DATA SHEET

UZZ9000

Sensor Conditioning Electronic

Product specification

Supersedes data of 2000 May 19

2000 Nov 27

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Sensor Conditioning Electronic

UZZ9000

FEATURES

- One chip fully integrated signal conditioning IC
- Accuracy better than 1° together with KMZ41 in 100° angle range
- Temperature range from −40 to 150 °C
- Adjustable angle range
- Adjustable zero point.

GENERAL DESCRIPTION

The UZZ9000 is an integrated circuit that combines two sinusoidal signals (sine and cosine) into one single linear output signal. When used in conjunction with the magnetoresistive sensor KMZ41 it provides a measurement system for angles up to 180°. The UZZ9000 can also be used for other applications in which an angle has to be calculated from a sine and a cosine signal. A typical application would be any kind of resolver application.

The two input signals are converted into the digital domain with two separate AD-converters. A CORDIC algorithm performs the inverse tangent transformation. Since today's applications typically require analog output signals (e.g. potentiometers), the resulting signal is transferred back to the analog domain.

The UZZ9000 enables the user to set both the angle range and the zero point offset. These ranges are set by external voltage dividers.

PINNING

SYMBOL	PIN	DESCRIPTION
$+V_{O2}$	1	sensor 2 positive differential input
$+V_{O1}$	2	sensor 1 positive differential input
V_{DD2}	3	digital supply voltage
V_{SS}	4	digital ground
GND	5	analog ground
RST	6	reset of the digital part; note 1
TEST1	7	for production test; note 1
TEST2	8	note 2
DATA_CLK	9	trim-mode data-clock; note 1
SMODE	10	serial mode programmer; note 1
TEST3	11	note 2
V_{OUT}	12	output voltage
Var	13	angle-range input set
V_{offin}	14	offset input set
OFFS2	15	offset trimming input sensor 2
OFFS1	16	offset trimming input sensor 1
V_{DDA}	17	analog supply voltage
GND	18	analog ground
TEST4	19	for production test; note 1
TEST5	20	for production test; note 1
V_{DD1}	21	digital supply voltage
T_{out}	22	test output
$-V_{O2}$	23	sensor 2 negative differential input
$-V_{O1}$	24	sensor 1 negative differential input

Notes

1. Connected to ground.

2. Pin to be left unconnected.

QUICK REFERENCE DATA

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT
V_{DDA}	supply voltage	note 1	4.5	5	5.5	V
V_{DD1}	supply voltage	note 1	4.5	5	5.5	V
V_{DD2}	supply voltage	note 1	4.5	5	5.5	V
I_{CCtot}	total supply current		–	13	15	mA
A	angle range	in 10° steps with KMZ41	30	–	180	deg
A	accuracy	with ideal input signal; range = 100°	±0.45	–	–	deg

Note

1. V_{DDA}, V_{DD1} and V_{DD2} must be connected to the same supply voltage.

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LIMITING VALUES

In accordance with the Absolute Maximum Rating System (IEC 60134).

SYMBOL	PARAMETER	CONDITIONS	MIN.	MAX.	UNIT
V_{DDA}	supply voltage		−0.3	+6	V
V_{DD1}	supply voltage		−0.3	+6	V
V_{DD2}	supply voltage		−0.3	+6	V
V_{pin}	voltage at all pins		−0.3	V_{DD}	V
T_{stg}	storage temperature		−55	+150	°C
T_j	operating temperature	125 to 150 °C; max 200 hours	−40	+150	°C

THERMAL CHARACTERISTICS

SYMBOL	PARAMETER	VALUE	UNIT
$R_{th\ j\text{-}a}$	thermal resistance from junction to ambient	80	K/W

ESD SENSITIVITY

SYMBOL	PARAMETER	CONDITIONS	VALUE	UNIT
ESD	ESD sensitivity	human body model	2	kV
		machine model	±150	V

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ELECTRICAL CHARACTERISTICS

T_{amb} = −40 to +150 °C; V_{DD} = 4.5 to 5.5 V; typical characteristics for T_{amb} = 25 °C and V_{DD} = 5 V unless otherwise specified.

