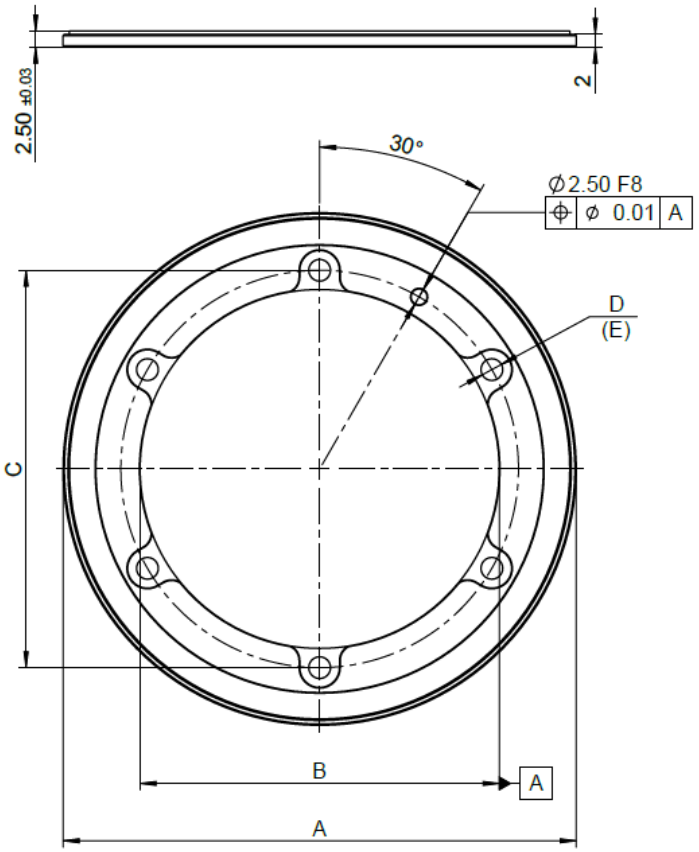
GRR-xxx	A	B	C	D	E
055-A11	ø39 h7	ø17 H7	ø22	4 x ø2,70 (90°)	M2,5
069-A11	ø53 h7	ø29 H7	ø35	3 x ø3,40 (120°)	M3
080-A11	**ø64 h7**	**ø40 H7**	**ø46**	**6 x ø3,40 (60°)**	**M3**
096-A11	ø80 h7	ø56 H7	ø62	6 x ø3,40 (60°)	M3

Dimensions are in mm.
Screw hole dimensions for fastener according ISO 7380-1.
E ... screw size

3.3.4. Rotor for GMI-ROT-096: **GRR-096-A11**

GMI Rotary Encoder - Rotor
GRR-096-A11-ST
stainless steel

GMI Rotary Encoder - Rotor
GRR-096-A11-AL
aluminum



Size comparison table. The 096 mm size is highlighted.

GRR-xxx	A	B	C	D	E
055-A11	ø39 h7	ø17 H7	ø22	4 x ø2,70 (90°)	M2,5
069-A11	ø53 h7	ø29 H7	ø35	3 x ø3,40 (120°)	M3
080-A11	ø64 h7	ø40 H7	ø46	6 x ø3,40 (60°)	M3
096-A11	**ø80 h7**	**ø56 H7**	**ø62**	**6 x ø3,40 (60°)**	**M3**

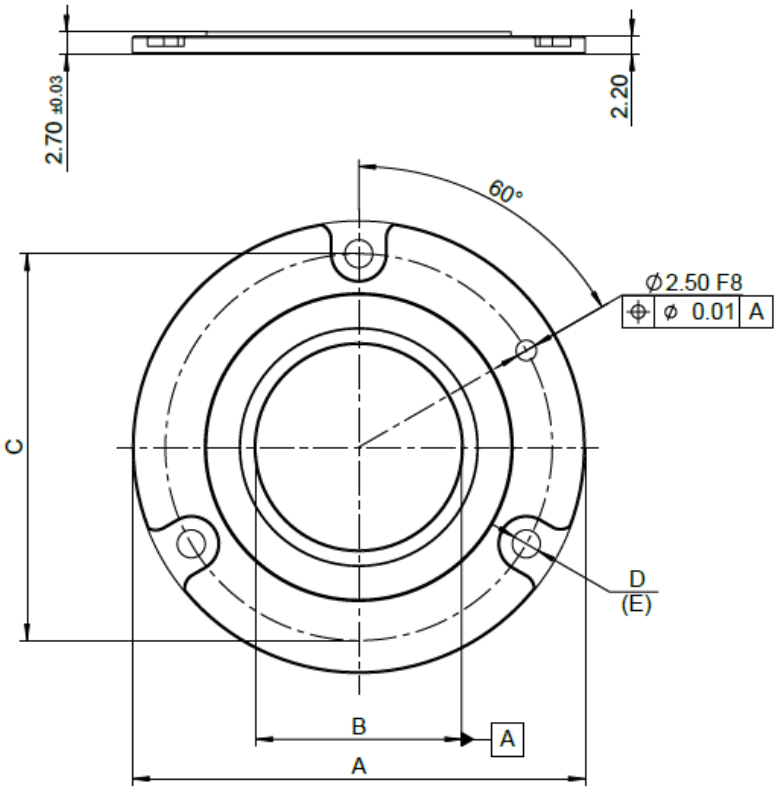
Dimensions are in mm.
Screw hole dimensions for fastener according ISO 7380-1.
E ... screw size

3.4. **G**MI **R**otary Encoder - **R**otor: **GRR-B11 screws outside**

3.4.1. Rotor type B11 for GMI-ROT-055: **GRR-055-B11**

GMI Rotary Encoder - Rotor
GRR-055-B11-ST
stainless steel

GMI Rotary Encoder - Rotor
GRR-055-B11-AL
aluminum



Size comparison table. The 055 mm size is highlighted.

