

## TSYS03

### Digital Temperature Sensor

#### Product Description

The TSYS3 is a miniature digital temperature sensor that provides factory calibrated highly accurate temperature data.

The device contains a durable temperature sensor element, A/D converter, and microcontroller to manage data communications via an I<sup>2</sup>C interface.

TSYS3 is available in a TDFN8 or a XDFN6 package to easily adapt to the space available on a PC board. These packages are very small and have low thermal mass which provides a quick response to temperature changes.

The operating and measurement temperature range is -40 to +125°C with a resolution of  $\pm 0.01^\circ\text{C}$ .

Operating and sleep currents are extremely low making this sensor ideal for mobile and battery power applications

#### Features

- High Accuracy  $\pm 0.5^\circ\text{C}$  @ Temp.:  $0^\circ\text{C}$  to  $+60^\circ\text{C}$
- Adjustment of high accuracy temperature range on request
- Low Supply Current  $< 5 \mu\text{A}$  (standby  $< 0.4 \mu\text{A}$ )
- I<sup>2</sup>C Interface up to 1MHz
- Small IC-Package TDFN8 2.5mm x 2.5mm and XDFN6 1.5mm X 1.5mm
- Operating Temperature Range:  $-40^\circ\text{C}$  to  $+125^\circ\text{C}$
- Programmable I2C Address

#### Applications

- Industrial Control
- Replacement of Precision RTDs, Thermistors and NTCs
- Heating / Cooling Systems
- HVAC
- Medical probes and patient monitoring
- Weather Stations
- Fitness watches and wearables
- Consumer appliances

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### Absolute Maximum Ratings

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.

Parameter	Symbol	Condition	Min	Typ	Max	Unit
Supply Voltage	$V_{DD}$	---	-0.3	---	+5.5	V
Operating Temperature	$T_{op}$	---	-40	---	+125	°C
Storage temperature	$T_{stor}$	---	-55	---	+150	°C
ESD rating	ESD	Human Body Model (HBM) pin to pin incl. $V_{DD}$ & GND	-4	---	+4	kV
Humidity	Hum	Non-condensing	0	---	95	RH

### Operating Conditions

Parameter	Symbol	Condition	Min	Typ	Max	Unit
Operating Supply Voltage	$V_{DD}$	stabilized	2.4	3.3	5.5	V
Supply Current	$I_{DD}$	1 sample per second	---	5	---	$\mu$ A
Standby current	$I_s$	No conversion, $V_{DD} = 5.0V$ $T = +25^\circ C$ $T = +85^\circ C$ $T = +125^\circ C$	---	0.16 0.32 1.02	0.34 1.32 6.27	$\mu$ A
Peak Supply Current	$I_{DD}$	$V_{DD} = 5.0 V$ $T = 25^\circ C$ $T = -40^\circ C \dots +125^\circ C$	345 327	402	486 515	$\mu$ A
Conversion time	$T_{CONV}$	---	---	12	---	ms
Serial Data Clock I2C	$F_{SCL}$	---	---	---	1	MHz
VDD Capacitor	---	Place close to the chip	100			nF

### Operational Characteristics

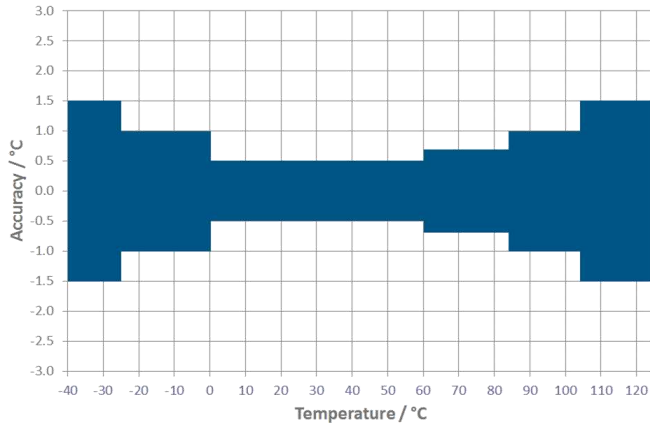
If not otherwise noted, 3.3V supply voltage is applied.

