Infrared Thermopile Sensor

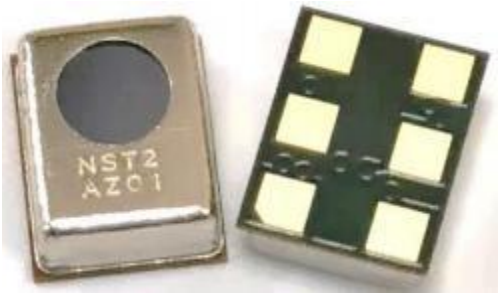
SL-S -TRS-5.5D1 is a digital output differential infrared thermopile sensor, including MEMS thermopile sensor chip, NTC thermistor and professional signal conditioning ASIC chip. The ASIC chip is equipped with 24-bit Sigma-Delta high-precision ADC, OTP memory and interface circuit.

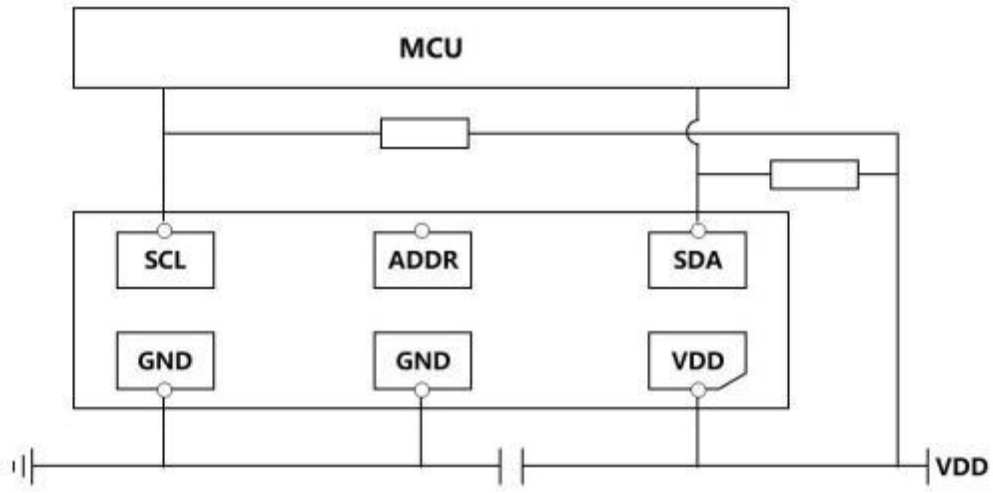
Features

- SMT technology, small size
- MEMS Thermopile Technology
- High response rate, fast response time
- 5.5μm long pass filter window
- NTC compensate
- I2C communication protocol
- Wide range of applications

Application

- Smart wearable devices
- Smart phone
- Industrial temperature monitoring
- Non-contact surface body temperature measurement
- Intelligent temperature sensing and control





1.Absolute maximum ratings

List 1. Absolute Maximum Ratings

Performance parameters	Symbol	Min	Typ	Max	Unit	Remark
Supply voltage	VDD	-0.3		6.5	V	
Digital output voltage		-0.3		VDDIO+0.3	V	
ESD protection			4		kV	HBM
Storage temperature		-40		125	℃	

