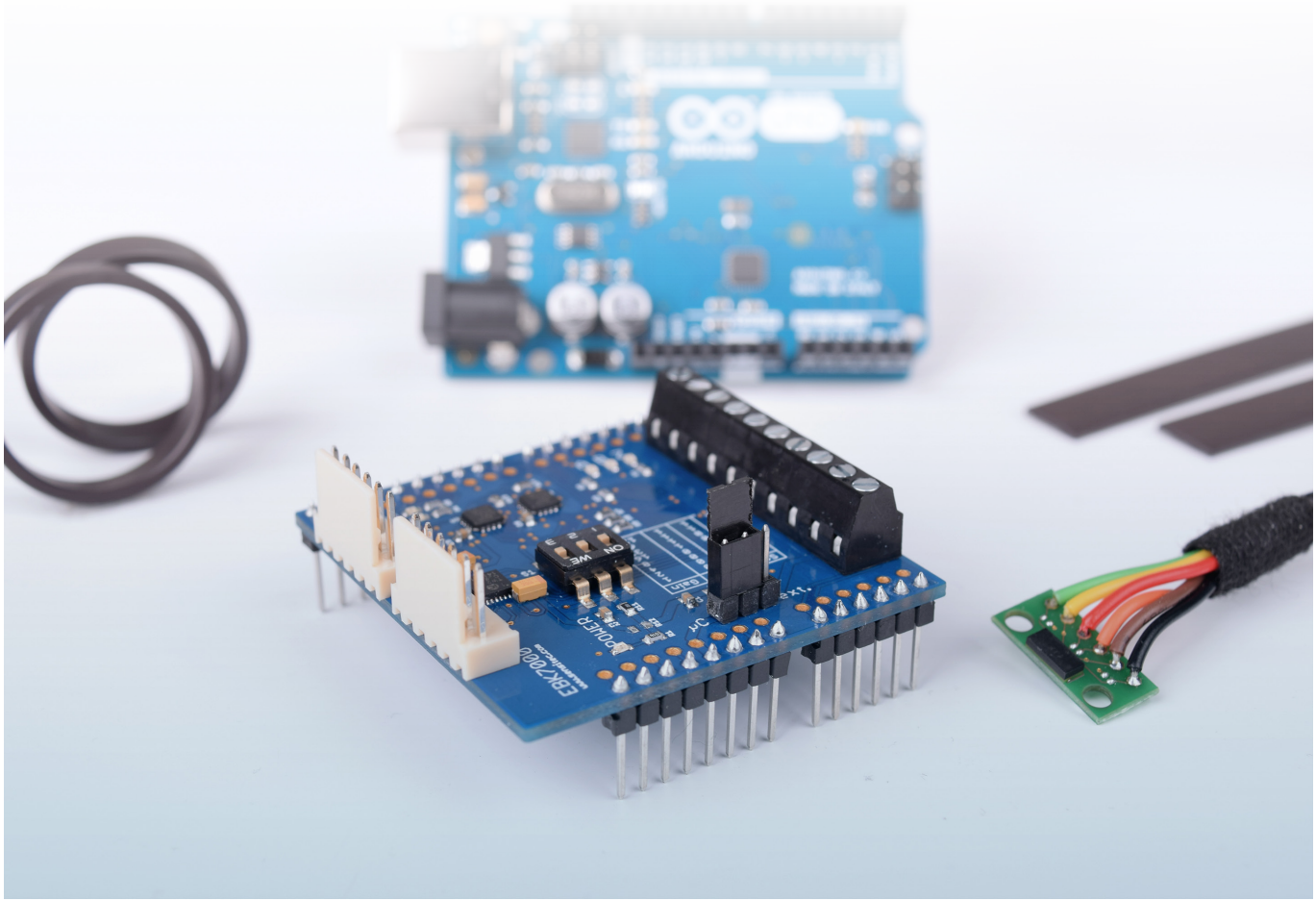
SENSITEC
MAGNETORESISTIVE SENSORS

PRODUCT INFORMATION

EBK7000

Evaluation Kit for Angle and Length Measurement with MagnetoResistive Sensor Technology



Content

1. Safety Indication

With this sample kit you are able to gain experience with MR-sensor technology for linear and angular measurement systems.

Please note, the parts of the Evaluation-Kit are sensitive to electrostatic discharge.

Please do not touch the magnetic scales with the magnet or other magnetic parts.

Keep away from strong electromagnetic fields.

Please note the polarity of the power supply.

Disconnect from supply for setting the jumper.