Parameter	Symbol	Condition	Min	Typ	Max	Unit
Temp. Measurement Range	$T_{RANG}$	---	-40	---	125	°C
Accuracy 1	$T_{ACC1}$	$0^\circ C < T < +60^\circ C$ $V_{DD} = 3.2V - 3.4V$	-0.5	---	+0.5	°C
Accuracy 2	$T_{ACC2}$	$60^\circ C < T < +85^\circ C$ $V_{DD} = 3.2V - 3.4V$	-0.7	---	+0.7	°C
Accuracy 3	$T_{ACC3}$	$-25^\circ C < T < +105^\circ C$ $V_{DD} = 3.2V - 3.4V$	-1.0	---	+1.0	°C
Accuracy 4	$T_{ACC4}$	$-40^\circ C < T < +125^\circ C$ $V_{DD} = 3.2V - 3.4V$	-1.5	---	+1.5	°C
PSRR	---	$V_{DD} = 2.4 - 5.5$ $T = 25^\circ C, C = 100nF$	---	---	0.1	°C
Self-Heating	SH	10 samples/s, 60s, still air	---	---	+0.1	°C

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## Accuracy



## Analogue to Digital Converter

Parameter	Symbol	Condition	Min	Typ	Max	Unit
Resolution	---	---	---	16	---	bit
Conversion Time	$t_c$	---	---	12	---	ms

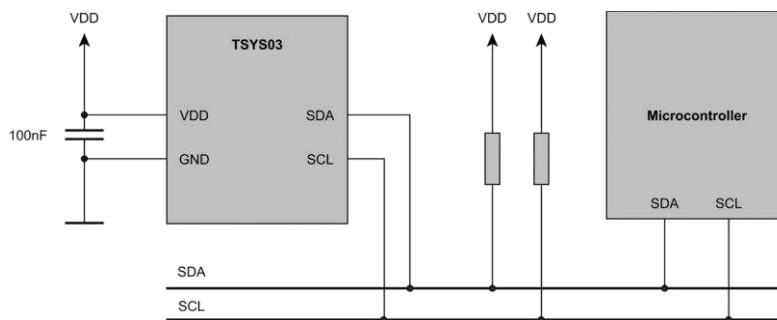
## Digital Inputs (SCLK, SDA)

Parameter	Symbol	Condition	Min	Typ	Max	Unit
Input High Voltage	$V_{IH}$	$V_{DD} = 3.0 \dots 5.5V$	$0.7 V_{DD}$	---	$V_{DD}$	V
Input Low Voltage	$V_{IL}$	$V_{DD} = 3.0 \dots 5.5V$	$0.0 V_{DD}$	---	$0.3 V_{DD}$	V
Input leakage Current	$I_{leak\_25}$ $I_{leak\_85}$	$T = 25^\circ C$ $T = 85^\circ C$	---	0.01 0.25	0.14 1.40	$\mu A$
Input Capacitance	$C_{IN}$	---	---	---	6	pF

## Digital Outputs (SDA)

Parameter	Symbol	Condition	Min	Typ	Max	Unit
Output High Voltage	$V_{OH}$	$I_{Source} = 1mA$	$0.8 V_{DD}$	---	$V_{DD}$	V
Output Low Voltage	$V_{OL}$	$I_{Sink} = 1mA$	$0.0 V_{DD}$	---	$0.2 V_{DD}$	V

## Connection Diagram



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### Pin Function Table

TDFN Package

Pin	Name	Type	Function
1	V <sub>DD</sub>	Power	Supply Voltage
2	SCL	Digital Input	I <sup>2</sup> C: Serial Data Clock
3	SDA	Digital Input / Output	I <sup>2</sup> C Data Input / Output
4	VSS	Power	Ground
5 ... 8	NC	---	Not connected / Do not connect