2.Performance parameters

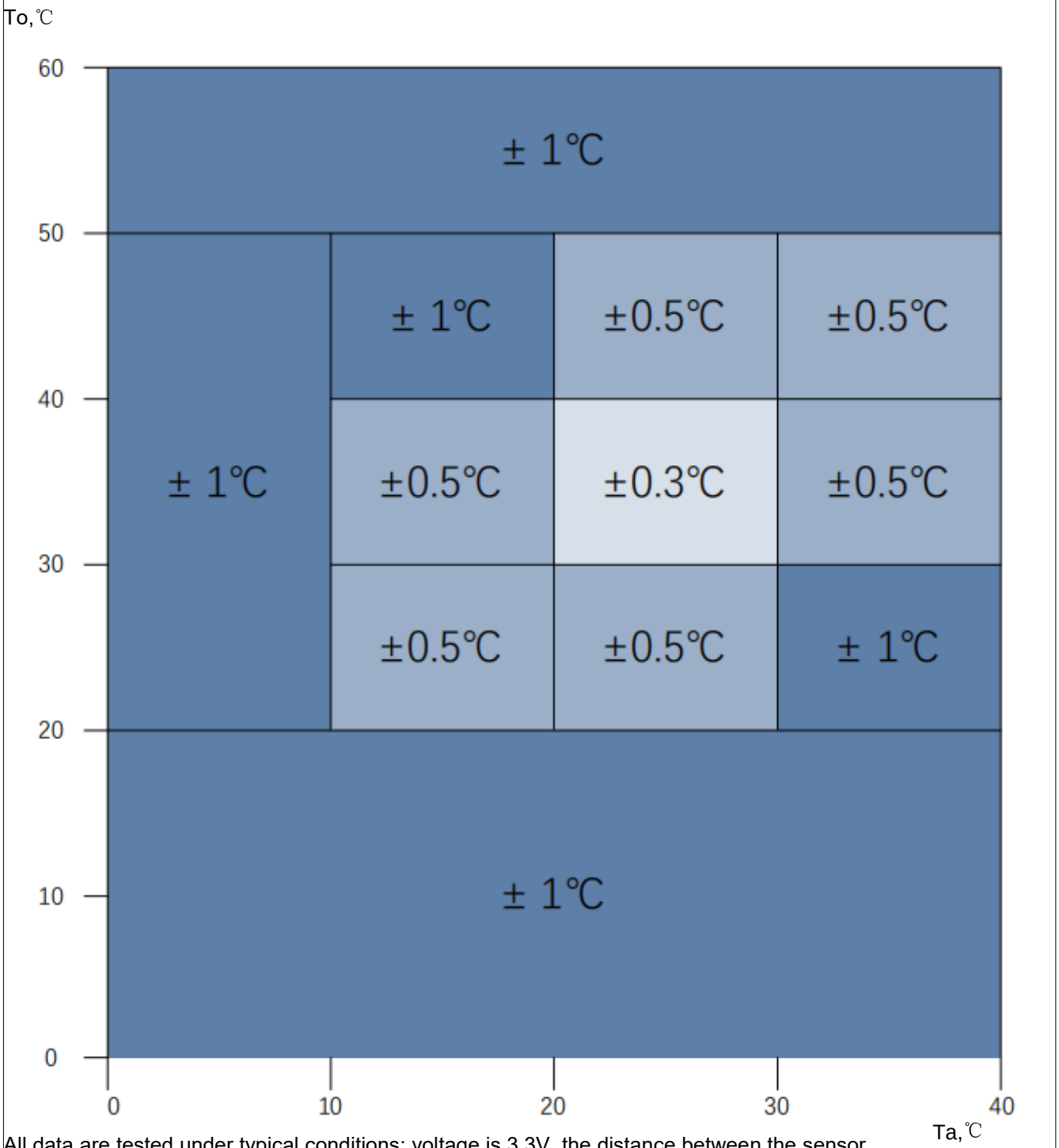
List 2. Sensor performance parameter table

Performance parameters	Symbol	Min	Typ	Max	Unit	Remark
Device size			4.72 × 3.76×2.05（± 0.05）		mm	
Sensitive areas			0.7 ×0.7		mm2	
Field of view			110		°	
Thermistor resistance			100 ± 2%		kΩ (25℃)	
Thermistor Beta value			3950 ± 1%		K(25℃/50℃)	
Operating temperature			-20 ~ 100		℃	
Supply voltage			1.8 ~ 5.5		V	
Power supply current (25℃) During acquisition	I_{DD_pgaoff}		900		μA	PGA off (Gain<=2)
	I_{DD_pgaon}		1500		μA	PGA on (Gain>=4)
Standby current (25℃)		100			nA	
ADC resolution			24		Bit	Thermopile sensors
			16		Bit	Temperature(NTC)

The conditions when no special provisions are made are VCC=3.3V, test environment temperature25°C

SL-S -TRS-5.5D1 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. The accuracy is shown in the following graph for Ta between 0°C and 40 °C and To between 0°C and 60°C.

