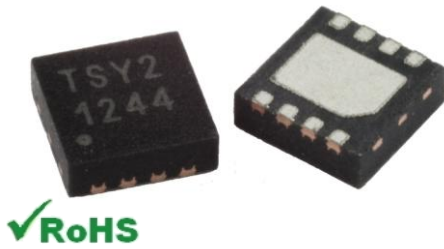


# TSYS02D Digital Temperature Sensor



- High Accuracy Temperature Sensor
- 16 bit Resolution
- High Speed, low Response Time
- Low Power Consumption
- I<sup>2</sup>C Interface
- Small TDFN8 Package

## DESCRIPTION

The TSYS02D is a single chip, temperature sensor.

It provides factory calibrated data corresponding to the measured temperature.

The data is provided via **I<sup>2</sup>C interface**.

The temperature range is -40°C ... +125°C while the resolution is 0.01°C.

The TSYS02D can be interfaced to any microcontroller by an I<sup>2</sup>C interface.

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

## FEATURES

High Accuracy  $\pm 0.2^{\circ}\text{C}$  @ Temp.:  $-5^{\circ}\text{C}$  ...  $+50^{\circ}\text{C}$   
 Adjustment of high accuracy temperature range on request  
 Low Supply Current  $< 420\mu\text{A}$  (standby  $< 0.14\mu\text{A}$ )  
 I<sup>2</sup>C Interface up to 400kHz  
 Small IC-Package TDFN8 2.5mm x 2.5mm  
 Operating Temperature Range:  $-40^{\circ}\text{C}$  ...  $+125^{\circ}\text{C}$

## APPLICATIONS

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

# TSYS02D Digital Temperature 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 | Conditions   | Min            | Typ | Max  | Unit |
|-----------------------|--------|--|----------------|-----|------|------|
| Supply Voltage        | VDD    |  | -0.3           |     | +3.6 | V    |
| Operating Temperature | Top    |  | -40            |     | +125 | °C   |
| Storage temperature   | Tstor  |  | -55            |     | +150 | °C   |
| ESD rating            | ESD    | Human Body Model (HBM)<br>pin to pin incl. VDD & GND | -2             |     | +2   | kV   |
| Humidity              | Hum    |  | Non condensing |     |      |      |

## OPERATING CONDITIONS

| Parameter                          | Symbol            | Conditions  | Min   | Typ          | Max          | Unit     |
|------------------------------------|-------------------|---|-------|--------------|--------------|----------|
| Operating Supply Voltage           | V <sub>DD</sub>   | stabilized  | 1.5   |              | 3.6          | V        |
| Supply Current                     | I <sub>DD</sub>   | 1 sample per second   |       | 18           |              | μA       |
| Standby current                    | I <sub>S</sub>    | No conversion, V <sub>DD</sub> = 3V<br>T = 25°C<br>T = 85°C |       | 0.02<br>0.70 | 0.14<br>1.40 | μA<br>μA |
| Peak Supply Current                | I <sub>DD</sub>   | During conversion   |       | 420          |              | μA       |
| Conversion time                    | T <sub>CONV</sub> |   |       | 43           |              | ms       |
| Serial Data Clock I <sup>2</sup> C | F <sub>SCL</sub>  |   |       |              | 400          | kHz      |
| VDD Capacitor                      |                   | Place close to the chip                                     | 100nF |              |              |          |

