PJ85718

±1°C Remote and Local Temperature Sensor with Digital Interface In a MSOP-8 Package

GENERAL DESCRIPTION

The PJ85718 is a digital temperature sensor with ± 1°C accuracy. Temperature data can be read out directly via SMBus interface by MCU or SoC chip.

PJ85718 has two independent channels: one remote and one local sensor. The remote sensor could be connected to an external Diode or BJT transistor (diode-connected mode).

Each chip is calibrated in factory before shipment to customers. There is no need for re-calibration anymore for ±1°C accuracy.

It includes a band-gap circuit, an Analog to Digital converter, a calibration unit with non-volatile memory and a digital interface block.

It integrates an 11-bit ADC, which can offer 0.125°C resolution. The maximum temperature readout range can be up to 160°C plus offset shifting register.

It has 2 logic output pin (/ALERT, /THERM) with open drain structure, which are active low as default.

Available Package : MSOP-8

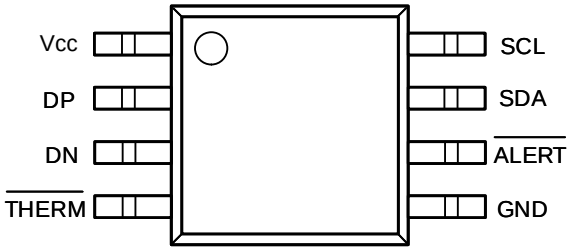
FEATURES

- Operation Voltage : 1.75V to 5.5V
- Average Quiescent Current : 45uA at 1.0con/s
- Standby Current : 3.0uA (Max.)
- Temperature Accuracy without calibration:
  - ±1°C from 0°C to 100°C
  - ±2°C from -4°C to 125°C
- 11 bit ADC for 0.125°C resolution
- Digital interface compatible with SMBus, 2-wire and I^2C
- Temperature Range up to 160°C plus offset shifting register for Remote Sensor Channel
- Programmable Over/Under Alarm Temperature and Hysteresis Temperature
- Independent Remote and Local Temperature Sensing Channel
- Support SMBus ALERT Response Address
- Temperature Range: -40°C to 125°C

APPLICATIONS

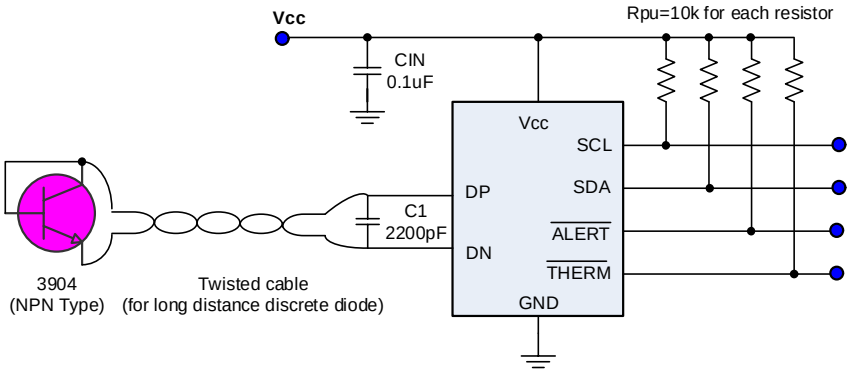
- Desktop & Notebook Computer
- Telecom Equipment
- Multi-cell Battery Pack
- Smart HVAC System

PIN CONFIGURATION



MSOP-8 (TOP VIEW)

