Long range digital infrared thermopile sensor

SL-FW-TRS-5.5D1/N1 series of sensors are independently developed by our company. They are new high-precision digital output differential infrared thermoplastic sensors suitable for various non-contact temperature measurement products and industries. They have the characteristics of high infrared response rate, high repeatability and high reliability. The sensor is packaged in TO-39 metal tube shell. And inside the package shell, it contains MEMS thermoplastic sensor chip and professional signal conditioning ASIC chip. The ASIC chip is equipped with 24-bit Sigma-Delta high-precision ADC, low-noise instrument amplifier PGA and interface circuit, and built-in high-precision thermistor chip, which can compensate for ambient temperature.

Features

- High-precision digital temperature sensor
- Easy to implement, no temperature calibration required by the user
- Directly output the measured temperature without external circuits
- Measuring distance 30~50 cm
- MEMS Thermopile Technology
- High response rate, fast response time
- Stranded I²C port
- TO-39 Metal tube package

Application

- Remote temperature measurement
- Smart Home Appliances
- Industrial Temperature Monitoring
- Intelligent temperature sensing and control
- Non-contact surface temperature measurement

1.Absolute Maximum Ratings

List 1. Absolute Maximum Ratings

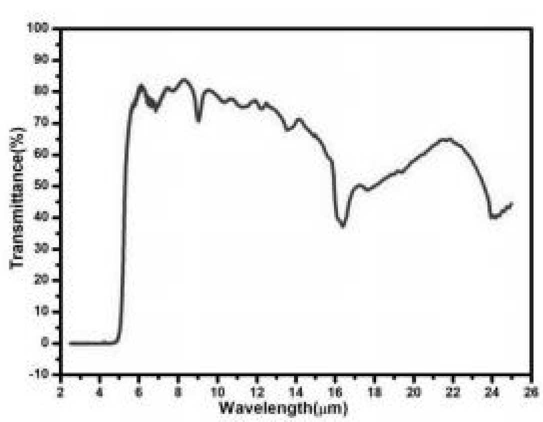
Parameter	Symbol	Min	Typ	Max	Unit	Remark
Supply voltage	VDD	-0.3		4.2	V	
Digital output voltage		-0.3		VDDIO+0.3	V	
ESD protection	HBM		±2		kV	
Storage humidity				40%	RH	
Storage temperature		-40		100	℃	

2.Performance parameters

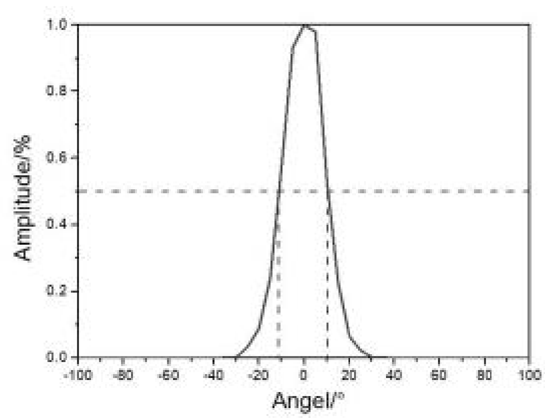
List 2. Sensor performance parameters

Parameter	Symbol	Min	Typ	Max	Unit	Remark
Chip size			1.3 × 1.3		mm2	
Sensitive Areas			0.98 ×0.98		mm2	
Field of view			10		°	
Response rate			60		V/W	FW-D1
			81		V/W	FW-N1
Working temperature			-30 ~ 80		℃	
Supply voltage		2.3	3.3	3.6	V	
Typical application mode working current	I_{avdd}		733	800	μA	default configuration
	I_{sleep}		5		μA	
Standby current (25℃)		100			nA	
ADC resolution			24		Bit	
Temperature measurement range		-30		350	℃	Application of measuring object temperature
		28		42		Temperature measurement application
Temperature measurement accuracy			±2（To≤100℃）		℃	Material temperature application
			±3% Reading（To>100℃）			

The conditions when no special provisions are made areVCC= 3.3V, Test environment temperature25℃, PGA Gain64x.