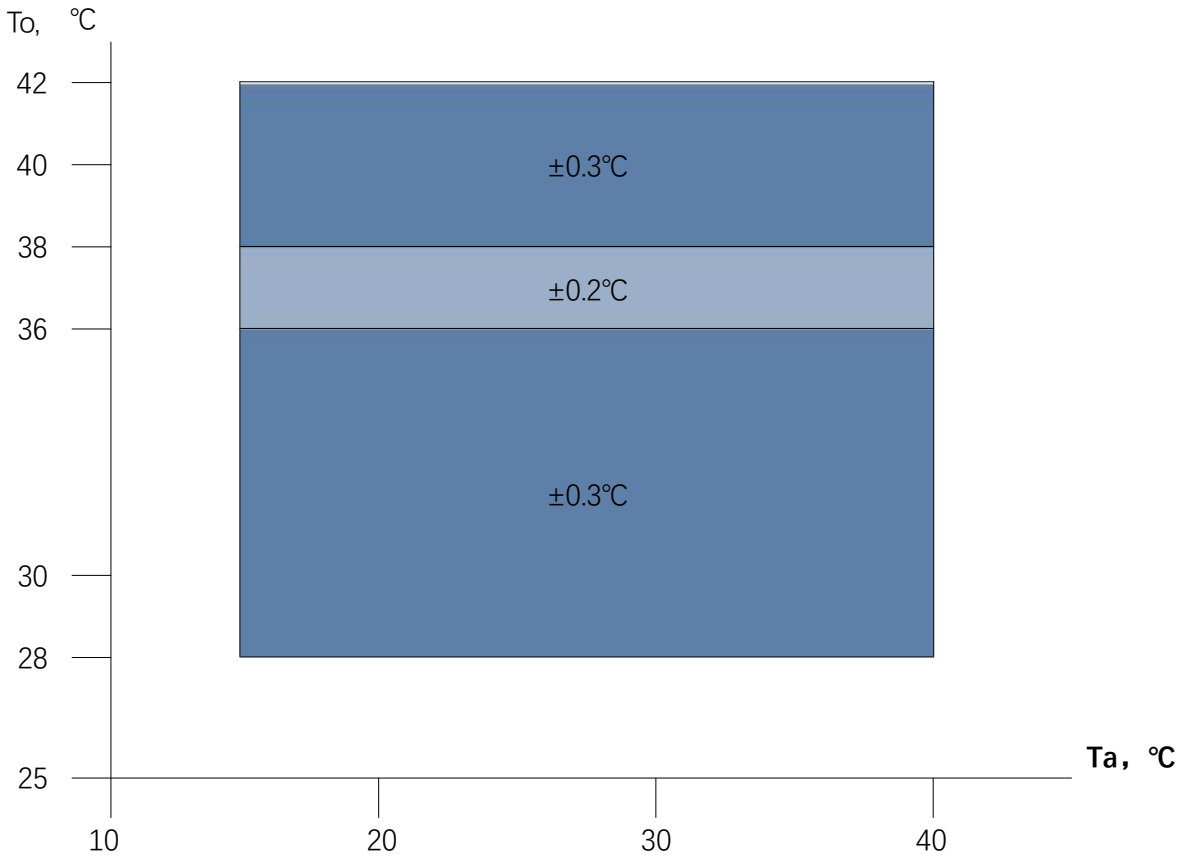


All data are tested under typical conditions: voltage is 3.3V, the distance between the sensor and the target is 2cm, the temperature measurement target is a standard black body furnace, and the corresponding ambient temperature is achieved by changing the temperature of the environmental chamber. All accuracy specifications are only applicable under stable isothermal conditions, and the sensor accuracy does not represent the final product accuracy.

Picture 1. SL-S-TRS-5.5D1（Ta,To）Standard accuracy

SL-S -TRS-5.5D1 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. The accuracy is shown in the following graph for Ta between 15C and 40°C and To between 28°C and 42°C.



All data are tested under typical conditions: voltage is 3.3V, the distance between the sensor and the target is 2cm, 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 2 SL-S-TRS-5.5D1（Ta,To）medical precision

In designing application, it is important to understand that the accuracy given in Figures 1 and 2 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.Thermistor temperature resistance table

List 3. NTC RT List

T(℃)	Rnom(kΩ)	T(℃)	Rnom(kΩ)	T(℃)	Rnom(kΩ)	T(℃)	Rnom(kΩ)	T(℃)	Rnom(kΩ)
-40	3324.301	-11	605.410	18	137.909	47	40.125	76	14.066
-39	3119.086	-10	573.605	19	131.589	48	38.608	77	13.602
-38	2927.677	-9	544.152	20	125.601	49	37.158	78	13.155
-37	2749.070	-8	516.307	21	119.925	50	35.770	79	12.725
-36	2582.337	-7	489.977	22	114.544	51	34.428	80	12.311
-35	2426.625	-6	465.075	23	109.439	52	33. 142	81	11.913
-34	2281.145	-5	441.516	24	104.596	53	31.911	82	11.529
-33	2145.170	-4	419.226	25	100.000	54	30.732	83	11.159
-32	2018.027	-3	398.131	26	95.637	55	29.602	84	10.803
-31	1899.096	-2	378.162	27	91.510	56	28.520	85	10.459
-30	1787.802	-1	359.257	28	87.587	57	27.482	86	10.120
-29	1683.674	0	341.355	29	83.856	58	26.487	87	9.794
-28	1586.152	1	323.531	30	80.308	59	25.533	88	9.479
-27	1494.782	2	306.762	31	76.931	60	24.618	89	9.175
-26	1409.145	3	290.980	32	73.717	61	23.740	90	8.882
-25	1328.852	4	276.120	33	70.657	62	22.897	91	8.600
-24	1253.542	5	262. 122	34	67.742	63	22.089	92	8.327
-23	1182.879	6	248.932	35	64.966	64	21.313	93	8.064
-22	1116.555	7	236.496	36	62.320	65	20.568	94	7.811
-21	1054.280	8	224.768	37	59.798	66	19.852	95	7.566
-20	995.786	9	213.702	38	57.393	67	19.165	96	7.330
-19	941.187	10	203.257	39	55.099	68	18.505	97	7.102
-18	889.832	11	193.394	40	52.911	69	17.871	98	6.882
-17	841.514	12	184.078	41	50.823	70	17.261	99	6.669
-16	796.039	13	175.273	42	48.829	71	16.675	100	6.464
-15	753.227	14	166.950	43	46.926	72	16. 112	101	6.266
-14	712.910	15	159.078	44	45.108	73	15.570	102	6.074
-13	674.931	16	151.631	45	43.371	74	15.049	103	5.889
-12	639.143	17	144.583	46	41.712	75	14.548	104	5.711