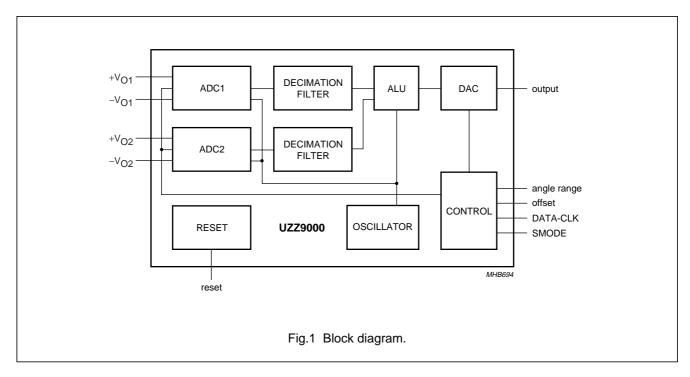| SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT
V_{DDA}	supply voltage		4.5	5	5.5	V
V_{DD1}	supply voltage		4.5	5	5.5	V
V_{DD2}	supply voltage		4.5	5	5.5	V
I_{DD}	supply current	without load	–	10	15	mA
$(+V_O)-(-V_O)$	differential input voltage	referred to V_{DD}	±6.6	–	±28	mV/V
	common mode range	referred to V_{DD}	490	–	510	mV/V
	lost magnet threshold	referred to V_{DD}	–	3	–	mV/V
f_{ext}	external clock frequency	for trim interface	0.1	–	1	MHz
f_{int}	internal clock frequency	T_j = −40 to 150 °C	2.3	4	5.7	MHz
C_{load}	output load		–	–	50	pF
		with series resistance >300 Ω	–	–	200	nF
V_{reset}	switching voltage threshold for power on/off	between falling and rising V_{DD}	2.8	–	4.5	V
	hysteresis		–	0.3	–	
V_{out}	output voltage range for valid ranges	lower bound	5	–	6	% V_{DD}
		upper bound	94	–	95	% V_{DD}
V_d	diagnostic area	for irregular input signal	0	–	4	% V_{DD}
			96	–	100	% V_{DD}
A	accuracy	with ideal input signal; range = 100°	±0.45	–	–	degree
Res	resolution	range = 100°	0.1	–	–	degree
t_{on}	power up time		–	–	20	ms
t_r	response time	to 95% of final value	–	0.7	1.2	ms
V_{LM}	sensor voltage	lost magnet threshold	12	15	20	mV

FUNCTIONAL DESCRIPTION

The UZZ9000 is a mixed signal IC for angle measurement systems. The UZZ9000 has been designed for the double sensor KMZ41. It combines two analog signals (sine and cosine) into a linear output signal. The analog measurement signals on the IC input are converted to digital data by two ADC's. Each ADC is a Sigma-Delta modulator employing a 4th order continuous time architecture with an over-sampling ratio of 128 to achieve high resolution. The converter output is a digital bit-stream with an over-sampling frequency of typically 500 kHz. The bit-stream is fed into a decimation filter which performs both low pass filtering and down-sampling. The IC has two input channels each of which has its own ADC and decimation filter. The two decimation filter outputs are 15-bit digital words at a lower frequency of typically 3.9 kHz which is the typical sampling frequency of the sensor system. The digital representations of the two signals are then used to calculate the current angle by the ALU. This calculation is carried out using the so-called CORDIC algorithm. The angle is represented by a 13-bit resolution. A DAC converts the digital signal back to the analog domain.

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Fig.1 Block diagram.

The following list gives a short description of the relevant block functions:

1. The ADC block contains two Sigma Delta AD converters, sensor offset correction circuitry and the circuitry required for the sensitivity and offset adjustment of the chip output voltage curve.

2. The decimation filter block comprises two digital low pass decimation filters convert the low resolution high speed bit stream output from the ADC's into a low speed digital word.

3. The ALU block derives an angle value from the two digital inputs using the CORDIC algorithm.

4. The DAC converts the output of the ALU block to an analog signal.

5. The CONTROL block provides the clock and the control signals for the chip.

6. The RESET block supplies a reset signal during power-up and power-down when the power supply is below a certain value.

