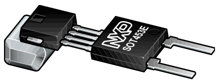


KMI17/4

Rotational speed sensor

Rev. 1 — 1 September 2014 **Product data sheet**

1. Product profile

1.1 General description

Based on the Anisotropic MagnetoResistive (AMR) effect, the KMI17/4 detects the rotational speed of passive target wheels (i.e. having ferromagnetic teeth). This design delivers secure speed information over a wide range of speed, air gap and temperature. It delivers the speed information via a current protocol at the supply pins.

CAUTION

Do not press two or more products together against their magnetic forces.

1.2 Features and benefits

- System in package
- Two wire standard current interface
- Large range of operating terminal voltage
- Wide temperature range
- High ElectroStatic Discharge (ESD) protection
- Very low jitter
- Automotive qualified in accordance with AEC-Q100 Rev-G (grade 0)
- Customer Production Test Mode (CPTM)

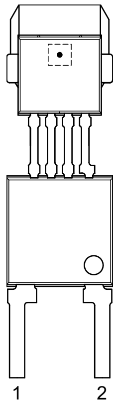
1.3 Quick reference data

Table 1. Quick reference data

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
V_{CC}	supply voltage	normal operation mode; $T_{amb} \leq 175$ °C; referred to pin GND	4.5	-	16	V
T_{amb}	ambient temperature	normal operation mode	–40	-	+150	°C
I_{CCL}	LOW-level supply current		5.88	7.0	8.4	mA
I_{CCH}	HIGH-level supply current		11.76	14.0	16.8	mA
f_o	output frequency	normal operation mode	0	-	20	kHz
d_{ST}	start-up air gap of encoder wheel to sensor surface	after power-on; at start-up of encoder wheel	0.5	-	2.4	mm

2. Pinning information

Table 2. Pinning

Pin	Symbol	Description	Simplified outline
1	V_{CC}	supply pin	
2	GND	ground pin	

3. Ordering information

Table 3. Ordering information

Type number	Package		
	Name	Description	Version
KMI17/4	SIP2	plastic single-ended multi-chip package; magnetized ferrite magnet (4.25 × 5.2 × 3 mm); 4 interconnections; 2 in-line leads	SOT453E