Test conditions：25℃ 100 kΩ , B25/50 = 3950K ±1%

4.Control Register

List 4. General registers

Address	Description	R/W	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0	Default
0x00	SPI_Ctrl	RW	SDO_Active		Softreset			Softreset		SDO_Active	0x00
0x01	Part_ID	R	PartID<7:0>								0x00
0x02	Status	R	Error_code<3:0>						1'b0	DRDY	0x00
0x06	Data_ Thermopile	R	Data_P<23:16>								0x00
0x07		R	Data_P<15:8>								0x00
0x08		R	Data_P<7:0>								0x00
0x09	Data_Temp	R	Data_T<15:8>								0x00
0x0A	Data_Temp	R	Data_T<7:0>								0x00
0x30	CMD	RW	Sleep_time<3:0>				Sco	Measurement_ctrl<2:0>			0x00
0x6C	OTP_CMD	RW	Blow_start<6:0>							margin	0x00

Reg0x00
SDO_Active: 1: 4 wire SPI, 0:3 wire SPI
Soft_reset: 1: Reset all registers (except "margin"), and this bit automatically returns to 0 after reset.
Reg0x01
PartID: 8-bit Part ID for OTP programming, corresponding to OTP register Reg0xA4. Read-only from address 0x01.
Reg0x02
DRDY: 1, indicating that a data collection is completed and the collected data can be read.
Error_code: When the diagnostic function is enabled, these bits store error information.
Reg0x06-Reg0x08
Data_Thermopile: 24-bit Thermopile Sensor Raw Data: Data_P<23:16>=0x06<7:0>, Data_P<15:8>=0x07<7:0>, Data_P<7:0>=0x08<7:0>
Reg0x09-Reg0x0A
Data_Temp: 16bit NTC raw data: Data_T<15:8> = 0x09<7:0>, Data_T<7:0> = 0x0A<7:0>
Reg0x30
Sleep_time<3:0>: 0000: 0msk, 000: 62.5ms, 0010: 125ms …… 1111: 1s, Only valid during sleep mode operation.
Measurement_control<1:0>: 000b, indicates a single temperature signal acquisition. 001b, indicates a single sensor signal acquisition. 010b, indicates a combined acquisition mode (a temperature signal acquisition is immediately followed by a sensor signal acquisition). 011b: indicates a sleep mode (a combined acquisition mode is performed periodically, the interval is determined by "sleep_time". 100b: OTP programming mode, enter this mode when programming the OTP library.
Sco：1, Indicates the start of acquisition and automatically returns to 0 after the acquisition is completed (except during sleep mode).
Reg0x6C
Blow_start <6:0>: Writing 0110101b to this bit starts programming the OTP. The entire OTP bank will be automatically programmed with the contents stored in the corresponding OTP registers. The OTP bank can only be programmed once.
Margin: Provides critical read condition to filter out “weak programmed” bit when OTP is reloaded during soft reset. It is recommended to set this bit after OTP programming at factory to check if OTP bank has been programmed properly.

5.OTP register

List 5. OTP register

Address	Description	R/W	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0	Default
0xA4	Part_ID	RW	Part ID<7:0>								OTP
0xA5	Sys_config	RW	DAC_on	P_T_ration <1:0>		Vout_sel	Regulator_ sel	Unipolar	Raw_ data_ on	Diag_on	OTP
0xA6	P_config	RW	1'b0	Input_ swap	Gain_P<2:0>			OSR_P<2:0>			OTP
0xA7	T_config_ 1	RW	Temp_sel<1:0>		Gain_T<2:0>			OSR_P<2:0>			OTP
0xA8	T_config_2	RW	4b0000				T_offset_trim<3:0>				OTP
0xA9	DAC_limit	RW	DAC_limit_h<3:0>				DAC_limit_l<3:0>				OTP
0xAA	Cal_OTP_ 1	RW	Cal_coff_ 1<7:0>								OTP
…	…	RW	…								OTP
0xBB	Cal_OTP_ 18	RW	Cal_coff_ 19<7:0>								OTP
0xBC	Redundancy	RW	Redundancy<7:0>								OTP

Reg0xA4
PartID: The 8-bit Part ID programmed by OTP can also be read from address 0x01.
Reg0xA5
Vout_sel: 0: Set the DAC output to rail-to-rail, that is, consistent with the voltage on the VDD pin. 1: Set the DAC output to a fixed voltage output with an output range of 0-1.5 * VEXT.
Regulator_sel: 0: Set the VEXT voltage to 1.8V. 1: Set the VEXT voltage to 3.6V.
Unipolar: 0: ADC output in bipolar format. 1: ADC output in unipolar format. (Only effective when "raw_data_on" = 1).
Diag_on: 1， Enable diagnostic features.
Reg0xA6
Input Swap: Swapping inputs internally in the ADC.
Gain_P: Set the gain of the sensor signal acquisition channel. 000: Gain = 1, 001: Gain = 2, 010: Gain = 4, 011: Gain = 8, 100: Gain = 16, 101: Gain = 32, 110: Gain = 64, 111: Gain = 128.
OSR_P: Set the oversampling rate of the sensor signal acquisition channel.000: 1024X , 001: 2048X , 010: 4096X, 011: 8192X, 100: 256X , 101: 512X, 110: 16384X , 111: 32768X.
Reg0xA7
Temp_sel: Set to 10b (external temperature sensor).
Gain_T: Set the gain of the temperature acquisition channel. 000: Gain = 1, 001: Gain = 2, 010: Gain = 4, 011: Gain = 8, 100: Gain = 16, 101: Gain = 32, 110: Gain = 64, 111: Gain = 128.
OSR_T: Set the oversampling rate of the temperature acquisition channel.000: 1024X , 001: 2048X， 010: 4096X , 011: 8192X, 100: 256X, 101: 512X , 110: 16384X, 111: 32768X
Reg0xA8
T_offset_trim: Set the offset voltage of external temperature acquisition from 0V to VEXT (set to 0x08).
Reg0xAA- Reg0xBB
Cal_coff: Coefficients for sensor calibration (set 0xAB to 0x04 and 0xB3 to 0x08).
Reg0xBC
Redundancy: Represents a pointer that causes pointed OTP bit to operate as programmed, even if programming fail.