XDFN Package

Pin	Name	Type	Function
1	NC	---	Not connected / Do not connect
2	VSS	Power	Ground
3	SDA	Digital Input / Output	I <sup>2</sup> C Data Input / Output
4	SCL	Digital Input	I <sup>2</sup> C: Serial Data Clock
5	V <sub>DD</sub>	Power	Supply Voltage
6	NC	---	Not connected / Do not connect

### I<sup>2</sup>C Interface

An I<sup>2</sup>C communication message starts with a start condition and it is ended by a stop condition. Each command consists of two bytes: the address byte and command byte.

### I<sup>2</sup>C Address

The standard I<sup>2</sup>C address is 0x40 (0b1000000x). Every sensor will respond to this address. But the sensor can also react to a second, alternative I<sup>2</sup>C address.

It is possible to do a one-time subsequent writing of an alternative static I<sup>2</sup>C address. This leads to a wrong memory CRC but the sensor is still functional.

The alternative address could be written to the sensor already during production. There won't be a wrong CRC at the end in this case.

It is also possible to write an alternative I<sup>2</sup>C address to the sensor during operation. This address is temporarily and is overwritten during a software reset or a hardware restart.

Further information on writing the alternative I<sup>2</sup>C address are given in the Application Note.

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## Commands

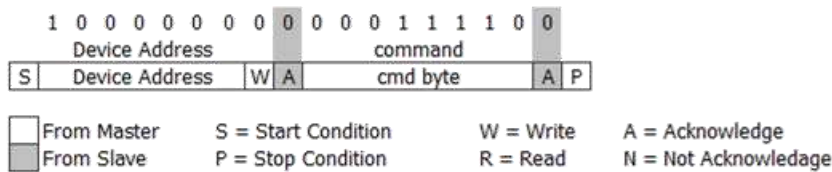
There are four commands:

- Reset
- Read Serial Number
- Start Conversion
- Read ADC

Command	Hex
Reset	0x1E
Read Serial Number	0x0A
Start Conversion	0x46
Read ADC	0x00

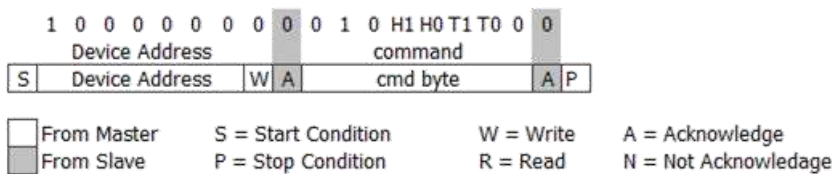
## Reset Sequence

The reset of TSYS03 can be sent at any time. When SDA line is blocked by an undefined state the only way to get the TSYS03 to work is to send a power on reset or several SCL cycles. This is not needed when the last command was not a conversion.



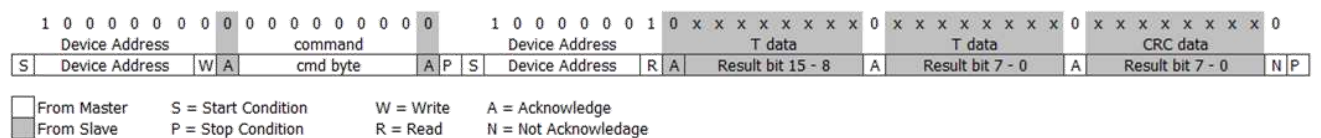
## Start Conversion

A conversion must be started and conducted before the ADC result can be read.



## Reading ADC Result

The temperature reprinting ADC result is read including CRC checksum.

