WHITE PAPER

Measurements with the KMA36 (optional: Demo board G-MRMO-024)

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ABSTRACT

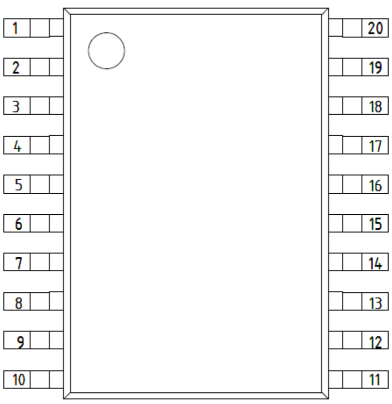
Angle positioning as well as linear displacement measurements are widely used in many industrial domains such as automation or robotic. Often these applications require good accuracy, very good repeatability and a fast response time.
Magneto-resistive sensors are very well suited for measuring angles, rotations and positions contactless very precisely.
The main drawback of many sensors is the need of sensitive measuring circuits to convert the sensor signals into useful data.
This application note focuses on the versatile applicable KMA36 which is an easy-to-use solution with a built-in MR sensor expanded by an ASIC making data available either as an individually customized analog signal or as digital data.

DESCRIPTION

The KMA36 is magnetic universal encoder for precise rotational or linear measurements. This system-on-chip combines a magneto resistive element along with analog to digital converter and signal processing in a standard small SOIC package.

By using the well established **A**nisotropic **M**agneto **R**esistive technology, the KMA36 is able to determine contactless the magnetic angle of an external magnet over 360°, as well as the incremental position on a magnetic pole strip with 5 mm pole length.
Mounted on the KMA36 Demo board G-MRMO-024 the configuration and data communication (I2C) as well as the analog signal output are easily accessible via pinheads. Some rarely changed configurations (like I2C address) are set by solder-jumper on the backside of the board.