7. The Oscillator generates the master clock.

Angle range selection

In order to accommodate varying applications, both the mechanical input angular range of the UZZ9000 and the zero point of the output curve are user programmable. This section describes how to select a desired mode.
The output curve is adjusted by changing the angular range as shown in Fig.2. Without any zero point offset, the ramp-up starts at mechanical $0°$ ($\alpha1 = 0°$). When using a KMZ41 sensor, the maximum angular range $\Delta\alpha$ is $0°$ to $180°$. For the UZZ9000, smaller angular ranges can be set. In this case, $\alpha2$ becomes smaller than $180°$ and the output curve is clipped at this position. The location of discontinuity X_D (change from lower to upper clipping area) depends on the adjusted range and can be calculated as follows:
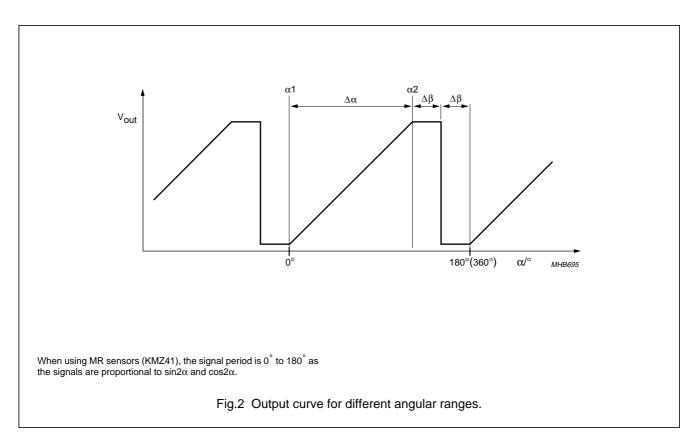
$$X_D = \Delta\alpha + \frac{180° - \Delta\alpha}{2}$$

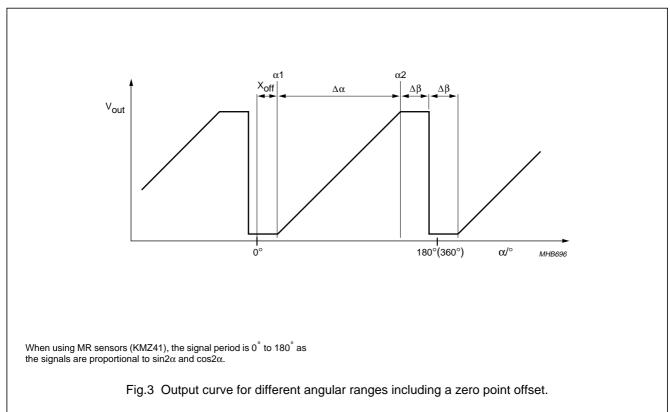In order to compensate for tolerances, the zero point of the output curve can be shifted by $±5°$ in steps of $0.5°$. The effect of this measure is shown in Fig.3. Now $\alpha1$ is no longer identical with mechanical $0°$, but with the zero point shift X_{off}. Consequently, the location of discontinuity X_D can be calculated as follows:

$$X_D = x_{off} + \Delta\alpha + \frac{180° - \Delta\alpha}{2}$$

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When using MR sensors (KMZ41), the signal period is $0°$ to $180°$ as
the signals are proportional to $\sin 2\alpha$ and $\cos 2\alpha$.

Fig.2 Output curve for different angular ranges.

When using MR sensors (KMZ41), the signal period is $0°$ to $180°$ as
the signals are proportional to $\sin 2\alpha$ and $\cos 2\alpha$.

Fig.3 Output curve for different angular ranges including a zero point offset.

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Angle range setting

To select one of 16 different angular ranges, an external voltage (see Table 1) must be applied to pin 13 of the UZZ9000 (Var). During the ICs initialisation phase, which directly follows power-on reset or an external reset, this voltage is read and then converted into the digital domain. The digital value is stored until the next reset state occurs. Consequently, the angular range cannot be changed during normal operation but is still fixed after initialisation phase. Note that the voltage at pin 13 must be ratiometric to V_{DDA} and also stable over temperature and lifetime. This is ensured, for instance, when providing this voltage via a (trimmable) resistor divider connected to V_{DDA}, which is the analog supply of the UZZ9000. The following defines the % value of the supply voltage V_{DDA} that must be supplied to pin 13 to select a certain range. When using the 30° angular range, a constant zero point offset of 15° is added. Consequently, when using the 30° range, the zero point offset can be programmed between 10° and 20° only (see Zero point offset setting).

