TSYS02D -FAMILY

Digital Temperature Sensors

Product Description

The TSYS02 is a single device Temperature Sensing System (TSYS). It provides factory-calibrated data corresponding to the measured temperature. The data is provided via I^{2}C 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 I^{2}C interface.

The TDFN8[1] package provides smallest size and very fast time response.

Features

- High Accuracy
  - TSYS02D: ±0.2°C @ Temp.: -5°C … +50°C
  - TSYS02-04D: ±0.4°C @ Temp.: -5°C … +50°C
  - TSYS02-08D: ±0.8°C @ Temp.: -5°C … +50°C
  - TSYS02-12D: ±1.2°C @ Temp.: -5°C … +50°C
- Adjustment of high accuracy temperature range on request
- Low Supply Current < 420µA (standby < 0.14µA)
- I^{2}C 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

[1] Thin Dual Flat No-Lead

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

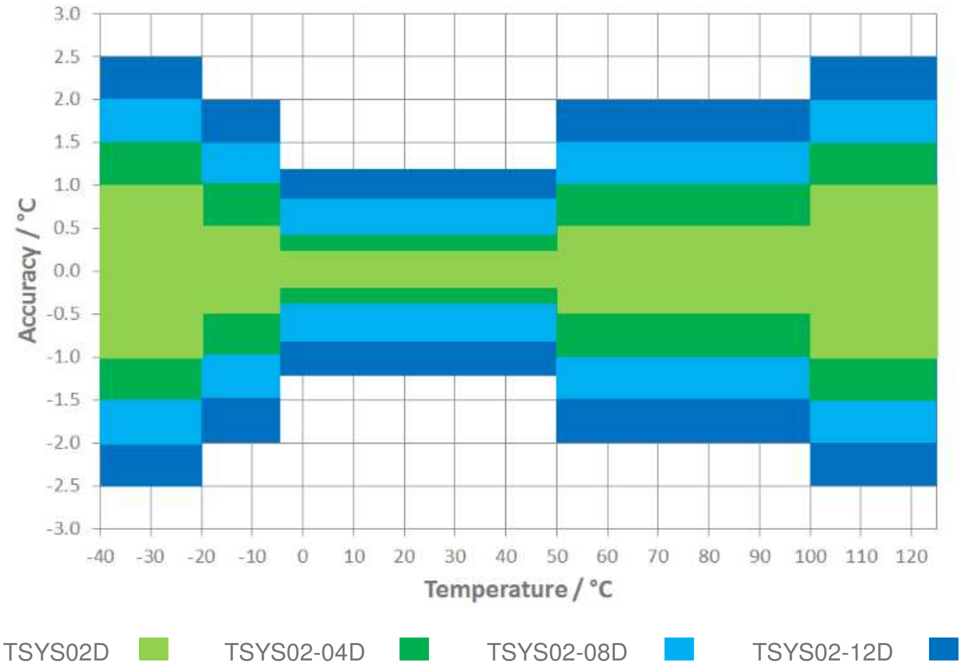
Parameter	Symbol	Condition	Min	Typ	Max	Unit
Operating Supply Voltage	V_{DD}	stabilized	1.5	---	3.6	V
Supply Current	I_{DD}	1 sample per second	---	18	---	µA
Standby current	I_S	No conversion, V_{DD} = 3V T = +25°C T = +85°C	---	 0.02 0.70	 0.14 1.40	 µA µA
Peak Supply Current	I_{DD}	During conversion	---	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	°C
			TSYS02-04D	-0.4	---	+0.4	
			TSYS02-08D	-0.8	---	+0.8	
			TSYS02-12D	-1.2	---	+1.2	
Accuracy 2	T_{ACC2}	-20°C < T < +100°C V_{DD} = 3.2V – 3.4V	TSYS02D	-0.5	---	+0.5	°C
			TSYS02-04D	-1.0	---	+1.0	
			TSYS02-08D	-1.5	---	+1.5	
			TSYS02-12D	-2.0	---	+2.0	
Accuracy 3	T_{ACC3}	-40°C < T < +125°C V_{DD} = 3.2V – 3.4V	TSYS02D	-1.0	---	+1.0	°C
			TSYS02-04D	-1.5	---	+1.5	
			TSYS02-08D	-2.0	---	+2.0	
			TSYS02-12D	-2.5	---	+2.5	
PSRR	---	V_{DD} = 2.7 – 3.6, T = 25°C, C = 100nF		---	---	0.1	°C
Self Heating	SH	10 samples/s, 60s, still air		---	---	0.1	°C

Accuracy



Analogue to Digital Converter

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

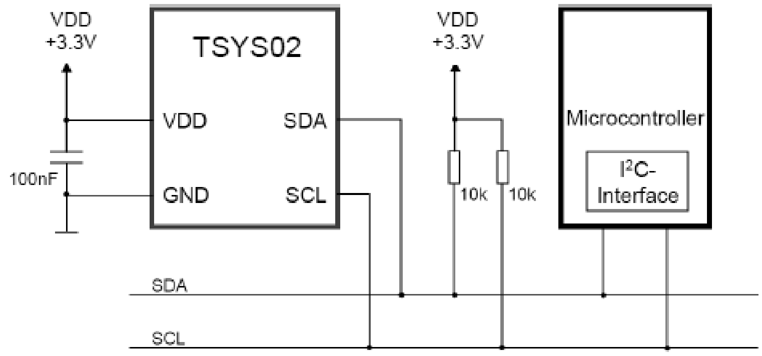
Digital Inputs (SCLK, SDA)

Parameter	Symbol	Condition	Min	Typ	Max	Unit
Input High Voltage	V_{IH}	V_{DD} = 1.5…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} I_{leak_85}	T = 25°C T = 85°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•V_{DD}	---	V_{DD}	V
Output Low Voltage	V_{OL}	I_{Sink} = 1mA	0.0•V_{DD}	---	0.2•V_{DD}	V

Connection Diagram



Pin Function Table

Pin	Name	Type	Function
1	V_{DD}	Power	Supply Voltage
2	SCL[2]	Digital Input	I²C: Serial Data Clock
3	SDA[3]	Digital Input / Output	I²C 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.