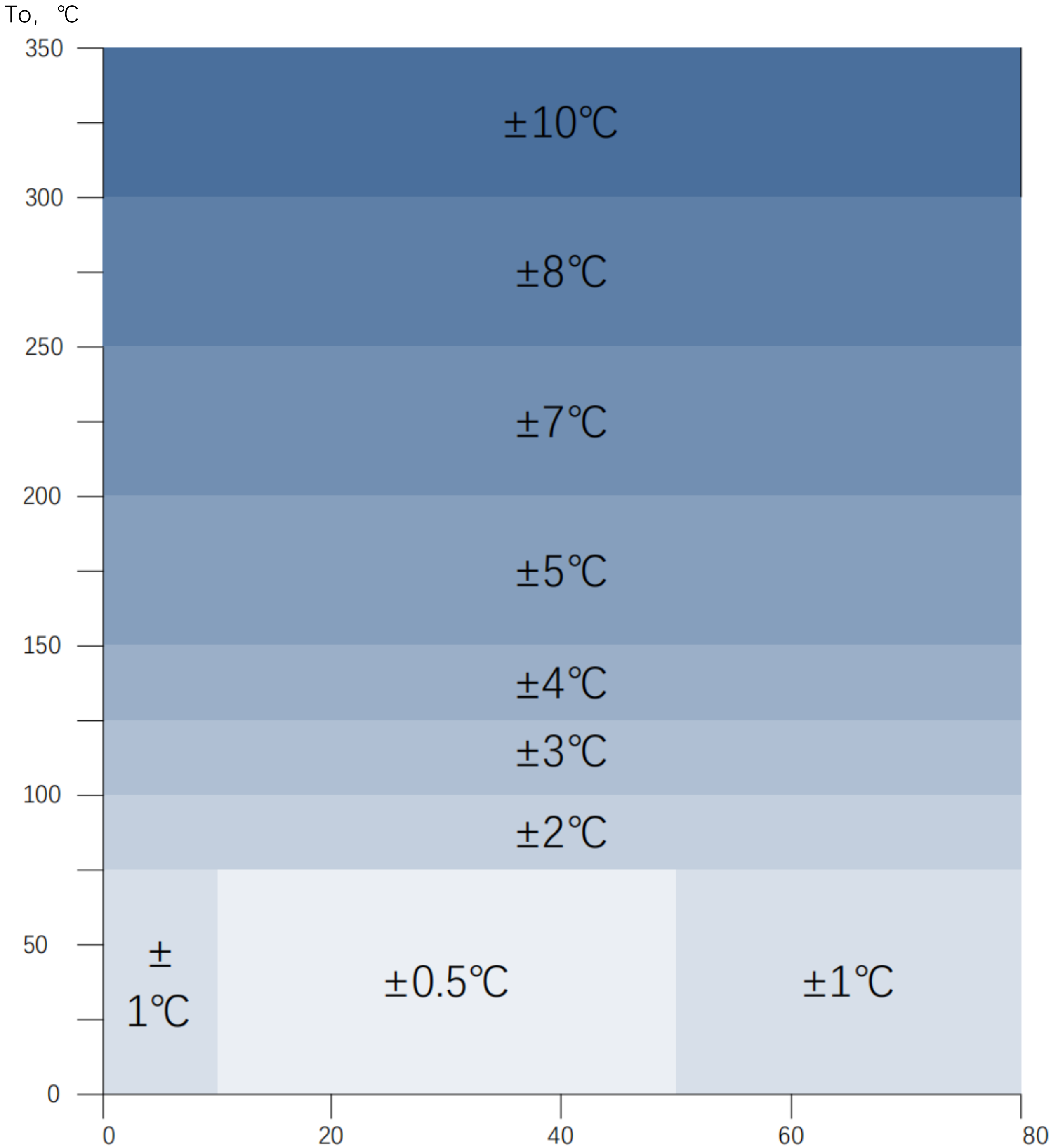
Picture 1. Transmission spectrum of the filter



Picture2. Sensor field of view

SL-FW-TRS-5.5D1/N1 Standard temperature accuracy index

All accuracy specifications are measured under stable isothermal conditions and with the object under test completely covering the sensor's FOV. When Ta between 0°C to 80°C and To between 0°C to 350°C, The accuracy is shown in the following chart。