KMA36 - PIN ASSIGNMENT

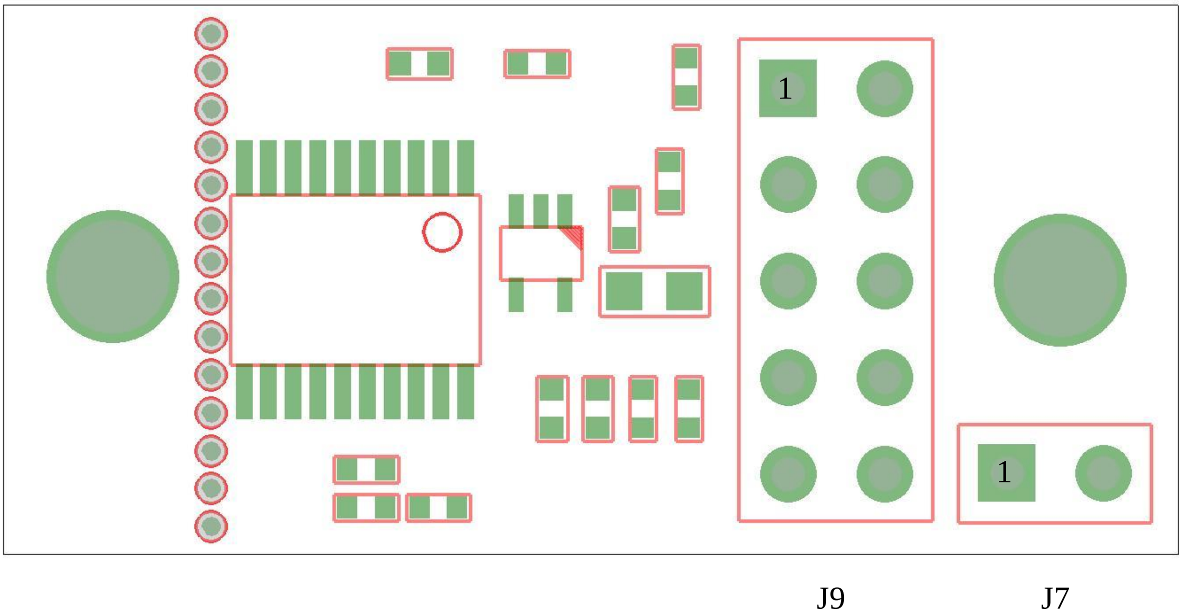


Pin No. KMA36 TSSOP	Symbol	Type	Description
1	A1	NC	Not connected
2	A0	I	Slave adress configuration pin
3	DVCC_SE	O	Drive pin to power sensor
4	SDA	I/O	Two-wire interface data pin
5	PWM	O	PWM output
6	SCL	I	Two-wire interface clock pin
7	GND_SE	S	Sensor supply ground pin
8	VCC_SE	S	Sensor power supply pin
9	NC	NC	Not connected
10	NC	NC	Not connected
11	NC	NC	Not connected
12	COILP	I	Coil power supply pin
13	COILN	I	Coil power supply pin
14	AREF	I	Asic analog reference
15	NC	NC	Not connected
16	GND_AS	S	Asic supply ground
17	NC	NC	Not connected
18	VCC_AS	S	Asic power supply
19	DCOILN	O	Drive pin to coil power supply
20	DCOILP	O	Drive pin to coil power supply

Figure 1: Pin assignment of KMA36
(for further details please refer the KMA36 datasheet)

Measurements with the KMA36 (optional: Demo board G-MRMO-024)

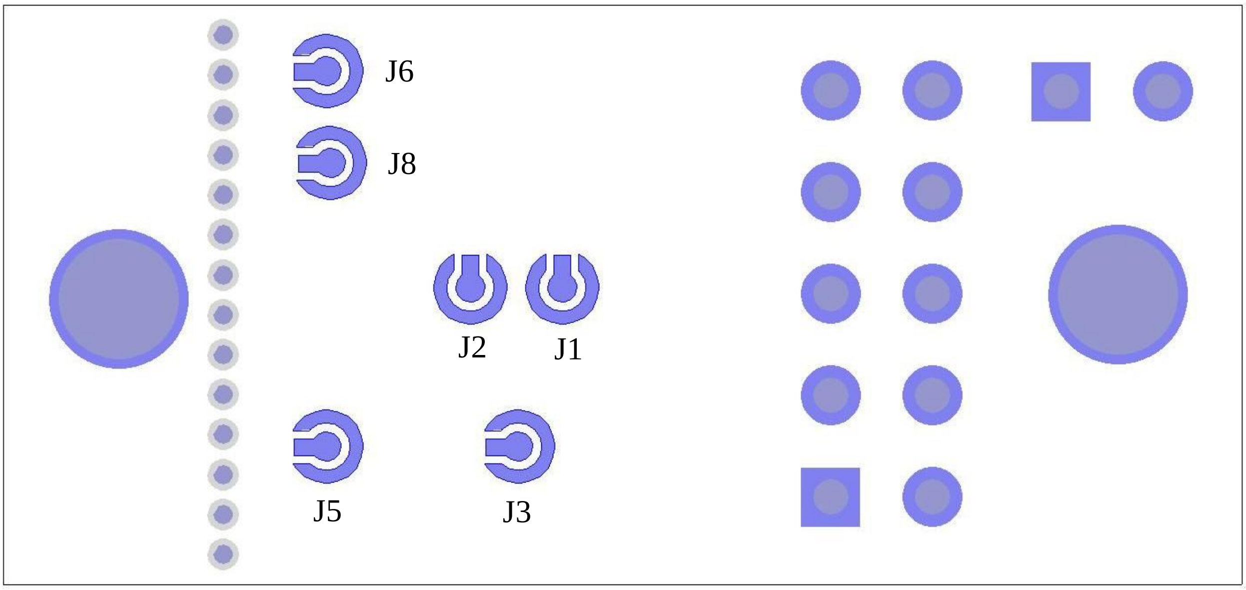
KMA36 DEMO BOARD- PIN ASSIGNMENT & DESCRIPTION



