KMA36 universal magnetic encoder

- Contactless Absolute 360° (180°) angle measurement
- Incremental mode
- Linear mode
- Standard I2C Interface (100 kHz)
- Programmable resolution up to 13 bit (0.04 degree)
- Very low hysteresis
- High accuracy mode
- User programmable parameters
- Low power mode
- Sleep and automatic wake-up over I2C
- Programmable zero position
- Device address hardware configurable
- Small Pb-Free package (TSSOP20)
- RoHS compliant

DESCRIPTION

The KMA36 is a universal magnetic encoder for precise rotational or linear measurement. These position sensors feature a system-on-chip technology that combines a magnetoresistive element along with analog to digital converter and signal processing in a standard small package. By using Anisotropic Magneto Resistive (AMR) technology, the KMA36 is able to determine contactlessly 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. Its sleep and low power mode as well as automatic wake-up over I2C – make the KMA36 ideal for many battery applications. Position data can be transmitted using a PWM or two-wire (SDA, SCL) communication bus. Using the programmable parameters, the user can have access to a wide range of configuration to ensure the maximum of freedom and functionalities.

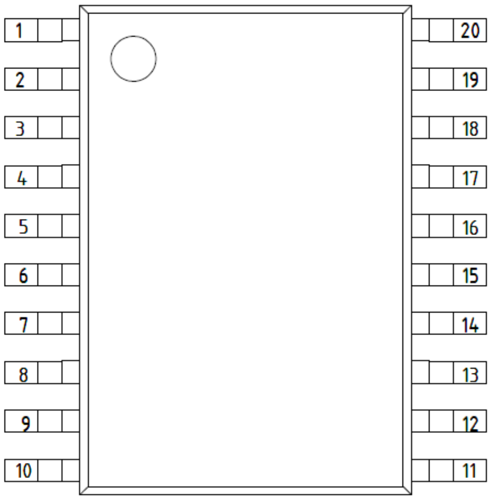
KEY-FEATURES

Resolution	**13 Bit / 0.04 degree**
Operating power supply range of 3V to 5.5V	**3.0 – 5.5V**
Operating temperature	**- 25 - +85 °C**
Average current	**10 – 30 mA**
Sleep current	**1.2 mA**
Data Update rate	**24 – 720 Hz**
I^2C Clockrate	**Up to 100 kBit/s**

APPLICATIONS

Industrial environment
Harsh environment
Handling machine
Machine tools
Robotics
Potentiometer
Motor motion control

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

ELECTRICAL CHARACTERISTICS

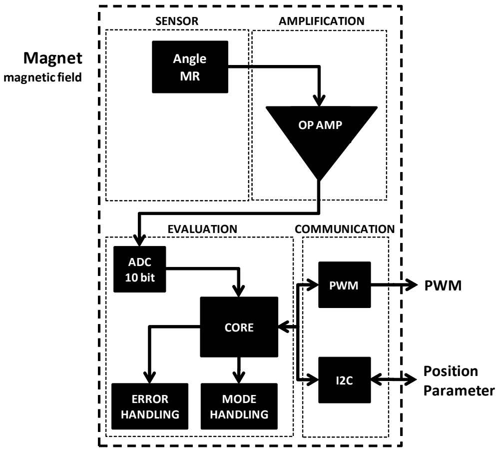


Figure 2: Functional block description

Unless otherwise specified, all voltages are referenced to the power ground supply VSS. Typical values are based on Top= 25 °C, VCC = 5 V. They are given only as design guidelines and are not tested in production. Data based on characterization results, design simulation and/or technology characteristics are indicated in the table footnotes and are not tested in production.

Absolute maximum ratings are limiting values of permitted operation and should never be exceeded under the worst possible conditions either initially or consequently. If exceeded by even the smallest amount, instantaneous catastrophic failure can occur. And even if the device continues to operate satisfactorily, its life may be considerably shortened.

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Absolute maximum ratings

CAUTION: Exceeding these values may destroy the product.