6.Digital communications

SL-S-TRS-5.5D1 provides I2C communication protocol for serial communication. The choice of communication protocol is based on the CSB state.

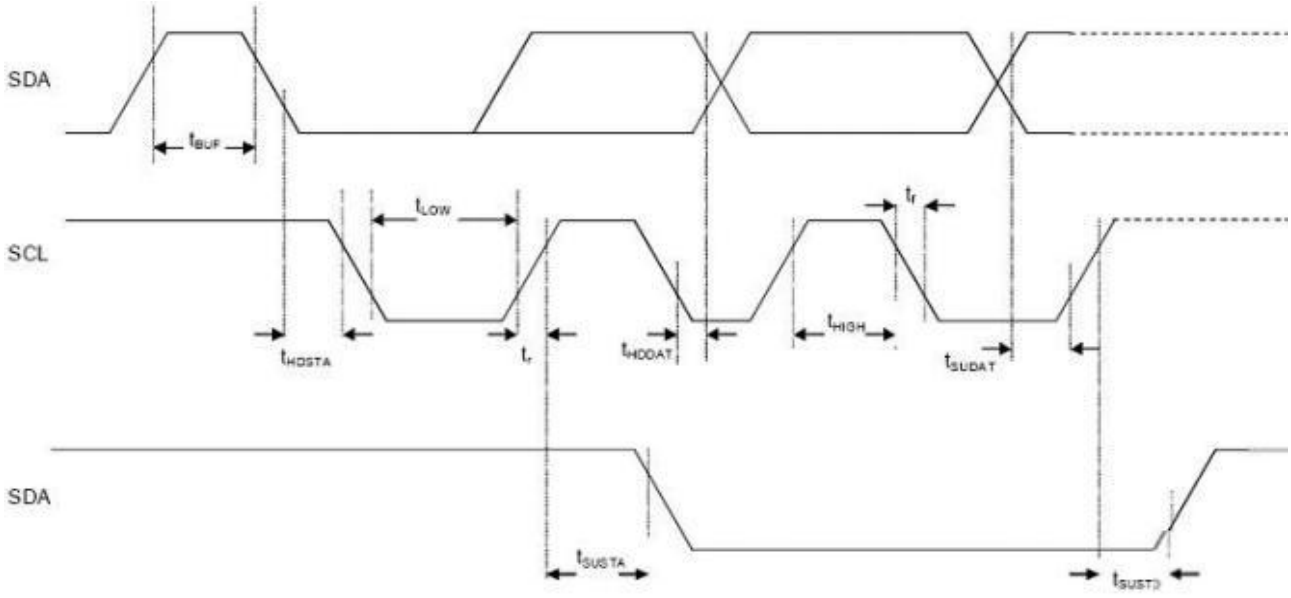
The I2C bus uses SCL and SDA as signal lines, both of which are externally connected to VDDIO through pull-up resistors so that they remain high when the bus is idle. The I2C device address of SL-S -TRS-5.5D1 is shown in the following table. The LSB bit of the 7-bit device address is determined by the SDO pin. If SDO is connected to VDDIO, the 7-bit I2C address is "1101101". If SDO is connected to GND, the 7-bit I2C address is "1101100".