Top View

Pin	***Function***	***Description***
J9.1	SCL	I2C serial clock
J9.2	Gnd	Power ground
J9.3	SDA	I2C serial data
J9.4	5V DC	Power +5V DC
J9.5	Gnd	Power ground
J9.6	5V DC	Power +5V DC
J9.7	PWM	Analog mode - pwm output signal
J9.8	A1	Reserved – do not connect
J9.9	Aout	Analog mode - analog output signal (0..5V DC)
J9.10	A0	Configuration pin (please refer the KMA36 datasheet)
J7.1	A0	Configuration pin (please refer the KMA36 datasheet)
J7.2	DcoilP	Analog mode: Connect to J7.1 to set analog mode zero reference angle I2C mode: Connect to J7.1 to set I^2C slave address to 0x5A

Measurements with the KMA36 (optional: Demo board G-MRMO-024)

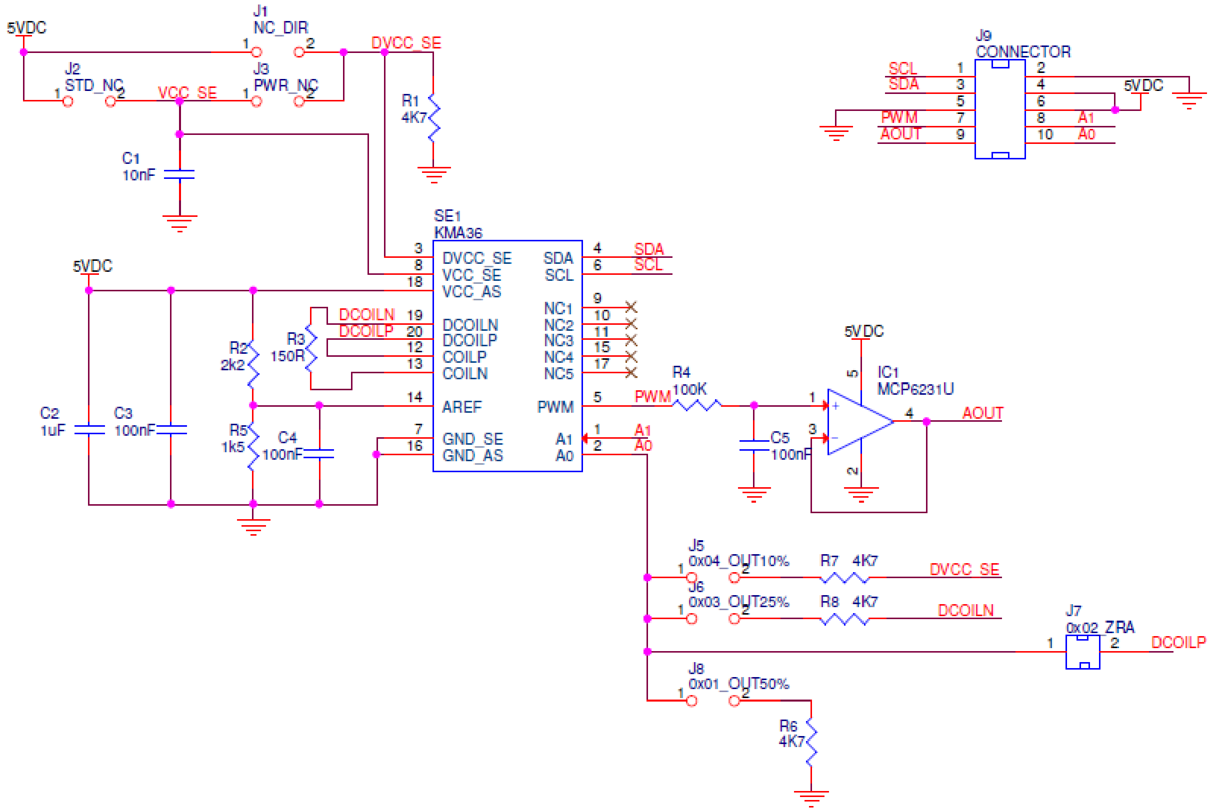


Bottom View

Jumper	*Function /Name*	*Mode*	*Description*
J1	NC_DIR	Analog	Rotation direction configuration (connect for clockwise) **(open by default)**
J2	STD_NC	Analog	Set this jumper to permanently power the internal MR-sensor. **(set by default)**
J3	PWR_NC	Analog	Set this jumper to control the power of the internal MR-sensor by software (used by 'low power mode') **(open by default)**
