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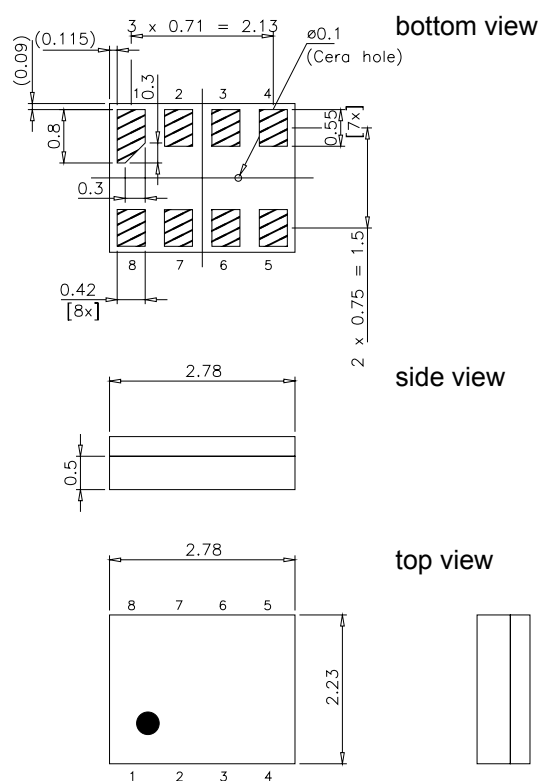
Digital barometric pressure sensor
Preliminary data

Applications

- Barometers / weather forecast
- Altimeters
- GPS receivers
- Mobile phones
- Hard disk drives
- Sensor nodes
- Variometers / vertical velocity indication


Features

- **Surface Mounted Technology (SMT)**
- Pressure range from 300 hPa to 1100 hPa
- Supply voltage of 1.7 V to 3.6 V
- Low current consumption
- Very small size of 2.78 mm × 2.23 mm
- Very low height of typically 0.67 mm
- Pressure inlet port on the bottom side
- Operating temperature range of –30 °C to +85 °C
- High power supply rejection
- I²C and SPI interface
- 16 bit ADC
- Internal oscillator
- RoHS compatible


Pin configuration

Pin	Name	I/O	Function in I ² C mode	Function in SPI mode
1	VDD	Supply	Supply voltage	Supply voltage
2	SEL	I	Interface protocol selection	Interface protocol selection
3	GND	Supply	Ground supply	Ground supply
4	EOC	O	End of conversion	End of conversion
5	RST&SS	I	Reset	Slave select
6	MISO	O	High impedance	Master In Slave Out (MISO)
7	SDA/MOSI	I/O	I ² C data signal	Master Out Slave In (MOSI)
8	SCL/SCLK	I	I ² C clock signal	SPI clock signal

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General description

The T5400 is a fully calibrated digital pressure sensor. Based on the proven EPCOS piezoresistive MEMS technology the sensor module provides high accuracy and long-term stability. The very small size of only 2.78 mm × 2.23 mm and the low current consumption allows the integration into a multitude of mobile and stationary applications like personal navigation devices, mobile phones, altimeters and hard disk drives. Two high speed serial interfaces, I²C (3.4 MHz) and SPI (20 MHz), offer a high flexibility to connect the T5400 to almost every microcontroller platform.

After initialisation calibration coefficients need to be transferred from the sensor memory to the microcontroller. Afterwards the sensor transmits the raw pressure and temperature readings on request. The user can select between four different operating modes from 5.1 Pa (0.42 m) to 2.7 Pa (0.22 m) RMS noise. The calculation of the actual pressure and altitude is done by the microcontroller.

Electrical characteristics

Temperature range for specification
unless otherwise noted:

$$T = -30\text{ °C} \dots +85\text{ °C}$$

Ambient temperature of test conditions:

$$T_A = 25\text{ °C}$$

Supply voltage:

$$V_{DD} = 1.8\text{ V}$$

All voltages refer to ground.