4. Functional diagram

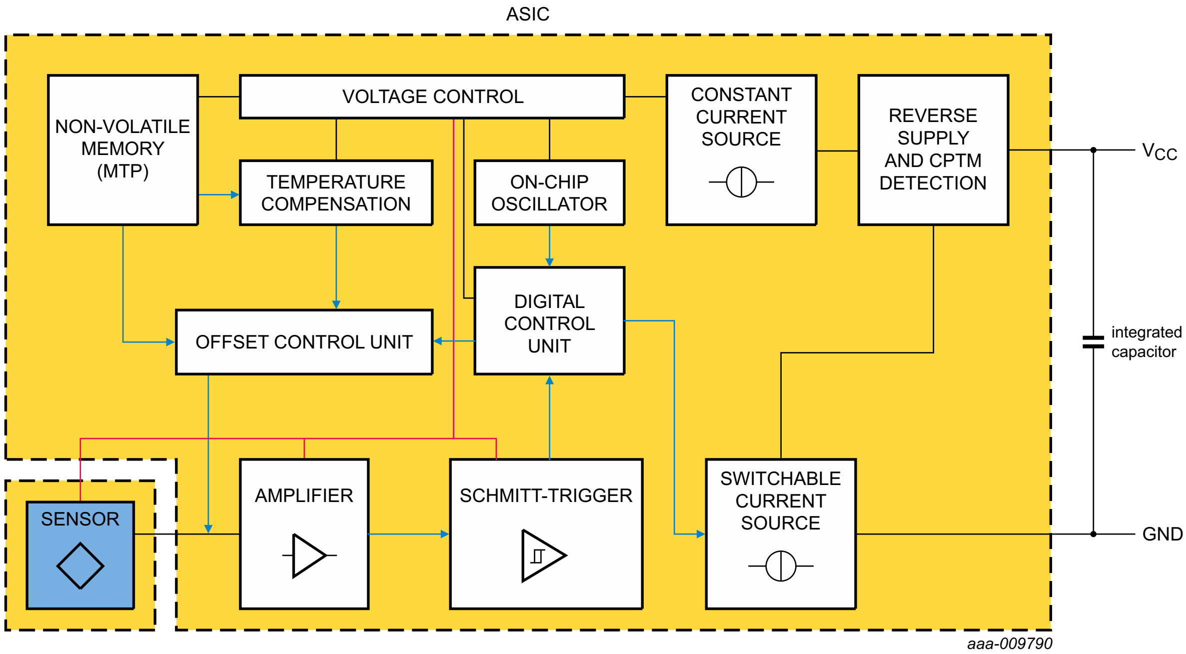


Fig 1. Functional diagram of KMI17/4

5. Functional description

5.1 Functional principle

The KMI17/4 is sensitive to the motion of ferrous gear wheels. The functional principle is shown in Figure 2. Due to the effect of flux bending, the different directions of magnetic field lines in the MR sensor element cause an electrical signal. Because of the chosen sensor orientation and the direction of ferrite magnetization the KMI17/4 is sensitive to movement in the y direction in front of the sensor only; also see Figure 3.

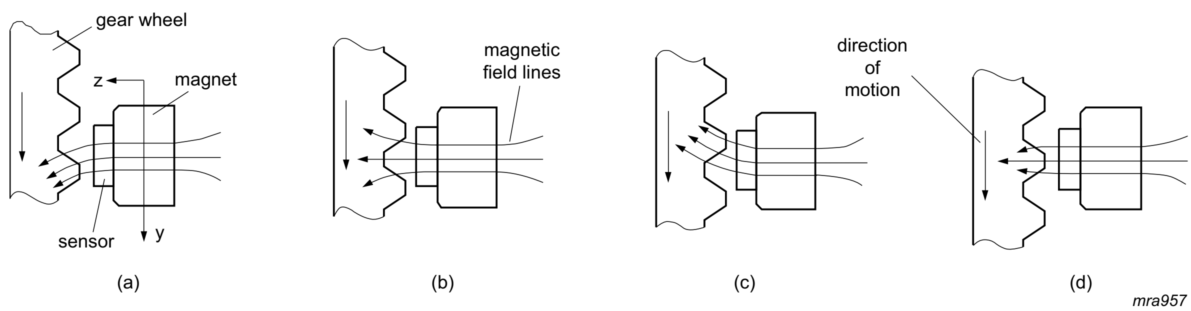


Fig 2. Functional principle

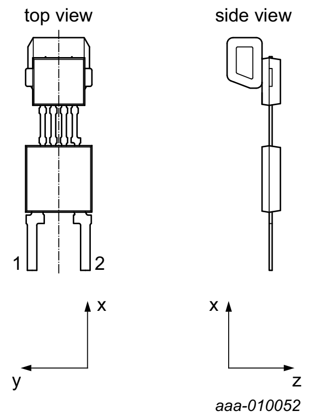
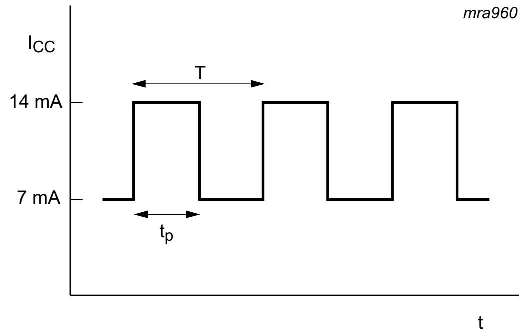


Fig 3. Definition of coordinate system

The KMI17/4 comprises an MR sensor element and an Application-Specific Integrated Circuit (ASIC) for signal conditioning (see Figure 1). Within the ASIC, the sinusoidal signal coming from the MR element is amplified and passed to a Schmitt-trigger. The later provides a conversion of the sinusoidal sensor signal into a rectangular output signal. At the output pins, this rectangular output signal is provided as a modulation of the supply current between a low level of 7 mA typically and a high level of 14 mA typically (see Figure 4). With this current interface, safe sensor signal transport to the detection circuit by using only a two-wire cable is provided. An integrated capacitor between the supply terminals provides superior performance of the sensor concerning immunity to and emission of electromagnetic disturbances.



output duty cycle: $\delta_o = \frac{t_p}{T} \times 100\ \%$

Fig 4. Output as a function of time

The offset control unit provides compensation of voltage offsets, which are included in the MR bridge output due to fabrication tolerances. Therefore, during final test of each device, this offset is measured at two different temperatures and stored in the non-volatile memory. In combination with an on-chip temperature sensor, this two-point calibration allows compensation of the temperature-dependent MR bridge offset.