Symbol	Parameter	Condition	Min.	Typ.	Max.	Unit
T_{op}	Operating temperature		- 25		+ 85	°C
T_{sto}	Storage temperature		- 40		+ 85	°C
V_{cc}	Operating voltage		2.9		6	V
V_{in}	Input voltage on any Pin	Except on A1	-0.5		6.5	V
V_{in}	Input voltage on A1		-0.5		13	V
I_{in}	DC Current through any I/O Pin				40	mA
I_{in}	DC Current through S Pin				200	mA
I_{in}	DC Current through any C Pin				60	mA

Table 1: Absolute maximum ratings

- **Operating conditions**

Symbol	Parameter	Condition	Min.	Typ.	Max.	Unit
T_{op}	Operating temperature		- 25		+ 85	°C
V_{cc}	Operating voltage		3		5.5	V
V_{in}	Input voltage on I/O pin		-0.3		5.3	V
A_{Ref}	External Analog Reference		2.0[1)]		V_{CC}	V
R_{AREF}	Analog Reference input resistance		-	32	-	kΩ

Table 2: Operating conditions

1) Apply 2.0V at AREF for best results

Please refer to the typical application section to know which external components should be connected.

- **AC/DC characteristics**

Symbol	Parameter	Condition	Min.	Typ.	Max.	Unit
I_{avg}	Average current[1)]	Except in sleep mode, V_{cc} = 5V	10		30	mA
I_{sleep}	Sleep current	V_{cc} = 5V		1.2		mA
V_{IL}	Input low voltage	V_{cc} = 5V, I_{OL} = 10 mA			0.6	V
V_{IH}	Input high voltage	V_{cc} = 5V, I_{OH} = 10 mA	3			V
V_{OL}	Output low voltage	V_{cc} = 5V, I_{OL} = 10 mA			0.6	V
V_{OH}	Output high voltage	V_{cc} = 5V, I_{OH} = 10 mA	4.3			V

Table 3: AC/DC characteristics

1) Current measurement has been done with a standard circuit including a voltage divider on AREF.

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- **System parameters**

Symbol	Parameter	Condition	Min.	Typ.	Max.	Unit
f_{data}	Update rate[1) 2)]		24		720	Hz
t_{start}	Starting time			5		ms
α_r	Resolution	H_0=25 kA/m [3)]		13		Bit
$\Delta\alpha_L$	Linearity error	H_0=25 kA/m [3)]		±0.3	±1	°
$\Delta\alpha_H$	Hysteresis error	H_0=25 kA/m [3)]		±0.1	±0.25	°
V_{bwn}	Brown-out reset voltage			2.7		V
t_{bwn}	Brown-out reset pulse width			2		µs
H_y	Applied magnetic field		15	25	60	kA/m
R_{COIL}	Internal coil resistance		75	100	150	Ω
Δ_{PWM}	PWM output resolution			10		bit
f_{PWM}	PWM frequency			7.8		kHz

Table 4: System parameters

1) Maximum is measured in speed mode with minimum oversampling. Minimum is measured with maximum oversampling.
2) When using the analog-output configuration then update rate is fixed at 88Hz
3) System parameters apply only for recommended measurement setup (please refer to the arrangement section)

Update rate

f_{data} = 1 / (1.4 msec x oversampling / const)

SPD Bit	const
0	1
1	2

SYSTEM OUTPUT

The system has two possible hardware output configurations: two-wire interface or analog output.

- **Analog Output**

The system has a Pulse Width Modulation unit with 10 bit resolution which can be easily coupled with a first order low-pass filter[1)] to generate an analog output between Vss and Vcc corresponding to 0° and 360°. In this hardware configuration, all internal registers are loaded with initial values. No digital configuration is necessary, all available configurations can be set by changing the hardware setup[2)] of the KMA36.

1) Please refer to the typical application section for further information.
2) Please refer to the hardware configuration section for further information.

- **I^2C (Digital Output)**

The KMA36 has an I^2C Interface unit (two-wire interface, standard I^2C-bus specification defined by Philips Semiconductors) with an 8-bit data bus which can be easily used to retrieve measurement and configuration information. (Please refer to the two-wire interface section for details)

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TWO WIRE IN INTERFACE

- **Physical interface parameters**

Symbol	Parameter	Condition	Min.	Typ.	Max.	Unit
B_{rt}	Clockrate		10	50	100	kBit/s
A_L	Address length			7		bit
A_S	Address[1)]			0x59		Hex

Table 5: Physical interface parameters

1) Please refer to the hardware configuration section to determine how to configure other addresses.