RoHS

Products built by Sensitec GmbH are in accordance with the requirements as defined in

- European Directive 2011/65/EU (RoHS-II)
  Restriction of the use of certain Hazardous Substances
- European Directive 2002/96/EC (WEEE)
  Waste Electrical and Electronic Equipment

2. Content of the Evaluation Kit

Quantity	Name	Marking	Description
1	EBK7000		Evaluation board
1	AL796	red	2 mm
1	AL780	white	5 mm
1	AA745	yellow	Sensor for diametral magnet
1	GF708	blue	Reference sensor
1	Magnet		Magnet diametral
1	MWI0046KAC-UH		Pole ring 2 mm
1	MWI0018KAE-UH		Pole ring 5 mm
1	MLI0050UAC-UA		Linear scale 2 mm
1	MLI0020UAE-UA		Linear scale 5 mm
1	Magnetic Viewer		Magnetic Viewer

3. Measurement Configurations

The quality of the measurement signals and the evaluation significantly depend on the setup of sensor in reference to the measuring scale. In order to get familiar with the system it might be helpful starting with an arrangement with a pole wheel mounted at the end of a motor shaft and the sensor positioned in the same axis (see example 1 in figure 1).

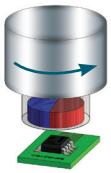
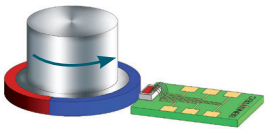
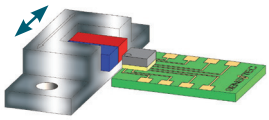
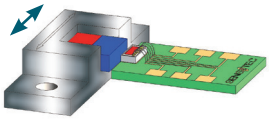
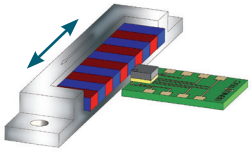
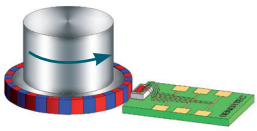
		Configuration	Application Example
1		Rotating magnet; sensor mounted on a substrate on the axis of rotation	Absolute angle measurement up to 360° at the shaft end (axial) AA745 + Magnet
2		Rotating magnet; sensor mounted on a substrate perpendicular to the axis of rotation	Absolute angle measurement up to 180° at the shaft circumference AA745 + Magnet
3		Magnet moves linearly; sensor mounted at the edge of a substrate	Absolute length measurement along a magnet AA745 + Magnet
4		Magnet moves linearly; sensor mounted at the edge of a substrate	Magnetic switch GF708 + Magnet
5		Linear magnetic scale with fixed pole length (pitch); sensor mounted perpendicular to the magnetic track on the scale	Incremental length measurement AL700 + Magnet
6		Magnetic pole ring with fixed pitch; sensor mounted on substrate radial to the pole ring; sensor surface in the plane of the pole ring	Incremental angle measurement at the shaft circumference AL700 + Magnet

Fig. 1: Possible configurations.

4. Composition EBK7000

The evaluation kit allows to learn how different factors impact on the resolution of the measurement signal (length of magnetic pole pitch, interpolation factor, etc.)

As a rule of a thumb the distance between the sensor chip and the surface of the pole wheel must not exceed 50% of the magnetic pole length.

The EBK7000 was developed as an extension board for an Arduino microcontroller system. This provides an opportunity for software adjustment of gain and interpolation factor. Analog and digital sensor signals can be received and processed by the microcontroller.