Figure 7 shows a typical test and application circuit, where resistor R_L provides the conversion of the current signal into a voltage signal at the detection circuit.

5.2 Modes of operation

5.2.1 Start-up mode

When supply voltage has been applied between terminals V_{CC} and GND, all circuit parts of the KMI17/4 are set into a defined initial state. The offset control unit instantly applies an offset compensation voltage to the signal input. It is derived from the respective content of the non-volatile memory and the device temperature. The device then enters the normal operation mode.

5.2.2 Normal operation mode

During normal operation mode, the temperature-dependent offset is continuously compensated, based on the actual chip temperature. For signal frequencies greater than 1 Hz, the offset compensation changes only by 1 bit per signal period. Therefore, additional jitter is limited. For frequencies below 1 Hz offset changes are compensated instantly. At signal frequencies greater than 16 Hz a duty cycle-dependent offset control loop is activated. This control loop monitors the duty cycle of the output signal, which should ideally (i.e. without offset) be at 50 %. In order to maintain a duty cycle of 50 %, the offset compensation is controlled. Using this measure, offsets due to external magnetic fields or eddy currents are compensated.

5.2.3 CPTM

CPTM is a test mode, that allows the air gap safety margin to be measured for a KMI17/4, when mounted in the application. CPTM is entered, when a negative supply voltage ($-V_{CC}$) is applied to the sensor. The characteristic feature of CPTM is, that by variation of $-V_{CC}$ a variable offset voltage is added to the sensor voltage within the ASIC. This offset voltage in turn corresponds to an equivalent magnetic offset field (H_{eq}).

Practically, in the CPTM and while the encoder wheel is rotating, $-V_{CC}$ should be varied, until the sensor device is just at the edge of failure. The edge of failure is just before output pulses disappear. The value of $-V_{CC}$, adjusted to reach this state, corresponds to the safety margin regarding magnetic offset (H_{eq}). The relation $-V_{CC}$ versus H_{eq} is device type specific. Finally, the magnetic offset margin corresponds to an air gap margin. The relation between magnetic offset and air gap depends on the type of encoder used. Figure 5 shows the characteristic of H_{eq} versus $-V_{CC}$ in principle.

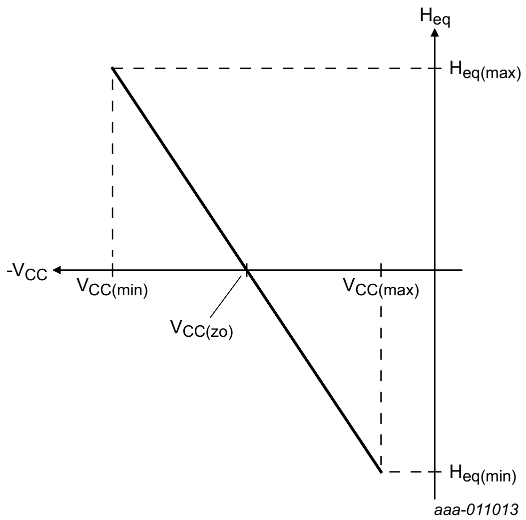


Fig 5. Equivalent magnetic field strength versus supply voltage in Customer Production Test Mode (CPTM)

6. Limiting values

Table 4. Limiting values

In accordance with the Absolute Maximum Rating System (IEC 60134). Voltages are referred to pin GND.