J2 / J3			**Do not set J2 and J3 at the same time**
J5	OUT_10%	Analog	Set this jumper to adjust an output voltage of 10% (0.5V DC) at the dedicated zero reference angle (0 degree) **(set by default)**
		I2C	Set this jumper to set I2C slave address to 0x5C
J6	OUT_25%	Analog	Set this jumper to adjust an output voltage of 25% (1.25V DC) at the dedicated zero reference angle (0 degree) **(open by default)**
		I2C	Set this jumper to set I2C slave address to 0x5B
J8	OUT_50%	Analog	Set this jumper to adjust an output voltage of 50% (2.5V DC) at the dedicated zero reference angle (0 degree) **(open by default)**
		I2C	Set this jumper to set I2C slave address to 0x59
J5 / J6 / J8			**Do not set J5 and/or J6 and/or J8 at the same time**

Measurements with the KMA36 (optional: Demo board G-MRMO-024)

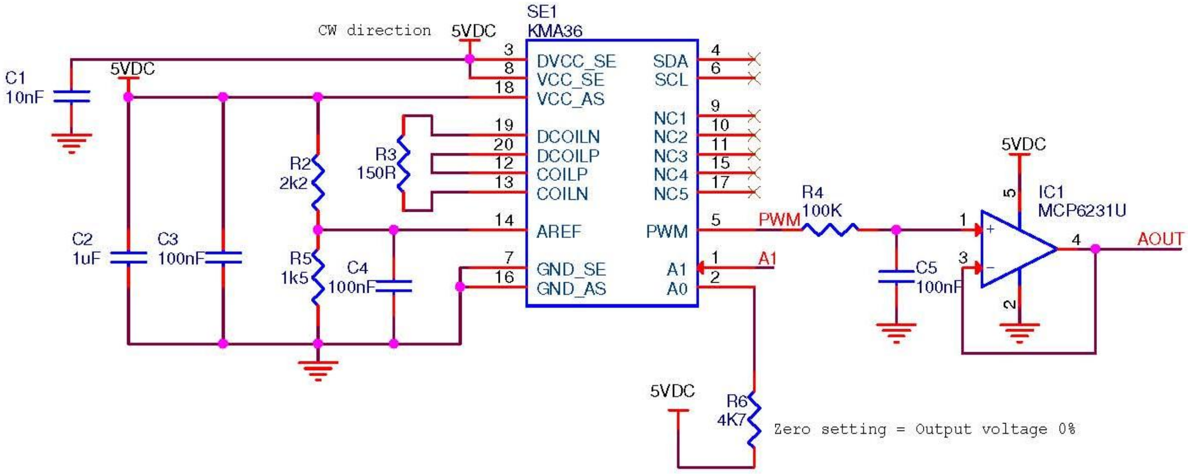
KMA36 DEMO BOARD - SCHEMATIC



Measurements with the KMA36 (optional: Demo board G-MRMO-024)

KMA36 - TYPICAL APPLICATION (IN DETAIL)