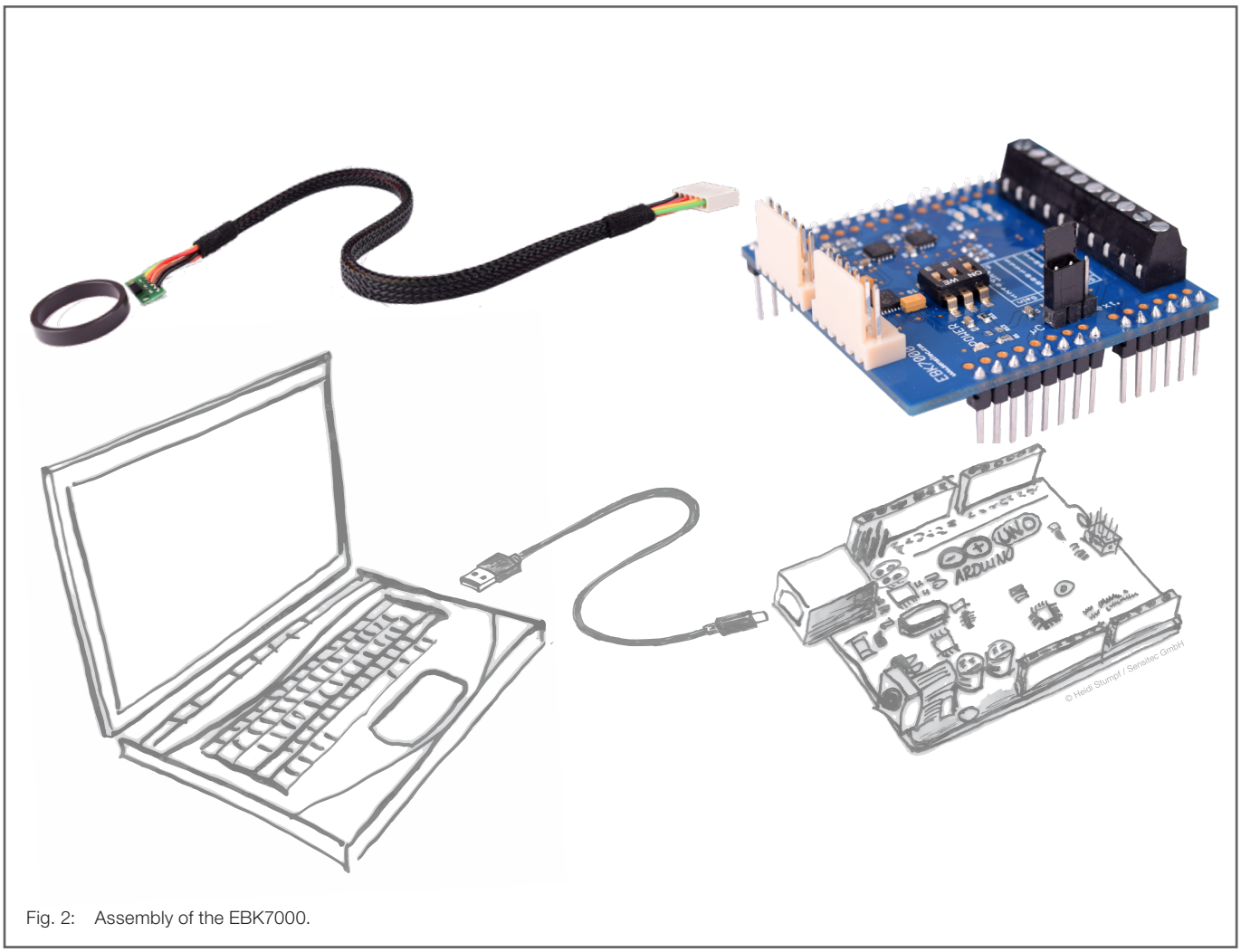


Fig. 2: Assembly of the EBK7000.

4.1 Signal Conditioning

Signal processing of MR sensor signals is realized by an interpolation ASIC. Basis of the signal conditioning are amplifiers, A/D converters and logic functions. The output signals of the MR sensor are amplified in order to operate the A/D converter in an optimal range. The change of the sensor signal is converted to a square wave with 90 degrees phase shift between sine and cosine channel and the set resolution. Interpolation is a multiplication of the basic period of the system. An interpolation factor of one is similar to a comparator circuit. Both sensor signals are resolved with four flanks.

The signal processing is done by an interpolation ASIC IC-TW2 of IC-Haus Company implemented on the board. This provides an adjustable interpolation from 0.25 up to 64 with an increment of 0.25. The interpolation is configurable via a two wire interface. As standard an interpolation factor of 64 is set.

4.2 Startup

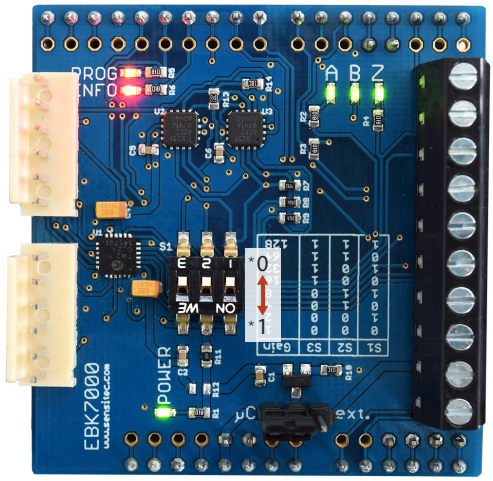
It is possible to supply the evaluation kit via external voltage (5V) or by the Arduino microcontroller. The adjustment is made via the jumper “power supply”. The green LED (LED Power) indicates power on.

With the DIP switch you can choose the gain factor of the analogue sensor signals which are connected to SIN and COS. Table 1 shows the gain configuration.

The three LEDs on the EBK7000 show the states of the digital signals A, B and Z. A yellow LED indicates the programming activities of the ASIC.

Gain	S.1 [A0]	S.2 [A1]	S.3 [A2]
1	0	0	0 *
2	1	0	0
4	0	1	0
8	1	1	0
16	0	0	1
32	1	0	1
64	0	1	1
128	1	1	1
Programming via Arduino	0	0	0

Table 1: Gain configuration.



* Switch setting

Fig. 3: LEDs of the EBK7000.

For a quick start, you can use software examples of Sensitec site download.

These examples are for testing purposes only.

Sensitec does not guarantee the function and assumes no liability for possible damages.

5. Pin Assignment

Figure 4 shows the pin assignment of the EBK7000. SENSOR1 is the connection for the incremental sensor. SENSOR2 can be connected to an optional reference sensor. On the screw terminal the analog and digital outputs and the external power supply are available. The LED is for free use. It is connected high active to digital PIN11 (PWM) of the Arduino microcontroller.