		Min.	Typ.	Max.	Unit	Note or condition
Current consumption¹⁾	I_{IDLE}	—	0.15	0.3	µA	−30 °C ... 25 °C
		—	1	—	µA	25 °C ... 70 °C
		—	3	—	µA	70 °C ... 85 °C
	I_{PEAK_P}	—	790	—	µA	during pressure measurement ²⁾
	I_{PEAK_T}	—	500	—	µA	during temperature measurement ²⁾
Pressure range	p	300	—	1100	hPa	
Resolution pressure reading		—	2.9	—	Pa	
Absolute accuracy pressure sensor³⁾	Δp	−3	−1	+2	hPa	$p = 300\text{ hPa} \dots 1100\text{ hPa}$ $T = 0\text{ °C} \dots 65\text{ °C}$
		−3	0	+5	hPa	$p = 300\text{ hPa} \dots 1100\text{ hPa}$ $T = -20\text{ °C} \dots 0\text{ °C}$
Relative accuracy pressure sensor³⁾	Δp	—	± 0.15	—	hPa	$p = 950\text{ hPa} \dots 1050\text{ hPa}$ $T = 25\text{ °C}$
		—	± 0.14	—	hPa	$T = 25\text{ °C} \dots 40\text{ °C}$ $p_{const} = 500\text{ hPa} \dots 1100\text{ hPa}^{4)}$

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	Min.	Typ.	Max.	Unit	Note or condition
Resolution temperature reading	—	0.01	—	K	
Absolute accuracy temperature sensor³⁾ ΔT	-1.5	± 0.5	+1.5	K	T = 25°C
	-2	± 1	+2	K	T = 0°C ... 70 °C
Solder drift³⁾	-1	—	+3	hPa	after one week

¹⁾ Ensured by design.

²⁾ Without interface activity.

³⁾ Specified during qualification. Given values are $\pm 3\sigma$ values for new parts; solder drift is shown separately.

⁴⁾ Relative accuracy over temperature at constant pressure in the range of 500 hPa ... 1100 hPa

	Min.	Typ.	Max.	Unit	Note or condition
Power supply rejection¹⁾	—	1.4	—	hPa	Normal operation $V_{DD} = 1.7 \text{ V} \dots 3.6 \text{ V}$
	—	8.7	—	Pa	100 mV _{P-P} , 217 Hz square wave plus 100 mV random noise in 10 MHz bandwidth
Start-up time t_S	—	—	10	ms	Delay between power on and first serial communication
Wake-up time t_{WU}	—	2	2.5	ms	Wake up time from idle mode to start of first measurement

¹⁾ Ensured by design.

Operation modes

	typ. RMS noise ¹⁾ (Pa)	typ. RMS noise (m)	Avg. current @ 1SPS ²⁾ (μA)	Typ. Conversion time (ms) ³⁾	Max. Conversion time (ms) ³⁾
Temperature			1.6	1.4	2
Low	5.1	0.42	2.6	1.4	2
Standard	3.5	0.29	7.2	7.3	8
High	3.2	0.27	13.3	15.2	16
Ultra high ⁴⁾	2.7	0.22	51.3	63.8	66

¹⁾ The noise data is derived from the standard deviation of ten successive samples.

²⁾ Samples per second, typical conversion times, including wake-up phase.

³⁾ excluding wake-up time.

⁴⁾ Requires the average of two temperature measurements: one before and one after the pressure measurement.

Absolute maximum ratings

		Min.	Max.	Unit	Note or condition
Operable temperature range	T	−30	+85	°C	
Storage temperature range	T _{STG}	−40	+85	°C	
Storage temperature range	T _{STGT}	0	+60	°C	stored in tape
Operable power supply voltage	V _{DD}	1.7	3.6	V	V _{DD,min} already includes influence of ripples and noise
Power supply voltage	V _{DD}	−0.3	4.25	V	below T = 25 °C the minimum supply voltage is V _{DD} = −0.4 V
Voltage at any digital pad	V _{pad}	V _{SS} −0.3	V _{DD} +0.3	V	The voltage must stay within the above specified V _{DD} range
Overpressure	p _{MAX}		6000	hPa	
ESD voltage	V _{ESD_MM}		200	V	machine model ¹⁾
ESD voltage	V _{ESD_HBM}		2000	V	human body model ²⁾
Latch-up	tested according to JESD78 at V _{DD,max} and T = 25 °C				

¹⁾According to JESD22-A115A.

²⁾According to JESD22-A114E.