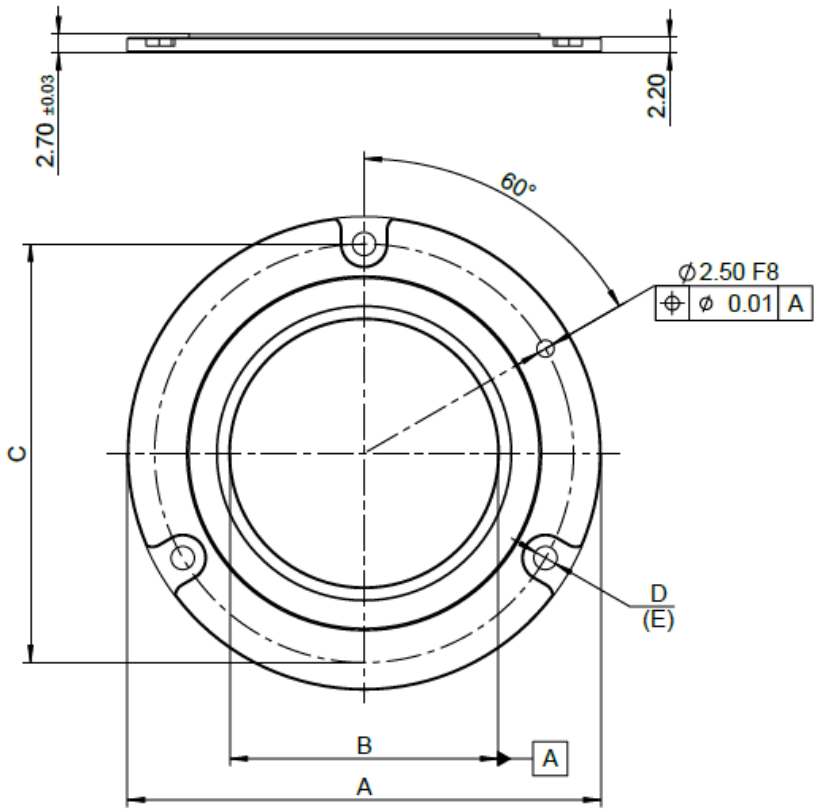
GRR-xxx	A	B	C	D	E
055-B11	**ø55 h7**	**ø25 H7**	**ø47**	**3 x ø3,40 (90°)**	**M3**
069-B11	ø69 h7	ø39 H7	ø61	3 x ø3,40 (120°)	M3
080-B11	ø80 h7	ø50 H7	ø72	6 x ø3,40 (60°)	M3
096-B11	ø96 h7	ø66 H7	ø88	6 x ø3,40 (60°)	M3

Dimensions are in mm.
Screw hole dimensions for fastener according ISO 7380-1.
E ... screw size

3.4.2. Rotor type B11 for GMI-ROT-069: **GRR-069-B11**

GMI Rotary Encoder - Rotor
GRR-069-B11-ST
stainless steel

GMI Rotary Encoder - Rotor
GRR-069-B11-AL
aluminum



Size comparison table. The 069 mm size is highlighted.

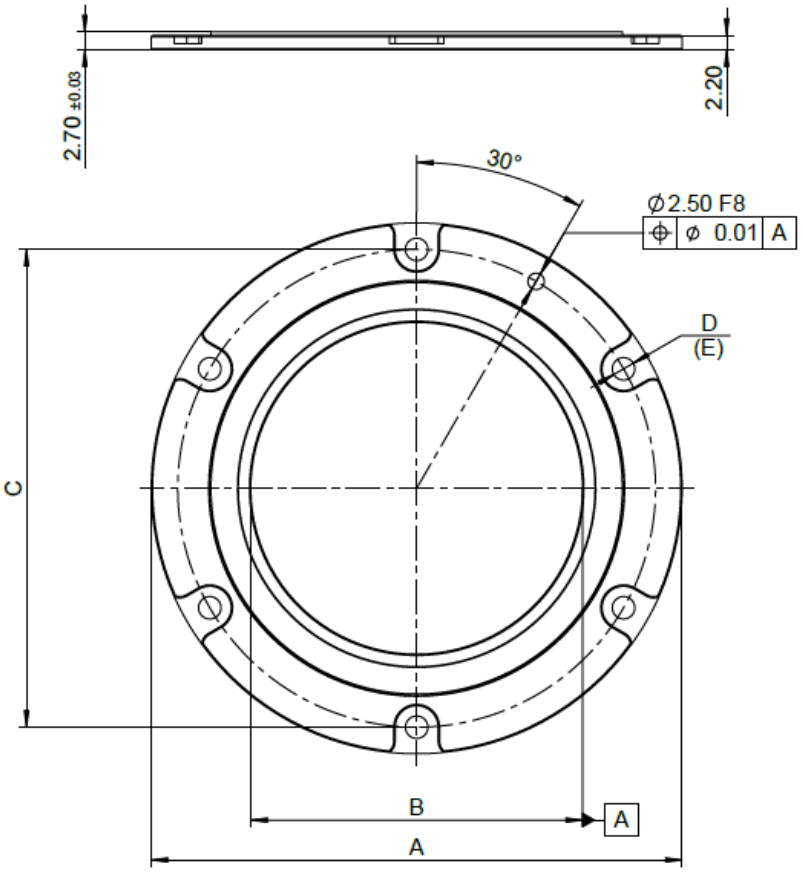
GRR-xxx	A	B	C	D	E
055-B11	ø55 h7	ø25 H7	ø47	3 x ø3,40 (90°)	M3
069-B11	**ø69 h7**	**ø39 H7**	**ø61**	**3 x ø3,40 (120°)**	**M3**
080-B11	ø80 h7	ø50 H7	ø72	6 x ø3,40 (60°)	M3
096-B11	ø96 h7	ø66 H7	ø88	6 x ø3,40 (60°)	M3

Dimensions are in mm.
Screw hole dimensions for fastener according ISO 7380-1.
E ... screw size

3.4.3. Rotor type B11 for GMI-ROT-080: **GRR-080-B11**

GMI Rotary Encoder - Rotor
GRR-080-B11-ST
stainless steel

GMI Rotary Encoder - Rotor
GRR-080-B11-AL
aluminum



Size comparison table. The 080 mm size is highlighted.

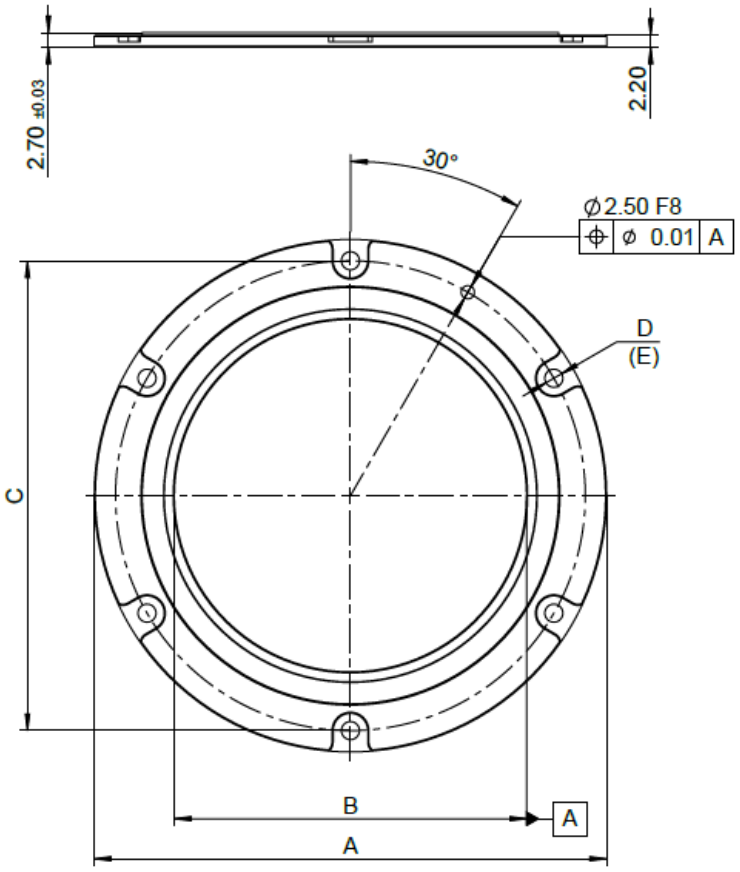
GRR-xxx	A	B	C	D	E
055-B11	ø55 h7	ø25 H7	ø47	3 x ø3,40 (90°)	M3
069-B11	ø69 h7	ø39 H7	ø61	3 x ø3,40 (120°)	M3
080-B11	**ø80 h7**	**ø50 H7**	**ø72**	**6 x ø3,40 (60°)**	**M3**
096-B11	ø96 h7	ø66 H7	ø88	6 x ø3,40 (60°)	M3

