SD5003

PWM Output Digital Temperature Sensor

Features

- Open drain PWM output
- PWM output mode: fixed period, duty cycle varies with temperature
- ±1.5°C maximum error at -40℃~+100℃ range
- ±2.0°C maximum error at -55℃~+125℃ range
- 170uA typical operating current at 3V supply
- 2.7V ~ 5.5V power supply range
- SOP8 or TO-92 package, pin compatible with TMP03

Description

SD5003 is a highly accurate temperature measurement IC with digital PWM output. An internal sensor produces a voltage signal that is proportional to temperature. It is then digitized by a built-in ADC, and modulated into a PWM waveform. The typical error is ± 0.8℃ for the -40℃ ~ +100℃ range, and ±1.0℃ for the -55 ℃ ~+125℃ range.

Output pin DOUT is open drain which facilitates multi-voltage system applications.

Applications

Temperature control systems, industrial process control, power system thermal protection, ambient temperature measurement.

Ordering Information

Package	Part Number
TO-92	SD5003A
SOP8	SD5003B

Pin Diagram and Descriptions

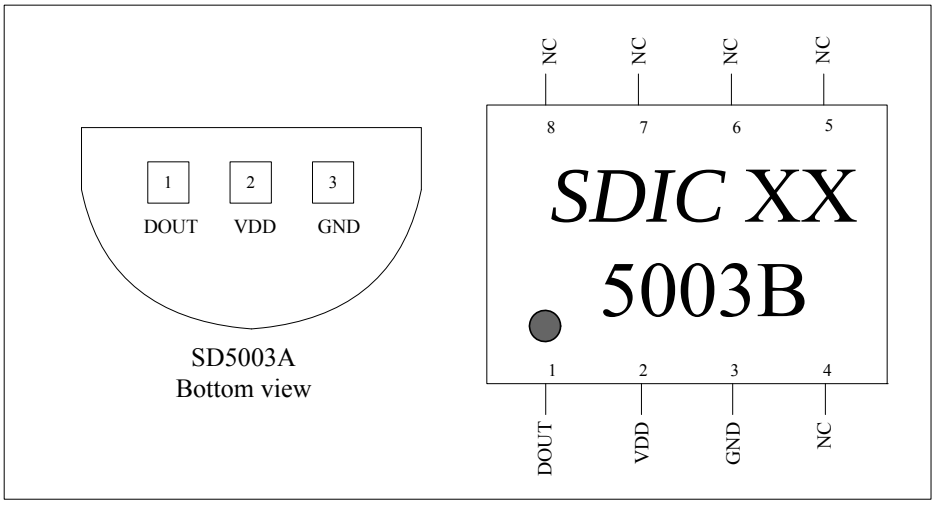


Figure 1. TO-92 and SOP8 pin out diagram

Table 1. Pin Descriptions

Pin Number	Pin Name	Attribute	Description
1	DOUT	I/O	PWM output Temperature linearly proportional to duty cycle
2	VDD	Power	
3	GND	Ground	
4 – 8	NC	--	No Connect

Functional Description

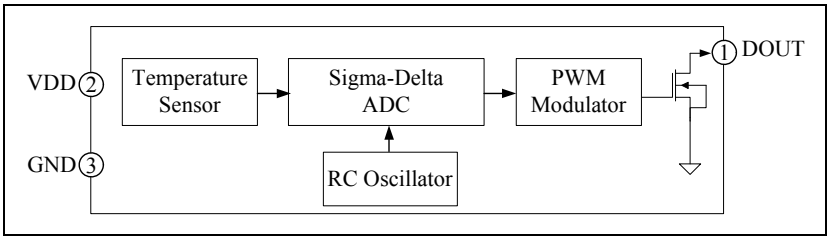


Figure 2. Functional block diagram

Figure 2 is the functional block diagram of SD5003. It is a digital temperature sensor with open drain PWM output. The maximum measurement error in the -55℃ ~ +125℃ range is less than ±2℃. The internal sensor generates a voltage signal that is proportional to temperature. The signal is digitized by an ADC, and then converted to PWM output through the PWM modulator.

PWM Output

SD5003 output is in PWM format as shown in Figure 3. The period T is fixed at around 50ms. The high state T1 is shortened as the temperature down. Temperature data is obtained through the T and T1 ratio. RC oscillation frequency change does not affect the measurement value.