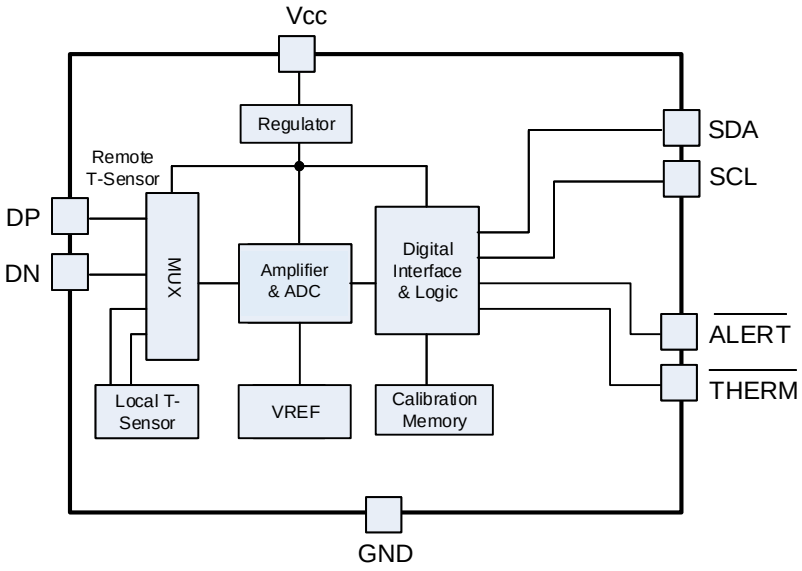
APPLICATION SCHEMATIC



FUNCTIONAL PIN DESCRIPTION

TERMINAL		DESCRIPTION
NUMBER	NAME	
1	Vcc	**Power supply input pin**, using **0.1uF** low ESR ceramic capacitor to ground
2	DP	**Remote sensor positive input pin**, it could be positive node of Diode, or BJT transistor (diode-connected mode). It is recommended to use **2200pF bypass capacitor** to remove noise between DP and DN pin.
3	DN	**Remote sensor negative input pin**, it could be negative node of Diode, or BJT transistor (diode-connected mode). It is recommended to use **2200pF bypass capacitor** to remove noise between DP and DN pin.
4	$\overline{\text{THERM}}$	**Open drain output** with active low. need a pull-up resistor to Vcc.
5	GND	**Ground pin**.
6	$\overline{\text{ALERT}}$	**Open drain output** with active low. need a pull-up resistor to Vcc.
7	SDA	**Digital interface data input** or output pin, need a pull-up resistor to Vcc.
8	SCL	**Digital interface clock input pin**, need a pull-up resistor to Vcc.

FUNCTION BLOCK



ORDERING INFORMATION

ORDER NUMBER	Slave Address (R/W)	Package	Description
PJ85718M_R2	**0x99/98**	**MSOP-8**	**Halogen free RoHS compliant in T/R, 3,000 pcs/Reel**

Order PN	Slave Address (R/W)	Accuracy	Green[1]	Package	Marking ID	Packing	MPQ	Operation Temperature
PJ85718M_R2	0x99/98	±1°C	Halogen free	MSOP-8	A3 YM DNN	Tape & Reel	3,000	-40°C ~+125°C
PJ85718AM_R2	0x91/90	±1°C	Halogen free	MSOP-8	A4 YM DNN	Tape & Reel	3,000	-40°C ~+125°C
PJ85718BM_R2	0x93/92	±1°C	Halogen free	MSOP-8	A5 YM DNN	Tape & Reel	3,000	-40°C ~+125°C
PJ85718CM_R2	0x95/94	±1°C	Halogen free	MSOP-8	A6 YM DNN	Tape & Reel	3,000	-40°C ~+125°C
PJ85718DM_R2	0x9B/9A	±1°C	Halogen free	MSOP-8	A7 YM DNN	Tape & Reel	3,000	-40°C ~+125°C
PJ85718EM_R2	0x97/96	±1°C	Halogen free	MSOP-8	A8 YM DNN	Tape & Reel	3,000	-40°C ~+125°C
PJ85718FM_R2	0x9D/9C	±1°C	Halogen free	MSOP-8	A9 YM DNN	Tape & Reel	3,000	-40°C ~+125°C
PJ85718GM_R2	0x9F/9E	±1°C	Halogen free	MSOP-8	A0 YM DNN	Tape & Reel	3,000	-40°C ~+125°C

Note 1

1. Panjit can meet RoHS 2.0/REACH requirement. So most package types Panjit offers only states halogen free, instead of lead free.