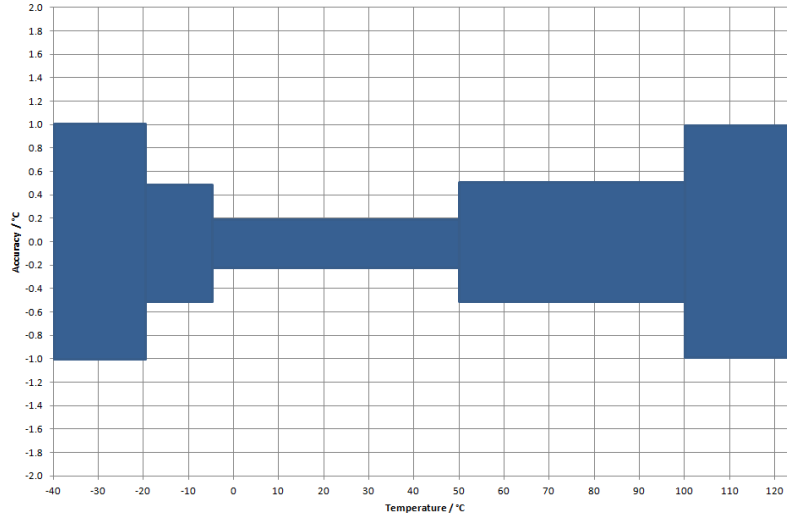
## OPERATIONAL CHARACTERISTICS

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

| Parameter                         | Symbol            | Conditions  | Min  | Typ | Max  | Unit |
|-----------------------------------|-------------------|---|------|-----|------|------|
| Temp. Measurement Range           | T <sub>RANG</sub> |   | -40  |     | 125  | °C   |
| Accuracy 1                        | T <sub>ACC1</sub> | -5°C < T < +50°C<br>V <sub>DD</sub> = 3.2V – 3.4V   | -0.2 |     | +0.2 | °C   |
| Accuracy 2                        | T <sub>ACC2</sub> | -20°C < T < +100°C<br>V <sub>DD</sub> = 3.2V – 3.4V | -0.5 |     | +0.5 | °C   |
| Accuracy 3                        | T <sub>ACC2</sub> | -40°C < T < +125°C<br>V <sub>DD</sub> = 3.2V – 3.4V | -1.0 |     | +1.0 | °C   |
| PSRR<br>Power Supply Reject Ratio |                   | V <sub>DD</sub> = 2.7 – 3.6<br>T = 25°C, C = 100nF  |      |     | 0.1  | °C   |
| Temperature Resolution            | T <sub>RES</sub>  |   |      |     | 0.01 | °C   |
| Self Heating                      | SH <sub>1</sub>   | 10 samples/s, 60s, still air                        |      |     | 0.1  | °C   |

# TSYS02D Digital Temperature Sensor

## ACCURACY



## ANALOGUE TO DIGITAL CONVERTER

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

## DIGITAL INPUTS (SCLK, SDA)

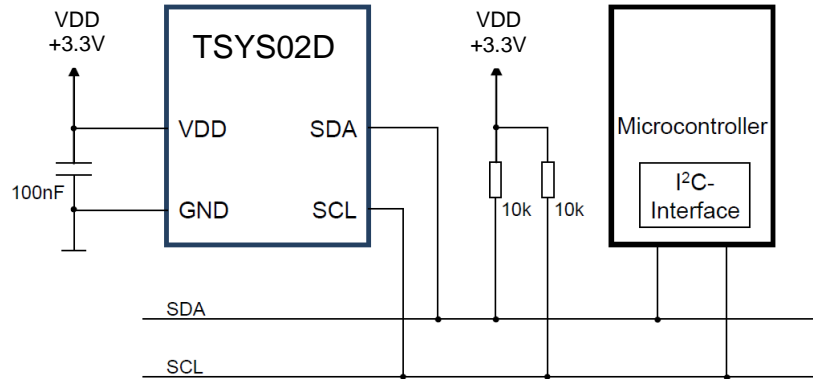
| Parameter             | Symbol                           | Conditions                             | Min          | Typ          | Max          | Unit    |
|-----------------------|----------------------------------|--|--------------|--------------|--------------|---------|
| Input High Voltage    | $V_{IH}$                         | $V_{DD} = 1.5...3.6V$                  | $0.7 V_{DD}$ |              | $V_{DD}$     | V       |
| Input Low Voltage     | $V_{IL}$                         | $V_{DD} = 1.5...3.6V$                  | $0.0 V_{DD}$ |              | $0.3 V_{DD}$ | V       |
| Input leakage Current | $I_{leak\_25}$<br>$I_{leak\_85}$ | $T = 25^{\circ}C$<br>$T = 85^{\circ}C$ |              | 0.01<br>0.25 | 0.14<br>1.40 | $\mu A$ |
| Input Capacitance     | $C_{IN}$                         |  |              |              | 6            | pF      |