Dimensions are in mm.
Screw hole dimensions for fastener according ISO 7380-1.
E ... screw size

3.4.4. Rotor type B11 for GMI-ROT-096: **GRR-096-B11**

GMI Rotary Encoder - Rotor
GRR-096-B11-ST
stainless steel

GMI Rotary Encoder - Rotor
GRR-096-B11-AL
aluminum



Size comparison table. The 096 mm size is highlighted.

GRR-xxx	A	B	C	D	E
055-B11	ø55 h7	ø25 H7	ø47	3 x ø3,40 (90°)	M3
069-B11	ø69 h7	ø39 H7	ø61	3 x ø3,40 (120°)	M3
080-B11	ø80 h7	ø50 H7	ø72	6 x ø3,40 (60°)	M3
096-B11	**ø96 h7**	**ø66 H7**	**ø88**	**6 x ø3,40 (60°)**	**M3**

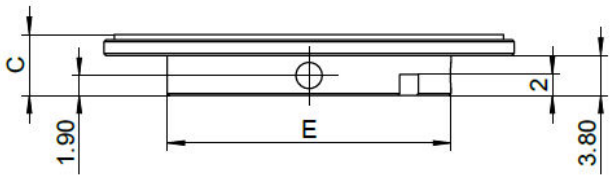
Dimensions are in mm.
Screw hole dimensions for fastener according ISO 7380-1.
E ... screw size

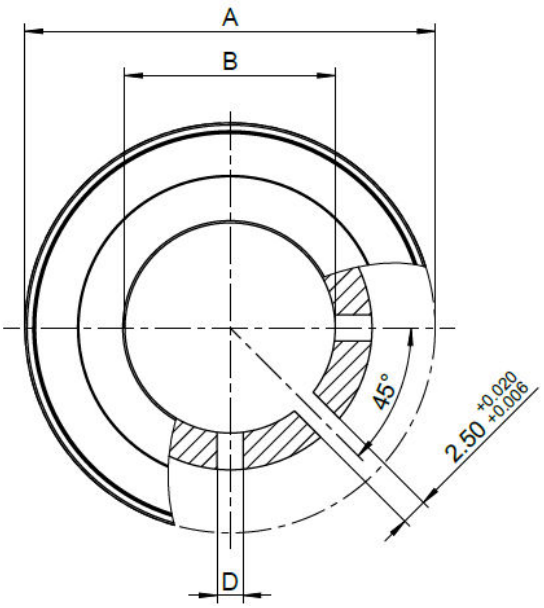
3.5. **G**MI **R**otary Encoder - **R**otor: **GRR-C11 screws radial**

3.5.1. Rotor type C11 for GMI-ROT-055: **GRR-055-C11**

GMI Rotary Encoder - Rotor
GRR-055-C11-ST
stainless steel

GMI Rotary Encoder - Rotor
GRR-055-C11-AL
aluminum





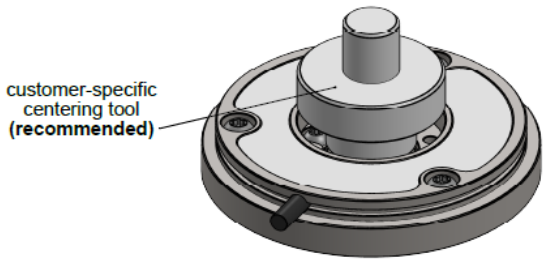
Size comparison table. The 055 mm size is highlighted.

GRR-xxx	A	B	C	D	E
055-C11	**ø39 +0.00/-0.05**	**ø20 H7**	**5.80 ±0.05**	**2 x M3 (90°)**	**ø27 ±0.05**
069-C11	We offer customized rotors based on the application requirements. Please send your requirements at office@flux.gmbh				
080-C11					
096-C11					

Dimensions are in mm.
Screw hole dimensions for fastener according ISO 7380-1.
E ... screw size

4. Mounting recommendation

4.1. Stator GRS sensor-side mounting



GMI Rotary Encoder
GRS sensor side mounting and centering

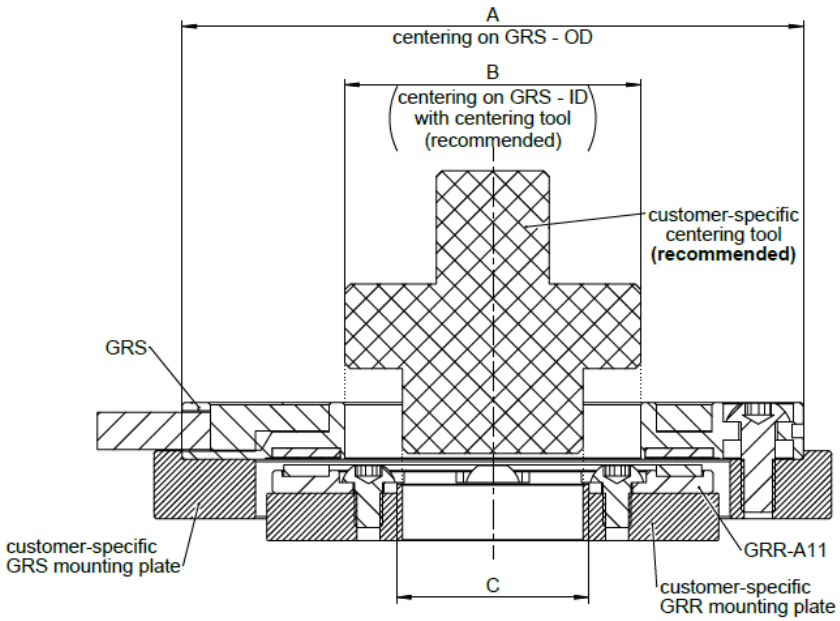


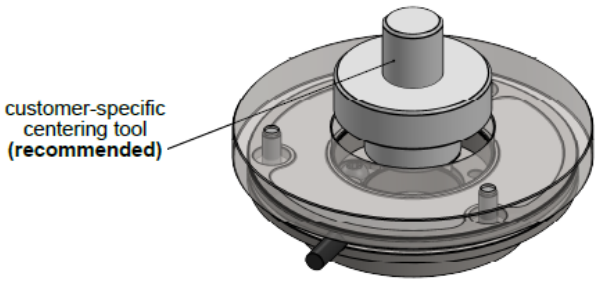
Fig. 4.1.: GMI Rotary Encoder: GRS sensor-side mounting and centering recommendation

GMI-ROT-xxx	A	B	C
055	ø55 H7	ø26.20 h7	ø17 h7
069	ø69 H7	ø40.20 h7	ø29 h7
080	ø80 H7	ø51.20 h7	ø40 h7
096	ø96 H7	ø67.20 h7	ø56 h7

Dimensions are in mm.