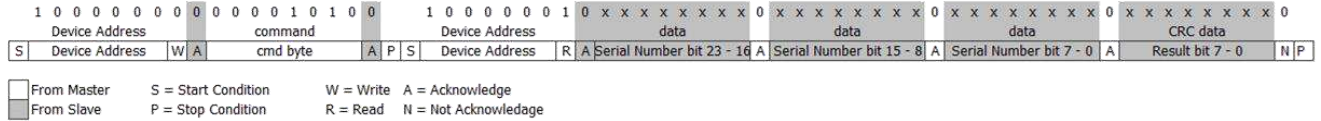


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## Read Serial Number

The serial number is written to non-volatile memory along with other values during production. It represents the chip position on the production wafer.



## CRC byte

The CRC byte can be used to check for bad data.

It is determined over the entire data using polynomial 0x31.

## Temperature Calculation

TEMPERATURE POLYNOMIAL

ADC:                      ADC Result

$$T / ^\circ\text{C} = -40^\circ\text{C} + \text{ADC} \times 165 / (2^{16}-1)$$

EXAMPLE

ADC16:                    26682 (0x683A)

$$T / ^\circ\text{C} = -40 + 26682 \times 165 / (2^{16}-1)$$

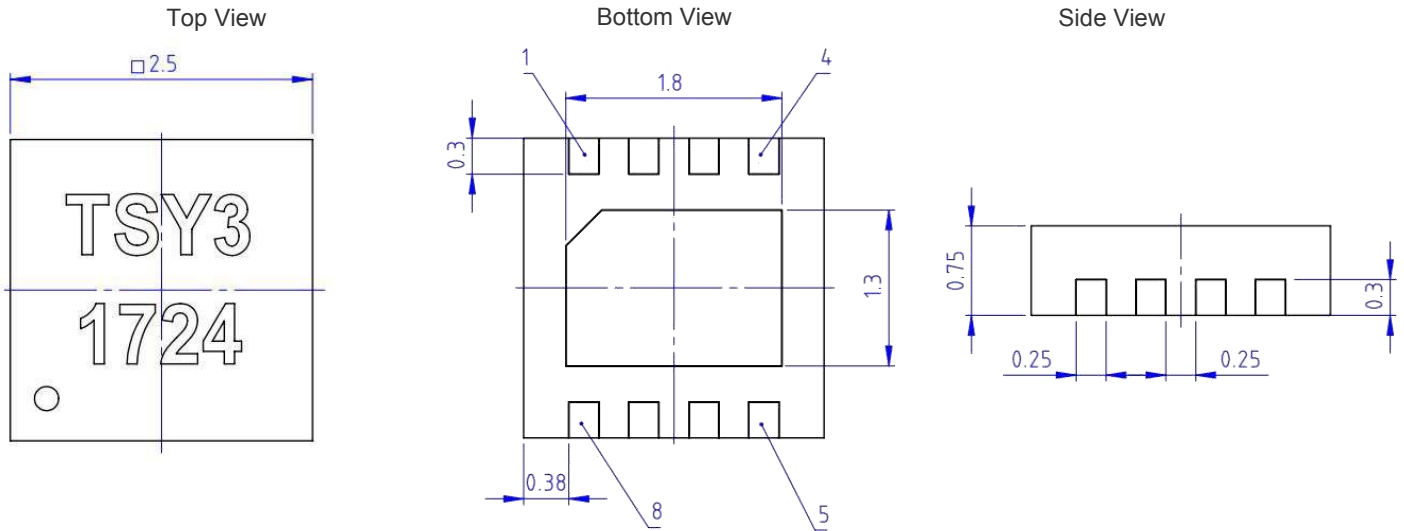
$$T / ^\circ\text{C} = 27.18^\circ\text{C}$$