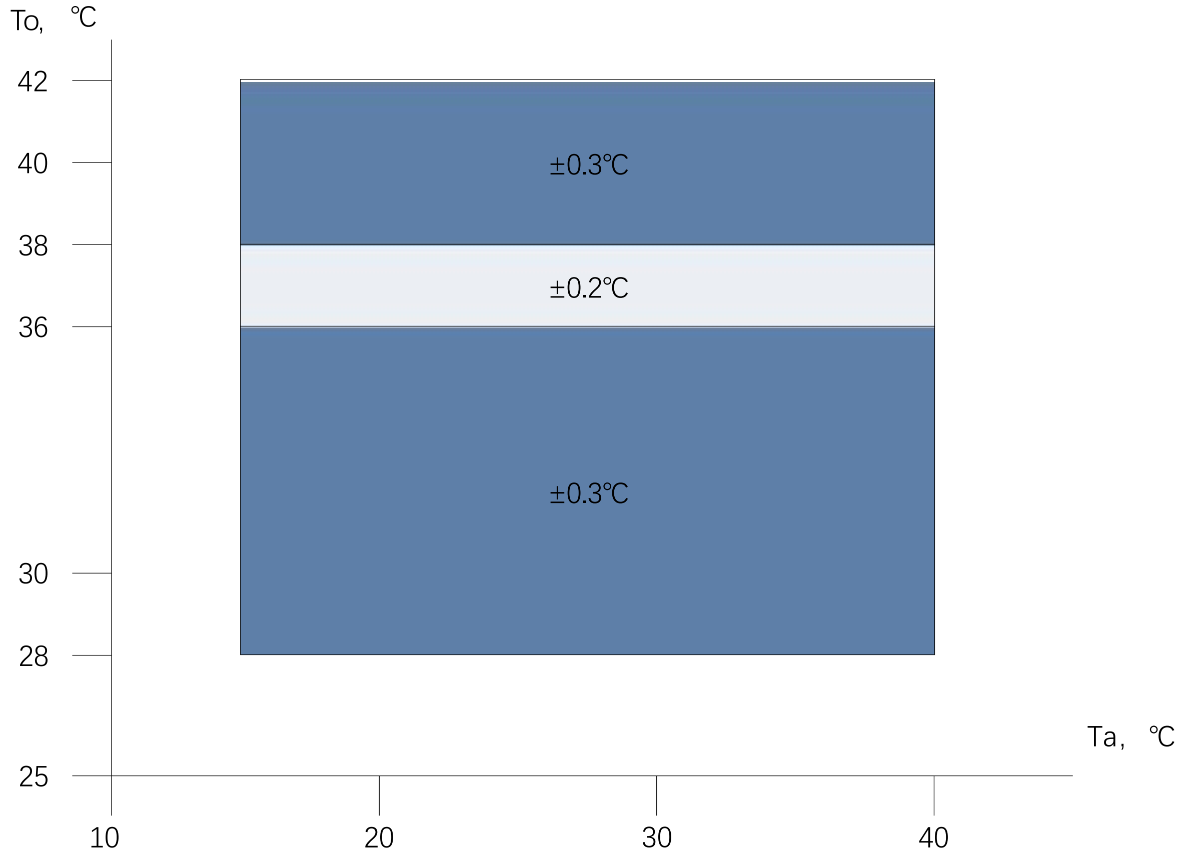


All data are tested under typical conditions: voltage is 3.3V, the distance between the sensor and the target is 40cm, Ta, ℃.The temperature measurement target is a standard black body furnace, and the corresponding ambient temperature is achieved by changing the temperature of the environmental chamber.
All accuracy specifications are only applicable under stable isothermal conditions, and the sensor accuracy does not represent the final product accuracy.

Picture 3.SL-FW-TRS-5.5D1/N1(Ta,To)Standard accuracy

SL-FW-TRS-5.5D1/N1 Medical temperature accuracy indicators

All accuracy specifications are measured under stable isothermal conditions and with the object under test completely covering the sensor's FOV.
When Ta is between 15°C and 40°C and To is between 28°C and 42°C, the accuracy is shown in the following graph.



All data are tested under typical conditions: voltage is 3.3V, the distance between the sensor and the target is 40cm, the temperature measurement target is a standard black body furnace, and the corresponding ambient temperature is achieved by changing the temperature of the environmental chamber.
All accuracy specifications are only applicable under stable isothermal conditions, and the sensor accuracy does not represent the final product accuracy.