Symbol	Parameter	Conditions	Min	Max	Unit
V_{CC}	supply voltage	normal operation mode			
		–40 °C < T_{amb} < +60 °C; lifetime mission profile	-	18	V
		–40 °C < T_{amb} < +60 °C; 5 minutes	-	28	V
		–40 °C < T_{amb} < +150 °C; lifetime mission profile	-	16	V
		150 °C < T_{amb} < 175 °C; 12 × 10 minutes total	-	16	V
		CPTM; 10 °C < T_{amb} < 50 °C	–28	-	V
T_{amb}	ambient temperature		–40	+150	°C
		peak value; V_{CC} < 16 V; 12 × 10 minutes total	–40	+175	°C
H_{ext}	external magnetic field strength	–40 °C < T_{amb} < +175 °C	-	30	kA/m

7. Recommended operating conditions

Table 5. Operating conditions

The encoder is a ferromagnetic gear wheel with a module of 2.1 mm. The module m of a gear wheel is defined as the ratio of outer diameter D and number of teeth N (m = D/N).

Symbol	Parameter	Conditions	Min	Max	Unit
V_{CC}	supply voltage	normal operation mode; $T_{amb} \leq 175$ °C; referred to pin GND	4.5	16	V
		CPTM	–27	–5	V
R_L	load resistance		50	75	Ω
C_L	load capacitance		-	22	nF
T_{amb}	ambient temperature	normal operation mode	–40	+150	°C
		CPTM	10	50	°C
f_o	output frequency	normal operation mode	0	20	kHz
		CPTM	-	2.5	kHz

8. Characteristics

Table 6. Characteristics

Characteristics are valid for the operating conditions specified in Section 7; voltages are referred to pin GND; unless otherwise specified.

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
Normal operation mode						
$V_{CC(swon)}$	switch-on supply voltage	[1]	-	-	4.5	V
$t_{d(on)}$	turn-on delay time	[2]	-	-	1	ms
$V_{CC(swoff)}$	switch-off supply voltage	$I_{CC} = I_{CCH}$ [1]	-	-	3.8	V
		$I_{CC} = I_{CCL}$ [1]	-	-	4.27	V
$I_{CC(swoff)}$	switch-off supply current	$V_{CC} < 4$ V	2.5	-	4.0	mA
I_{CCL}	LOW-level supply current		5.88	7.0	8.4	mA
I_{CCH}	HIGH-level supply current		11.76	14.0	16.8	mA
I_{CCH}/I_{CCL}	HIGH-level supply current to LOW-level supply current ratio		1.8	2.0	2.2	-
C_{itg}	integrated capacitance	between supply terminals	-	2.2	-	nF
$\|H_{th}\|$	magnetic field strength threshold (absolute value)	in y direction; including hysteresis and offset	-	-	300	A/m
dI_{CC}/dt	rate of change of supply current	I_{CCL} to I_{CCH} (10 % to 90 % and 90 % to 10 %); $R_L = 50$ Ω; no C_L	6	-	28	mA/μs
δ_o	output duty cycle	H in y direction > 500 A/m	30	-	70	%
f_o	output frequency	normal operation mode	0	-	20	kHz
		CPTM	-	-	2.5	kHz

Table 6. Characteristics *...continued*

Characteristics are valid for the operating conditions specified in Section 7; voltages are referred to pin GND; unless otherwise specified.

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
Period jitter with ideal ferromagnetic encoder with a module[3] of 2.1 mm minimum and track width = 10 mm. The sensor reading point is located within a distance x of ±1 mm next to the center of the encoder track; see Figure 6						
σ(T)	period jitter	low-field; RMS value; due to noise at large air gaps; H in y direction = 500 A/m [4]	-	-	0.5	%
		high-field; RMS value; due to noise; H in y direction = 2500 A/m; f_o < 2.5 kHz [4]	-	-	0.1	%
Air gap with ideal ferromagnetic encoder with a module[3] of 2.1 mm minimum and track width = 10 mm. The sensor reading point is located within a distance x of ±1 mm next to the center of the encoder track; see Figure 6						
d_{ST}	start-up air gap of encoder wheel to sensor surface	after power-on; at start-up of encoder wheel	0.5	-	2.4	mm
d	air gap of encoder wheel to sensor surface	in normal mode after 10 wheel rotations	0.5	-	2.8	mm
Customer Production Test Mode (CPTM)						
$V_{CC(zo)}$	zero offset supply voltage	H_{eq} = 0 A/m	−16	−15.5	−15	V
I_{CCL}	LOW-level supply current		−4.0	−3.5	-	mA
I_{CCH}	HIGH-level supply current		−8.4	−7	−6.02	mA
$\Delta H/\Delta V_{CC}$	magnetic field strength variation with supply voltage	see Figure 5	50	52	56	(A/m)/V

[1] Once V_{CC} has exceeded $V_{CC(swon)}$, the sensor switches on and current levels and current ratios are maintained until V_{CC} falls below $V_{CC(swoff)}$.