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Electrical interface characteristics

		Min.	Typ.	Max.	Unit	Comment
External capacitance between V_{DD} and GND	C_{VDD}	90	—	—	nF	
Capacitances of I/O pins	C_{IO}	—	—	10	pF	
Voltage input low level	V_{IL}	—	0	$0.3 \cdot V_{DD}$	V	
Voltage input high level	V_{IH}	$0.7 \cdot V_{DD}$	V_{DD}	—	V	
Voltage output low level	V_{OL}	—	0	$0.2 \cdot V_{DD}$	V	$I_{OL} = 1\text{mA}$
Voltage output high level	V_{OH}	$0.8 \cdot V_{DD}$	V_{DD}	—	V	$I_{OH} = 1\text{mA}$

The T5400 can be operated either in I²C or SPI slave mode. Depending on the logic level of the SEL pad, the I²C mode (SEL=high) or the SPI mode (SEL=low) is selected.

I²C mode

The I²C interface is compatible to NXP specification UM10204, Rev. 03, June 19, 2007. Standard, fast, fast plus and high-speed modes are supported.

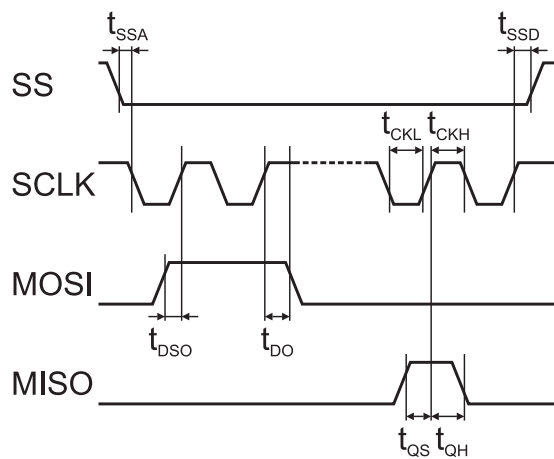
		Min.	Typ.	Max.	Unit	Comment
SCL clock frequency	f_{SCL}	—	—	3.4	MHz	Standard, fast, fast-plus and Hs-mode
Voltage output low level	V_{OL}	—	0	$0.2 \cdot V_{DD}$	V	$I_{OL} = 3\text{mA}$
Pull-up resistor on SDA and SCL	R_{PU}	1	4.7	—	k Ω	
Capacitive load for each bus line		—	—	100	pF	

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SPI mode

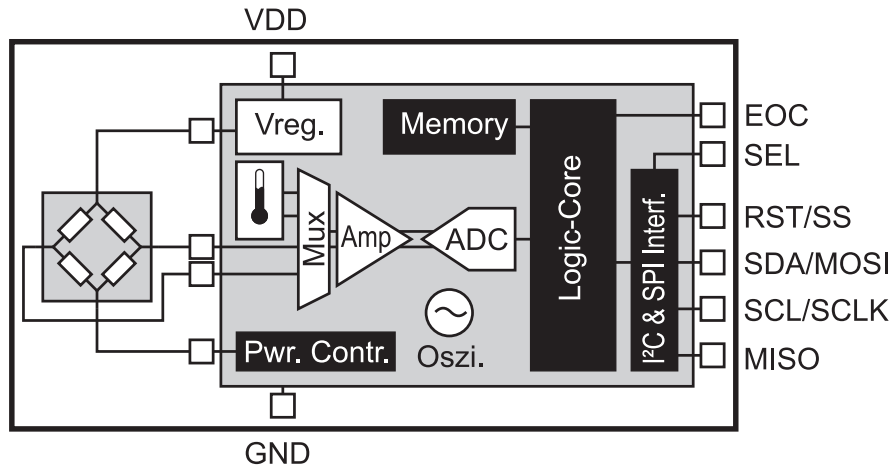
		Min.	Typ.	Max.	Unit
SCLK clock frequency	f_{SCL}	—	—	20	MHz
SS activation time	t_{SSA}	21	—	—	ns
SCLK clock low time	t_{CKL}	21	—	—	ns
SCLK clock high time	t_{CKH}	21	—	—	ns
SS deactivation time	t_{SSD}	21	—	—	ns
MOSI setup time	t_{DSO}	6	—	—	ns
MISO setup time	t_{QS}	10	—	—	ns
MOSI hold time	t_{DO}	6	—	—	ns
MISO hold time	t_{QH}	0	—	—	ns
Maximum capacitive load	C_{MAX}	—	25 ¹⁾	—	pF

¹⁾ Typically at $f_{\text{SCL}} = 20 \text{ MHz}$.