## DIGITAL OUTPUTS (SDA)

| Parameter           | Symbol   | Conditions         | 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    |

# TSYS02D Digital Temperature Sensor

## CONNECTION DIAGRAM



## PIN FUNCTION TABLE

| Pin   | Name | Type                 | Function                             |
|-------|------|----------------------|--------------------------------------|
| 1     | VDD  | 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       |

## INTERFACE DESCRIPTION

### 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 I<sup>2</sup>C address is 0b1000000x.

### COMMANDS

There are four commands:

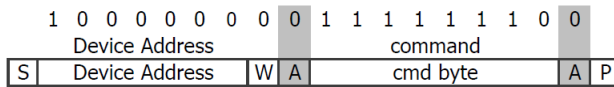
- Reset
- Read PROM (serial number)
- Read ADC16 Temperature Data (with SCL hold)
- Read ADC16 Temperature Data (without SCL hold)

| Command  | Hex Value |
|--|-----------|
| Reset  | 0x7E      |
| Read ADC16 Temperature Data (with SCL hold)    | 0x E3     |
| Read ADC16 Temperature Data (without SCL hold) | 0x F3     |
| Read first 8 bytes of Serial Number            | 0x FA0F   |
| Read last 6 bytes of Serial Number             | 0x FCC9   |

# TSYS02D Digital Temperature Sensor

## RESET SEQUENCE

The reset of TSYS02D can be sent at any time. When SDA line is blocked by an undefined state the only way to get the TSYS02D 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.

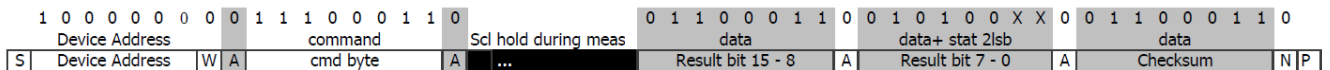


From Master     SCL Slave Poll    S = Start Condition    W = Write    A = Acknowledge  
 From Slave    P = Stop Condition    R = Read    N = Not Acknowledge

## CONVERSION AND ADC READ

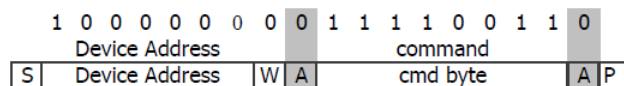
A conversion can be started by sending this command to TSYS02D. When the command is sent to the sensor it stays busy until conversion is done. All other commands except the reset command will not be executed during this time. When conversion is finished the data can be accessed by sending a Read command. If an acknowledge appears from the TSYS02D, you may then send 24 SCLK cycles to get all result bits. Every 9<sup>th</sup> 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 TSYS02D.

### WITH HOLD



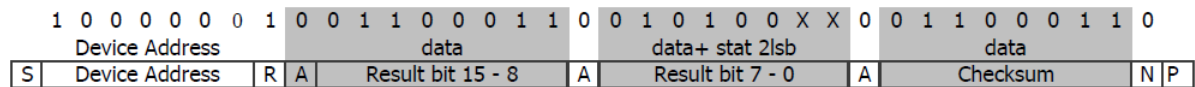
From Master     SCL Slave Poll    S = Start Condition    W = Write    A = Acknowledge  
 From Slave    P = Stop Condition    R = Read    N = Not Acknowledge

