



TSYS02D-FAMILY

Digital Temperature Sensors

Product Description

The TSYS02* is a single device, temperature sensor. It provides factory-calibrated data corresponding to the measured temperature. The data is provided via I²C interface.

The temperature range is -40°C ... +125°C while the resolution is 0.01°C. The TSYS02 can be interfaced to any microcontroller by an I²C interface.

The TDFN8 package provides smallest size and very fast time response.

Features

- High Accuracy
 - TSYS02D: $\pm 0.2^{\circ}\text{C}$ @ Temp.: -5°C ... +50°C
 - TSYS02-04D: $\pm 0.4^{\circ}\text{C}$ @ Temp.: -5°C ... +50°C
 - TSYS02-08D: $\pm 0.8^{\circ}\text{C}$ @ Temp.: -5°C ... +50°C
 - TSYS02-12D: $\pm 1.2^{\circ}\text{C}$ @ Temp.: -5°C ... +50°C
 - TSYS02-05-1D $\pm 0.5^{\circ}\text{C}$ @ Temp.: 0°C ... +60°C
- Adjustment of high accuracy temperature range on request
- Low Supply Current < 420µA (standby < 0.14µA)
- I²C Interface up to 400kHz
- Small IC-Package TDFN8 2.5mm x 2.5mm
- Operating Temperature Range: -40°C ... +125°C

Applications

- Industrial Control
- Replacement of Precision RTDs, Thermistors and NTCs
- Heating / Cooling Systems
- HVAC

*Temperature System Sensor

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 | --- | +3.6 | 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 | -2 | --- | +2 | kV |
| Humidity | Hum | --- | Non condensing | | | --- |

Operating Conditions

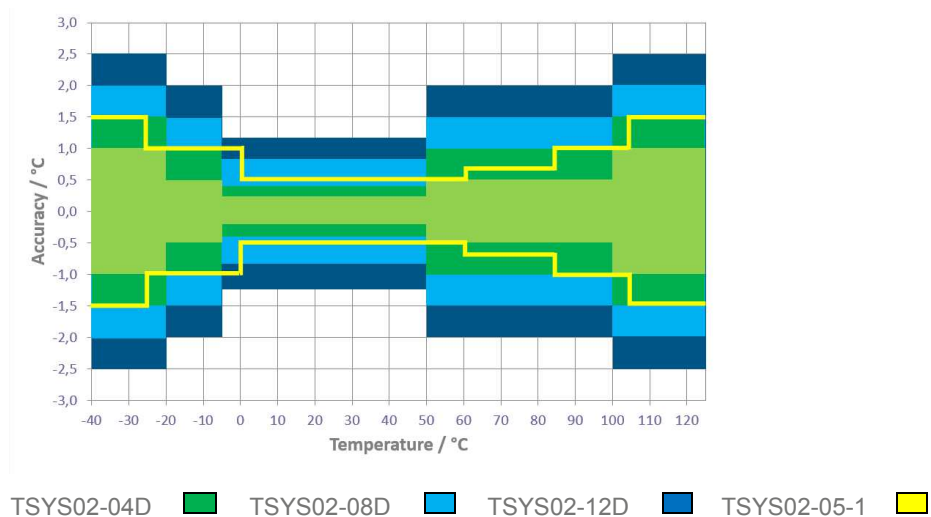
| Parameter | Symbol | Condition | Min | Typ | Max | Unit |
|--------------------------|------------|--|-----|--------------|--------------|----------|
| Operating Supply Voltage | V_{DD} | stabilized | 1.5 | --- | 3.6 | V |
| Supply Current | I_{DD} | 1 sample per second | --- | 18 | --- | μA |
| Standby current | I_S | No conversion, $V_{DD} = 3V$ $T = +25^{\circ}C$ $T = +85^{\circ}C$ | --- | 0.02 0.70 | 0.14 1.40 | μA μA |
| Peak Supply Current | I_{DD} | During conversion | --- | 420 | --- | μA |
| Conversion time | T_{CONV} | --- | --- | 43 | --- | ms |
| Serial Data Clock I2C | F_{SCL} | --- | --- | --- | 400 | kHz |
| 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} | -5°C < T < +50°C V _{DD} = 3.2V – 3.4V | TSYS02D | -0.2 | --- | +0.2 | |
| | | | TSYS02-04D | -0.4 | --- | +0.4 | |
| | | | TSYS02-08D | -0.8 | --- | +0.8 | |
| | | | TSYS02-12D | -1.2 | --- | +1.2 | |
| | | 0°C < T < +60°C V _{DD} = 3.2V – 3.4V | TSYS02-05-1D | -0.5 | --- | +0.5 | |
| Accuracy 2 | T _{ACC2} | -20°C < T < +100°C V _{DD} = 3.2V – 3.4V | TSYS02D | -0.5 | --- | +0.5 | |
| | | | TSYS02-04D | -1.0 | --- | +1.0 | |
| | | | TSYS02-08D | -1.5 | --- | +1.5 | |
| | | | TSYS02-12D | -2.0 | --- | +2.0 | |
| | | 60°C < T < +85°C V _{DD} = 3.2V – 3.4V | TSYS02-05-1D | -0.7 | --- | +0.7 | |
| Accuracy 3 | T _{ACC3} | -40°C < T < +125°C V _{DD} = 3.2V – 3.4V | TSYS02D | -1.0 | --- | +1.0 | |
| | | | TSYS02-04D | -1.5 | --- | +1.5 | |
| | | | TSYS02-08D | -2.0 | --- | +2.0 | |
| | | | TSYS02-12D | -2.5 | --- | +2.5 | |
| | | -25°C < T < +105°C V _{DD} = 3.2V – 3.4V | TSYS02-05-1D | -1.0 | --- | +1.0 | |
| Accuracy 4 | T _{ACC4} | -40°C < T < +125°C V _{DD} = 3.2V – 3.4V | TSYS02-05-1D | -1.5 | --- | +1.5 | |
| PSRR | --- | V _{DD} = 2.7 – 3.6, T = 25°C, C = 100nF | | --- | --- | 0.1 | |
| Self Heating | SH | 10 samples/s, 60s, still air | | --- | --- | 0.1 | |