ABSOLUTE MAXIMUM RATINGS

Over operating free-air temperature range (unless otherwise noted) (1)

PARAMETER		MIN	MAX	Unit
Supply Voltage	V_{CC} to GND	-0.3	7	V
SDA, SCL Voltage	V_{SDA}/V_{SCL} to GND	-0.3	7	V
DXP Voltage	V_{DXP} to GND	-0.3	V_{CC}+0.3	V
DXN Voltage	V_{DXN} to GND	-0.3	0.3	V
/THERM, /ALERT Voltage	V_{THERM}/V_{ALERT} to GND	-0.3	7	V
DXN Current	I_{DXN} to GND	-1.0	1.0	mA
Operating junction temperature range	T_J	-50	150	°C
Storage temperature range	T_{stg}	-65	150	°C

(1) Stresses beyond those listed under ***absolute maximum ratings*** may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under ***recommended operating conditions*** is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

HANDLING RATINGS

PARAMETER	DEFINITION	MIN	MAX	UNIT
ESD(1)	Human Body Model (HBM) ESD stress voltage(2)	-2	2	kV
	Charged Device Model (CDM) ESD stress voltage(3), all pins	-1	1	kV

(1) Electrostatic discharge (ESD) to measure device sensitivity and immunity to damage caused by assembly line electrostatic discharges into the device.

(2) Level listed above is the passing level per ANSI, ESDA, and JEDEC JS-001. JEDEC document JEP155 states that 500-V HBM allows safe manufacturing with a standard ESD control process.

(3) Level listed above is the passing level per EIA-JEDEC JESD22-C101. JEDEC document JEP157 states that 250-V CDM allows safe manufacturing with a standard ESD control process.

RECOMMENDED OPERATING CONDITIONS

PARAMETER		MIN	TYP	MAX	UNIT
V_{CC}	Supply Voltage	2.5		5.5	V
T_A	Operating Ambient temperature	-40		125	°C

ELECTRICAL CHARACTERISTICS

Test Condition: C_{IN} = 0.1uF, C_1 = 2200pF, V_{CC} = 3.0V to 5.0V, unless otherwise specified, all limits are 100% test at T_A=25°C. (1)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
V_{CC}	Supply voltage range		1.75		5.5	V
T_{RAC}	Temperature Accuracy (Remote Sensor)	T_A = 0 to 110°C	-1.0		1.0	°C
		T_A = -40 to 125°C	-2.0		2.0	°C
T_{LAC}	Temperature Accuracy (Local Sensor)	T_A = 0 to 110°C	-1.0		1.0	°C
		T_A = -40 to 125°C	-1.8		1.8	°C
I_{AOC}	Average Operating Current	V_{IN} = 3.3V, 1.0 con/s		35	40	uA
		V_{IN} = 5.0V, 1.0 con/s		45	50	uA
I_{SD}	Shutdown Current	Enable STB bit, force SDA/SCL to Vcc or GND		3	6	µA
V_{ODL}	Open Drain Output Voltage	/ALERT, /THERM pin, sink 5mA	0		0.2	V
I_{ODL}	Open Drain Leakage	/ALERT, /THERM pin Leakage	-1.0		1.0	uA
T_{CON}	Conversion time (each channel)	From active to finish completely		16		mS
DIGITAL INTERFACE						
C_{IL}	Logic Input Capacitance	SDA, SCL pin		3		pF
V_{IH}	Logic Input High Voltage	SDA, SCL pin	1.4		V_{CC}+0.3	V
V_{IL}	Logic Input Low Voltage	SDA, SCL pin	-0.3		0.62	V
I_{INL}	Logic Input Current	SDA, SCL pin	-1.0		1.0	uA
I_{OLS}	Logic Output Sink Current	SDA, /ALERT, /THERM pin, forced 0.2V		5		mA
f_{CLK}	SCL frequency	Fast Mode	10		400	KHz
		High Speed Mode	0.001		1	MHz
t_{LOW}	Clock low period time		1300			nS
t_{HIGH}	Clock high period time		600			nS
t_{BUF}	Bus free time	Between Stop and Start condition	1200			nS
$t_{HD:STA}$	Hold time after Start condition		600			nS
$t_{SU:STA}$	Repeated Start condition setup time		600			nS
$t_{SU:STO}$	Stop condition setup time		600			nS
$t_{HD:DAT}$	Data Hold time		100			nS
$t_{SU:DAT}$	Data Setup time		100			nS
t_F	Clock/Data fall time				300	nS
t_R	Clock/Data rise time				1000	nS