[2] After supplying more than $V_{CC(swon)}$ to the device, it needs a turn-on delay time of $t_{d(on)}$ to reach stable operation. A stable supply current indicates stable operation.

[3] Module m of the gear wheel is defined as the ratio of outer diameter D and number of teeth N: m = D/N.

[4] RMS value measured as spread of the delay between zero-crossing of the magnetic field and output of the associated speed pulse. Extra jitter is possible due to disturbances on the supply line and other non-ideal conditions.

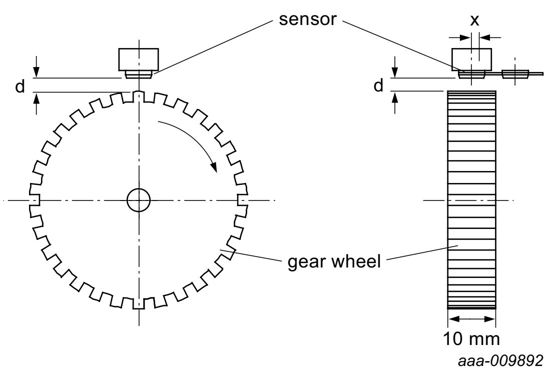


Fig 6. Sensor positioning

9. Electromagnetic compatibility

The following tests have verified EMC:

9.1 Emission

CISPR25: radiated emission, Absorber-Lined Shielded Enclosure (ALSE) method.

9.2 Immunity to electrical transients

Tests were carried out with external protection circuit.

- ISO 7637-2 (second edition 2004): electrical transient conduction on supply lines; test pulses 1, 2a, 3a, 3b and 5a
- ISO 7637-3: electrical transient transmission by capacitive and inductive coupling

9.3 Immunity to radiated disturbances

- ISO 11452-2: antenna in absorber lined shielded enclosure
- ISO 11452-4: Bulk Current Injection (BCI)
  - Substitution method and closed loop method
- ISO 11452-5: strip line
- ISO 11452-7: Direct Power Injection (DPI)
  - Differential mode and common mode

10. ElectroStatic Discharge (ESD)

The following tests have verified ESD in accordance with ISO 10605:

10.1 Powered contact discharge

±16 kV (C = 330 pF, R = 2 kΩ), function performance status II

10.2 Unpowered contact discharge

±25 kV (C = 150 pF, R = 330 Ω), function performance status III

10.3 Powered air discharge

±8 kV (C = 330 pF, R = 330 Ω), function performance status II

10.4 Unpowered air discharge

±25 kV (C = 330 pF, R = 330 Ω), function performance status III

11. Application information

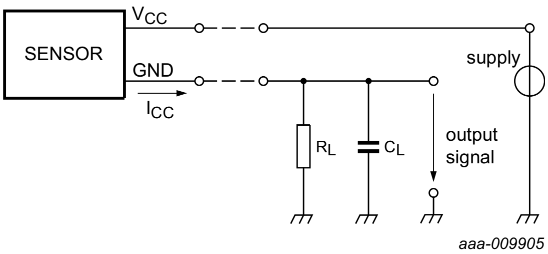


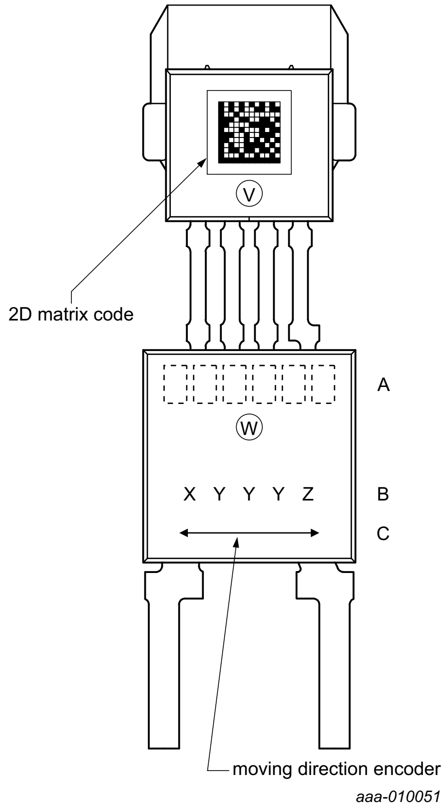
Fig 7. Test and application circuit

12. Test information

12.1 Quality information

This product has been qualified in accordance with the Automotive Electronics Council (AEC) standard *Q100 Rev-G - Failure mechanism based stress test qualification for integrated circuits*, and is suitable for use in automotive applications.

13. Marking



A: leading letters of type number (6 characters max.)

B: day code/date code

X: product manufacturing code; m for manufacturing Manila

YYY: day of year

Z: year of production (last figure)

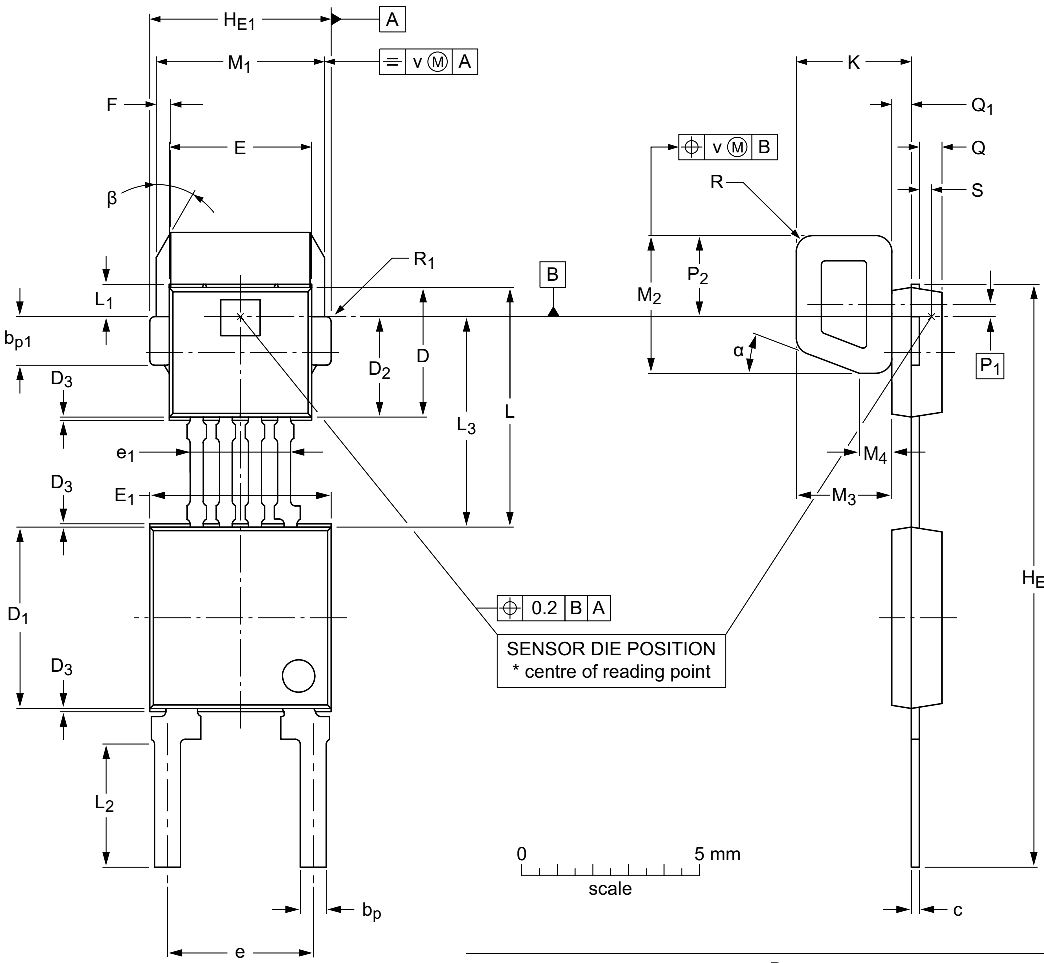
C: moving direction

2D matrix code: norm: ISO/IEC DIS 16022/ECC 200; matrix dimension 12 dots × 12 dots; matrix field size approximately 1.62 mm × 1.62 mm. The 2D code defines a unique identification number, which is linked in a data base to the different batch numbers and test results.