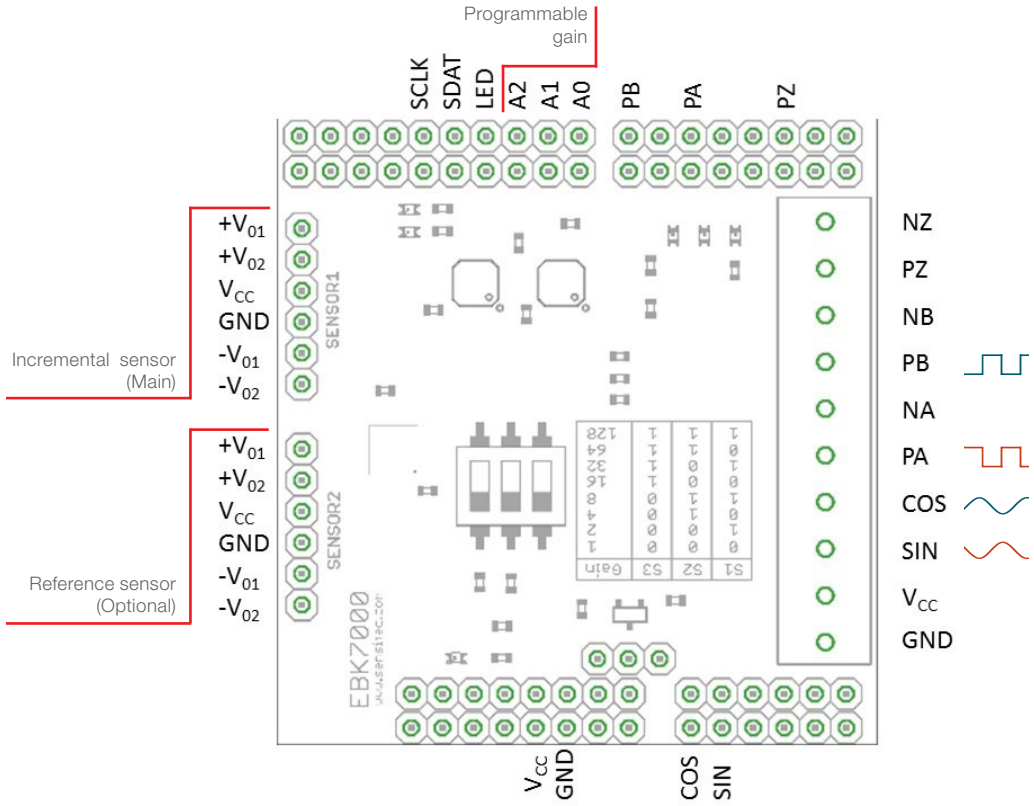


Fig. 4: Pin assignment of the EBK7000.

The pin assignment of the sensor modules is equal for all types. It is shown in Figure 5.

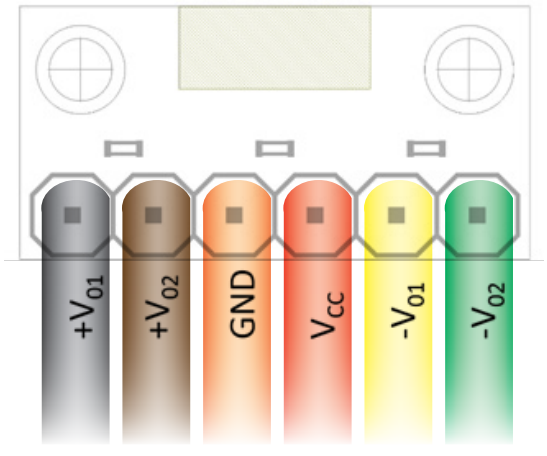


Fig. 5: Pin assignment of the sensor modules.

6. Programming of Gain and Interpolation Factor

By using the Arduino it overrides the settings of the DIP switch and the gain can be switched via software. Pullup resistors are connected to the configuration lines. For setting a gain factor via software the respective output of the Arduino (PIN 8, 9, 10) must be set high and all switches must be set 0. The configuration options are shown in Table 1.

The interpolation factor is set by the iC-TW2. The configuration data is stored in the ASIC. To adjust the interpolation factor there are 8 bits available in register 0x02. Possible are 64 values at increments of 0.25. Table 2 lists the possible interpolations and their associated register codes. Access to the register of the iC-TW2 by two wire interface. More information about programming the iC-TW2 at www.ichaus.de.