Accuracy



Analogue to Digital Converter

| Parameter | Symbol | Condition | Min | Typ | Max | Unit |
|-----------------|--------|-----------|-----|-----|-----|------|
| Resolution | --- | --- | 16 | | | bit |
| Conversion Time | t_c | --- | --- | 43 | --- | ms |

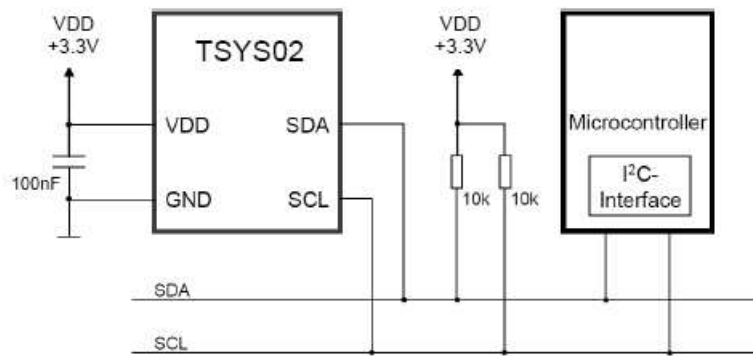
Digital Inputs (SCLK, SDA)

| Parameter | Symbol | Condition | Min | Typ | Max | Unit |
|-----------------------|----------------------------------|--------------------------------------|--------------------|--------------|--------------------|---------|
| Input High Voltage | V_{IH} | $V_{DD} = 1.5 \dots 3.6V$ | $0.7 \cdot V_{DD}$ | --- | V_{DD} | V |
| Input Low Voltage | V_{IL} | $V_{DD} = 1.5 \dots 3.6V$ | $0.0 \cdot V_{DD}$ | --- | $0.3 \cdot V_{DD}$ | 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 | μA |
| Input Capacitance | C_{IN} | --- | --- | --- | 6 | pF |

Digital Outputs (SDA)

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

Connection Diagram



Pin Function Table

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

I²C Interface

An I²C 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.

I²C Address

The I²C address is 0b1000000x.