- **Timing parameters**

Symbol	Parameter	Condition	Min.	Typ.	Max.	Unit
$t_{SU:STA}$	Start setup time		4.7			µs
$t_{HD:STA}$	Start hold time		4.0			µs
$t_{SU:STO}$	Stop setup time		4.0			µs
t_{HIGH}	Clock high time		4.0		50	µs
t_{LOW}	Clock low time		4.7			µs
t_r	Rise time				1	µs
t_f	Fall time				0.3	µs
$t_{SU:DAT}$	Data input setup time		0.25			µs
$T_{HD:DAT}$	Data input hold time		0.3			µs
t_{BUF}	Bus free time		4.7			µs

Table 6: Start, stop and data timing parameters

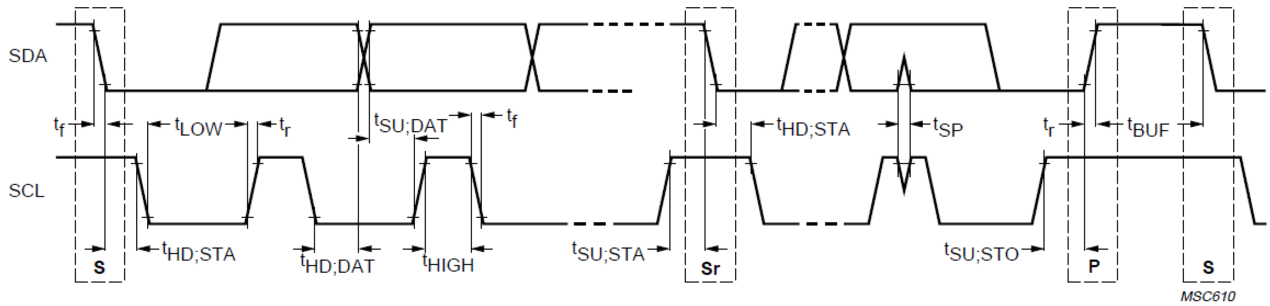


Figure 3: Timing definitions[2)]

2) Please refer to the standard I²C-bus specification defined by Philips Semiconductors for further information.

- **Registers (Overview)**

The KMA36 contains the following I/O registers:

Registers of the KMA36			
Register	**Size**	**Read/Write**	**Function**
KCONF	8 bit	R/W	Configuration bits
KRES	16 bit	W	Resolution
MA	16 bit	R	Magnetic angle
ILC	32 bit	R	Incremental counter

Table 7: Registers of the KMA36

- **I^2C Bus**

The KMA36 is always operating as a pure slave.

- **I^2C Reading data**

It is possible to read up to seven bytes as described in the following figure. No special protocol is used by the reading-data process.

TWI - Read data

Byte	0	1	2	3	4	5	6
	MA0	MA1	ILC0	ILC1	ILC2	ILC3	KCONF
Read/Write	R	R	R	R	R	R	R
Initial value	0x00	0x00	0x00	0x00	0x00	0x00	0x03

Byte 0:1 - MA1:0: Magnetic angle
Unsigned integer giving the magnetic angle in degree with the configured resolution

Byte 2:5 - ILC3:0: Incremental linear counter
Signed long giving the incremental linear counter in degree with the configured resolution.

Byte 6 - KCONF: Configuration register
Unsigned char giving the configuration register value.

Table 8: Read data

- **I^2C Writing data (general)**

The KMA36 can be controlled using two internal registers. The configuration (KCONF) is an 8-bit register and the resolution (KRES) is a 16-bit register. To write the 16-bit register (KRES) through the two-wire interface with an 8-bit data bus, it is necessary to send the high byte first and then the low byte.

In order to change the KMA configuration, four bytes should be sent through the two-wire 8-bit data bus. The first three bytes correspond to the configuration and resolution registers. The last byte contains a 8-Bit Cyclic Redundancy Check (CRC) value which can be calculated as described in the example.

TWI - Send data

Byte	0	1	2	3
	KCONF	KRESH	KRESL	KCRC
Read/Write	W	W	W	W
Initial value	-	-	-	-

Byte 0: KCONF: Configuration register
Contains the desired system configuration.

Byte 1:2 - KRES: Resolution register
Contains the desired resolution.

Byte 3 - KCRC: CRC
Contains the cyclic redundancy check.