INTER (7:0) Adr 0x02, Bit 7:0 R/W			
CODE	**STEP** Angle Steps Per Period	**IPF** Interpolation Factor	
0x00	256	64	115 kHz [1]
0x01	1	0.25	460 kHz
0x02	2	0.5	460 kHz
0x03	3	0.75	460 kHz
0x04	4	1	460 kHz
0x05	5	1.25	460 kHz
. . .	. . .	. . .	460 kHz
0x3C	60	15	460 kHz
0x3D	61	15.25	460 kHz
0x3E	62	15.5	460 kHz
0x3F	63	15.75	460 kHz
0x40	64	16	460 kHz
0x41	65	16.25	230 kHz
0x42	66	16.5	230 kHz
0x43	67	16.75	230 kHz
0x44	68	17	230 kHz
0x45	69	17.25	230 kHz
. . .	. . .	. . .	230 kHz

INTER (7:0) Adr 0x02, Bit 7:0 R/W			
CODE	**STEP** Angle Steps Per Period	**IPF** Interpolation Factor	
0x7C	124	31	230 kHz
0x7D	125	31.25	230 kHz
0x7E	126	31.5	230 kHz
0x7F	127	31.75	230 kHz
0x80	128	32	230 kHz
0x81	129	32.25	115 kHz
0x82	130	32.5	115 kHz
0x83	131	32.75	115 kHz
0x84	132	33	115 kHz
0x85	133	33.25	115 kHz
. . .	. . .	. . .	115 kHz
0xFA	250	62.5	115 kHz
0xFB	251	62.75	115 kHz
0xFC	252	63	115 kHz
0xFD	253	63.25	115 kHz
0xFE	254	63.5	115 kHz
0xFF	255	63.75	115 kHz

Notes: For fosc = 29.4 MHz, FREQ= 0, CLKDIV = 0. [1] 115 kHz is fin()max for commutation operation (MODE = 3).

Tab. 2: Interpolation factors.

Table 3 shows the standard assignment of the registers. This represents the factory settings of the EBK7000.

Description	Register Address	Value
ASIC ID	0 [0x00] [1]	130
Operating Modes	1 [0x01]	16
Interpolation	2 [0x02]	0
Index Position	3 [0x03]	127
Index Width	4 [0x04]	1
Conversion Settings	5 [0x05]	35
	6 [0x06]	6
Gain	7 [0x07]	4
Offset A	8 [0x08]	0
Offset B	9 [0x09]	0

Register Address	Value
10 [0x0A]	15
11 [0x0B]	8
12 [0x0C]	0 (Reserved)
13 [0x0D]	0 (Reserved)
14 [0x0E]	0
15 [0x0F] [1]	Monitor

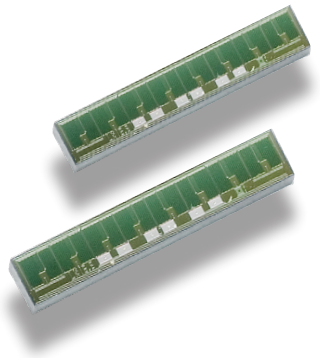
[1] Read only.

Tab. 3: Default configuration of the registers iC-TW2.

7. Technical Data

AMR Length Sensor AL796 [red]

MagnetoResistive FixPitch Sensor



The AL796 is an AnisotropicMagnetoResistive (AMR) position sensor. The sensor contains two Wheatstone bridges shifted against each other. The output signals are proportional to sine and cosine of the coordinate to be measured.

The MR strips of this FixPitch sensor geometrically match to a pole length of 2 mm (equal to a magnetic period of 4 mm). Additionally, the sensor layout incorporates PerfectWave technology, i. e. the position of each block of MR strips has a special arrangement to filter higher harmonics and to increase the signal quality. The resistances in this FixPitch sensor are distributed over several poles (2), thus the errors in the measurement scale are reduced without any signal delay. The amplitude is almost constant in a wide working range between sensor and magnetic scale.

Absolute Maximum Ratings

Symbol	Parameter	Min.	Max.	Unit
V_{CC}	Supply voltage	-9.0	+9.0	V
T_{amb}	Ambient temperature	-40	+125	°C

Electrical Characteristics (25°C, H = 25 kA/m, V_{CC} = 5 V)

Symbol	Parameter	Min.	Typ	Max.	Unit
V_{CC}	Supply voltage	-	5.0	-	V
R_S	Sensor resistance	1.1	1.7	2.3	kΩ
V_{off}	Offset voltage per V_{CC}	-2.0	-	+2.0	mV/V
V_{peak}	Signal amplitude per V_{CC}	9	11	13	mV/V
TC_{Vpeak}	Temperatur coefficient of V_{peak}	-0.48	-0.42	-0.36	%/K

This sensor is typically used as: Incremental sensor.

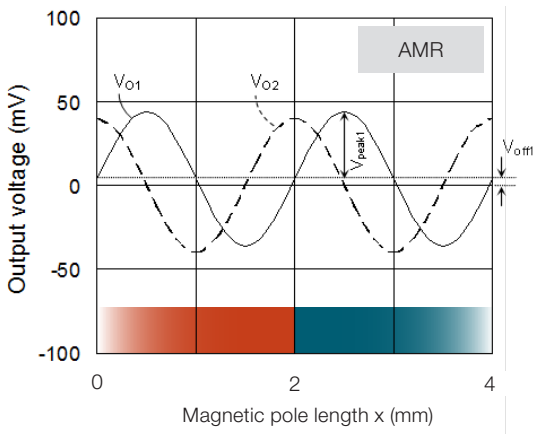
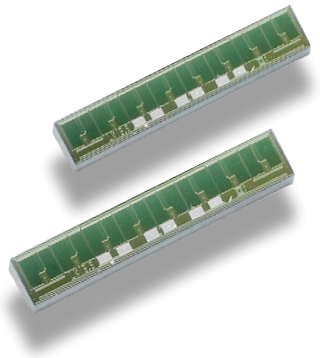


Fig. 6: Output signals as function of linear displacement.