List 6. I2C Device address

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

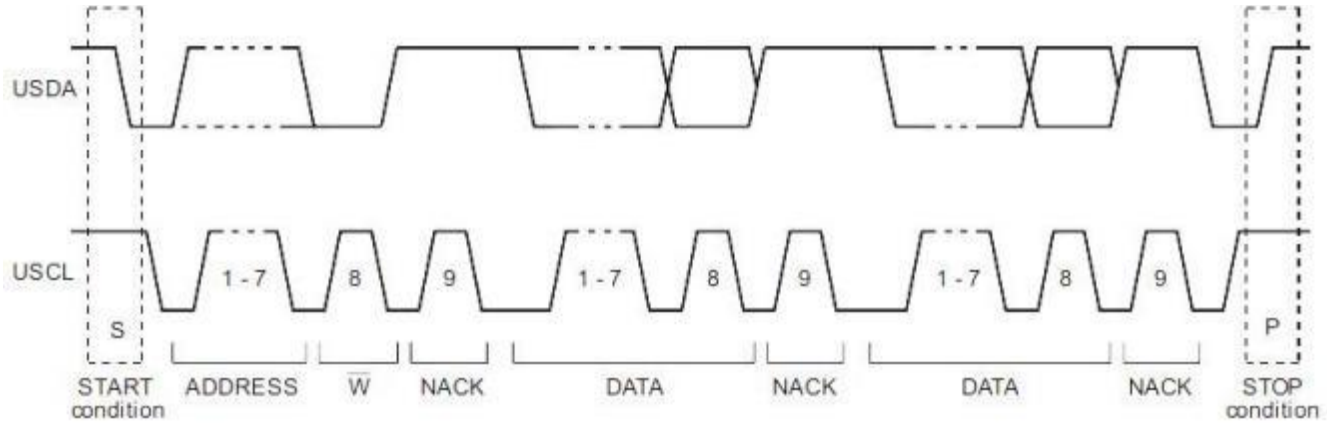
List 7. I2C Electrical characteristics of communication pins

Symbol	Parameter	Condition	Min	Max	Unit
fscl	Clock frequency			400	kHz
tscl_l	SCL low pulse		1.3		μs
tscl_h	SCL High pulse		0.6		μs
Tsda_setup	SDA Build time		0.1		μs
Tsda_hold	SDA Keep time		0.0		μs
tsusta	The build time at the start of each		0.6		μs
thdsta	Start condition hold time		0.6		μs
tsusto	Stop condition setup time		0.6		μs
tbuf	The interval between two communications		1.3		μs



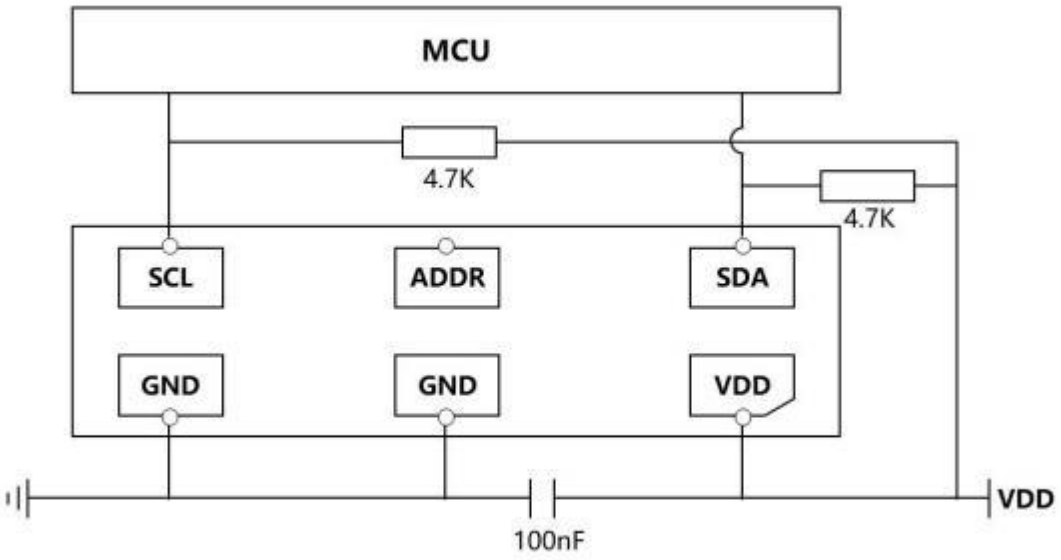
Picture 3. I2C Timing diagram

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.