Table 9: Send data

Example

	KCONF	KRESH	KRESL	KCRC
data	0x03	0x7F	0xFF	0x7F

KCRC = 0xFF - (KCONF + KRESH + KRESL) + 0x01

KCRC = 0xFF - (0x03 + 0x7F + 0xFF) + 0x01 = 0x7F

Table 10: CRC Example

- **KCONF (Configuration register)**

The configuration register is used to control and monitor the status and modes of the system:

KCONF - Configuration register

Bit	7	6	5	4	3	2	1	0
	SLP	-	LIN	CNT	PWR	SPD	OVCS1	OVSC0
Read/Write	W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Initial value	0	0	0	0	0	0	1	0

Bit 7 - SLP: Sleep mode
Writing this bit to one enables the sleep mode. This bit will be always set to zero by hardware.

Bit 5 - LIN: Mode
Writing this bit to one disables the rotational mode and enables the linear mode.

Bit 4 - CNT: Mode
Writing this bit to one enables the incremental counter mode. By writing it to zero, the counter mode is turned off.

Bit 3 - PWR: Low power mode
Writing this bit to one enables the low power mode.

Bit 2 - SPD: Speed mode
Writing this bit to one enables the fast speed mode.

Bit 1:0 - OVCS1:0: Oversampling
These bits determines the accuracy of the angle evaluation.

Table 11: KCONF – Configuration Register

The system has three possible main configurations:

- Rotational measurement — used to measure the angle of a rotating magnet disc centered above the magnetic sensor center of the KMA36. [1)]
- Linear measurement — used to measure the linear movement of the KMA36 along a magnetic pole strip with 5mm pole length. A lookup table is used for internal error correction [1)]
- Sleep mode — used to power down the KMA36. Wake up is initiated by I^2C communication

[1)] Please refer to the arrangement section.

- **CNT-Bit (KCONF register)**

In addition, there is an incremental counter implemented, which can be enabled by writing a one to the CNT-Bit in the KCONF register.

- **SPD-Bit (KCONF register)**

The measurement update rate can be increased by activating the fast mode with SPD bit. In fast mode measurement accuracy is reduced.

Update rate

f_{data} = 1 / (1.4 msec x oversampling / const)

SPD Bit	const
0	1
1	2

Table 12: Update rate

- **PWR-Bit (KCONF register)**

The power current consumption can be reduced with the low power mode accessible through the PWR bit. In low power mode only **180°** measurement are possible.

- **OVCS-Bits (KCONF register)**

To increase the measurement accuracy, it is possible to configure the oversampling rate by using the OVSCx bits. Please notice that a higher accuracy leads to a reduction of the update rate (Please refer to the Update rate table)

OVCS1	OVSC0	Oversampling
0	0	2
0	1	4
1	0	8
1	1	32

Table 13: OVSC - Oversampling

- **KRES (Resolution register)**

The resolution can be set to any decimal value between 1 and 32768. Any other value would lead to unexpected system behavior.

KRES - Resolution register

Bit	15	14	13	12	11	10	9	8
KRESH	KRES15	KRES14	KRES13	KRES12	KRES11	KRES10	KRES9	KRES8
KRESL	KRES7	KRES6	KRES5	KRES4	KRES3	KRES2	KRES1	KRES0
Bit	7	6	5	4	3	2	1	0
Read/Write	W	W	W	W	W	W	W	W
	W	W	W	W	W	W	W	W
Initial value	0	1	1	1	1	1	1	1
	1	1	1	1	1	1	1	1

Table 14: KRES - Resolution Register

For example, a resolution of decimal 360 (0x00168) leads to rotational data in steps of 1 degree. A resolution of decimal 3600 (0x0E10) results in steps of 0.1°.

HARDWARE CONFIGURATION

The hardware configuration depends on the desired output: two-wire interface or analog.

In two-wire interface configuration, the slave address of the system can be configured by connecting A0 and another pin as described in following table.

TWI - Slave address configuration

Address	Connection	
0x59	A0	GND
0x5A	A0	DCOILP
0x5B	A0	DCOILN
0x5C	A0	DVCC_SE
0x5D	A0	VCC

Table 15: TWI / I^2C Slave address configuration

In analog mode, the rotation direction can be configured by connecting DVCC_SE and a power supply pin. The user zero reference angle calibration can be activated by connecting A0 and COILP. When the user zero reference angle calibration is active, the next evaluated magnetic angle will be set as the new zero reference angle. The user selectable output voltage for the zero reference angle can be configured by connecting A0 in series with a 4,7k ohm resistor and a port pin. The percentage indicated is relative to the power supply value Vcc and is defined at the zero reference angle position.