AMR Length Sensor AL780 [white]

MagnetoResistive FixPitch Sensor



The AL780 is an AnisotropicMagnetoResistive (AMR) position sensor. The sensor contains two Wheatstone bridges shifted against each other. The output signals are proportional to sine and cosine signals of the coordinate to be measured.

The MR strips of this FixPitch sensor geometrically match to a pole length of 5 mm (equal to a magnetic period of 10 mm). Additionally, the sensor layout incorporates PerfectWave technology, i.e. the position of each block of MR strips has a special arrangement to filter higher harmonics and to increase the signal quality. The output amplitude is almost constant in a wide working range between sensor and magnetic scale.

Absolute Maximum Ratings

Symbol	Parameter	Min.	Max.	Unit
V_{CC}	Supply voltage	-9.0	+9.0	V
T_{amb}	Ambient temperature	-40	+125	°C

Electrical Characteristics (25°C, H = 25 kA/m, V_{CC} = 5 V)

Symbol	Parameter	Min.	Typ	Max.	Unit
V_{CC}	Supply voltage	-	5.0	-	V
R_S	Sensor resistance	1.35	1.60	1.85	kΩ
V_{off}	Offset voltage per V_{CC}	-1.0	-	+1.0	mV/V
V_{peak}	Signal amplitude per V_{CC}	9.0	11	13	mV/V
TC_{Vpeak}	Temperatur coefficient of V_{peak}	-0.48	-0.42	-0.36	%/K

This sensor is typically used as: Incremental sensor.

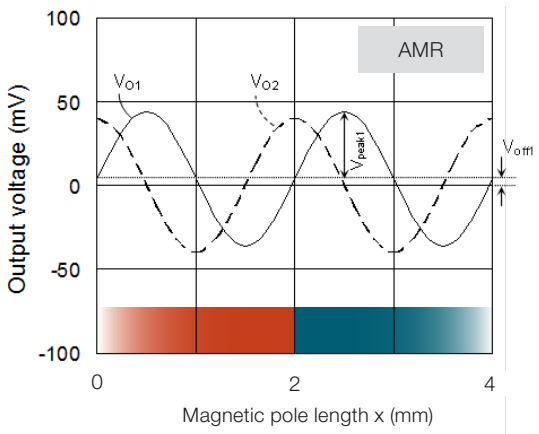


Fig. 7: Output signals as function of linear displacement.

AMR Angle Sensor AA745 [yellow]

MagnetoResistive FreePitch Sensor

The AA745A is a Freepitch position sensor based on the AnisotropicMagnetoResistive (AMR) effect. The sensor contains two Wheatstone bridges with common ground and supply pin V_{CC}. They are shifted at a relative angle of 45° to one another. Additionally, the sensor layout incorporates PerfectWave technology, i.e. the sensor stripes are designed to reduce harmonic distortions.

A rotating magnetic field in the sensor plane delivers two sinusoidal output signals with the double frequency of the angle α between sensor and magnetic field direction.

Absolute Maximum Ratings

Symbol	Parameter	Min.	Max.	Unit
V_{CC}	Supply voltage	-9.0	+9.0	V
T_{amb}	Ambient temperature	-40	+125	°C

Electrical Characteristics (25°C, H = 25 kA/m, V_{CC} = 5 V)

Symbol	Parameter	Min.	Typ	Max.	Unit
V_{CC}	Supply voltage	-	5.0	-	V
R_S	Sensor resistance	1.35	1.60	1.85	kΩ
V_{off}	Offset voltage per V_{CC}	-2.0	-	+2.0	mV/V
V_{peak}	Signal amplitude per V_{CC}	12.0	13.0	14.0	mV/V
TC_{Vpeak}	Temperatur coefficient of V_{peak}	-0.31	-0.35	-0.39	%/K

This sensor is typically used as: Incremental sensor.