Picture 4. SL- FW-TRS-5.5D1/N1（Ta,To）Medical precision

In application design, it is important to understand that the accuracy given in Figures 3 and 4 is only guaranteed under thermal equilibrium conditions and isothermal conditions (no temperature difference on the sensor package). If there is a temperature difference on the sensor package, the measured accuracy will be affected. Conditions that can cause temperature differences in the sensor package, such as hotter (or colder) components on the bottom or side of the sensor, or the sensor is very close to the object being measured, which will locally heat the sensor.

3.General registers

List 3. General registers

Address	Description	R/ W	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0	Default
0x00	Soft Reset	W			SOFTRE SET			SOFTR ESET			0x00
0x02	Data_ready	R					Temp_rd y		To_drd y	Ta_drd y	0x00
0x03	Data_ready	R			To_raw_ drdy	Ta_raw_dr dy					0x00
0x10	Object temp out Tobj after DSP and IIR filter	R	data1_out<23:16>								0x00
0x11		R	data1_out<15:8>								0x00
0x12		R	data1_out<7:0>								0x00
0x16	Ambient temp out (internal temperature sensor) Ta datal after calibration	R	temp_value<23:16>								0x00
0x17		R	temp_value <15:8>								0x00
0x18		R	temp_value <7:0>								0x00
0x22	To raw data before calibration	R	data_raw_out<23:16>								0x00
0x23		R	data_raw_out<15:8>								0x00
0x24		R	data_raw_out<7:0>								0x00
0x30	CMD	RW			sleep_en	clk_mode	mode_en	mode_sel<2:0>			0x00

Reg0x00
Soft_reset: 1, Reset the general register. After the reset is completed, this bit automatically returns to 0. Reg0x02
Temp_rdy: 1, Tobj The data is ready after being processed by DSP algorithm.
To_drdy: 1, To voltage value after calibrated data is ready.
Ta_drdy: 1, The data after calibration of ambient temperature (internal temperature sensor) is ready.
Reg0x03
To_raw_drdy: 1, To The raw data were prepared before calibration.
Ta_raw_drdy: 1, Prepare raw data before calibrating the ambient temperature (internal temperature sensor).
Reg0x10-Reg0x12
Data_out: The target temperature is output after being processed by the DSP algorithm and the output is a 2's complement code. DATA1/2^14 (℃)
Data_MSB<23:16> = 0x10<7:0> , Data_ CSB<15:8> = 0x11<7:0> ,Data_ LSB<7:0> = 0x12<7:0>.
Reg0x16-Reg0x18
Temp_Value: The data of external ambient temperature (internal temperature sensor) after calibration is output as 2's complement code. TEMP/2^14 (℃)
Temp_MSB<23:16> = 0x16<7:0> , Temp_ CSB<15:8> = 0x17<7:0> , Temp_ LSB<7:0> = 0x18<7:0>
Reg0x22-Reg0x24
Data_raw_out: To original data of voltage value before calibration, output as 2's complement code
Data_Raw_MSB<23:16> = 0x22<7:0> , Data_Raw_CSB<15:8> = 0x23<7:0> ,Data_Raw_LSB<7:0> = 0x24<7:0>.
Reg0x30
Sleep_en: 1, Entering sleep mode; 0, Exit Sleep mode.
Clk_mode: 1, 600KHz; 0, 1.2MHz.
Mode_en: 1, start FSM;
Mode_sel<2:0>: 000/001: Continuous conversion(Ta-To);

4.EEPROM register

List 4. EEPROM register

Address	Description	R/W	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
0x92	Chip_Address	RW		Chip_Address<6:0>						
0x93	Sys_config	RW	FILT_COEF<2:0>			output_mode<1:0>		OSR_T<2:0>		
0x94	Sys_config	RW	adc_dith er en	SERIAL_filter_en					VT_scale	
0x95	Sensor_Config	RW			Gain_P<2:0>			OSR_P<2:0>		

Reg0x92

Chip_Address<6:0>: I^{2}C address can be configured; The wildcard 7-bit address for I^{2}C is always 0x7F.