Table 1 Definition of voltages to set UZZ9000 angular ranges

ANGULAR RANGE (°)	MIN. (%)	NOM. (%)	MAX. (%)	UNIT (%)
0 to 30	33.47	33.73	33.99	V_{DDA}
0 to 40	35.69	35.95	36.21	V_{DDA}
0 to 50	37.91	38.17	38.43	V_{DDA}
0 to 60	40.14	40.40	40.66	V_{DDA}
0 to 70	42.36	42.62	42.88	V_{DDA}
0 to 80	44.58	44.84	45.10	V_{DDA}
0 to 90	46.80	47.06	47.32	V_{DDA}
0 to 100	49.02	49.28	49.54	V_{DDA}
0 to 110	51.25	51.51	51.77	V_{DDA}
0 to 120	53.47	53.73	53.99	V_{DDA}
0 to 130	55.69	55.95	56.21	V_{DDA}
0 to 140	57.91	58.17	58.43	V_{DDA}
0 to 150	60.13	60.39	60.65	V_{DDA}
0 to 160	62.36	62.62	62.88	V_{DDA}
0 to 170	64.58	64.84	65.10	V_{DDA}
0 to 180	66.80	67.06	67.32	V_{DDA}

Zero point offset setting

To adjust the zero point offset or to set it to 0°, an external voltage has to be applied to the UZZ9000 at pin 14 (VOFFIN). The function is similar to that described

previously. After reset the voltage is read, converted into the digital domain and then stored until another reset state occurs. Consequently, the zero point offset cannot be adjusted without a reset. It is recommended to use a resistor divider connected to V_{DDA} to generate this voltage. Table 2 defines the allowed voltage ranges as a percentage of the supply V_{DDA}.

Table 2 Definition of voltages to set a certain zero point offset

ZERO POINT OFFSET (°)	MIN. (%)	NOM. (%)	MAX. (%)	UNIT (%)
−5	33.47	33.73	33.99	V_{DDA}
−4.5°	35.14	35.40	35.66	V_{DDA}
−4°	36.80	37.06	37.32	V_{DDA}
−3.5°	38.47	38.73	38.99	V_{DDA}
−3°	40.13	40.39	40.65	V_{DDA}
−2.5°	41.80	42.06	42.32	V_{DDA}
−2°	43.47	43.73	43.99	V_{DDA}
−1.5 °	45.13	45.39	45.65	V_{DDA}
−1°	46.80	47.06	47.32	V_{DDA}
−0.5°	48.60	48.72	48.98	V_{DDA}
0°	50.13	50.39	50.65	V_{DDA}
0.5°	51.80	52.06	52.32	V_{DDA}
1°	53.46	53.72	53.98	V_{DDA}
1.5°	64.58	55.39	55.65	V_{DDA}
2°	56.79	57.05	57.31	V_{DDA}
2.5°	58.46	58.72	58.98	V_{DDA}
3°	60.13	60.39	60.65	V_{DDA}
3.5°	61.79	62.05	62.31	V_{DDA}
4°	63.46	63.72	63.98	V_{DDA}
4.5°	65.12	65.38	65.64	V_{DDA}
5°	66.79	67.05	67.31	V_{DDA}

Offset trimming

To achieve a linear output characteristic, it is necessary to adapt the offsets of the two input signals to the input stage of the UZZ9000. For this reason a sensor offset cancellation procedure has been implemented in the UZZ9000 which is started by sending a special serial data protocol to the UZZ9000. This trimming procedure is required for both input signals.

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Trim interface

The serial interface used to switch the UZZ9000 into trim mode consists of the two terminals SMODE (pin 10) and DATA_CLK (pin 9). The structure of this protocol is shown in Fig.4.

All signal levels at DATA_CLK and SMODE must be selected according to the requirements listed in Table 3. The following points must be taken into account with regard to the asynchronous protocol.

The protocol starts with a falling edge at the SMODE,

which must occur at a high DATA_CLK level. The following five bits are used to code the message sent to the UZZ9000. They are transferred via the SMODE and are sampled with the rising edge of the DATA_CLK. During the fifth high level output of DATA_CLK (counted from the start condition onwards), a rising edge must appear at the SMODE and the DATA_CLK follows this with one more change to low level in order to successfully complete the protocol.
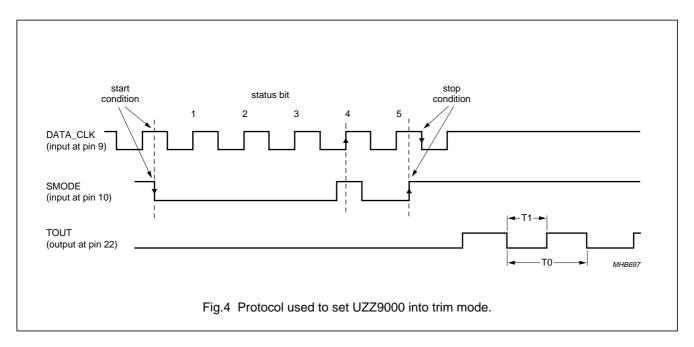

Fig.4 Protocol used to set UZZ9000 into trim mode.