The mounting of the Rotor (GRR) and the Stator (GRS) needs to be adapted according to the application. The customer-specific mounting plate is shown only as an example.

4.2. Stator GRS potting-compound-side mounting



GMI Rotary Encoder
GRS potting-compound-side mounting and centering

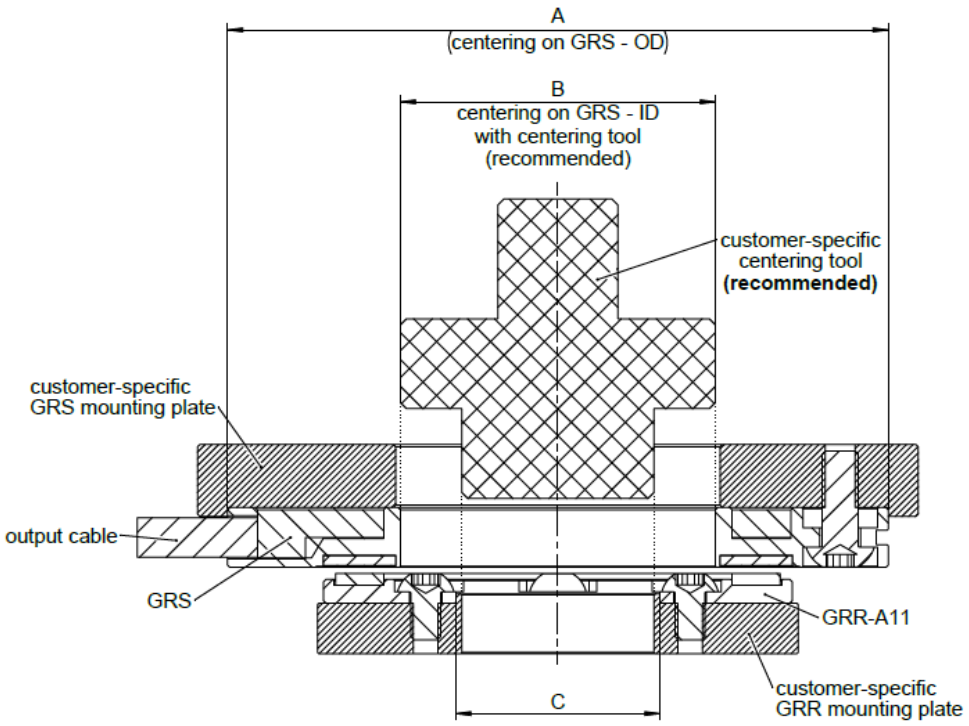


Fig 4.2.: GMI Rotary Encoder: GRS potting-compound-side mounting and centering.

GRS-xxx	A	B	C
055	ø55 H7	ø26.20 h7	ø17 h7
069	ø69 H7	ø40.20 h7	ø29 h7
080	ø80 H7	ø51.20 h7	ø40 h7
096	ø96 H7	ø67.20 h7	ø56 h7

Dimensions are in mm.

The mounting of the Rotor (GRR) and the Stator (GRS) needs to be adapted according to the application. The customer-specific mounting plate is shown only as an example.

5. Interface description

5.1. SSI00

The synchronous serial interface SSI is a unidirectional point to point communication channel. The transmission of the sensor output signal SSI DATA is synchronized by the common clock signal SSI CLOCK. The DATA and CLOCK signals are transmitted according to the RS-485 (EIA-485) standard, driven by RS-485 buffers.

Parameter	Note	Min.	Typ.	Max.	Unit
Clock frequency f_{clk}	data updated on rising clock edge	0.2		1.0	MHz
Monoflop time t_{mf}		30			µs
Total number for bits			28		bits
Number of data bits *N*			25		bits
Data alignment		right aligned unused MSB set LOW-"0"			
Number of status bits *S*	Error *E* (active high) Warning *W* (active high) Parity P (even)		3		bits

The data transmission and position latch starts with the first falling edge of the clock signal. The serial data update occurs on the rising clock edge.

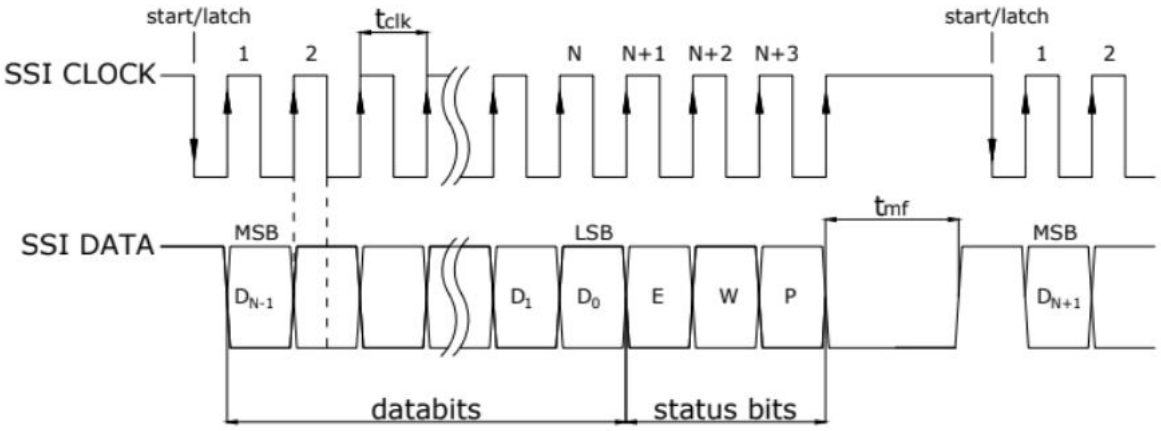


Fig. 5.1.: SSI00 signal waveform diagram

5.2. SSI01

The synchronous serial interface SSI is a unidirectional point to point communication channel. The transmission of the sensor output signal SSI DATA is synchronized by the common clock signal SSI CLOCK. The DATA and CLOCK signals are transmitted according to the RS-485 (EIA-485) standard, driven by RS-485 buffers.

Parameter	Note	Min.	Typ.	Max.	Unit
Clock frequency f_{clk}	data updated on rising clock edge	0.1		2.0	MHz
Monoflop time t_{mf}		20			µs
Total number for bits	only data bits transmitted		N		bits
Number of data bits *N*	only data bits transmitted		N		bits
Data alignment		not relevant			
Number of status bits *S*	no status bit is transmitted		0		bits

Data transmission and position latch starts with the first falling edge of the clock signal. The serial data update occurs on the rising clock edge.