Reg0x93

FILT_COEF<2:0>: IIR Filter coefficients
000 disable IIR Filter; 001 inhibition 17% signal; 010 inhibition 25% signal;
011 inhibition 50% signal; 100 inhibition 63% signal; 101 inhibition 75% signal;
110 inhibition 88% signal; 111 inhibition 94% signal

output_mode <1:0>: 00:I^{2}C, 01: PWM , 10; Relay , 11 : I^{2}C. EEPROM Load and latch
Changes to this value will only take effect when the value is programmed into the EEPROM and then the chip is reset.

OSR_T<1:0>: For ambient temperature measurement OSR。
000:512X ， 011:1024X ， 010:2048X ， 011:4096X ， 100:128X ， 101:256X ， 110:110:8192X ， 11:16384X。

Reg0x94

adc_dither_en: 1, Let ADC Internal jitter
SERIAL_filter_en: 1, Let I^{2}C can Input denoising filter.
VT_SCALE: 1 'b0: ±16 mv;1 'b1:±128 mv

Reg0x95

Gain_P<2:0>: Set the gain of the sensor signal acquisition channel. 000: gain=8, 001:gian=12, 010:gain=16, 011:gain=32, 100:gain=48, 101:gain=64, 110:gain=96, 111:gain=128
OSR_P<2:0>: Set the oversampling rate of the sensor signal acquisition channel.000:512X, 011:1024X, 010:2048X, 011:4096X, 100:128X, 101:256X, 110:110:8192X, 111:16384X

Reg0x97

RES_DAC<3:0>: 4'b1101 5/16*AVDD (Recommended)

5.Digital Communications

This digital device provides the I²C communication protocol for serial communication. The choice of communication protocol is based on the CSB state.

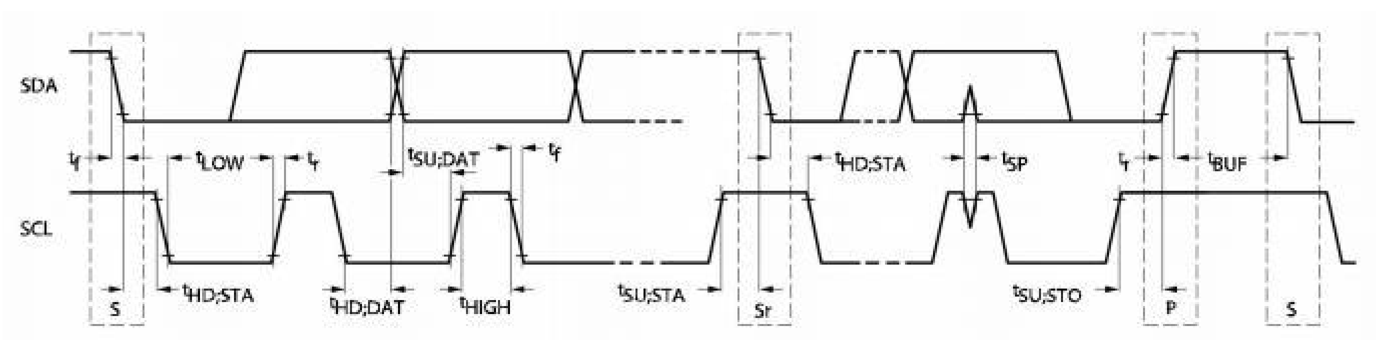
The I²C bus uses SCL and SDA as signal lines, both of which are externally connected to VDDIO through pull-up resistors so that they remain high when the bus is idle. The I²C device address of the digital device can be configured through the Chip_Address register 0x92. There is also a wildcard 7-bit address of 0x7F for the I²C bus, as shown in the following table.