Table 3 Definition of the trim interface signals

PARAMETER	MIN.	NOM.	MAX.	UNIT
UZZ9000 supply voltage	4.5	5	5.5	V
low level of DATA_CLK, SMODE	0	–	5	%V_{DD}
high level of DATA_CLK, SMODE	95	–	100	%V_{DD}
rise and fall time of DATA_CLK and SMODE signal edges (10 to 90% V_{DD}) and (90 to 10% V_{DD})	8	–	–	ns
DATA_CLK frequency	0.1	–	1	MHz

How to enter the trim mode

The status bits to be transmitted to the UZZ9000 are shown in Table 4. Note that a complete protocol has to be sent before normal operation can be resumed. The trim mode can also be exited by resetting the device. After entering one of the trim modes and provided there is a dynamic input signal, a square wave output is visible at the terminal T_{OUT} (pin 22).

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Table 4   Programming of trim modes

MODE	STATUS BITS				
	1	**2**	**3**	**4**	**5**
enter trim mode for sensor input channel 1	0	0	0	1	0
enter trim mode for sensor input channel 2	0	0	1	0	0
leave trim mode for either input channel	0	0	0	0	0

Reset

In addition to the external reset pin (pin 6), the UZZ9001 provides an internal power-up/ power-down reset logic which continuously monitors the supply voltage. When the supply voltage increases and reaches a safe level, reset becomes inactive and the device starts initialization. When the supply voltage exceeds the safe voltage level, the device is reset immediately. This internal reset logic can be over-ridden by the external pin RES (pin 6) in all modes and at any time. The reset pin RES (pin 6) is active when in the high position. It is internally pulled to ground and therefore need not be connected if the function is not required.

Diagnostic

The UZZ9000 provides powerful diagnostics features that allow the user to recognize certain failures of the device or system. A failure will occur when the output voltage V_{OUT} either rises above or falls below the normal operation range. Either one of the diagnostic areas is reached during any of the following conditions

1.   Short circuit between V_{OUT} and GND (R < 1 Ω).

2.   Short circuit between V_{OUT} and V_{DD} (R < 1 Ω).

3.   Disconnection of V_{DD} when the load is pulled down.

4.   Disconnection of GND when the load is pulled up.

5.   Invalid input signal from the sensor, e.g. Magnet Lost. This failure is assumed when the offset corrected input signal of sensor 1 and sensor 2 is below ± 15 mV.

The internal pull-up and pull-down resistors in the output buffer block ensure that V_{OUT} will be pulled to one of the power supplies when the other supply is disconnected so V_{OUT} reaches the diagnostic region even when there is no output load. If the external load is a pull-down resistor, then the device enters into the diagnostic area if V_{DD} is disconnected, but not if V_{SS} is disconnected. Similarly, if the load is a pull-up resistor, then the device will enter the diagnostic area if V_{SS} is disconnected, but not if V_{DD} is disconnected. It is not necessary to connect an output load to the UZZ9000. After recovering from short circuit to ground or supply voltage, the chip returns undamaged to the normal operation mode. There is no time limitation regarding short circuit of V_{OUT}.

Measurement dynamics

The UZZ9000 includes an on-chip RC Oscillator that generates the clock for the whole device. Consequently, no external clock supply is required for the measurement system. The nominal clock frequency of the on-chip oscillator is 4 MHz at room temperature. It varies with temperature change. At -40 °C the clock frequency may decrease to 2.3 MHz. At higher temperatures however, a frequency up to 5.7 MHz may be reached. This influences the dynamics of measurements. From an application point of view, two different effects have to be distinguished: The system delay, which means how long it takes until a changed input signal is recognized at the output, and the measurement update rate. The system delay is mainly caused by the settling time of the low pass decimation filter, which depends on the maximum frequency content (shape) of the input signals and the clock frequency. The following maximum values can be expected for the entire system delay. The measurement update rate, however, is directly related to the oscillator frequency. At room temperature, a new value is available every 0.26 ms. When taking the entire temperature range into account, update rates between 0.45 and 0.18 ms are possible. (see Table 5).