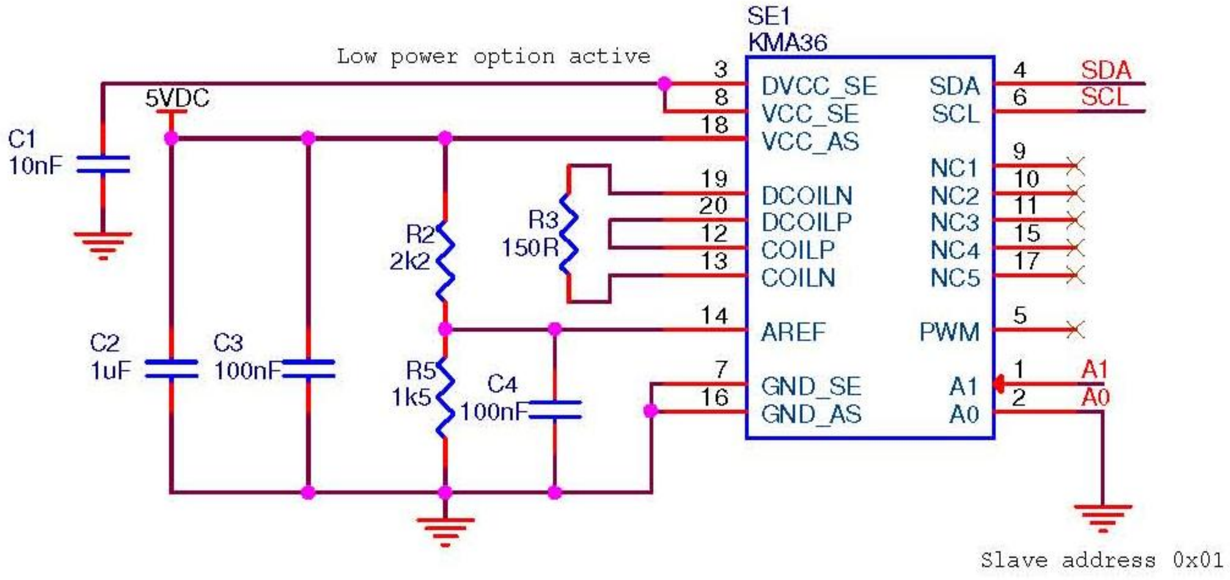
Typical application using the analog mode



Part	Function	Comment
C1	Buffer to power supply gnd	Optional but recommended
C2	Power supply stabilization	Optional but recommended
C3	Power supply stabilization	Optional but recommended
C4	Analog reference stabilization	Optional but recommended
C5	Cap. of 1. order passive low pass	→Converting PWM to analog voltage
R2	Part of voltage divider to provide 2V to AREF	Please refer to the KMA36 datasheet for details
R3	Series resistor of coil	Coil = 100R (typ), R_2 = 150R, → R_{series} = 250R, → I_{Coil} = 20mA (recommended)
R4	Res. of 1. order passive low pass	→Converting PWM to analog voltage
R5	Part of voltage divider to provide 2V to AREF	Please refer to the KMA36 datasheet for details
R6	Pull up resistor at A0	example, please refer datasheet for A0-options
SE1	KMA36 IC	-
IC1	OPAmp, impedance converter for low-pass	(example MCP6231) use rail-to-rail OPAmp

Measurements with the KMA36 (optional: Demo board G-MRMO-024)

Typical application using the I2C mode



Part	Function	Comment
C2	Power supply stabilization	Optional but recommended
C3	Power supply stabilization	Optional but recommended
C4	Analog reference stabilization	Optional but recommended
R2	Part of voltage divider to provide 2V to AREF	Please refer to the KMA36 datasheet for details
R3	Series resistor of coil	Coil = 100R (typ), R_2 = 150R, → R_{series} = 250R, → I_{Coil} = 20mA (recommended)
R5	Part of voltage divider to provide 2V to AREF	Please refer to the KMA36 datasheet for details
SE1	KMA36 IC	-