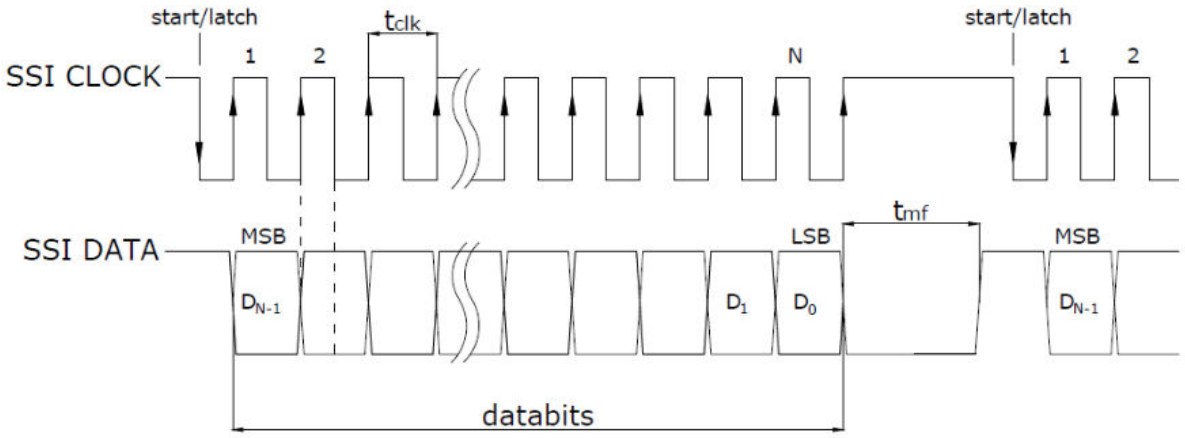


Fig. 5.2.: SSI01 signal waveform diagram

5.3. SSI02

The SSI02 version of the Synchronous Serial Interface SSI can be used to communicate with a Serial Peripheral Interface (SPI) controller.

The transmission of the sensor output signal SSI DATA is synchronized by the common clock signal SSI CLOCK. The DATA and CLOCK signals are transmitted according to the RS-485 (EIA-485) standard, driven by RS-485 buffers (compatible with RS-422).

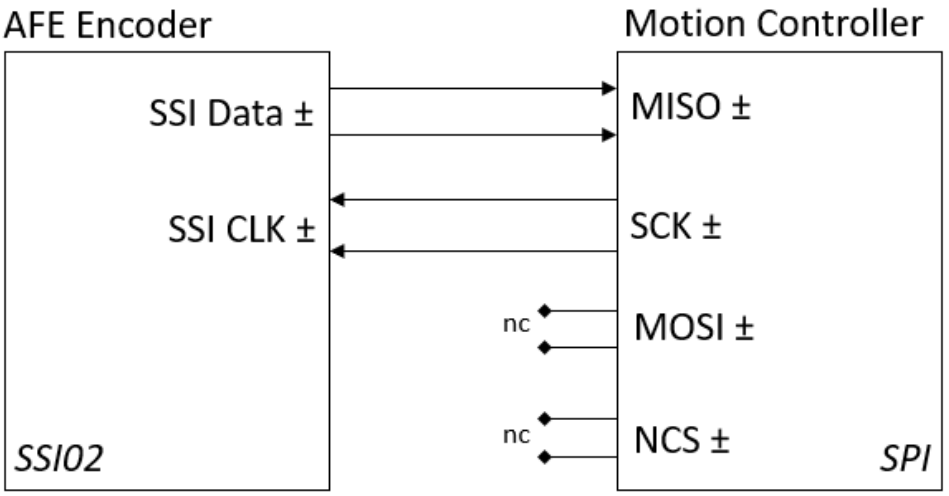


Fig.5.3.: Interfacing SSI02 interface to the SPI master

For interfacing the SSI02 the following connections are required:

- SSI Data must be connected to the SPI Master Input, Slave Output (MISO)
- SSI Clock must be connected to the SPI Serial Clock (SCK)
-

The SPI lines Master Output, Slave Input (MOSI) and SPI Not Chip Select (NCS) are not connected. In this configuration the encoder is continuously enabled and answers with the current position.

SPI Mode#2 is the only mode supported by SSI02. The required SPI configuration for Mode#2 is:

CPOL = '1'	SPI Clock (SCK) Idle Polarity is "1" / High
CPHA = '0'	SPI Data (MISO) is received/sampled on falling edge of the clock

Data transmission and position latch starts with the first falling edge of the clock signal. The serial data update occurs on the rising clock edge.

Parameter	Note	Min.	Typ.	Max.	Unit
Clock frequency f_{clk}	data updated on rising clock edge	0.2		1.0	MHz
Monoflop time t_{mf}		30			µs
Total number for bits	number of clock falling edges		24		bits
Number of position bits			22		bits
Data alignment		right aligned unused MSB set LOW-"0"			
Number of status bits *S*	Error *E* (active high)		1		bits

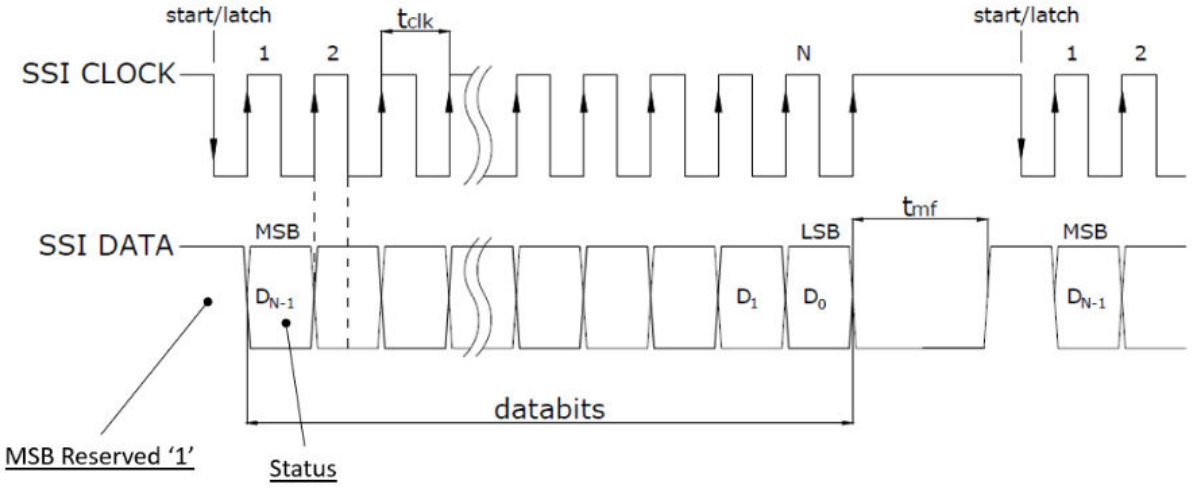


Fig.5.4. Time Diagram for the SSI02 interface

Bits conversion for the 24 bits (23 down to 0) for the SPI master:

Bit		Description
Reserved	23 (MSB)	To be ignored. Bit always on "1"
Status	22 ($\mathbf{D_{N-1}}$)	Error bit (active high) '0' position valid / '1' encoder error
Data bits	21 … 0 (LSB)	Position, right aligned. Unused MSB bits set on '0'

5.4. INCxx

Incremental TTL consists of two square-wave position signals — A and B — in quadrature which are phase-shifted by 90 degrees relative to each other. Additionally a differential Reference Index Signal (Z) is available for homing procedure.

