atrin | electronic

Expertise, variety and quality

www.atrinelec.com

آترین الکترونیک

تخـصص ، تنــوع و کیفـیت

02166766957 -02166766927

info@atrinelec.com

تهران پاساژ امجد طبقه۱ واحد ۱۶

@atrinelec

SMARTEC

SMT16030 DIGITAL TEMPERATURE SENSOR

Features

Absolute accuracy ± 0.7 °C
Linear output within 0.2 °C
Resolution better then 0.005 °C
Duty Cycle output
Calibrated on chip
TTL, CMOS compatible
Temperature range 175 °C (-45 to +130 °C)
Directly connectable to data input of microprocessor
Easy multiplexing of multiple sensors

Typical applications

Heater systems
Measuring instruments
Washing machines
Overheating protection
Appliances
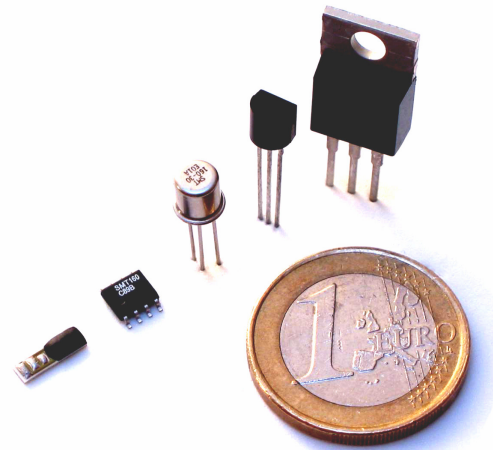
Introduction

The Smartec temperature sensor is a sophisticated full silicon temperature sensor with a digital output. The one wire output (duty-cycle modulated) can be directly connected to all kinds of micro-controllers without the need of A/D conversion. The temperature range is –45 °C to 150 °C. The high resolution (< 0.005 °C) makes the sensor useful for high precision applications. The sensor is available in various housings like T018, T092, T0220 and for high volume production in SOIC. Special housing can be manufactured on request.

Product highlights

The SMART TEMPERATURE SENSOR features a duty-cycle modulated square wave output voltage with linear response to temperatures in the -45 °C to +130 °C range. The absolute accuracy is better than 1.2 °C. In the range from -30 to +100 °C absolute accuracy is better than 0.7 °C, while the linearity is better than 0.2 °C (Model TO18).
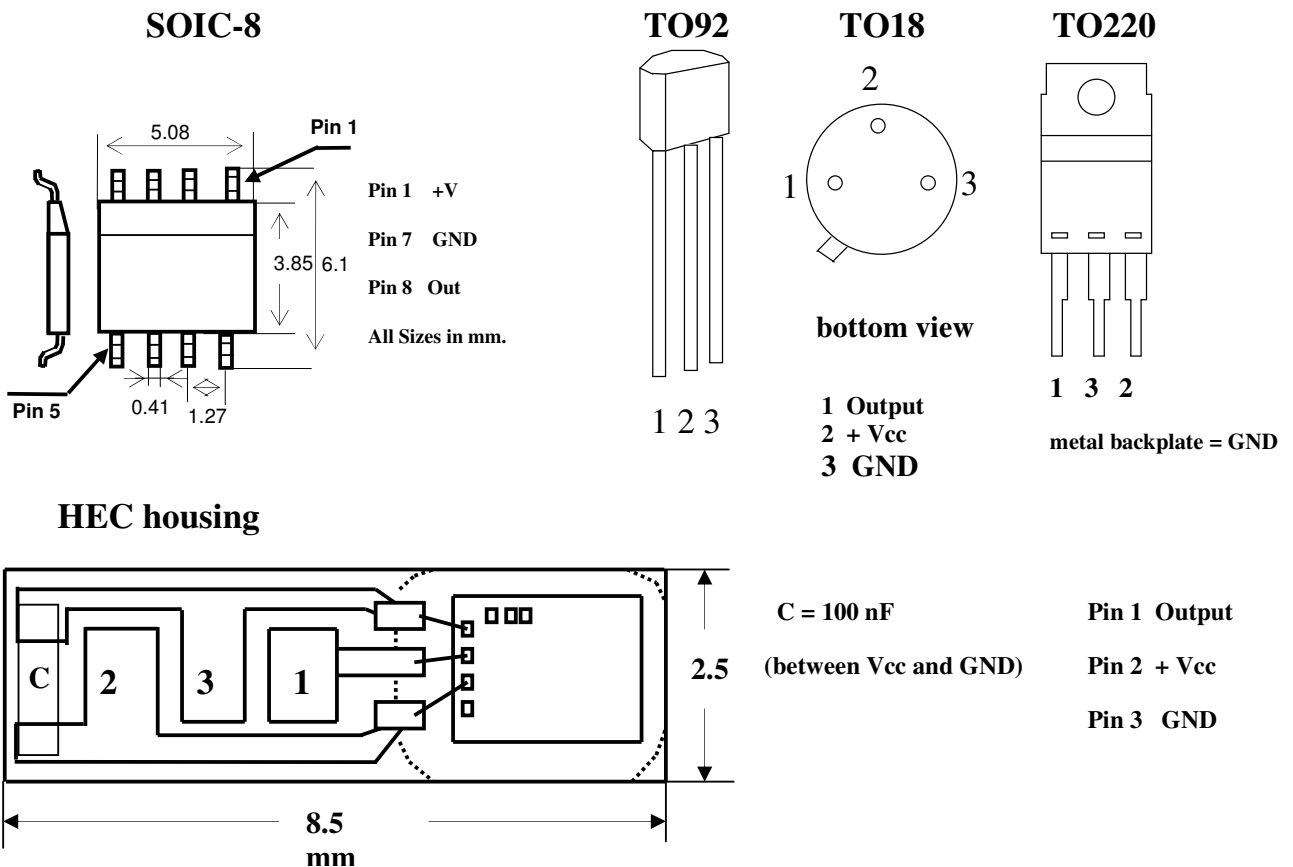
The SMART TEMPERATURE SENSOR is calibrated during test and burn-in of the chip. The integrated modulator ensures the sensor unit can communicate effectively with low-cost microcontrollers without the need of (onboard) A/D converters or an Xtal controlled oscillator.