Measurements with the KMA36 (optional: Demo board G-MRMO-024)

KMA36 – DETAILS (SWITCHING ANALOG / I2C MODE)

The KMA36 will always start in analog mode. To switch into I2C mode no special configuration is necessary. Calling the KMA36 via the two wire bus the first time will switch from analog-mode into digital mode. The analog output is disabled until the next power up to keep the performance high.
(Calling means to start an I2C data transfer with the **correct I2C address** of the KMA36. This address is configured by hardware[1)] – see above)

[1)] On demo board G-MRMO-024: jumper J5..J8

KMA36 – DETAILS (KCONF – CONFIGURATION REGISTER)

SLP-Bit: If the sleep-mode bit is set to '1' and the KCONF register is transmitted to the KMA36 the IC will fall immediately into sleep mode. While in sleep mode no measurements are done (no internal registers will be updated) and the analog output voltage will fall to zero volts. However, the KMA36 will listen to the I2C bus. If a message received which address fits, the KMA36 will wake up and restart working. For low-power applications with lower repetition rate a continuous 'polling' can be a solution to effectively decrease power consumption:

***write* KCONF (SLP=1)** → **wait until measure is necessary** → ***read* DATA** → ***write* KCONF (SLP=1)**

LIN-Bit: The LIN-Bit enables recalculation algorithms to adjust the sensor data to measurements with a 5mm pole strip (please refer to the datasheet for more details of this strip) for linear measures. These algorithms will only work with the dedicated 5mm pole strip and designed to reduce harmonics which will overlay the linear position data.

CNT-Bit: Setting the CNT-Bit to '1' enables the internal 4 Byte (31 Bit + sign) incremental counter. This counter will be written in respect to the configured resolution. For example, if the resolution (KRES) is set to '3600' (that means that a full rotation of a disc magnet is given in steps of 0.1°) a rotation of 3 full turns will saved as 3600 x 3 = 10800. (or -10800, dependent of the direction)
Using the maximum (recommended [1)]) resolution of 13bit (a full resolution is saved in 8192 steps = 0.04°) the counter register is large enough to save more than **260 thousands** turns before a data overflow will corrupt the data.

Reset of the counter register: The register will be cleared every time data is received via the I2C bus.

Using the incremental counter will have a little influence to the cycle time (update rate). Dependent on other configurations the cycle time may be reduced up to 3%.

[1)] Please refer to the KREF section of this application note for details of the resolution.

PWR-Bit: Setting the PWR-Bit to '1' enables the low-power-mode. In this mode the internal coil is not used. Not in low-power-mode the coil is powered ~50% of the duty cycle. Using low-power-mode will reduce the power consumption by the value of the coil-power determined by the supply voltage and the external coil series resistor multiplied by 50%:
Example:

- power supply 5VDC
- series resistor 150R

→ coil current = 20mA , x 50% duty cycle = 10mA
→ coil power = 5V x 10mA = 50mW

SPD-Bit: Please refer the datasheet for details. (→ update rate section)

KMA36 – DETAILS (KRES – RESOLUTION REGISTER)

Although the internal measure processes work with a resolution up to 15 bit (32768 steps) it is recommended to use a resolution of 13bit or less. Beyond this level the Linearity error will rise above the datasheet specification and 'missing codes' cannot be excluded.

The value written in the resolution-register (default/initial: '32768') must be between 1 and 32768. Any other value would lead to unexpected system behavior.