Commands

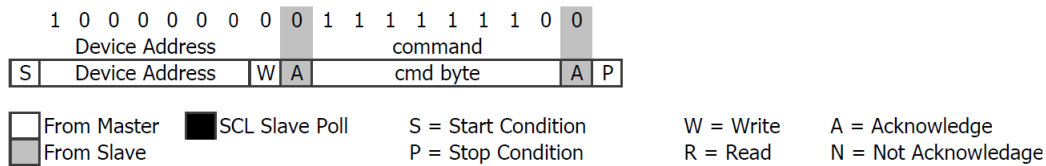
There are four commands:

- Reset
- Read PROM (serial number)
- Read ADC16 Temperature Data (with SCL hold)
- Read ADC16 Temperature Data (without SCL hold)

| Command | Hex |
|--|------|
| Reset | 0xFE |
| Read ADC16 Temperature Data (with SCL hold) | 0xE3 |
| Read ADC16 Temperature Data (without SCL hold) | 0xF3 |

Reset Sequence

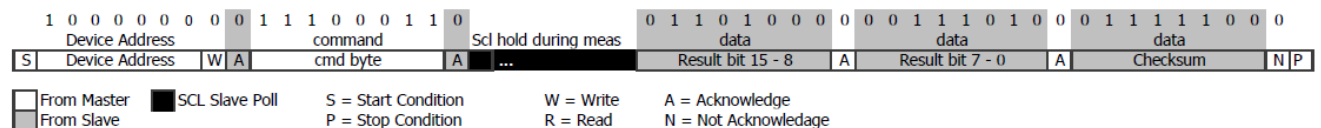
The reset of TSYS02 can be sent at any time. When SDA line is blocked by an undefined state the only way to get the TSYS02 to work is to send a power on reset or several SCL cycles. This is not needed when the last command was not a conversion.



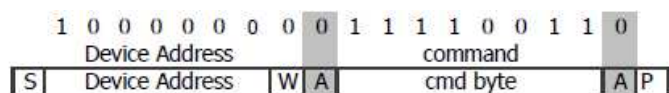
Conversion and ADC read

A conversion can be started by sending this command to TSYS02. When the command is sent to the sensor it stays busy until conversion is done. All other commands except the reset command will not be executed during this time. When conversion is finished the data can be accessed by sending a Read command. If an acknowledge appears from the TSYS02, you may then send 24 SCLK cycles to get all result bits. Every 9th bit the system waits for acknowledge. If the acknowledge is not sent the data clocking out of the chip stops. Two types of conversion commands for temperature reading are possible. If the “hold” command is issued, the SCL is held low during conversion, indicating when the conversion is finished. If the “no hold” is issued, the SCL line is not controlled by the TSYS02.

With Hold

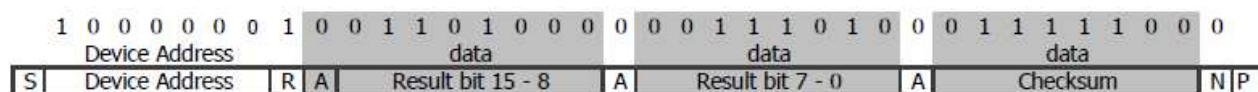


Without Hold



From Master
 SCL Slave Poll
 S = Start Condition W = Write A = Acknowledge
 From Slave P = Stop Condition R = Read N = Not Acknowledge

Poll if the conversion is finished by sending the address and check for acknowledge



From Master
 SCL Slave Poll
 S = Start Condition W = Write A = Acknowledge
 From Slave P = Stop Condition R = Read N = Not Acknowledge

Checksum

The TSY02 provides a CRC-8 checksum for error detection. The polynomial used is $x^8 + x^5 + x^4 + 1$.

Basic Considerations

CRC stands for Cyclic Redundancy Check. It is one of the most effective error detection schemes and requires a minimal amount of resources.

The types of errors that are detectable with CRC implemented in TSY02 are:

- Any odd number of errors anywhere within the data transmission
- All double-bit errors anywhere within the transmission
- Any cluster of errors that can be contained within an 8-bit window (1-8 bits incorrect)
- Most larger clusters of errors

A CRC is an error-detecting code commonly used in digital networks and storage devices to detect accidental changes to raw data.

The TSY02 uses an 8-bit CRC to detect transmission errors. The CRC covers all read data transmitted by the sensor. CRC properties are listed in the table below.

| | |
|----------------------|-----------------------|
| Generator polynomial | $x^8 + x^5 + x^4 + 1$ |
| Initialization | 0x00 |
| Protected data | Read data |
| Final operation | None |

CRC Calculation

To compute an n-bit binary CRC, line the bits representing the input in a row, and position the (n+1)-bit pattern representing the CRC's divisor (called a "polynomial") underneath the left-hand end of the row.

This is first padded with zeroes corresponding to the bit length n of the CRC.

If the input bit above the leftmost divisor bit is 0, do nothing. If the input bit above the leftmost divisor bit is 1, the divisor is XORed into the input (in other words, the input bit above each 1-bit in the divisor is toggled). The divisor is then shifted one bit to the right, and the process is repeated until the divisor reaches the right-hand end of the input row.