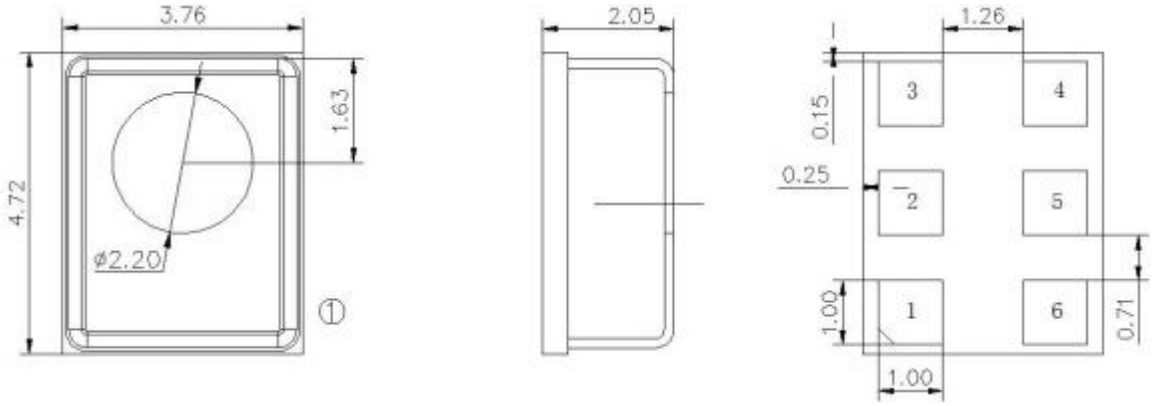
List 2. I2C Communication protocol

7.General application circuit



Picture 5. General application circuit

8.Mechanical specifications



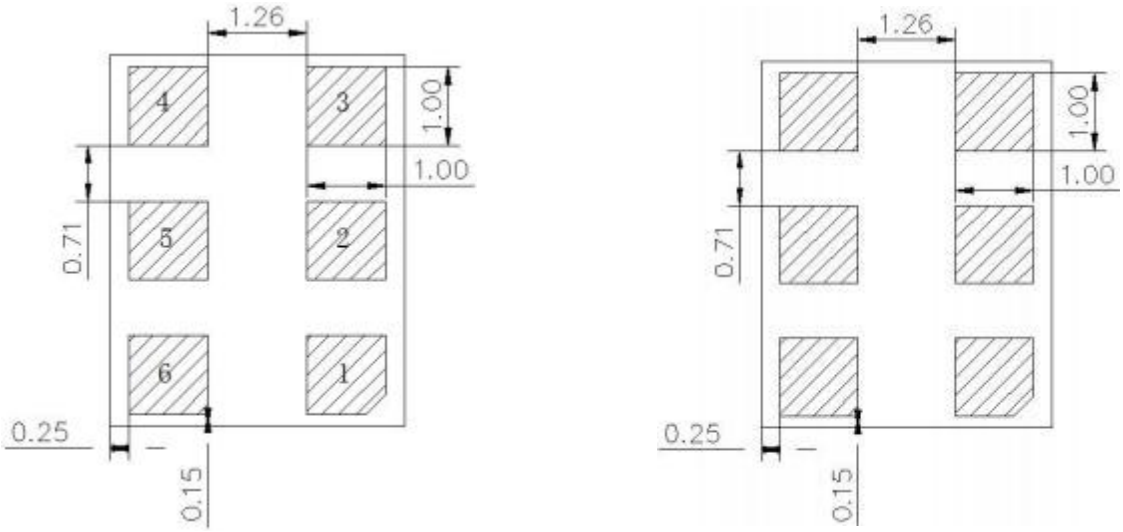
Top view Side view Bottom view

Picture 6. Outline size

List 8. Pin definition

Serial number	Symbol	Sefinition
1	VDD	Supply Voltage
2	GND	GROUND
4	SCL	I2C Data
5	ADDR	I2C Mmde address selection
6	SDA	I2C Clock

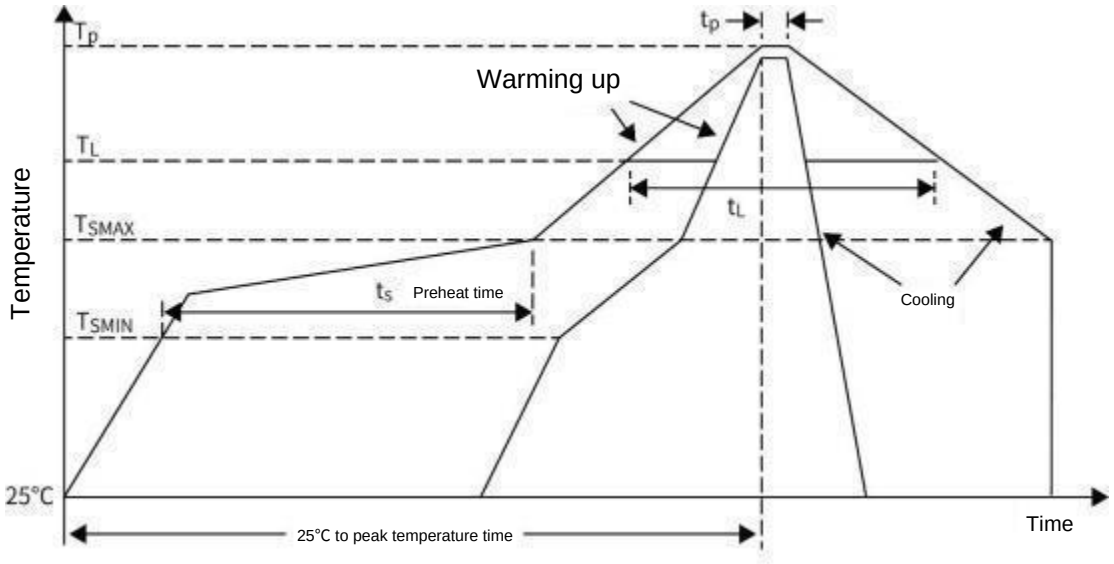
9.Recommended pad and steel mesh design



Recommended pad design Recommended steel mesh design

Picture 7. Recommended pad and steel mesh design (Unit: mm)

