# SAW Components

## Digital barometric pressure sensor

Miniature sensors

| | |
|---|---|
| **Series/type:** | **T5400** |
| **Ordering code:** | **B39000T5400P810** |
| Date: | April 25, 2013 |
| Version: | 1.5 |

# Digital barometric pressure sensor

**Preliminary data**

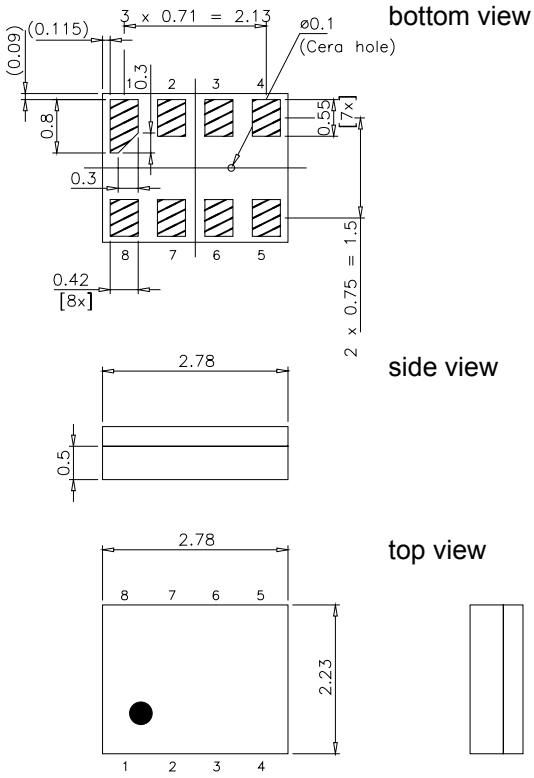
SMD

## Applications

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


## Features

- **S**urface **M**ounted **T**echnology (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 I²C 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 | I²C data signal | Master Out Slave In (MOSI) |
| 8 | SCL/SCLK | I | I²C clock signal | SPI clock signal |

## Digital barometric pressure sensor

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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 °C ... +85 °C
Ambient temperature of test conditions: $T_A$ = 25 °C
Supply voltage: $V_{DD}$ = 1.8 V

All voltages refer to ground.

| | | Min. | Typ. | Max. | Unit | Note or condition |
|---|---|---|---|---|---|---|
| **Current consumption[1)]** | $I_{IDLE}$ | — | 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 sensor[3)]** | Δp | –3 | –1 | +2 | hPa | p = 300 hPa ... 1100 hPa<br>T = 0 °C ... 65 °C |
| | | –3 | 0 | +5 | hPa | p = 300 hPa ... 1100 hPa<br>T = –20 °C ... 0 °C |
| **Relative accuracy pressure sensor[3)]** | Δp | — | ± 0.15 | — | hPa | p = 950 hPa ... 1050 hPa<br>T = 25 °C |
| | | — | ± 0.14 | — | hPa | T = 25 °C ... 40 °C<br>$p_{const}$ = 500 hPa ...1100 hPa[4)] |

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

1) Ensured by design.
2) Without interface activity.
3) Specified during qualification. Given values are ± 3σ 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 rejection[1)]** | | — | 1.4 | — | hPa | Normal operation $V_{DD}$ = 1.7 V ... 3.6 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.

## 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 | $I_{OL}$ = 1mA |
| Voltage output high level | $V_{OH}$ | $0.8 \cdot V_{DD}$ | $V_{DD}$ | — | V | $I_{OH}$ = 1mA |

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

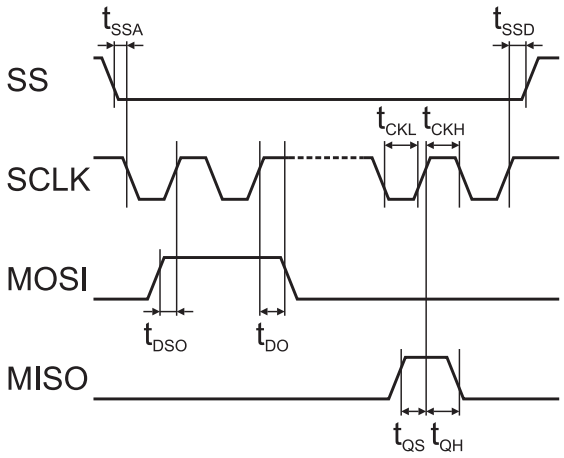
The I²C interface is compatible to NXP specification UM10204, Rev. 03, June 19, 2007. Standard, fast, fast plus and high-speed modes are supported.