Since the left most divisor bit zeroed every input bit it touched, when this process ends the only bits in the input row that can be nonzero are the n bits at the right-hand end of the row. These n bits are the remainder of the division step, and will also be the value of the CRC function.

The validity of a received message can easily be verified by performing the above calculation again, this time with the check value added instead of zeroes. The remainder should equal zero if there are no detectable errors.

CRC Examples

The input message 01101000 00111010 (0x683A: 24.69°C) will have as result 01111100 (0x7C)

Temperature Calculation

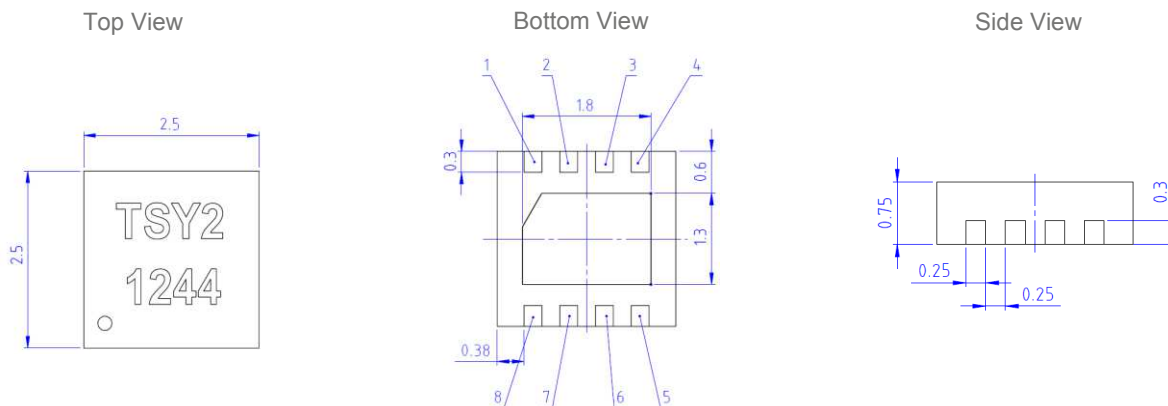
TEMPERATURE POLYNOMIAL

ADC16: ADC Result 16 bits
 $T / ^\circ\text{C} = \text{ADC16} / 2^{16} \times 175.72 - 46.85$

EXAMPLE

ADC16: 26682 (0x683A)
 $T / ^\circ\text{C} = 26682 / 2^{16} \times 175.72 - 46.85$
 $T / ^\circ\text{C} = 24.69^\circ\text{C}$

Dimensions



All dimensions are in mm, tolerances according ISO 2768-m

TSYS02-FAMILY

Digital Temperature Sensors

Marking

| Line | Description | Text |
|------|---------------------------|------|
| 1 | Product Name | TSY2 |
| 2 | Pin 1 Dot, Date Code YYWW | 1244 |

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 Name | Part Description | Comment |
|-------------|--------------|------------------------------------|--|
| G-NIMO-003 | TSYS02D | 0.2 DEG C ACCURACY I2C TEMP SENSOR | Digital Temperature Sensor, Acc. +/-0.2°C TDFN8, I2C Interface |
| 10208995-00 | TSYS02-04D | 0.4 DEG C ACCURACY I2C TEMP SENSOR | Digital Temperature Sensor, Acc. +/-0.4°C TDFN8, I2C Interface |
| 10207298-00 | TSYS02-08D | 0.8 DEG C ACCURACY I2C TEMP SENSOR | Digital Temperature Sensor, Acc. +/-0.8°C TDFN8, I2C Interface |
| 10208996-00 | TSYS02-12D | 1.2 DEG C ACCURACY I2C TEMP SENSOR | Digital Temperature Sensor, Acc. +/-1.2°C TDFN8, I2C Interface |
| 10212113-00 | TSYS02-05-1D | 0.5 DEG C ACCURACY I2C TEMP SENSOR | Digital Temperature Sensor, Acc. +/-0.5°C TDFN8, I2C Interface |

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 as possible.

NORTH AMERICA

Tel: +1 800 522 6752
customercare.ando@te.com

EUROPE

Tel: +31 73 624 6999
customercare.dlmd@te.com

ASIA

Tel: +86 0400 820 6015
customercare.chdu@te.com

te.com/sensorsolutions

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