The SMART TEMPERATURE SENSOR combines digital output and on-chip calibration to ensure major cost reductions and performance-related advantages.

In applications where multiple sensors are used, easy multiplexing can be obtained by using a corresponding number of microprocessor inputs or by using low cost digital multiplexers.

Since the sensor requires no subsequent calibration, optimal cost savings are recorded both during manufacturing and in the course of after-sales servicing.

Pin-out and housing.

SOIC-8

Pin 1

5.08

3.85 6.1

0.41 1.27

Pin 5

Pin 1   +V

Pin 7   GND

Pin 8   Out

All Sizes in mm.

TO92

1 2 3

TO18

2

1   3

bottom view

1 Output
2 + Vcc
3 GND

TO220

1   3   2

metal backplate = GND

HEC housing

C   2   3   1

8.5
mm

2.5

C = 100 nF

(between Vcc and GND)

Pin 1 Output

Pin 2 + Vcc

Pin 3   GND

Specifications

| Parameters | TO18 | | | TO92 | TO220 | HEC | SOIC-8 | |
	min	typ	max	max [1]	Max	max	max	Units
Supply voltage[2]	4.75	5	7.2	*	*	*	*	**V.**
Supply current	160		200	*	*	*	*	**µA.**
temperature range[3]	-45	-	130	*	*	*	*	**℃**
Total accuracy[4]	-30 + 100 ℃		0.7	1.2	1.7	1.5	1	**℃**
	-45 + 130 ℃		1.2	2	1.7	1.5	1.5	**℃**
Non linearity[5]			0.2	0.4	0.5	1.0	1.0	**℃**
Supply voltage sensitivity			0.1	*	*	*	*	**℃/V**
Repeatability			0.1	0.2	0.2	0.2	0.05	**℃**
Long term Drift			0.05	-	-	-	0.05	**℃**
Operating temperature	-45		130	*	*	*	*	**℃**
Storage temperature	-50		150	*	*	*	*	**℃**

Output

- duty cycle	=0.320+0.00470*t (t=temperature in C)							
- frequency	1	-	4	*	*	*	*	**Khz**
- noise			0.005	*	*	*	*	**℃**
- impedance			200	*	*	*	*	**Ohm**
- short circuit	infinite maximum current applied 40 mA							

[1] * All not mentioned specifications are the same as for TO18

[2] Case connected to ground

[3] The SMT 30-160-18 can be used from -65 to +160 °C for a short period without physical damage to the device. The specified accuracy applies only to the rated performance temperature range.

[4] Total accuracy includes all errors.

[5] Applicable from -30 to +100 °C

Product description

The SMT160-30 is a three terminal integrated temperature sensor, with a duty-cycle output. Two terminals are used for the power supply of 5 Volts and the third terminal carries the output signal. A duty cycle modulated output is used because this output is interpretable by a micro-processor without A-D converter, while the analogue information is still available. The SMT160-30 (TO18 model) has an overall accuracy of 0.7 °C in the range from -30 C to +100 °C and an accuracy of 1.2 °C from -45 to +130 °C. This makes the sensor especially useful in all applications where "human" (climate control, food processing etc.) conditions are to be controlled. Due to its very high resolution (< 0.005K) this sensor is especially suited for applications where very accurate measurements are needed.

The CMOS output of the sensor can handle cable length up to 20 meters. This makes the SMT160-30 very useful in remote sensing and control applications.

Understanding the specifications.

It is important to understand the meaning of the various specifications and their effects on accuracy. The SMT160-30 is basically a bipolar temperature sensor, with accurate electronics to convert the sensor signal into a duty cycle. During production the devices are calibrated.