(1) ***All devices are 100% production tested at T_A = +25°C; all specifications over the automotive temperature range is guaranteed by design, not production tested.***

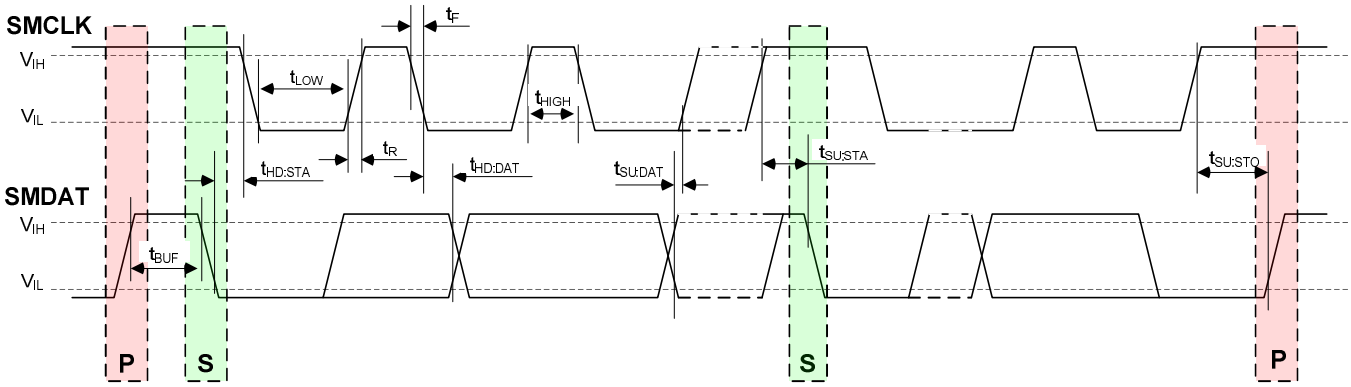


Figure 1. SMBus Timing Diagram

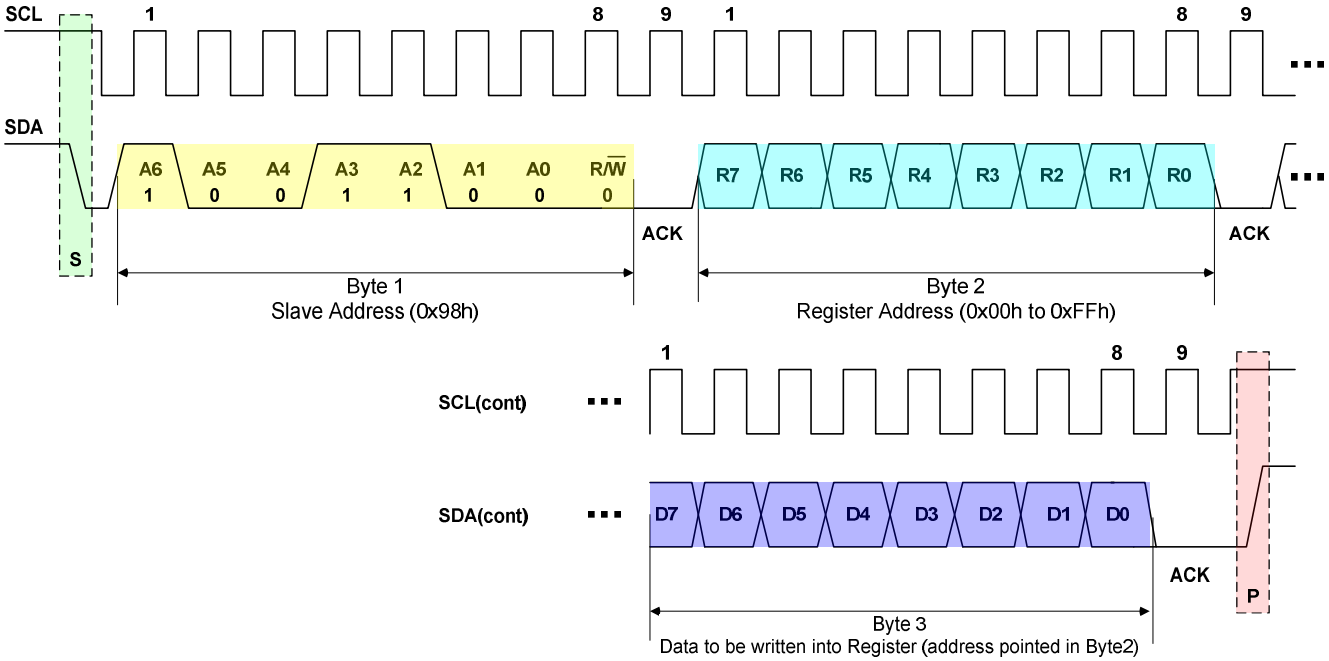


Figure 2. SMBus Write Timing Diagram

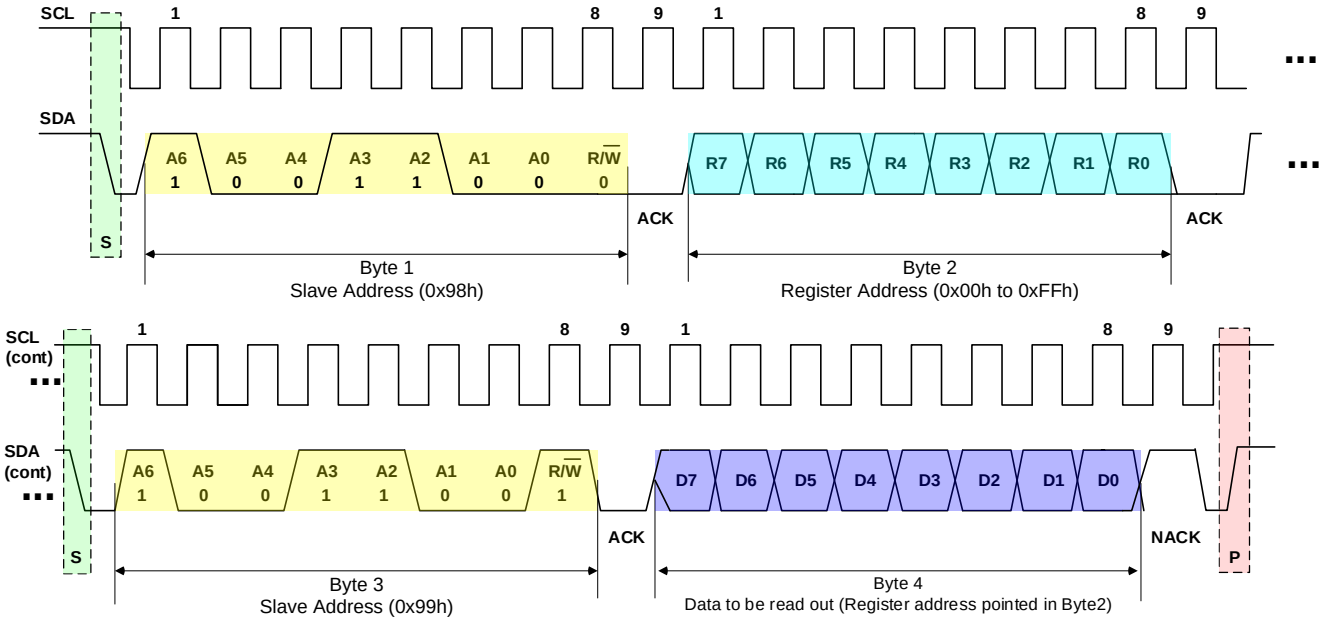


Figure 3. SMBus Read Timing Diagram

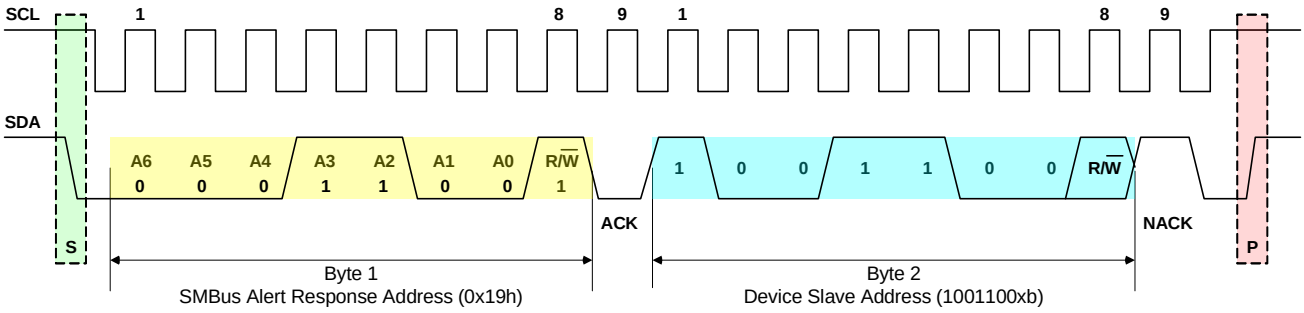


Figure 4. SMBus ALERT Response Diagram

Characteristics

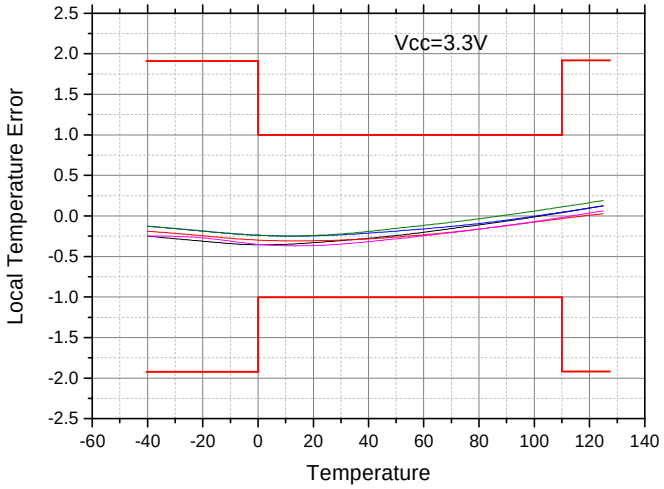


Figure 5. Local Temperature Error vs. Temperature

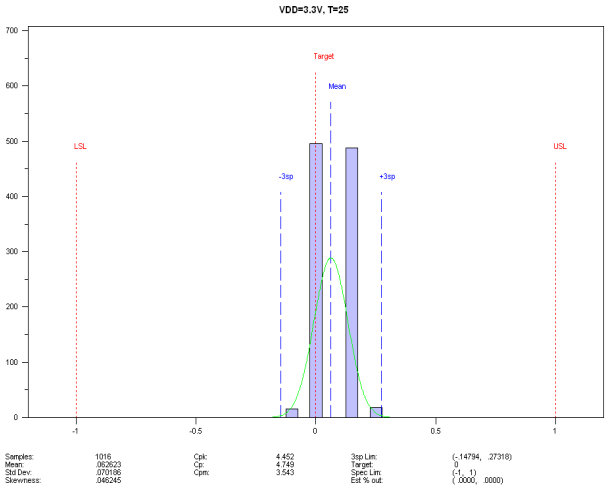