[2] Serial Clock Line
[3] Serial Data Line

Commands

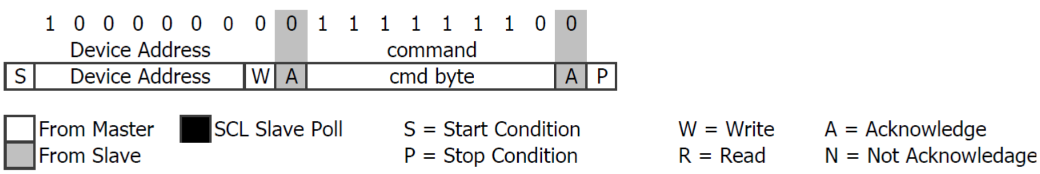
There are four commands:

- Reset
- Read PROM (serial number)
- Read ADC[4]16 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

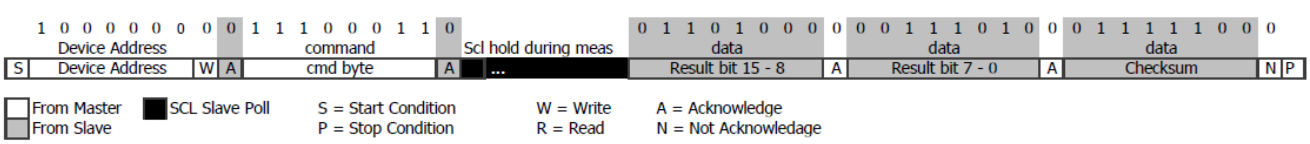
The reset of TSYS02 can be sent at any time. When SDA line is blocked by an undefined state the only way to get the TSYS02 to work is to send a power on reset or several SCL cycles. This is not needed when the last command was not a conversion.



Conversion and ADC read

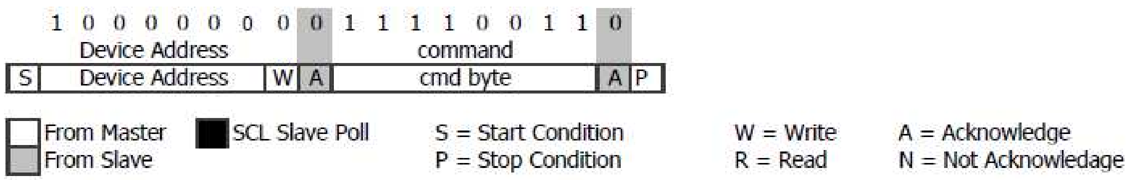
A conversion can be started by sending this command to TSYS02. When the command is sent to the sensor it stays busy until conversion is done. All other commands except the reset command will not be executed during this time. When conversion is finished the data can be accessed by sending a Read command. 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

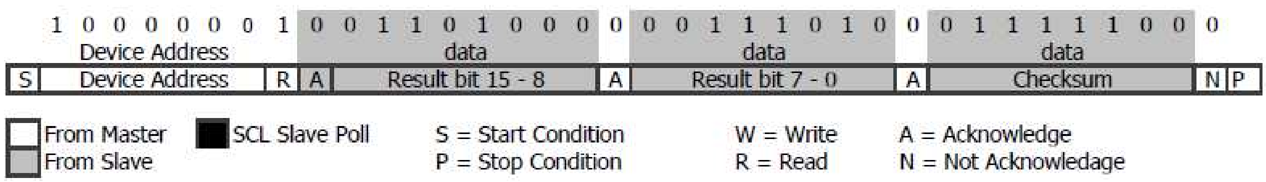


[4] Analog tot Digital Conversion

Without Hold



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



Checksum

The TSYS02 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 TSYS02 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 TSYS02 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 Calcualtion

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 POLYNOMAL

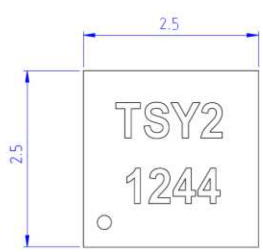
ADC16:	ADC Result 16 bits
T / °C =	ADC16 / 2^{16} x 175.72 – 46.85

EXAMPLE

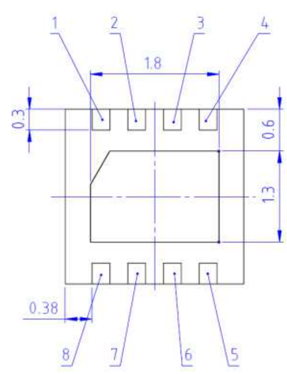
ADC16:	26682 (0x683A)
T / °C =	26682 / 2^{16} x 175.72 – 46.85
T / °C =	24.69°C

Dimensions

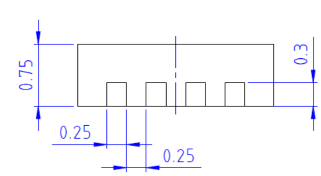
Top View



Bottom View



Side View



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 Desription	Comment
G-NIMO-003	TSYS02D	Digital Temperature Sensor, TDFN8, I2C Interface
G-NIMO-014	TSYS02-04D	Digital Temperature Sensor, TDFN8, I2C Interface
G-NIMO-012	TSYS02-08D	Digital Temperature Sensor, TDFN8, I2C Interface
G-NIMO-015	TSYS02-12D	Digital Temperature Sensor, 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.

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