List 5. I²C Device wildcard address

Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	W/R
1	1	1	1	1	1	1	0/1

List 6. I²C Bus Line Characteristics of Bus Devices SDA and SCL

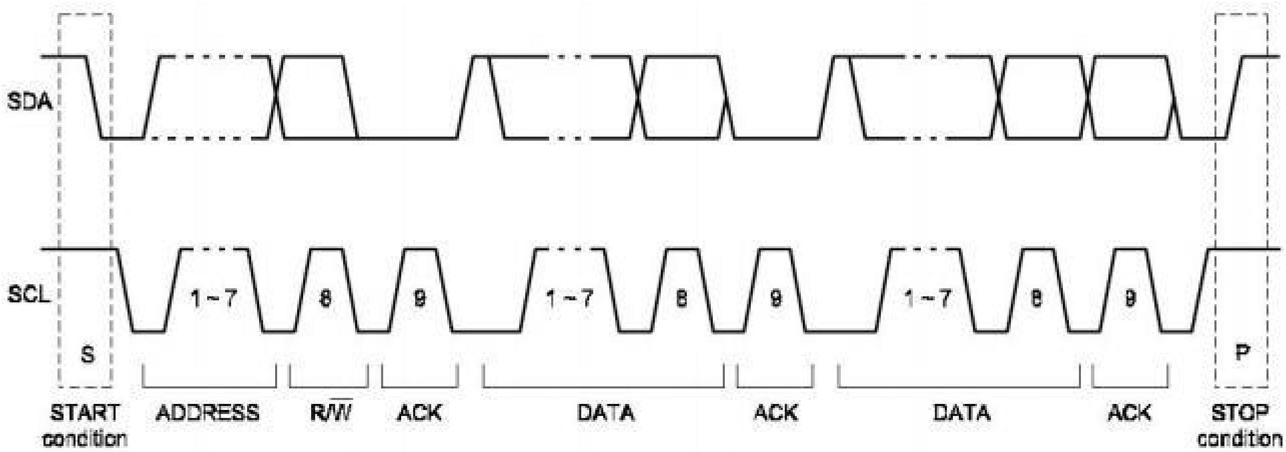
Symbol	Parameter	Min	Max	Unit
f_{SCL}	SCL clock frequency		400	kHz
t_{LOW}	SCL the low period of the clock	1.3		μs
t_{HIGH}	SCL high period of the clock	0.6		μs
$t_{SU;DAT}$	SDA build Time	100		ns
$t_{HD;DAT}$	SDA Keep time	0		μs
$t_{SU;STA}$	Setup time for repeated start condition	0.6		μs
$t_{HD;STA}$	Start condition hold time	0.6		μs
$t_{SU;STO}$	Stop condition setup time	0.6		μs
t_{BUF}	The interval between two communications	1.3		μs
t_r	SDA and SCL signal rise time		300	ns
t_f	SDA and SCL signal fall time		300	ns



Picture 5. I²C Timing diagram

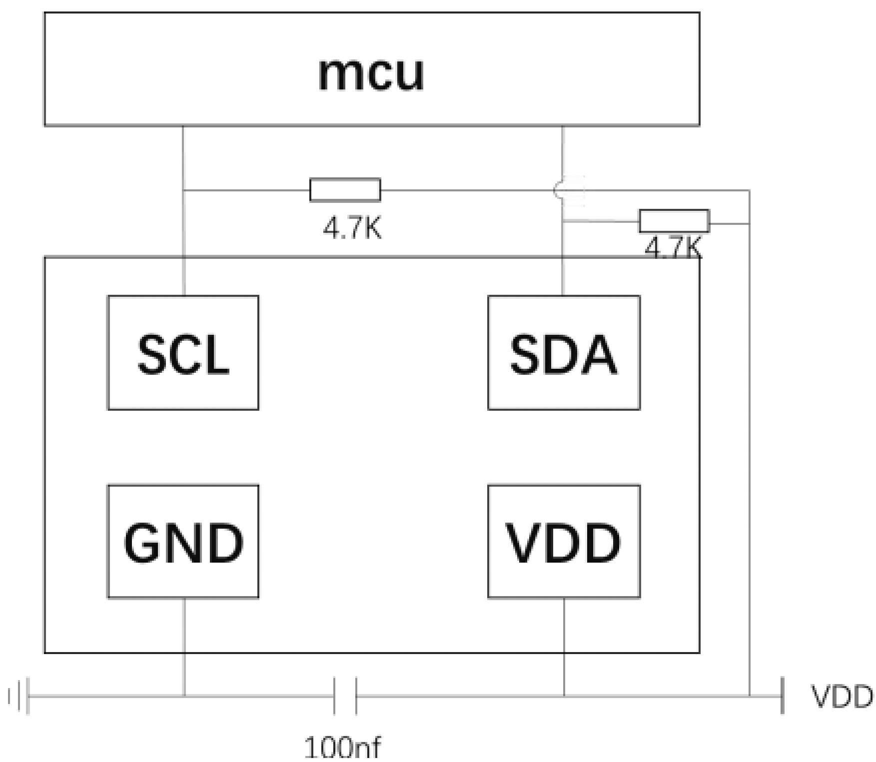
The I²C communication protocol has special bus signal conditions. The start (S) condition, stop (P) condition and binary data condition are shown in the figure below.