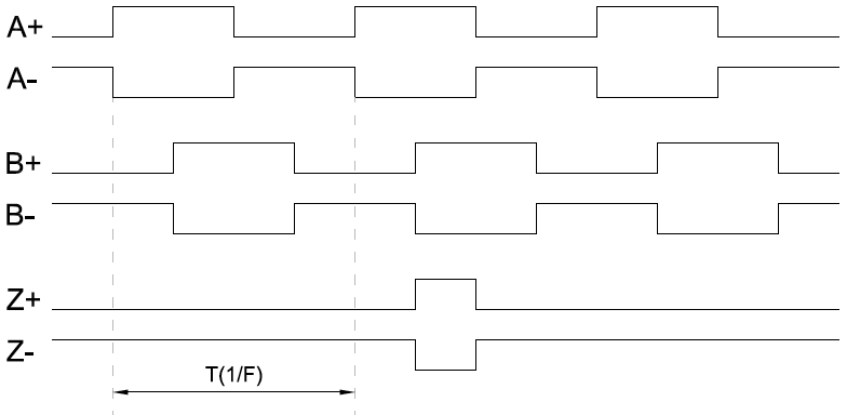


Fig.5.5.: Time diagram with differential TTL quadrature signal

INCxx	Output Frequency (F=1 / T)	Counts after x4 Decoding
INC00	5.000 MHz	20.0 Mio. / sec
INC01	2.500 MHz	10.0 Mio. / sec
INC02	1.250 MHz	5.0 Mio. / sec
INC03	0.625 MHz	2.5 Mio. / sec

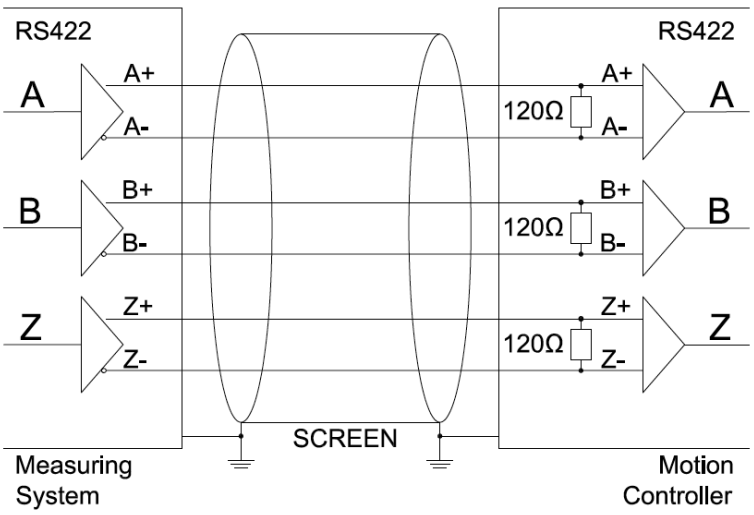


Fig.5.6.: Recommended electrical connection and buffering

The maximum operating speed of the encoder will be determined by the maximum output signal frequency (F = 1/T in Figure 5.2) and the output resolution. Maximum speed can be computed using the following formula:

Maximum speed = 4 x Maximum Output Frequency x Encoder resolution

To provide more information, the maximum encoder speed has been calculated for two resolutions(18 bits/rev. and 14 bits/rev.) and for various output frequencies.

Interface	Max. Frequency (before x4)	Max. Counts (after x4)	Maximum speed	
			@ 18 bits/rev	@ 14 bits/rev
INC00	5.000 MHz	20.0 Mio. / sec	4577 rpm	6000 rpm
INC01	2.500 MHz	10.0 Mio. / sec	2288 rpm	6000 rpm
INC02	1.250 MHz	5.0 Mio. / sec	1144 rpm	6000 rpm
INC03	0.625 MHz	2.5 Mio. / sec	572 rpm	6000 rpm

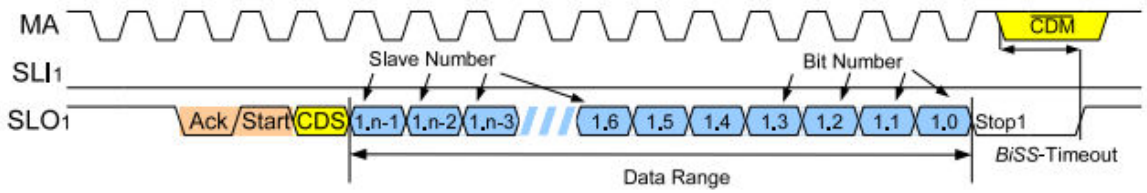
5.5. BIS00

The BIS00 is an implementation of the bidirectional interface BiSS/C® (registered trademark of IC-Haus GmbH) with the following main characteristics:

- data length reserved for encoder position is 32 bits
- encoder position data is right aligned (unused upper bits/MSB set on 0)

BIS00 is recommended for linear encoders. Although it can be used with rotary encoders, it may cause compatibility problems with some standard motion controllers that cannot ignore the unused upper bits.

Parameter	Note	Min.	Typ.	Max.	Unit
Clock frequency f_{clk}	data updated on rising clock edge	0		5.0	MHz
Processing time	not applicable, real-time encoder			0	ns
Total number for bits	n		40		bits
Number of position bits	Bits 39 down to 8		32		bits
Data alignment		right aligned unused MSB set LOW-"0"			
Number of status bits *S*	Bit 7 - not Error Bit 6 - not Warning		2		bits
CRC length	Bits 5 downto 0 Polynome: 0x43 ($X^6+X^1+X^0$) Start value: 0x00		6		bits



"Ack" bit is alway 1 Clock length for all FLUX encoders.

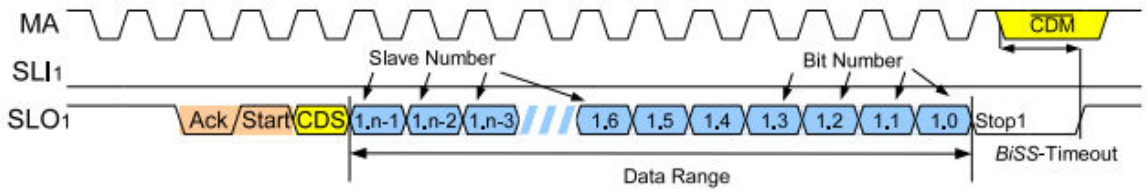
5.6. BIS10

The BIS10 is an implementation of the bidirectional interface BiSS/C® (registered trademark of IC-Haus GmbH) with the following main characteristics:

- data length reserved for encoder position is 24 bits
- encoder position data is left aligned (unused upper bits/MSB set on 0)

BIS10 is recommended for rotary encoders with resolution up to 24 bits.