Fig 8. Marking

14. Package outline

Plastic single-ended multi-chip package; magnetized ferrite magnet (4.25 x 5.2 x 3 mm); 4 interconnections; 2 in-line leads **SOT453E**



		M_1	M_2	M_3	M_4	P_1	P_2 max.	Q	Q_1	R	R_1	S	V
mm	max	5.4	4.45	3.05	1.2			0.75	0.65	0.7	0.3	0.48	
	nom					0.375	2.725						0.25
	min	5.0	4.05	2.85	0.8			0.65	0.55	0.2	0.1	0.28	

Dimensions (mm are the original dimensions)

Unit(1)		α	β	b_p	b_{p1}	c	D	D_1	D_2	D_3 max.	E	E_1	e	e_1	F	H_E	H_{E1}	K max.	L	L_1	L_2	L_3
mm	max	25°	35°	0.8	1.57	0.3	4.1	5.7	3.15		4.5	5.7	4.6	3.2	0.55	18.2	5.6		7.55	1.2	3.9	6.55
	nom									0.35								3.77				
	min	15°	25°	0.7	1.47	0.24	3.9	5.5	2.95		4.3	5.5	4.4	3.0	0.30	17.8	5.5		7.25	0.9	3.5	6.35

Note

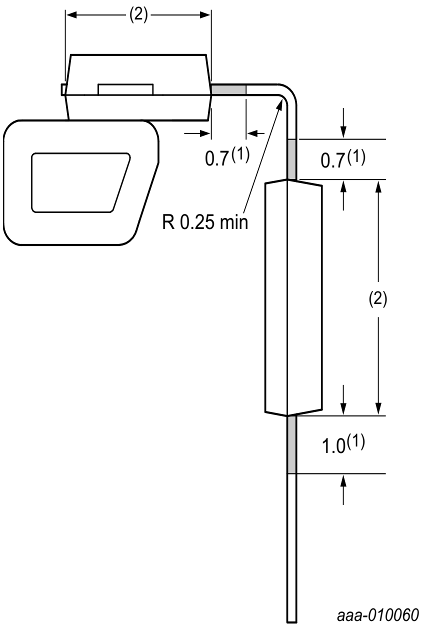
1. Glue thickness not included in Q1, M3 and M4.
2. 1 mm around plastic body the leadfinish is uncontrolled

sot453e_po

Outline version	References				European projection	Issue date
	IEC	JEDEC	JEITA			
SOT453E						~~13-11-05~~ 13-11-26

Fig 9. Package outline SOT453E

15. Handling information



Dimensions in mm

(1) No bending allowed.

(2) Plastic body and interface plastic body - leads: application of bending forces not allowed.

Fig 10. Bending recommendation

16. Solderability information

Recommended soldering process for leaded devices is wave soldering. The maximum soldering temperature is 260 °C for maximum 5 s.

17. Revision history

Table 7. Revision history

Document ID	Release date	Data sheet status	Change notice	Supersedes
KMI17_4 v.1	20140901	Product data sheet	-	-

18. Legal information

18.1 Data sheet status

Document status[1][2]	Product status[3]	Definition
Objective [short] data sheet	Development	This document contains data from the objective specification for product development.
Preliminary [short] data sheet	Qualification	This document contains data from the preliminary specification.
Product [short] data sheet	Production	This document contains the product specification.

[1] Please consult the most recently issued document before initiating or completing a design.

[2] The term ‘short data sheet’ is explained in section “Definitions”.

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20. Contents

Date of release: 1 September 2014

Document identifier: KMI17_4