When SCL is at a high level and SDA is at a falling edge, it marks the start of I²C data communication. The I²C master device sends the address of the slave device (7 bits) in sequence, followed by the direction control bit R/W to select the read/write operation. When the slave device recognizes this address, it generates an acknowledge signal and pulls SDA low in the ninth SCL (ACK) cycle.
SCL is at a high level and SDA is at a rising edge, marking the end of I²C data communication. When SCL is high, the data transmitted by SDA must remain stable. The value transmitted by SDA can only be changed when SCL is low.



Picture 6. I²C Communication Protocol

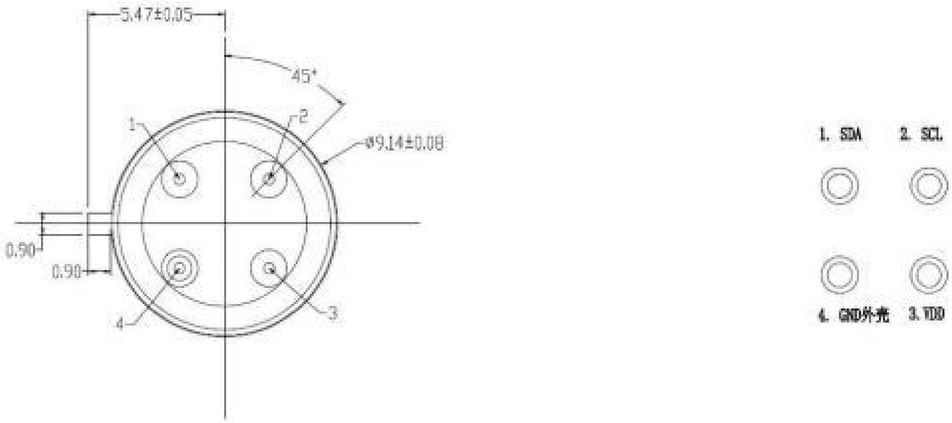
6.General Application Circuit



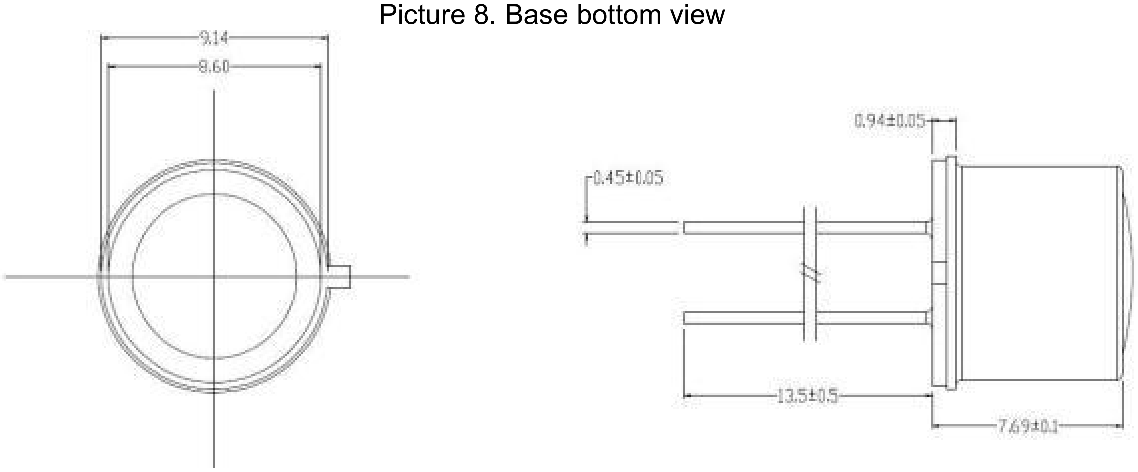
Picture 7. General Application Circuit

7.Mechanical specifications

1.Definition and size of base pins



Picture 8. Base bottom view

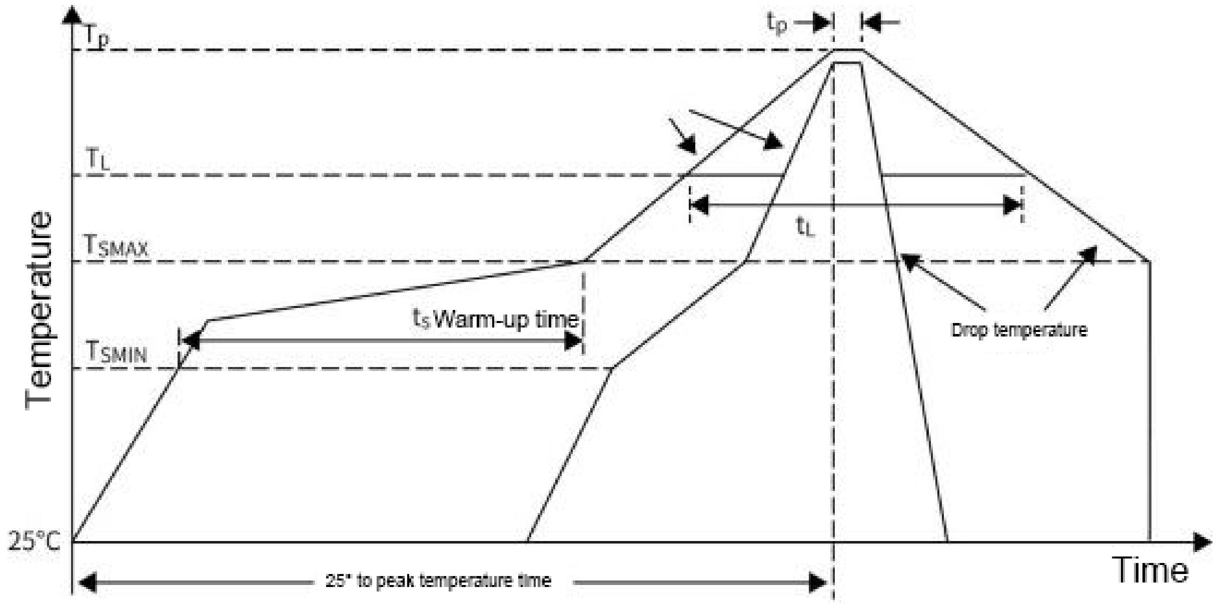


Picture 9. Base body dimensions

List 7. Pin definition

Number	Symbol	Definition
1	SDA	Serial data input/output (I2C Data)
2	SCL	Serial clock input (I2C Clock)
3	VDD	Core chip power supply (Supply Voltage)
4	GND	GROUND (Ground)

8.Recommended reflow profile



Picture 10. Recommended lead-free solder reflow temperature profile distribution diagram

List 8. Recommended lead-free solder reflow temperature profile distribution diagram