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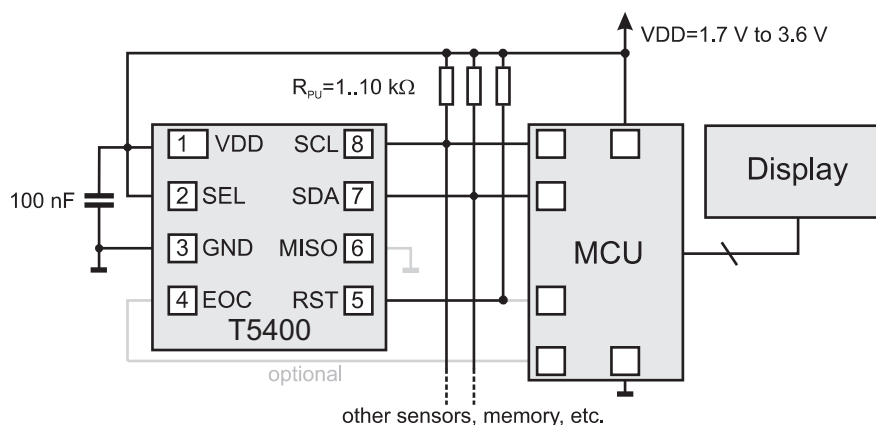
Function

The T5400 is a fully calibrated digital pressure sensor module. It consists of a piezoresistive MEMS pressure sensor element and an ASIC with integrated temperature sensor, analog to digital converter ADC, memory and digital circuitry. The analog bridge voltage of the pressure sensor and the output voltage of the temperature sensor are routed through a multiplexer and a gain stage to the ADC. The logic-core controls the different function blocks.



After initialisation the calibration parameters stored in the memory will be transmitted to the MCU (micro-controller unit). Afterwards only the raw pressure and temperature values are transmitted. After a request from the MCU a pressure or/and a temperature measurement is performed. Depending on the accuracy, time and power consumption requirements one out of four different operation modes can be selected before a measurement is executed.

The end of a measurement is indicated on the EOC (end of conversion) pin. Then the MCU can request the raw measurement values and calculate the actual pressure and temperature values using the calibration data. To optimize power consumption the T5400 enters the idle mode between two measurements. Further details and source code examples are available in an application note.

Typical application


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Assembly conditions

Solder reflow profile	According to EPCOS specification S_6001
Max. number of reflows	3
Max. peak temperature	260 °C
Moisture sensitivity level	MSL 3

Cautions and warnings

- Immersion of the sensor in liquids e.g. a flux cleaning process is not possible.
- For optimum performance avoid direct light exposure.
- Media compatibility with the pressure sensor must be ensured. Do not expose the sensor to corrosive or explosive gases.

Pressure conversion table

Unit	bar	mbar	Pa	hPa	kPa	mmHg	psi
1 bar	1	1000	100000	1000	100	750.063	14.504
1 mbar	0.001	1	100	1	0.1	0.750	0.0145
1 Pa	0.00001	0.01	1	0.01	0.001	0.0075	0.000145
1 hPa	0.001	1	100	1	0.1	0.750	0.0145
1 kPa	0.01	10	1000	10	1	7.5006	0.145
1 mmHg	0.00133	1.3332	133.322	1.3332	0.13332	1	0.01933
1 psi	0.0689476	68.9476	6894.76	68.9476	6.89476	51.7151	1

Annotations

- bar Bar
- Pa Pascal ($\equiv 1 \text{ N/m}^2$)
- hPa Hecto-Pascal ($\equiv 1 \text{ mbar}$)
- mmHg mm column of mercury ($\equiv 1 \text{ Torr}$)
- psi Pounds per square inch ($\equiv 1 \text{ lbf/in}^2$)

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References

Type	T5400
Ordering code	B39000T5400P810
Marking and package	C61157-A13-A1
Packaging	F61074-V8261-Z000
Date codes	L_1126
Soldering profile	S_6001
Qualification test procedure	S_0360
RoHS compatible	RoHS-compatible means that products are compatible with the requirements according to Art. 4 (substance restrictions) of Directive 2011/65/EU of the European Parliament and of the Council of June 8 th , 2011, on the restriction of the use of certain hazardous substances in electrical and electronic equipment ("Directive") with due regard to the application of exemptions as per Annex III of the Directive in certain cases.

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