The value stored in the register represents the equivalence to a full 360 degree rotation of the applied magnetic field. In other words:

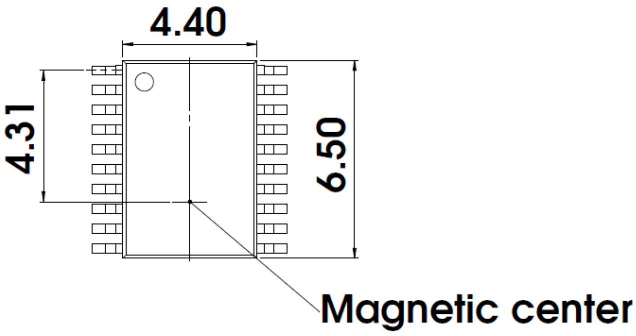
- resolution of '360' produce values (Bytes MA0-MA1) where 1 digit represents 1° [1)]
- resolution of '3600' produce values (Bytes MA0-MA1) where 1 digit represents 0.1° [1)]
- resolution of '8192' produce values (Bytes MA0-MA1) where 1 digit represents 360°/8192 = 0.044° [2)]
- resolution of '1000' produce values (Bytes MA0-MA1) where 1 digit represents 360°/1000 = 0.36° [3)]

[1)] This settings suits to angle measurements with desired results in degrees
[2)] Recommended maximum resolution
[3)] This settings suits to linear measurements with the 5mm pole strip: one pole-pair equals 10mm. A resolution set to '1000' will produce values where 1 digit represents 10mm /1000 = 10µm

KMA36 - DIFFERENT ARRANGEMENTS OF MEASUREMENTS

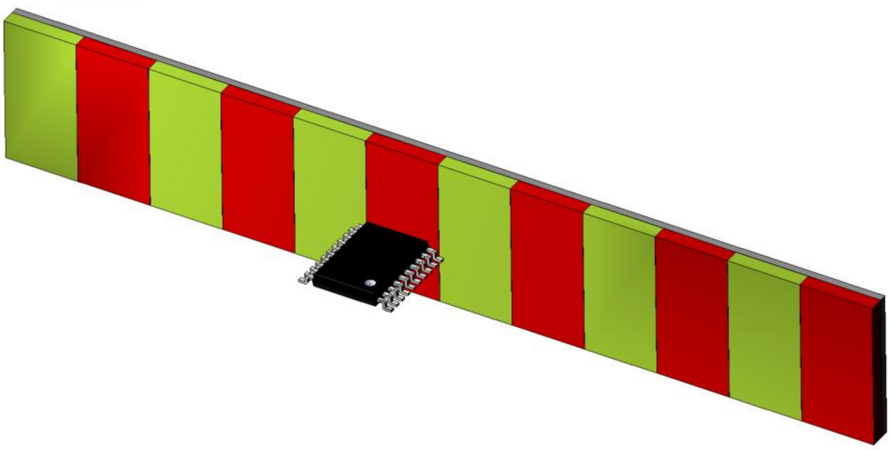
The KMA36 is recommended for two measurement arrangements:

1) **Rotational (angle) measurement** with disc-magnet that is placed exactly over the magnetic center of the KMA36.



In this arrangement it does not matter if the disc is placed over the top of the KMA36 or under the PCB. However, placing the magnet on top allows a minimization of the distance (gap) between the magnet and the sensor. A gap as small as possible is necessary for accurate measurement and good results.

2) **Linear measurement** (measurement of linear movement) with a magnetic pole strip.



Due to complex physical interrelations for this kind of arrangement more parameters will have to be respected:

a) The pole length has to be 5mm (typical accuracy: +/- 40µm / m)
b) The pole strip must be placed rectangular and as close as possible to the short side of the KMA36 (please refer to the drawing)

Measurements with the KMA36 (optional: Demo board G-MRMO-024)

These two modes of arrangement are recommended for best results. In addition the KMA36 is calibrated for this orientations and arrangements. Realizing arrangements as described above will produce high resolution linear correlations between angle/rotation and converted data (analog or digital) or linear position and converted data (analog or digital).