Figure 8. Local Temperature Error Distribution

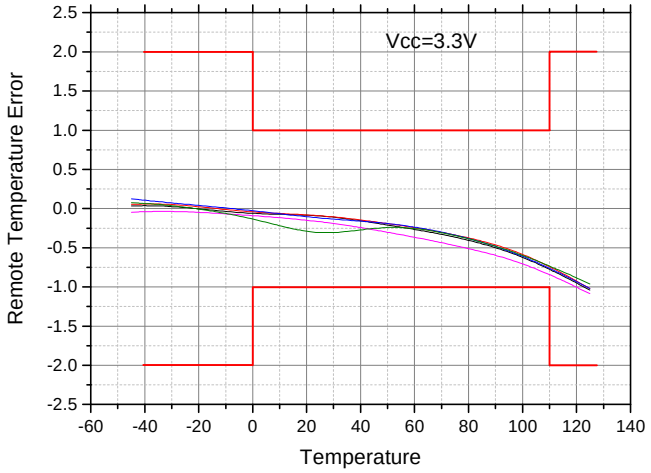


Figure 6. Remote temperature Error vs. Temperature

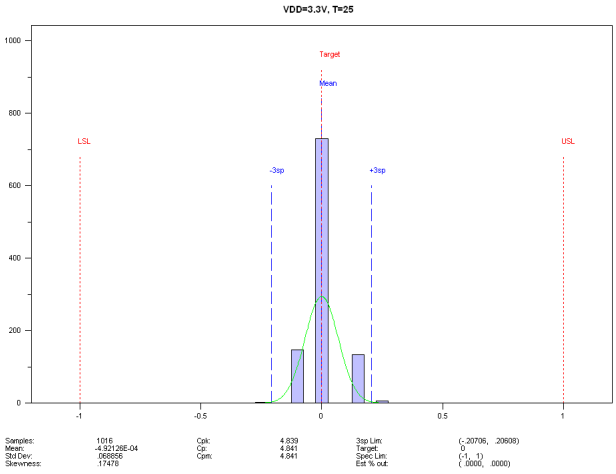


Figure 9. Remote Temperature Error Distribution

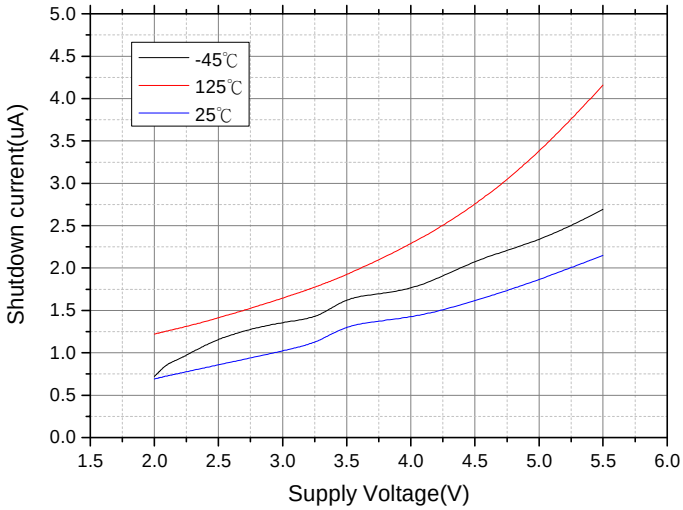


Figure 7. Shutdown current vs. Temperature

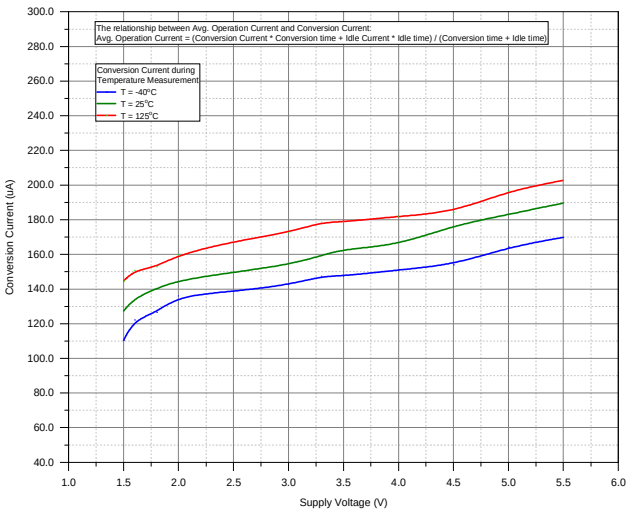


Figure 10. Conversion Current vs. Supply Voltage

FUNCTION DESCRIPTION

Overview

The chip can sense the local and remote temperatures and convert them into digital data by an11-bit ADC and two remote and local sensors. Also the chip supports programmable