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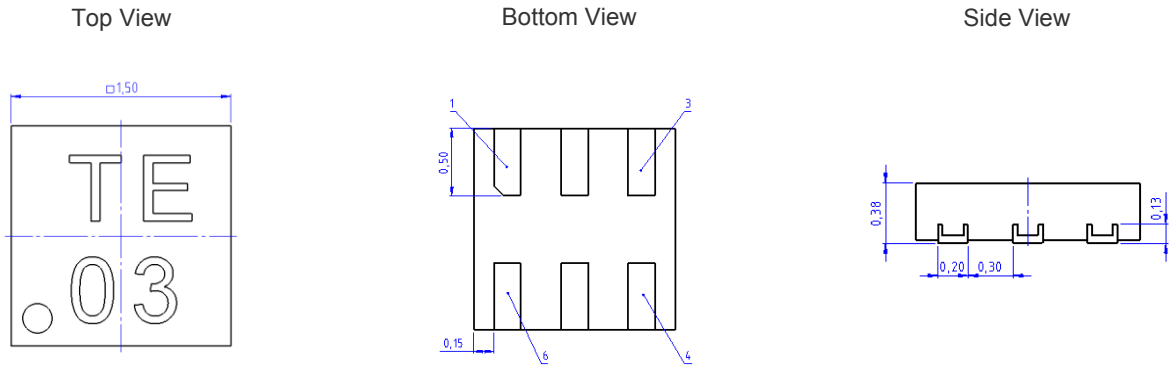
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## Dimensions

TDFN 2.5mm X 2.5mm



XDFN 1.5mm X 1.5mm



## Marking

Line	8L TDFN 2.5x2.5		6L XDFN 1.5x1.5	
	Description	Text	Description	Text
1	Product Name	TSY3	Product Name	TE
2	Pin 1 Dot, Date Code YYWW	1724	Pin 1 Dot, Product Name	03

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### Packaging Information

The TSYS03 will be delivered in tape and reel package.

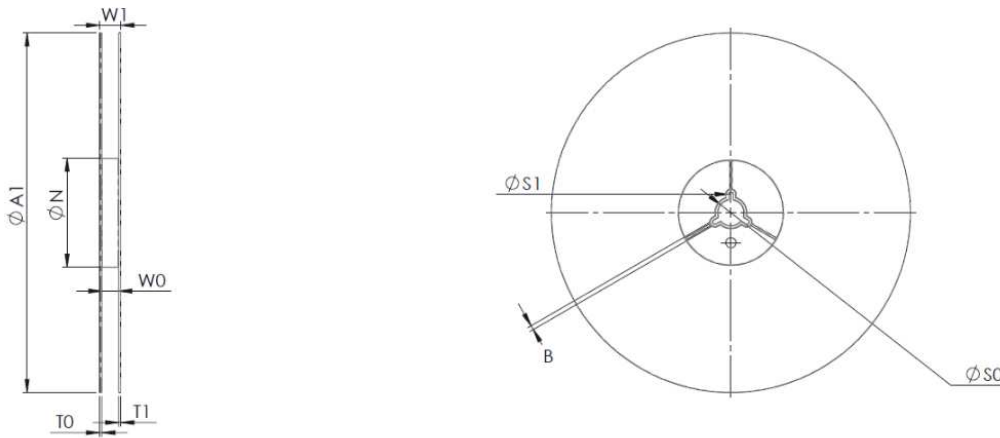
TDFN: Reel diameter: 7in (179mm): 3000 pieces per reel

XDFN: Reel diameter: 7in (179mm): 5000 pieces per reel

Each reel is equipped with a protective band and separately vacuum sealed into ESD protective moisture barrier bag. Furthermore, each bag contents a dry pack and humidity indicator.

Each bag is separately warped with bubble sheet and packed in a karton box, called pizza box.