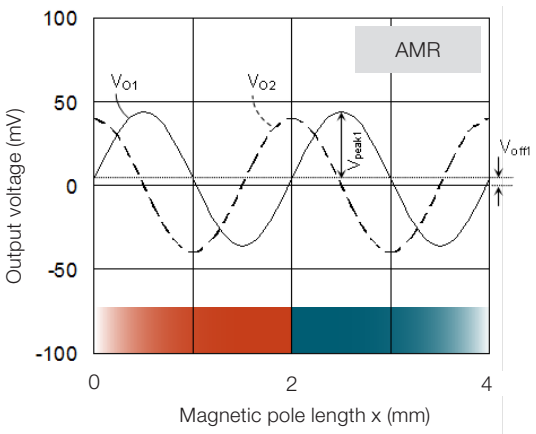
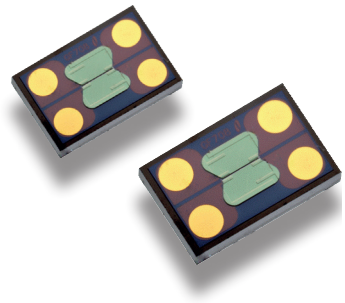


Fig. 8: Output signals as function of linear displacement.



GMR Magnetic Field Sensor GF708 [blue]

MagnetoResistive Magnetic Field Sensor

The GF708 is a magnetic field sensor using spin valve technology based on the GMR effect. The sensor contains a Wheatstone bridge with on-chip flux concentrations to improve the sensitivity. The high sensitivity and linear operating range of the sensor makes it ideal for precise magnetic field measurements, as well as for switching and reference sensor applications.

Absolute Maximum Ratings

Symbol	Parameter	Min.	Max.	Unit
V_{CC}	Supply Voltage	-9.0	+9.0	V
T_{amb}	Ambient temperature	-40	+125	°C

Electrical Characteristics (25°C, H = 25 kA/m, V_{CC} = 5 V)

Symbol	Parameter	Min.	Typ	Max.	Unit
V_{CC}	Supply Voltage	-	5.0	-	V
R_B	Bridge resistance	13	16	19	kΩ
TC_{RB}	Temperatur coefficient of R_B	0.08	0.12	0.14	%/K
S	Sensitivity	80	130	180	mV/V/mT
V_{lin}	Linear range of output voltage	30	40	50	mV/V
V_{range}	Electrical output range	30	56	70	mV/V
B_{OP}	Magnetic operation range	-18	-	+18	mT
B_{switch}	Magnetic switching range	-1.0	-	+1.0	mT

This sensor is typically used as: Reference sensor.

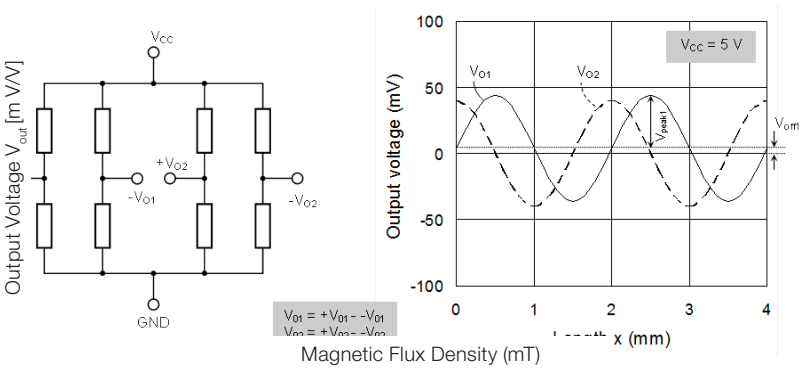
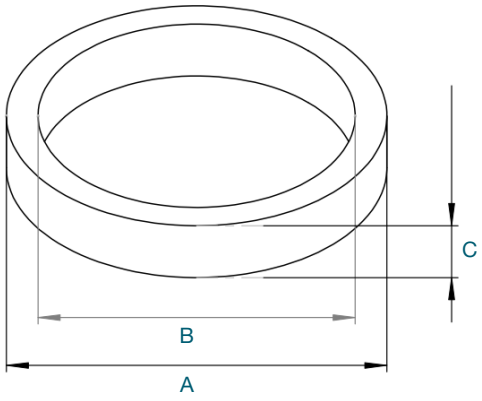
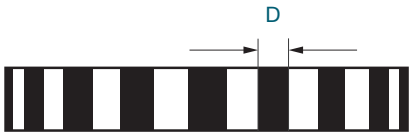


Fig. 9: Output signals as function of linear displacement.

8. Mechanical Characteristics

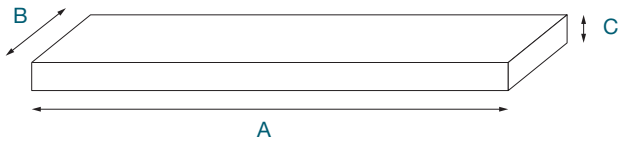
Pole Rings

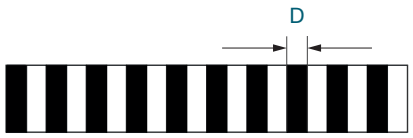




Article	Pole Pitch	Number of Poles	A	B	C	D
MWI0046KAC-UH	2.0 mm	46	29 mm	25 mm	5.5 mm	2.0 mm
MWI0018KAE-UH	5.0 mm	18	29 mm	25 mm	5.5 mm	5.0 mm