The output signal

The output is a square wave with a well-defined temperature-dependent duty cycle. The duty cycle of the output signal is linearly related to the temperature according to the equation:

$$D.C. = 0.320 + 0.00470*t$$

>   *D.C. = duty cycle*
>   *t = Temperature in °C*

A simple calculation shows that - for instance- at 0 °C:

D.C.= 0.320 or 32.0 % and at 130 °C

D.C.= 0.931 or 93.1 %

In the output frequency of the sensor there is no temperature information, only the duty cycle contains temperature information in accordance to the formula given above. The output signal may show low frequency jitter or drift. Therefore most oscilloscopes and counters are not suited for verifying the accuracy of these sensors. The temperature information contained in the duty-cycle value, however, is guaranteed to be accurate within the values specified for each model (housing).

Total accuracy
The mentioned equation is the nominal one. The maximum deviation from the nominal equation is defined as total accuracy. With temperatures above 100 °C the accuracy decreases.

Non linearity
Non-linearity as it applies to the SMT160-30 is the deviation from the best-fit straight line over the whole temperature range. For the temperature range of -30 °C to +100 °C the non-linearity is less than 0.2 °C (TO18).

Long-term drift
This drift strongly depends on the operating condition. At room temperature the drift is very low (< 0.05 °C). However at higher temperatures the drift will be worse, mainly because of changes in mechanical stress. This drift is partly irreversible and causes non-ideal repeatability and long-term effects. At temperatures above 100 °C (but in the operating range) a long-term drift better than 0.1 °C is to be expected.

Noise
The resolution is better than 0.005 °C. The standard deviation of the noise level (measured over a 20 ms. period) is below this 0.005 °C.

Time constants
The time constant of the sensor is measured under different circumstances.

To compare this with other types of sensors the same kind of measurements were done. The time constant is defined as the time required to reach 63% of an instantaneous temperature change.

The figures mentioned below are difficult to measure; an accuracy of around 5 % is a reasonable estimation. These figures only apply to the sensor built in a TO-18 housing and not the TO-92, the TO220 nor the naked chip. The values found only depend on the physical parameters of the measurement setup.

condition	timeconstant (s) (TO18)
mounted in an alu block of a certain temperature (mean value of different measurements)	0.6
in a bath filled with oil that was stirred (mean value of different measurements)	1.4
Moving air with a speed of about 3 m/s - without heatsink - with heatsink	13.5 5
Non moving air -without heatsink -with heatsink	60 100

Overview of time constants in different conditions

General operation

A simple way of measuring a duty cycle is to use a microcontroller. The sensor output can be directly connected to a microcontroller input. The microcontroller can determine the duty-cycle value by sampling the sensor output. If the microcontroller is not fast enough to determine the temperature accurately enough within one sensor output cycle, the sampling can be extended over multiple periods. This method has the advantage to filter out noise. From the theory of signal processing it can be derived that there is a fixed ratio between the sensors signal frequency, the sampling rate and the sampling noise. This sampling noise limits the accuracy and amounts to:

$$T_{error} = 200 * t_s / sqrt(6*t_m*t_p)$$

T_{error} = measurement error (= standard deviation of the sampling noise)
t_s = microcontrollers sampling rate
t_m = total measurement time
t_p = output signal periodicity of the sensor

Microcontrollers can sample at a high frequency so with a simple program it is possible to measure the sensor's duty cycle within 50 ms and a resolution of .01 °C.

NOTE:

The above mentioned error is NOT related to the intrinsic accuracy of the sensor. It just tells us what happens to the accuracy (standard deviation) of the measurement of a digital signal, when that signal is being sampled by a microcontroller.

About noise protection and how to prevent damage caused by a wrong power supply polarity.

The Smartec SMT16030 is based on a free running oscillator. Periodic spikes on the power supply line may make the oscillator synchronise, resulting in a false temperature reading. To overcome this problem it is advised to put a filter in the power supply line of the sensor. It is suggested to use a low pass RC filter as given below. An additional advantage also is the power supply polarity protection of the sensor. The resistor of 220 Ohm limits the current through the sensor to about 25 mA. At this current the sensor will survive a possible wrong power supply polarity. The software can detect the presence of the output signal and therefore a proper connection of the sensor. See below for a suggested diagram.
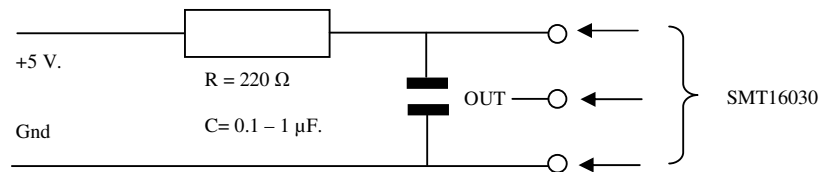
Power line noise filtering and polarity damage protection

For more information about how to measure duty cycles by means of a microcontroller, please refer to our application notes, available for download at our website WWW.SMARTEC.NL.