ANALOG - Rotation direction configuration

Direction	Connection	
CW	DVCC_SE	VCC
CCW	DVCC_SE	4,7K to GND

ANALOG - User selectable output for zero reference

Percent	Connection	
0%	A0	4,7K to VCC
10%	A0	4,7K to DVCC_SE
25%	A0	4,7K to DCOILN
50%	A0	4,7K to GND

ANALOG - Zero reference angle user calibration

Status	Connection	
Active	A0	COILP
Inactive	A0	-

Table 16: Analog-Mode configuration

KMA36 universal magnetic encoder

TYPICAL APPLICATION

- **Electrical circuit**

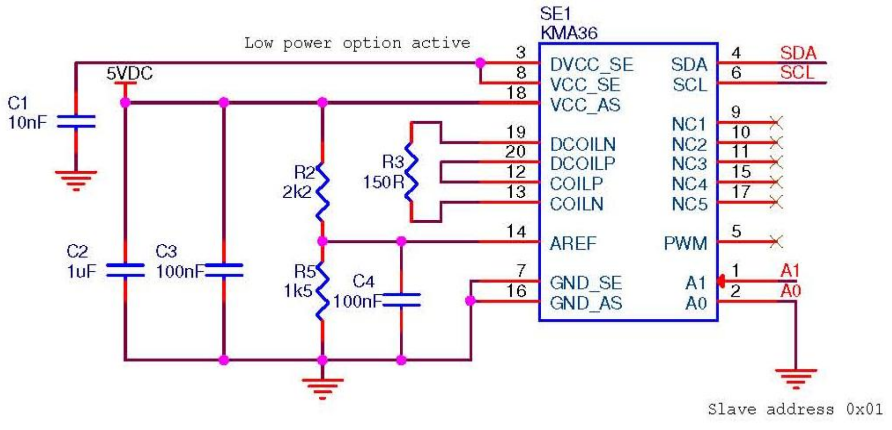


Figure 4: Typical circuit with two-wire interface

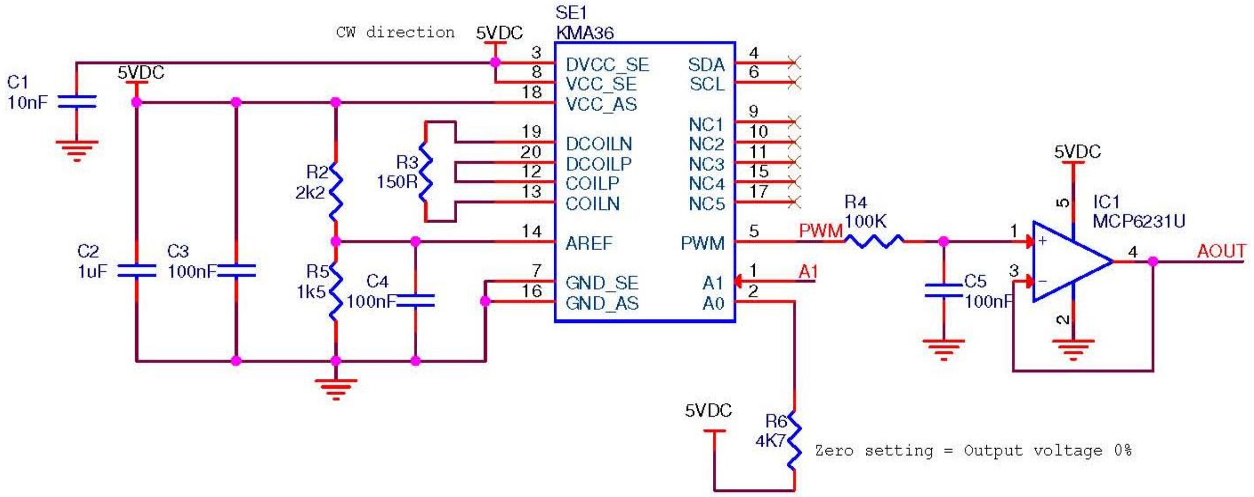


Figure 5: Typical circuit with analog interface

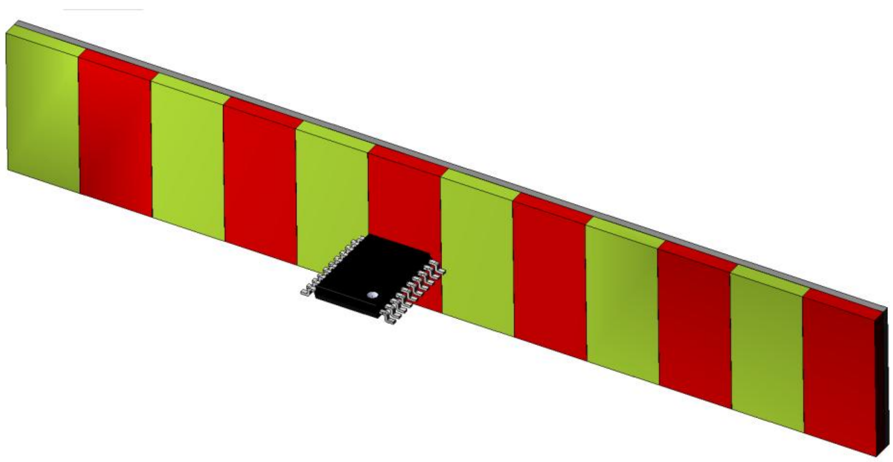
ARRANGEMENT

Due to the magneto resistive technology which senses the magnetic field in the sensor plane, it is advised to mount the magnet disc centered above the sensor center. Please refer to the magnets and scales section for more information about the magnetic center position of the KMA36. The magnetic scale should be placed perpendicularly to the KMA36 as depicted in the following figure rather in the middle along the width of the scale. For best results the KMA36 should be as close as possible to the magnet.

- **Rotational (recommended) setup (for best results)**

Rotational mode
Bit LIN = 0
Pay attention to the magnetic center of the KMA36

- **Linear setup**



Linear mode
Bit LIN =1
use magnetic pole strip with 5mm pole length for best results

Figure 6: Mounting

MAGNETS AND SCALES

Rotational Mode

The KMA36 can be used with a magnet, preferably of disc or square shape or a magnet scale with pole pitch 5mm.