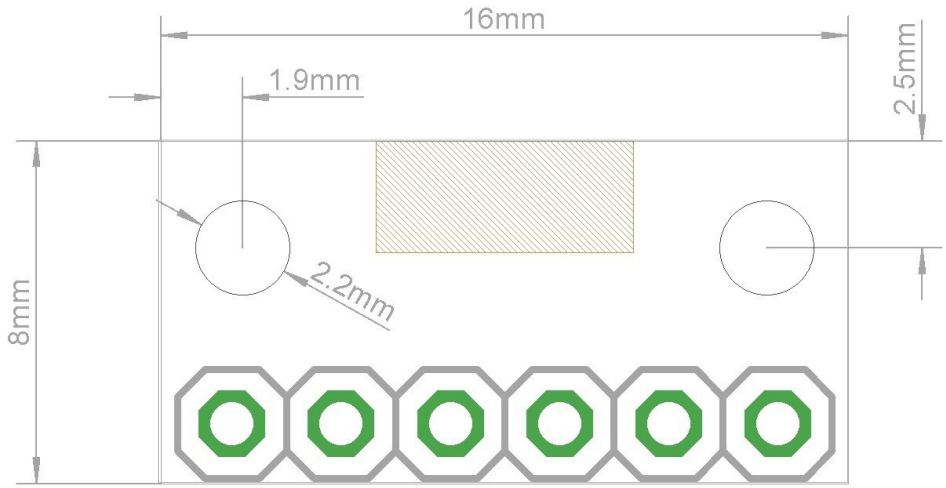
Linear Measuring Scales



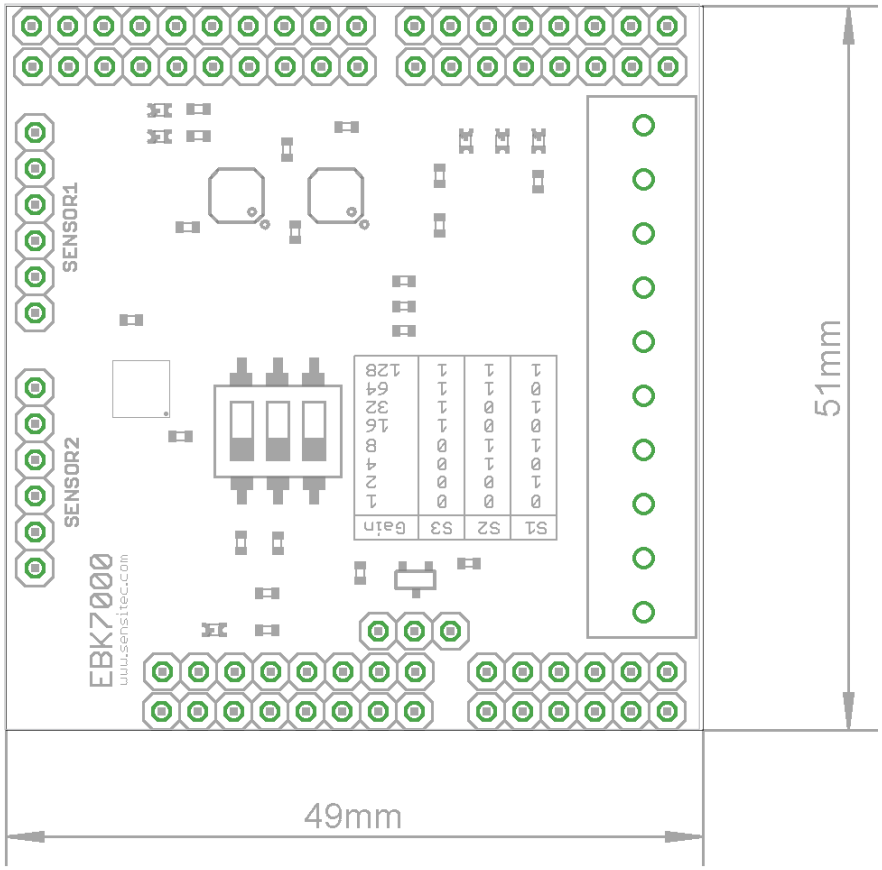


Article	Pole Pitch	Number of Poles	A	B	C	D
MLI0050UAC-UA	2.0 mm	50	100 mm	10 mm	1.3 mm	2.0 mm
MLI0020UAE-UA	5.0 mm	20	100 mm	10 mm	1.3 mm	5.0 mm

Sensor Board



Evaluation Board



9. Removal

CAUTION

Please observe the regulations regarding disposal of electric appliances and electronic devices! The symbol with the crossed-out waste bin means that electrical and electronic devices including their accessories must not be disposed of in the household garbage.

The materials are recyclable in accordance with their labeling. You can make an important contribution to protecting our environment by reusing, renewing and recycling materials and old appliances.

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Life Critical Applications

These products are not qualified for use in life support appliances, aeronautical applications or devices or systems where malfunction of these products can reasonably be expected to result in personal injury.

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