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Table 5 System delay and update rates of the UZZ9000

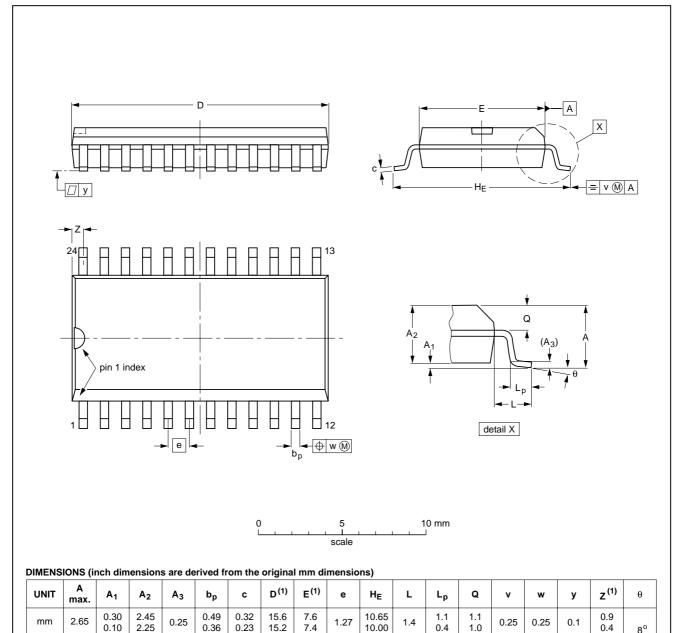| PARAMETER	MIN.	TYP.	MAX.	UNIT
system delay (time elapsed until 95% of the final value is reached)				
max. signal frequency < 200 MHz	–	–	0.6	ms
transients (step response)	–	–	1.2	ms
measurement update rate				
−40 °C	0.45	–	–	ms
25 °C (room temperature)	–	0.26	–	ms
150 °C	–	–	0.18	ms

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PACKAGE OUTLINE

SO24: plastic small outline package; 24 leads; body width 7.5 mm   **SOT137-1**

0   5   10 mm
scale

DIMENSIONS (inch dimensions are derived from the original mm dimensions)

UNIT	A max.	A₁	A₂	A₃	b_p	c	D⁽¹⁾	E⁽¹⁾	e	H_E	L	L_p	Q	v	w	y	Z⁽¹⁾	θ
mm	2.65	0.30 0.10	2.45 2.25	0.25	0.49 0.36	0.32 0.23	15.6 15.2	7.6 7.4	1.27	10.65 10.00	1.4	1.1 0.4	1.1 1.0	0.25	0.25	0.1	0.9 0.4	8º 0º
inches	0.10	0.012 0.004	0.096 0.089	0.01	0.019 0.014	0.013 0.009	0.61 0.60	0.30 0.29	0.050	0.419 0.394	0.055	0.043 0.016	0.043 0.039	0.01	0.01	0.004	0.035 0.016	

Note

1. Plastic or metal protrusions of 0.15 mm maximum per side are not included.

OUTLINE VERSION	REFERENCES				EUROPEAN PROJECTION	ISSUE DATE
	IEC	JEDEC	EIAJ			
SOT137-1	075E05	MS-013				~~97-05-22~~ 99-12-27

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DATA SHEET STATUS

DATA SHEET STATUS	PRODUCT STATUS	DEFINITIONS [1]
Objective specification	Development	This data sheet contains the design target or goal specifications for product development. Specification may change in any manner without notice.
Preliminary specification	Qualification	This data sheet contains preliminary data, and supplementary data will be published at a later date. Philips Semiconductors reserves the right to make changes at any time without notice in order to improve design and supply the best possible product.
Product specification	Production	This data sheet contains final specifications. Philips Semiconductors reserves the right to make changes at any time without notice in order to improve design and supply the best possible product.

Note

1. Please consult the most recently issued data sheet before initiating or completing a design.

DEFINITIONS

Short-form specification — The data in a short-form specification is extracted from a full data sheet with the same type number and title. For detailed information see the relevant data sheet or data handbook.

Limiting values definition — Limiting values given are in accordance with the Absolute Maximum Rating System (IEC 60134). Stress above one or more of the limiting values may cause permanent damage to the device. These are stress ratings only and operation of the device at these or at any other conditions above those given in the Characteristics sections of the specification is not implied. Exposure to limiting values for extended periods may affect device reliability.

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