For development purposes, MEAS offers a magnet disc made of plastic bonded Nd-Fe-B magnetic material which provides an homogenous magnetic field with sufficient magnetic field strength for typical application with the KMA36. The following table describes typical magnets parameters. Please refer to the website **http://www.magnetfabrik.de** (article number 67.044-1) and its application note section for more information.

Symbol	Parameter	Condition	Min.	Typ.	Max.	Unit
Ø	Diameter	Neofer 48/60p only		14		mm
T	Thickness	Neofer 48/60p only		2.5		mm
B_r	Magnetic field strength	Neofer 48/60p only		540		mT
T_{op}	Operating temperature	Neofer 48/60p only			150	°C

Table 17a: Typical MEAS disc-magnet specification

Linear Mode

The linear mode of the KMA36 is designed for a magnetic scale with pole pitch 5mm. A magnetic scale is made of a magnetic ferrite tape bonded on a steel support which guarantees mechanical stability. The steel support is made of an optimum stainless steel alloy that provides no loss of magnetic field strength. MEAS offers a standard scale with the following parameters for development purpose:

Symbol	Parameter	Condition	Min.	Typ.	Max.	Unit
L_T	Length	MEAS magnetic scale only		1		m
L_P	Pole length	MEAS magnetic scale only		5		mm
W	Width	MEAS magnetic scale only		10		mm
T	Thickness	MEAS magnetic scale only		1.3		mm
Δp	Accuracy	MEAS magnetic scale only		40		µm/m
T_{op}	Operating temperature	MEAS magnetic scale only	-40		100	°C

Table 17b: Typical MEAS magnet-scale specification

The correct magnet dimensions and assembly geometry depend on the specific arrangement of the application and are part of the specification of the entire system.