Curve characteristics		Lead Free
Average heating rate（T_{SMAX} to T_P）		Maximum 3℃/s
Preheat	Lowest temperature（T_{SMIN}）	150℃
	Maximum temperature（T_{SMAX}）	200℃
	Time（T_{SMIN} to T_{SMAX}）（t_S）	60-180 s
Time to reach above temperature	Temperature（T_L）	217℃
	Time（t_L）	60-150 s
Highest temperature（T_P）		260℃
Time within 5℃ of the peak temperature		20-40 s
Average cooling rate（T_P to T_{SMAX}）		Maximum 6℃/s
Time from 25℃ to peak temperature		Longest 8 min

Note: After reflow soldering, it is recommended to place it flat and let it stand for 5 minutes before moving the PCBA, otherwise the sensor cap may fall off.

9.Other advise

1. Pressure and electrostatic discharge exceeding the absolute maximum rating may damage the sensor. Please take appropriate handling precautions. Do not allow the sensor to contact corrosive cleaners. The optical window can be cleaned with alcohol and cotton swabs.
2. The sensor should be stored in a well-sealed environment and pay attention to moisture, humidity, shock, dust, and anti-static.
3. Before applying our products to some special situations (i.e. improper operation will directly affect the life of the semiconductor or cause physical damage), you should consult our company and representatives in advance. Our company will not assume any responsibility for unauthorized operations.