Parameter	Note	Min.	Typ.	Max.	Unit
Clock frequency f_{clk}	data updated on rising clock edge	0		5.0	MHz
Processing time	not applicable, real-time encoder			0	ns
Total number for bits	n		32		bits
Number of position bits	Bits 31 down to 8		24		bits
Data alignment		right aligned unused LSB set LOW-"0"			
Number of status bits *S*	Bit 7 - not Error Bit 6 - not Warning		2		bits
CRC length	Bits 5 downto 0 Polynome: 0x43 ($X^6+X^1+X^0$) Start value: 0x00		6		bits



"Ack" bit is alway 1 Clock length for all FLUX encoders.

6. Commissioning and Debugging

6.1. Mounting and commissioning

GMI-ROTARY encoders must be mounted in accordance with the mounting tolerances described in Chapter 3. The recommended mounting options are presented in Chapter 4.

The **GMI-ROTARY** encoder requires no calibration or additional commissioning.

As soon as the **GMI-ROTARY** encoders are mounted according to the specifications and powered up, they will provide high accuracy and high resolution positioning over the interface.

6.2. Debugging

The **GMI-ROTARY** encoders are equipped with a status LED(1).

LED Color	Status	Recommended actions
No color	System is not (correctly) Powered-Up.	Check wiring connection to the motion controller
Red Color		
Continuous	System configuration error	Please contact FLUX
Fast blinking(2)	Encoder in error mode	Check encoder mounting
Slow blinking(3)	Out of operating range	Check encoder air-gap
Yellow		
Continuous	Normal operation, but error was detected	Check encoder shielding connection Check encoder mounting
Green		
Continuous	Optimal performance	
Fast blinking(2)	Normal operation, not optimal performance	Check encoder runout
Slow blinking(3)	Normal operation, not optimal performance	Check encoder air gap

(1) Except for high temperature applications. Please contact FLUX for more information.
(2) Fast blinking ~ 0.4 sec.
(3) Slow blinking ~ 1.6 sec

7. Additional features

7.1. Multi-turn position (memory saved)

In **GMI-ROTARY** encoders, the multi-turn position can be automatically saved at power off and restored after powering on. Therefore, even a frameless encoder such as **GMI-ROTARY** can implement a virtual multi-turn function.

The encoder does not have any mechanism for monitoring position changes when it is not powered up, so this function should only be used when movement is either not possible or restricted to less than ± 90° when power is turned off.

Please contact us at office@flux.gmbh for more information.

7.2. Setting zero position and counting direction

The **GMI-ANGLE** encoder allows setting of the zero position and changing of the counting direction.
Over the BiSS-C Interface registers, both functions can be performed.

For more details, please see the full BiSS-C Interface Manual for FLUX Encoders.

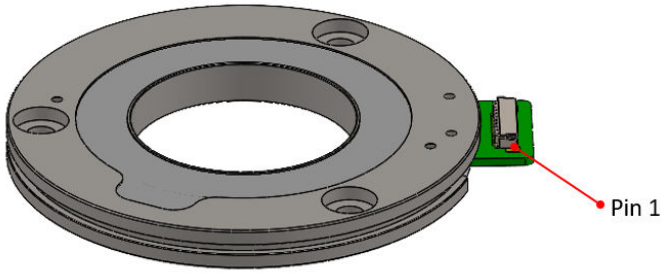
8. Connector and Wiring

8.1. Option “-WBT” - Connector **W**ire to **B**oard

Option available only for Aluminum Housing. For Stainless Steel housing cable versions K01 and K02 available.

Type	WBT: Wire to Board, connector on Top (rotor side)
Manufacturer	Amphenol ICC (FCI)
Part Number	10144041-10011LF (Series Minitek® 0.80mm)
Description	Connector Header Surface Mount Right Angle 10 position 0.031" (0.80mm)
Available accessories	WB0806K0200 - See Chapter 10.1

Option “-WBT”: Connector on the **TOP** side (sensor side), in the direction of the rotor:



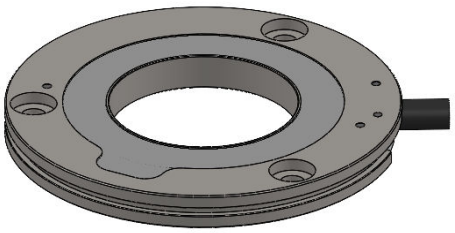
Pin	SSI & BISS-C	A/B/Z	Comments
1	Vdd	Vdd	Encoder Supply Voltage
2	GND	GND	Encoder Power Ground
3	*do not connect*	B+	
4	*do not connect*	B-	
5	*do not connect*	A+	
6	*do not connect*	A-	
7	SCLK+	*do not connect*	
8	SCLK-	*do not connect*	
9	SDATA+	Z+	
10	SDATA-	Z-	

Unused pins must not be connected.

8.2. Option “K01” - Cable

Type	Encoder with cable to open wire
Applicable for:	Output interfaces: INCxx (A/B/Z)
Not applicable for:	Output interfaces: BiSS-C, SSI
Outer jacket	PUR, suitable for energy chains
Applicable Standard	UL - AWM Style 20963 80°C
Temperature rating	dynamic: -20°C .. +80°C
Wrapping	4 x 2 x AWG 30 + 2 x AWG 28, TPE Isolation
Shield	Tinned copper braided. Coverage ≥ 85 %
Outer diameter	4.2 ± 0.1mm
Bending radius	21 mm single / 42 mm continuous bending
Maximum length	6 m

Option “-K01”: Cable integrated in the encoder rotor.

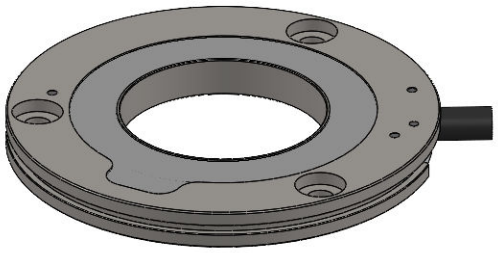


No.	AWG	Color	INCxx	Comments
1	28	violet	Vdd	Encoder Supply Voltage
2	28	black	GND	Encoder Power Ground
3	30	white	A+	
4	30	brown	A-	
5	30	green	B+	
6	30	yellow	B-	
7	30	grey	Z+	
8	30	pink	Z-	
9	30	blue	*not connected*	The pins must remain floating. Do not connect.
10	30	red	*not connected*	The pins must remain floating. Do not connect.