PACKAGE DRAWING

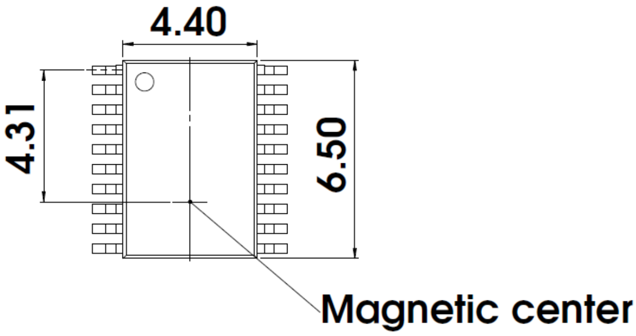


Figure 7: Package drawing (Magnetic center)

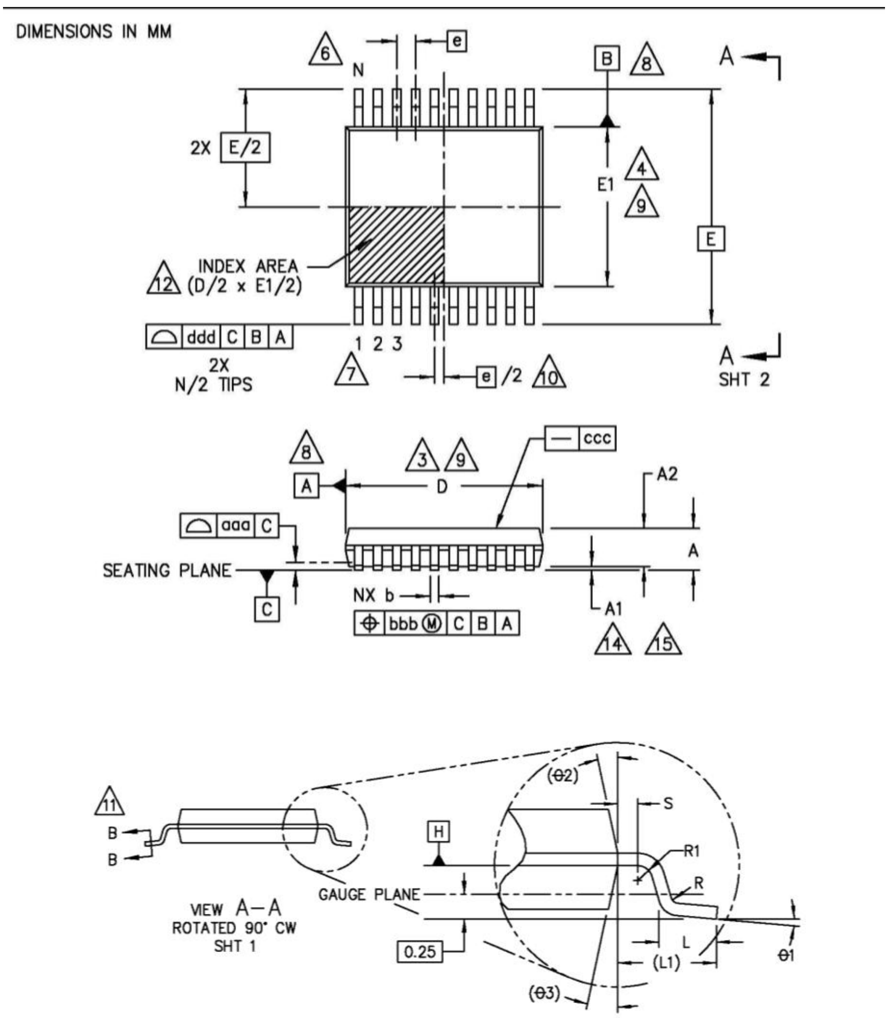


Figure 8: Package drawing

COMMON DIMENSIONS (MILLIMETERS)			
Symbol	**Min.**	**Typ.**	**Max.**
A	-	-	1.20
A1	0.05	-	0.15
A2	0.80	1.00	1.05
b	0.19	-	0.30
D	6.40	6.50	6.60
E	-	6.40	-
E1	4.30	4.40	4.50
e	-	0.65	-
L	0.45	0.60	0.75
N	-	20	-
R	0.09	-	-
S	0.20	-	-

Table 18: common dimensions

ORDERING CODE

Product	Description
KMA36	KMA36 TSSOP20

Table 19: Ordering codes

This data sheet contains data from the preliminary specification. Supplementary data will be published later. Measurement Specialties reserves the right to change the specification without notice, in order to improve the design and performance of the product.