### WITHOUT HOLD



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

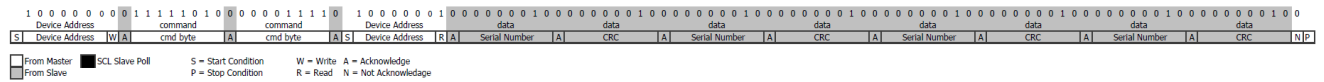
Poll if the conversion is finished by sending the address and check for acknowledge



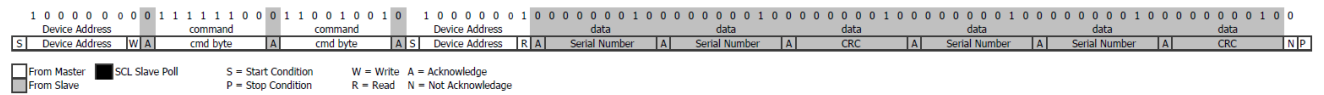
From Master     SCL Slave Poll    S = Start Condition    W = Write    A = Acknowledge  
 From Slave    P = Stop Condition    R = Read    N = Not Acknowledge

# TSYS02D Digital Temperature Sensor

## READ SERIAL NUMBER FIRST 8 BYTES



## READ SERIAL NUMBER LAST 6 BYTES



## TEMPERATURE CALCULATION

### TEMPERATURE POLYNOMIAL

ADC16: ADC Result 16 bits

$$T / ^\circ C = ADC16 / 2^{16} \times 175.72 - 46.85$$

### EXAMPLE

ADC16: 36636

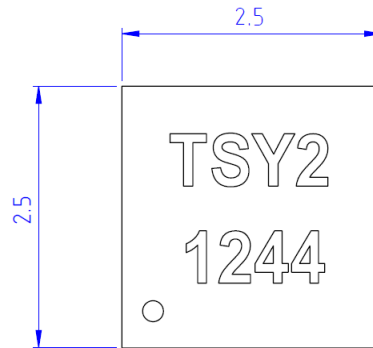
$$T / ^\circ C = 36636 / 2^{16} \times 175.72 - 46.85$$

T / °C = 51.38°C

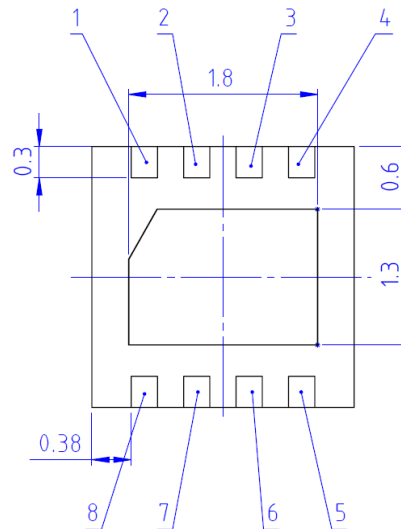
# TSYS02D Digital Temperature Sensor

## DIMENSIONS

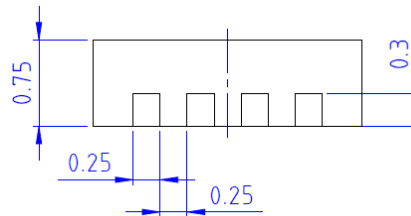
### TOP VIEW



### BOTTOM VIEW



### SIDE VIEW



## MARKING

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

# TSYS02D Digital Temperature Sensor

## ORDER INFORMATION

The TSYS02 temperature sensor family comprises currently three different solutions. Further customer specific adaptations are available on request. Please refer to the table below for part name, description and order information.

| Part Name      | Description   | Order Number      |
|----------------|---|-------------------|
| <b>TSYS02D</b> | <b>Digital Temperature Sensor, TDFN8, I2C Interface</b> | <b>G-NIMO-003</b> |
| TSYS02P        | Digital Temperature Sensor, TDFN8, PWM Interface        | G-NIMO-004        |
| TSYS02S        | Digital Temperature Sensor, TDFN8, SDM Interface        | G-NIMO-005        |

## 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.

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