8.3. Option “K02” - Cable

Type	Encoder with cable to open wire
Applicable for:	Output interfaces: BiSS-C, SSI
Not applicable for:	Output interfaces: INCxx (A/B/Z)
Outer jacket	Silicone rubber-based
Applicable standard	IEC 60754-1, IEC 60332-1-2
Temperature rating	dynamic: -25°C .. +180°C / static: -60°C .. +180 °C
Wrapping	3 x 2 x AWG 30, FEP Isolation
Shield	Tinned copper braided. Coverage ≥ 95 %
Outer diameter	3.3 ± 0.1mm
Bending radius	18 mm single / 36 mm continuous bending
Maximum length	3 m

Option “-K02”: Cable integrated in the encoder rotor.



No.	AWG	Color	SSI & BISS-C	Comments
1	30	red	Vdd	Encoder Supply Voltage
2	30	black	GND	Encoder Power Ground
3	30	grey	SCLK+	
4	30	blue	SCLK-	
5	30	green	SDATA+	
6	30	yellow	SDATA-	

8.4. Power Supply “Sense Lines”

GMI-ROTARY encoders do not support Power Supply “Sense Lines”.
With its low power consumption and minimum 4.35 V_{DC} operating voltage, there is no need to use the "Sense Lines" for cables up to 6 meters.

If the motion controller requires "Sense Lines", they can be connected directly to the respective Power Lines at the Motion Controller connector.

9. Ordering code

GMI-ROT	055	-A11	-19	-BIS10	-5V	-WBT	-ST
Rotary encoder	Diameter [mm]	Rotor (GRR) type	Resolution [Bits/Rev]	Output Interface	Supply Voltage	Connector Type and cable length in cm for Kxx	Housing material
	055	**-A11**	**17**	**BIS10**	**5V** - 4..6Vdc	**WBT**[1]-Wire-Board	**-ST** - Steel
	069	**-B11**	**18**	**BIS00**		**K01-xxx**[2]**-**Cable	**-AL** - Alu
	080	**-C11**	**19**	**SSI00**		**K02-xxx**[3]**-**Cable	
	096		**20**	**SSI01**			
			21	**SSI02**			
			22	**INC00**			
				INC01			
				INC02			
				INC03			

[1] Available only for Aluminum Housing “-AL”

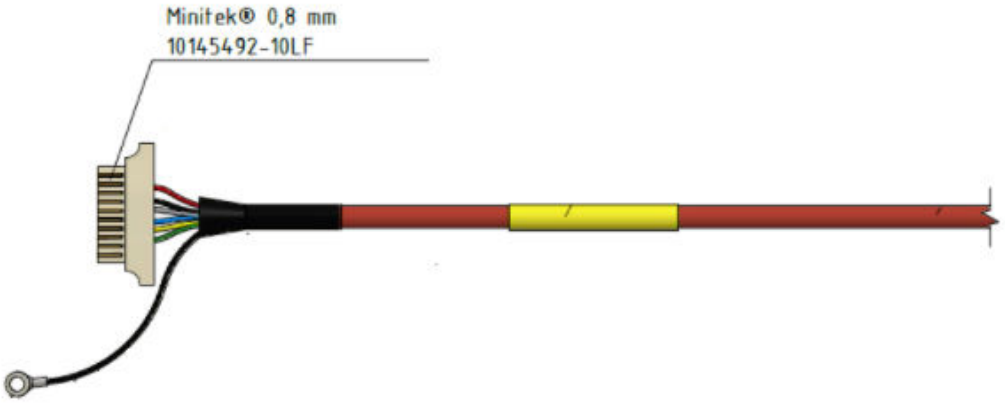
[2] K01 - Available for INCxx output interface. xxx - standard cable length available: 020, 050, 100, 200 [cm]

[2] K03 - Available for all BiSS and SSI output interfaces. xxx - standard cable length available: 020, 050, 100, 200 [cm]

10. Accessories

10.1. Assembly cable for “-WB” connector option

FLUX ordering code	**WB0806K0200**
Cable length	0.5 m
Left side	Connector 10145492-10LF Series Minitek® 0.80mm
Operating temperature	-25°C .. +85°C
Right side	Open wire
Cable specifications	
Outer jacket	Silicone rubber-based
Applicable standard	IEC 60754-1, IEC 60332-1-2
Temperature rating	dynamic: -25°C .. +180°C / static: -60°C .. +180 °C
Wrapping	3 x 2 x AWG 30, FEP Isolation
Shield	Tinned copper braided. Coverage ≥ 95 %
Outer diameter	3.3 ± 0.1mm
Bending radius	18 mm single / 36 mm continuous bending

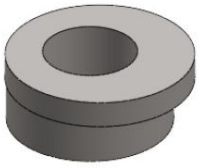


Left side connection:

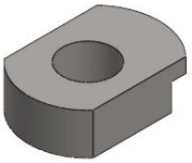
No.	AWG	Color	SSI & BISS/C	A/B/Z	SPI	Comments
1	30	red	Vdd	n.a.	Vdd	Encoder Supply Voltage
2	30	black	GND		GND	Encoder Power Ground
3..6	n.a.	n.a.	n.a.		n.a.	not connected
7	30	grey	SCLK+		SCLK+	
8	30	blue	SCLK-		SCLK+	
9	30	green	SDATA+		MISO+	
10	30	yellow	SDATA-		MISO-	

10.2. Servo Clamp

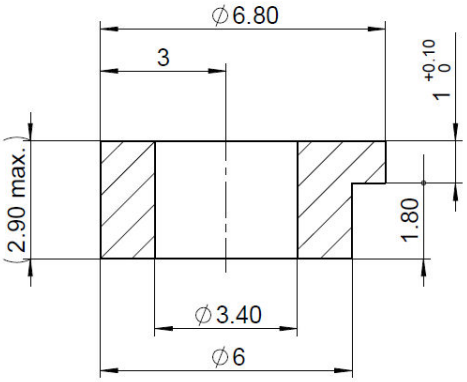
FLUX ordering code	Stainless steel: • **SC100-M3-6-ST** • **SC100-M3-8-ST** Aluminum: • **SC100-M3-6-AL** • **SC100-M3-8-AL**
Compatibility	With any size of ARH-100 (encoder stator) See chapter 3.2., dimension “G” in table for more details.

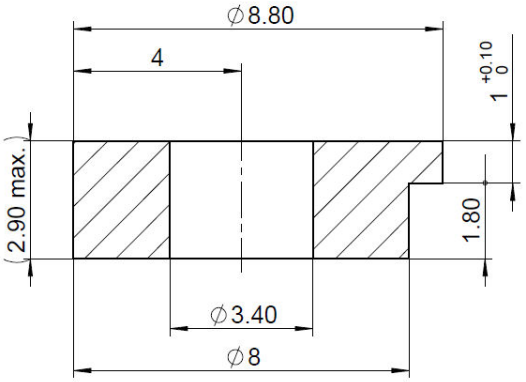


SC100-M3-6
stainless steel or aluminum



SC100-M3-8
stainless steel or aluminum





11. Revision history

Date	Version	Comments
2022-05	00	First built - based on the AFE-100 datasheet
2023-02	01	Interfaces INCxx, BIS10 updated.

Technical data is subject to change without notice.

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