### Dimension of Reel



**8L TDFN 2.5x2.5,**

**6L XDFN 1.5x1.5**

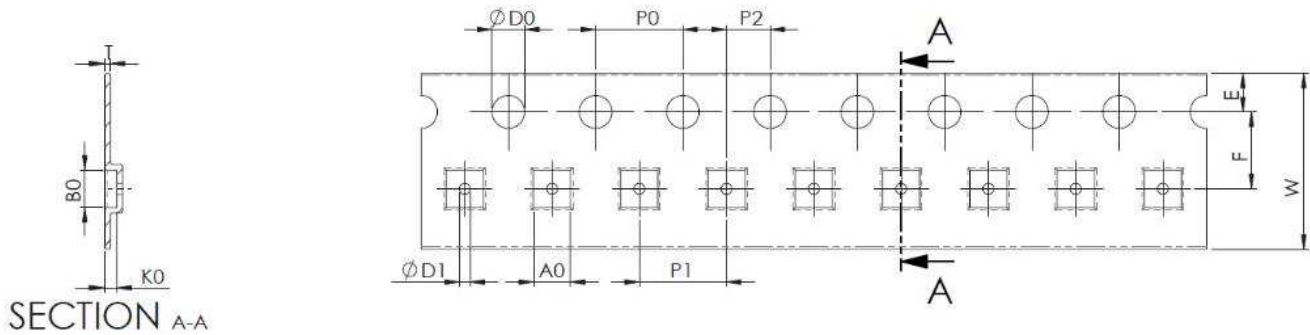
A1	179.00 +/- 0.5mm
B	1.5 min.
N	55.00 +/- 0.5mm
S0	20.20 min.
S1	13.00 mm
T0	1.80 mm
T1	1.80 mm
W1	8.40 mm



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## Dimension of Tape



**8L TDFN 2.5x2.5**

A0	2.75 +/- 0.10 mm
B0	2.75 +/- 0.10 mm
D0	1.55 +/- 0.05 mm
D1	1.00 min.
E	1.75 +/- 0.10 mm
F	3.50 +/- 0.05 mm
K0	1.00 +/- 0.10 mm
P0	4.00 +/- 0.10 mm
P1	4.00 +/- 0.10 mm
P2	2.00 +/- 0.50 mm
T	0.25 +/- 0.05 mm
W	8.00 +/- 0.30 mm

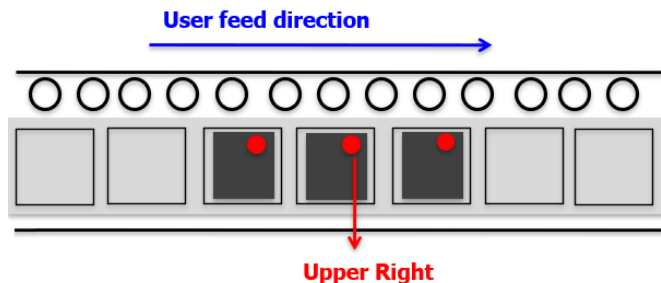
**6L XDFN 1.5x1.5**

A0	1.70 +/- 0.10 mm
B0	1.70 +/- 0.10 mm
D0	1.55 +/- 0.05 mm
D1	0.50 min.
E	1.75 +/- 0.10 mm
F	3.50 +/- 0.05 mm
K0	0.56 +/- 0.10 mm
P0	4.00 +/- 0.10 mm
P1	4.00 +/- 0.10 mm
P2	2.00 +/- 0.50 mm
T	0.25 +/- 0.05 mm
W	8.00 +/- 0.30 mm

## Orientation of Sensors inside Tape

8L TDFN 2.5x2.5,

6L XDFN 1.5x1.5



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### Order Information

Further customer specific adaptations are available on request. Please refer to the table below for part name, description and order information.

Part Number	Part Description	Comment
20011957-00	TSYS03 TEMP SENSOR TDFN8 2.5X2.5MM I2C	Digital Temperature Sensor, TDFN8, I2C Interface, one or multiple reels
20011957-01	TSYS03 TEMP SENSOR XDFN6 1.5X1.5MM I2C	Digital Temperature Sensor, XDFN6, I2C Interface, one or multiple reels

### EMC

Due to the use of these modules for OEM application no CE declaration is done. Especially line coupled disturbances like surge, burst, HF etc. cannot be removed by the module due to the small board area and low-price feature. There is no protection circuit against reverse polarity or over voltage implemented. The module will be designed using capacitors for blocking and ground plane areas in order to prevent wireless coupled disturbances as good

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