10.Recommended reflow profile

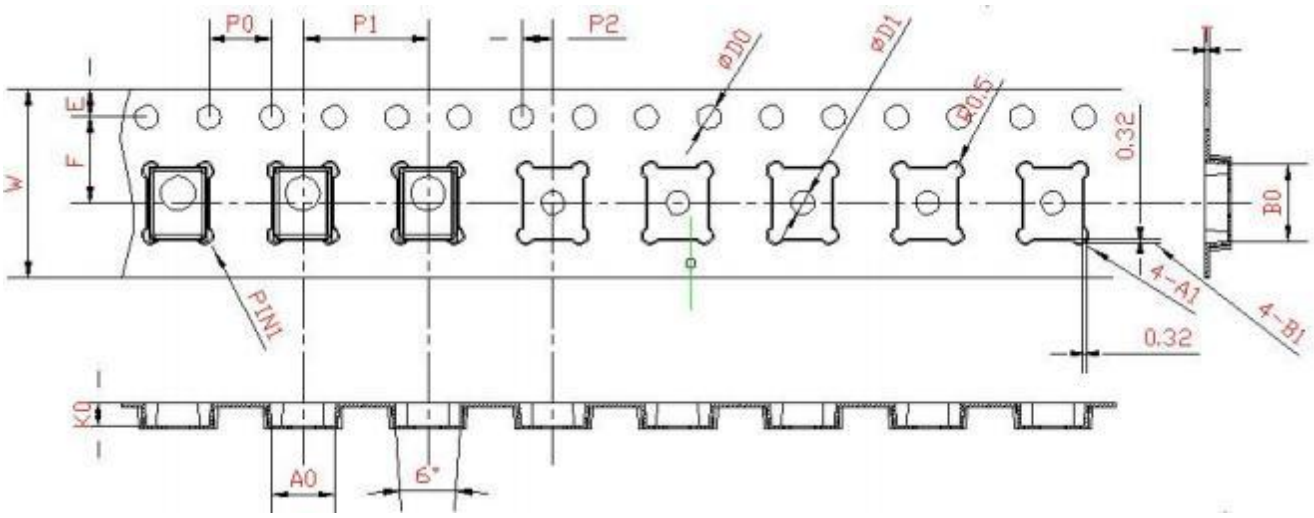


Picture 8. Recommended lead-free solder reflow temperature profile distribution diagram

List 9. Recommended lead-free solder reflow temperature curve distribution parameter table

Curve characteristics		Lead free
Average heating rate（T_{SMAX} to T_P)		Maximum 3℃/s
Preheat	Minimum 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
Peak 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

11.Boxing Specifications

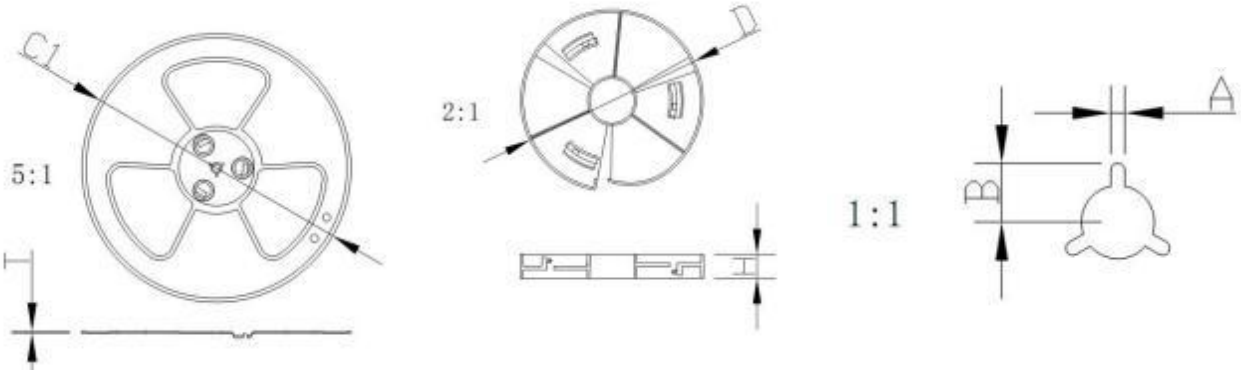


Picture 9. Carrier tape specifications

List 10. Carrier tape specifications (Unit：mm)

Symbol	Size	Symbol	Size
D0	1.50 ± 0.10	W	12.0 ± 0.30
D1	1.50 ± 0.10	E	1.75 ± 0.10
A0	4.06 ± 0.10	F	5.50 ± 0.10
B0	5.02 ± 0.10	P0	4.00 ± 0.10
K0	2.30 ± 0.10	P1	8.00 ± 0.10
T	0.30 ± 0.05	P2	2.00 ± 0.10

Note: (1) Tape and reel comply with EIA-481 standard. (2) Label is affixed to the outer packaging, and only the reel is inside.



Picture 10. Reel specifications

List 11. Reel Specifications

Symbol	Size	Unit
SPEC	13	inch
C1±1.0	Φ330	mm
A±0.2	2.6	mm
B±0.2	10.8	mm
T±0.2	2.0	mm
Available roll sizes	Carrier tape width: 12	mm
	D±0.5: Φ100	mm
	H+1:12.5	mm