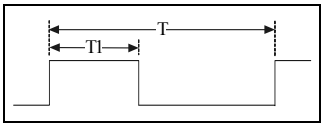


Figure 3. PWM output waveform

Celsius temperature is calculated as follows:

$$Temp(°C) = 235 - \frac{80 \times T}{T1}$$

Fahrenheit is calculated as follows:

$$Temp(°F) = 455 - \frac{144 \times T}{T1}$$

PWM Output Accuracy Calculation

If the variable *Temp* is in Celsius, according to the formula:

$$T1 = (T \times 80)/(235 - Temp)$$

The T1 value will be 36ms when the temperature is 125℃. If a 16-bit counter is used, the maximum external counting clock frequency is:

$$F_{max} = 65536 / 0.036 \approx 1.82MHz$$

Set the counting clock frequency Freq to 1MHz. The quantization error is:

$$T_{err} = 80 \times (\frac{Count}{Count1} - \frac{Count - 1}{Count1 + 1})$$

where: Count=T×Freq

Count1=T1(*Temp*) ×Freq

The PWM output resolution varies with temperature changes. It is 0.027℃ at -55℃, and 0.005℃ at 125℃. The higher the temperature, the better the resolution.

Temperature value accuracy will improve when the external counting clock frequency is increased. Table 2 lists several frequency and their quantization errors at -55℃.

Table 2. Relationship between Counting Clock Frequency and Quantization Error

Clock Freq （kHz）	Counter Digits （Bit）	Maximum Quantization Error T_{err}（℃）
1000	16	0. 027
512	15	0. 052
256	14	0. 10
128	13	0. 21

Recommendation: Counting clock frequency should not be less than 128KHz. Counter width should not be less than 13 bits.

Self Heating Effect

SD5003 temperature measurement accuracy will be affected by its own power consumption and chip package thermal resistance. The IC's own power consumption is very small (typically 0.51mW at 3V supply voltage), but will still bring a certain degree of temperature rise.

The SD5003A temperature rise is:

$$\Delta T \approx 0.51mW \times 162°C/W = 0.08°C$$

The SD5003B temperature rise is:

$$\Delta T \approx 0.51mW \times 240°C/W = 0.12°C$$

Temperature Calibration

SD5003 has been accurately calibrated in the factory. No further calibration by the user is needed.

Output Pin Description

SD5003's PWM output pin DOUT is an open drain port. A high level voltage other than VDD can be generated by an external pull-up resistor, this provides convenient access to other circuits with different power supplies.

IC Placement

SD5003 measures the IC's internal temperature. When it is used to monitor a heat source temperature, one should place the IC close to the heat source, and minimize the thermal resistance between them.

Typical Application

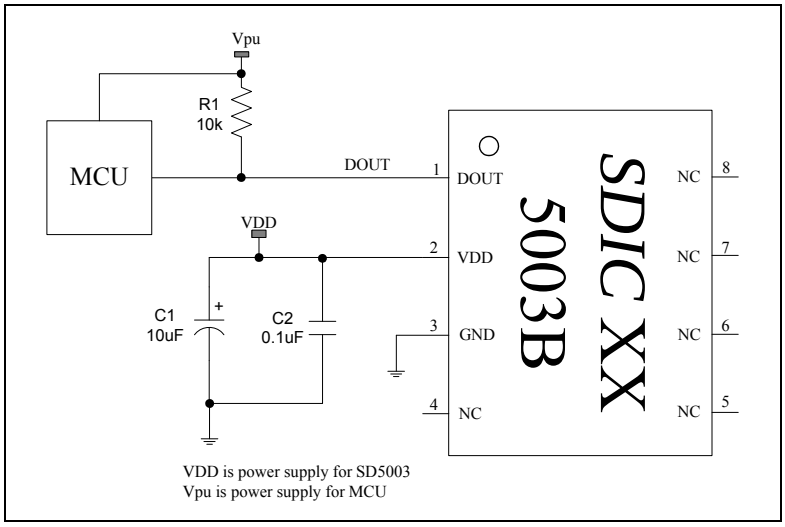


Figure 4. Typical application diagram

Electrical Specifications

Table 3. Absolute Maximum Ratings

Symbol	Parameter	Minimum	Maximum	Unit
T_A	Operating temperature	-55	+125	℃
T_S	Storage temperature	-65	+150	℃
V_{DD}	Supply voltage	-0. 3	+7. 0	V
V_{IN}, V_{OUT}	Digital input/output voltage	-0. 3	VDD+0. 3	V
T_L	Reflow temperature profile	Per IPC/JEDECJ-STD-020C		
$Iout_{max}$	Maximum output current		10	mA
ESD	HBM	2000		V

Remarks:

1. CMOS device can easily be damaged by electrostatics. It must be stored in conductive foam, and with care taken to not exceed the operating voltage range.
2. Turn off power before inserting or removing the device.