| | | 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 mA |
| Pull-up resistor on SDA and SCL | $R_{PU}$ | 1 | 4.7 | — | kΩ | |
| Capacitive load for each bus line | | — | — | 100 | pF | |

**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 $f_{SCL}$ = 20 MHz.

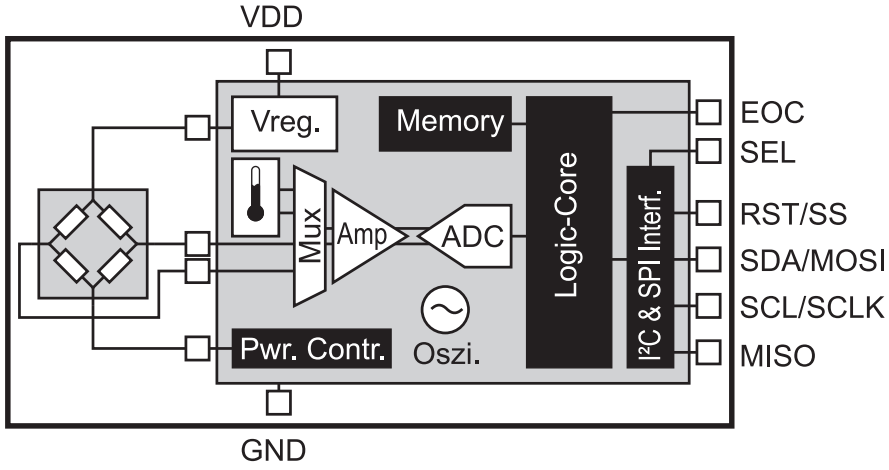


## Digital barometric pressure sensor

**Preliminary data** SMD

### Function

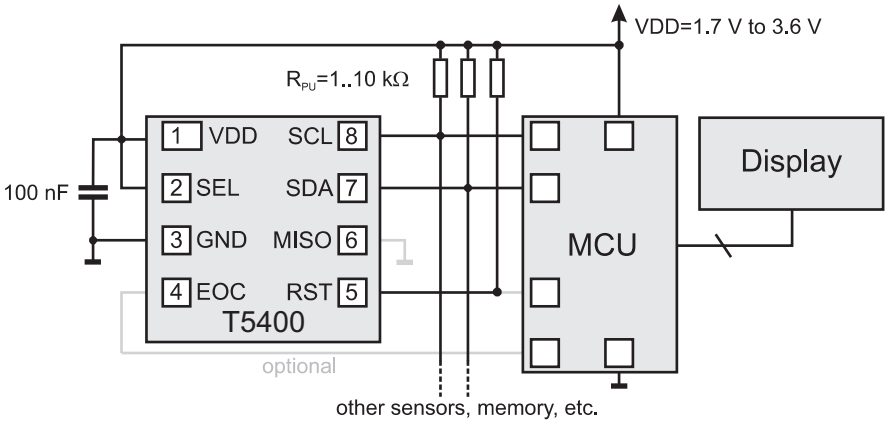
The T5400 is a fully calibrated digital pressure sensor module. It consists of a piezoresistive MEMS pressure sensor element and an ASIC with integrated temperature sensor, analog to digital converter ADC, memory and digital circuitry. The analog bridge voltage of the pressure sensor and the output voltage 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



### 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 (≡ 1 $N/m^2$)
- hPa Hecto-Pascal (≡ 1 mbar)
- mmHg mm column of mercury (≡ 1 Torr)
- psi Pounds per square inch (≡ 1 $lbf/in^2$)

## Digital barometric pressure sensor

Preliminary data

SMD

### 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 8th, 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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