high-limit, low-limit temperature settings for both sensor channels. If the measured temperature goes below the low-limit or above high-limit, /ALERT pin will be asserted. If the measured temperature exceeds THERM limit (programmable by user), /THERM pin will be asserted.

Digital Output of Temperature Data

The temperature measurement data are in the local temperature and remote temperature register (Read only). Both Remote and Local sensor temperatures are stored in 11-bit binary format with the eight most significant bits [MSB] stored in a high byte register and the three least significant bits [LSB] stored in the three MSB positions of the low byte register. And all other bits of low byte register are set to zero.

Table 1. Sensor Temperature vs. 8-bit Digital Data

Temperature (°C)	8-bit Digital Output (HEX)	8-bit Digital Output (BIN)
+127	0x7F	0 1 1 1 , 1 1 1 1
+100	0x64	0 1 1 0 , 0 1 0 0
+25	0x19	0 0 0 1 , 1 0 0 1
+2	0x02	0 0 0 0 , 0 0 1 0
+1	0x01	0 0 0 0 , 0 0 0 1
0	0x00	0 0 0 0 , 0 0 0 0
-1	0xFF	1 1 1 1 , 1 1 1 1
-2	0xFE	1 1 1 1 , 1 1 1 0
-25	0xE7	1 1 1 0 , 0 1 1 1
-100	0x9C	1 0 0 1 , 1 1 0 0
-127	0x81	1 0 0 0 , 0 0 0 1
-128	0x80	1 0 0 0 , 0 0 0 0

Table 2. Sensor Temperature vs. 11-bit Digital Data