Table 4. Electrical Specifications

(VDD=3.0V ~ 5.0V, T_A=25℃. **Bold items applicable for T_A=-55℃ ~ +125℃。**)

Symbol	Parameter	Minimum	Typical	Maximum	Unit	Conditions/Remarks
VDD	Supply voltage	2. 7	3. 0	5. 5	V	
T_A	Operating temperature	-55	--	+125	℃	
T	PWM cycle	--	50	--	ms	
Terr	Accuracy	--	**±0.8**	**±1.5**	℃	-40℃ ~ +100℃, VDD=2. 7 ~ 5. 5V
		--	±1.0	**±2.0**		-55℃ ~ +125℃, VDD=2. 7 ~ 5. 5V
Ivdd	Supply current	--	170	--	uA	
Tconv	Measurement cycle	65	85	110	ms	
PSRR	Power supply rejection ratio	--	0. 1	--	℃/V	VDD=2. 7V ~ 5. 5V[1]
DOUT open drain output drive strength						
Isink	Low current sink	4	--	--	mA	V_{OL}=0. 3V
Ileak	High leakage source	--	--	**1**	uA	V_{OH}=VDD

Note 1: PSRR parameter uses the temperature value at VDD=3.0V as reference.

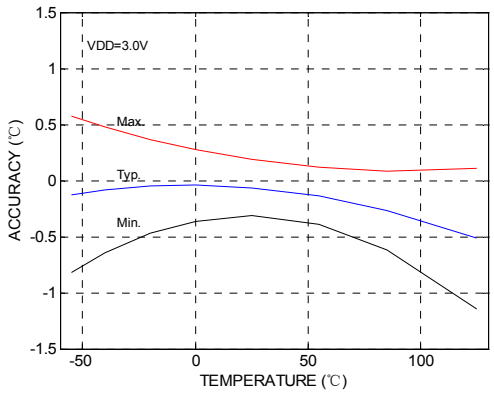


Figure 5. Temperature accuracy at 3V

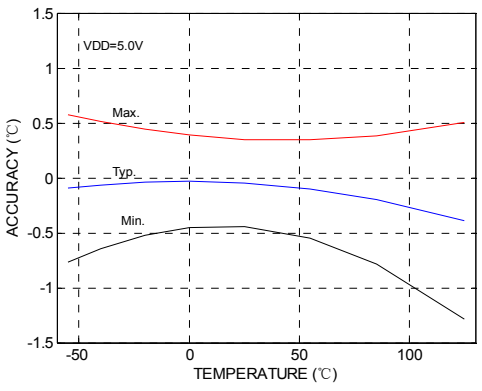


Figure 6. Temperature accuracy at 5V

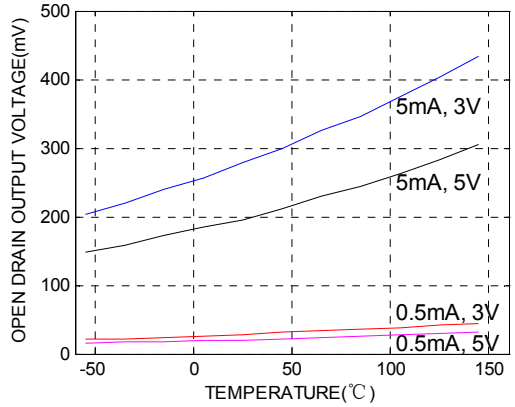


Figure 7. Open drain output voltage

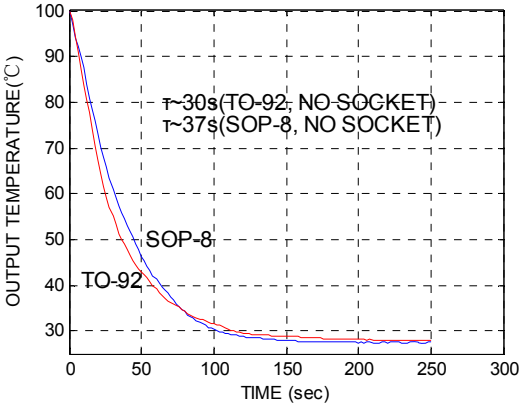


Figure 8. Thermal response time

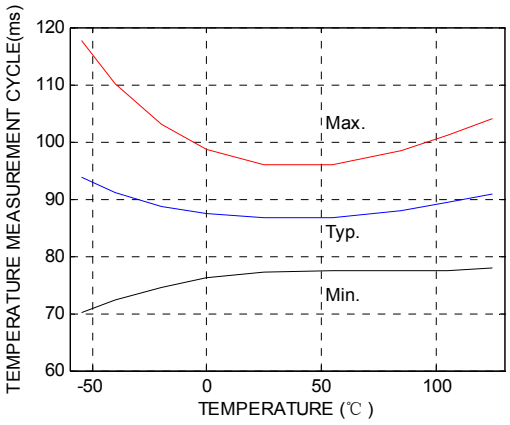


Figure 9. Temperature measurement cycle

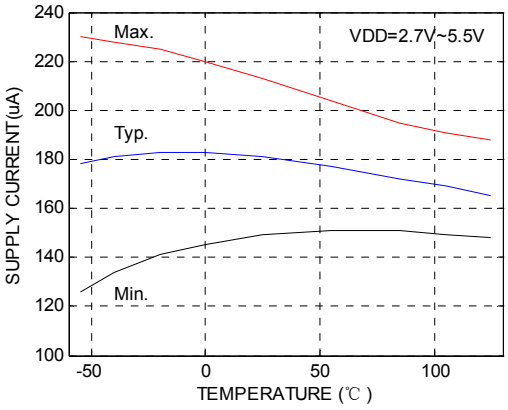


Figure 10. Supply current

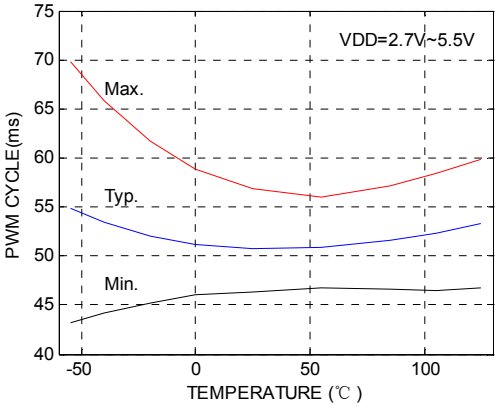


Figure 11. PWM cycle

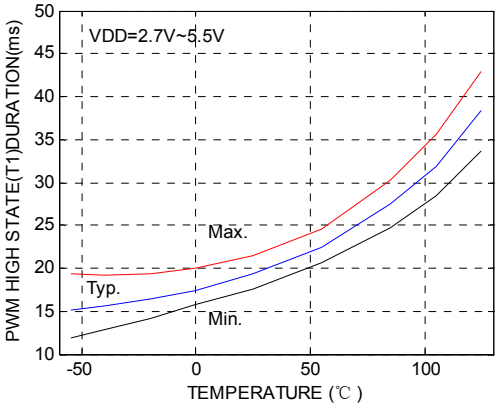
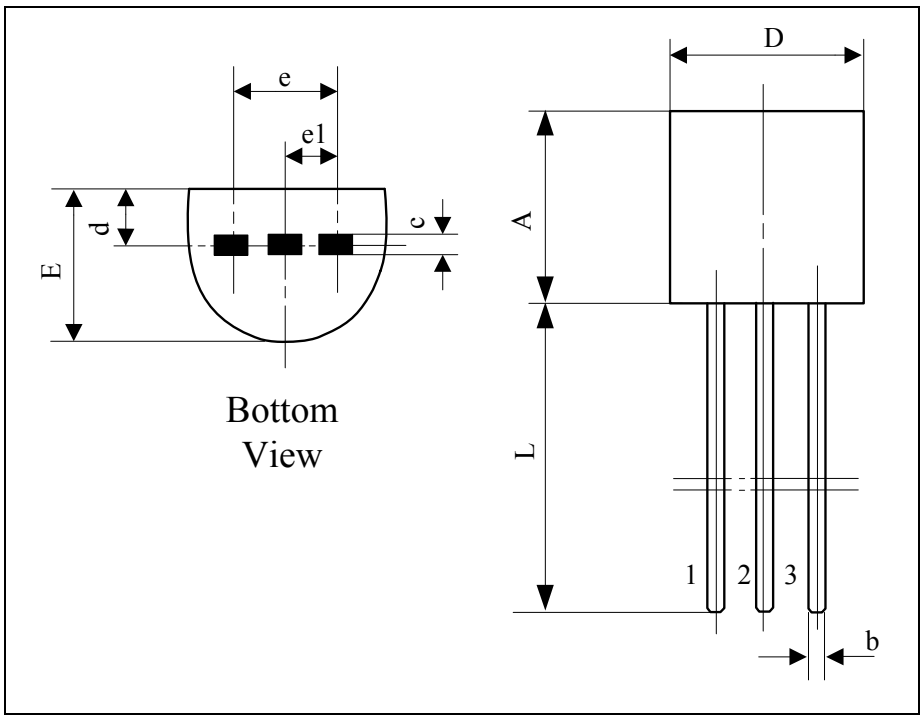