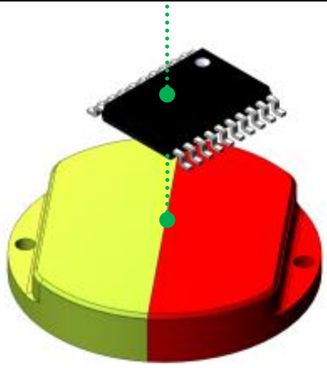
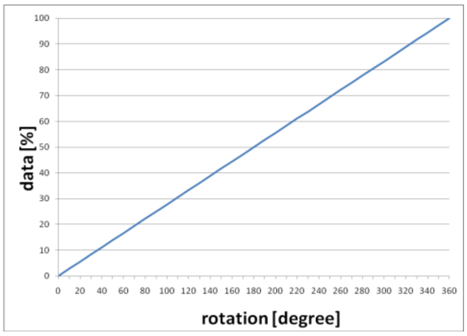
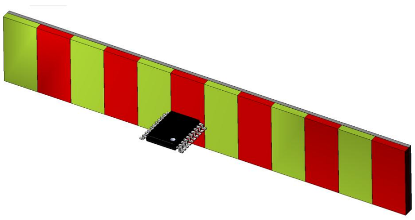
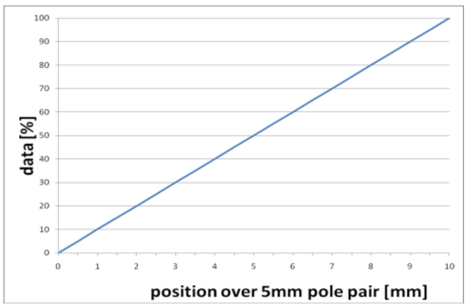
Enabling the software configurable LIN-Bit the KMA36 will be set in an optimized mode of operation for linear measurement. We strongly recommend setting this bit when using a linear arrangement.

In addition to these two arrangements there are many more possible designs combining a magnet (disc / scale / rod / ...) and the KMA36. Please refer to the KMA36 Application Notes to find examples of the different measurement arrangements.

Deviation from the recommended arrangements does not necessarily leads to unusable designs.
Placing the magnet to other positions and / or axis will result in non-linear data and a (possible) reduction of accuracy. Especially when using the I2C mode (which means that the received data will be post-processed by a microcontroller or PC) the master application will be able to use a correction calculation or just use a tailored LUT (look-up-table) to recover the linear correlation.

We recommend test measures with a concrete design to get a better idea of the available data.

In the following we show a few examples of arrangements and the expected data

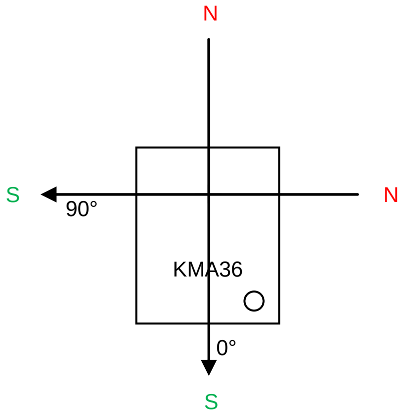
Description	Arrangement	Data
Rotational / angle magnet disc placed over magnetic sensor center		
Linear position (relative) with pole strip		

Measurements with the KMA36 (optional: Demo board G-MRMO-024)

MR-MEASUREMENTS - SPECIAL HINTS

To get best results with maximum repeatability take care of a few points regarding the arrangement:

- Keep the gap as small as possible
- Pay attention to mechanical tolerances and repeatability of the mechanical design
- Keep in mind that the **magnetic axis** of the KMA36 is **not** the center of the IC
- Please refer the following image to see the default magnetic reference angle configuration



ORDERING CODE

Product	Description	Article number
KMA36	KMA36 TSSOP20	G-MRMO-031
DemoBoard	Demo board for KMA36	G-MRMO-024

Measurement Specialties reserves the right to change the specification without notice, in order to improve the design and performance of the product.

ORDERING INFORMATION

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