Figure 12. PWM high duration

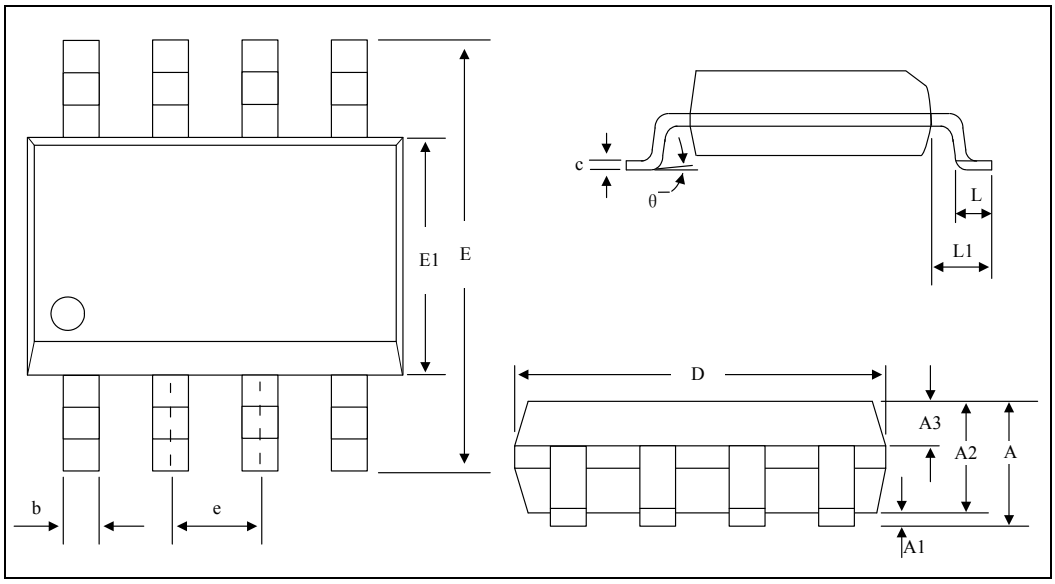
Packaging Information



Dimensions: mm

Symbol	Min.	Nom.	Max.
A	4. 3	——	5. 3
b	0. 3	——	——
c	0. 3	——	——
φD D	4. 3	——	5. 2
d	1.0	——	1.7
E	3.2	——	4.2
e	——	2.54	——
e1	——	1.27	——
L	12.7	——	——

Figure 13. TO-92 mechanical specification



Dimensions: mm

Symbol	Min.	Nom.	Max.
A	1.35	——	1. 80
A1	0. 10	——	0. 25
A2	1. 25	1. 40	1. 55
A3	0. 60	0. 65	0. 70
D	4. 78	4. 90	5. 00
E	5. 80	6. 00	6. 30
E1	3. 80	3. 90	4. 00
L	0. 40	——	1. 27
L1	1. 05BSC		
b	0. 33	——	0. 51
c	0. 19	——	0. 25
e	1. 27BSC		
θ	0°	——	8°

Figure 14. SOP8 mechanical specification