Temperature (°C)	11-bit Digital Output (HEX)	8-bit Digital Output (BIN) (MSB)	3-bit Digital Output (BIN) (LSB)
+127.875	0x3FF	0 1 1 1 , 1 1 1 1	1 1 1 X , X X X X
+100.500	0x324	0 1 1 0 , 0 1 0 0	1 0 0 X , X X X X
+25.750	0x0CE	0 0 0 1 , 1 0 0 1	1 1 0 X , X X X X
+2.250	0x012	0 0 0 0 , 0 0 1 0	0 1 0 X , X X X X
+1.125	0x009	0 0 0 0 , 0 0 0 1	0 0 1 X , X X X X
0.000	0x000	0 0 0 0 , 0 0 0 0	0 0 0 X , X X X X
-1.125	0x7F7	1 1 1 1 , 1 1 1 0	1 1 1 X , X X X X
-2.250	0x7EE	1 1 1 1 , 1 1 0 1	1 1 0 X , X X X X
-25.750	0x732	1 1 1 0 , 0 1 1 0	0 1 0 X , X X X X
-100.500	0x4DC	1 0 0 1 , 1 0 1 1	1 0 0 X , X X X X
-127.875	0x401	1 0 0 0 , 0 0 0 0	0 0 1 X , X X X X

Remote Sensor Higher than 127°C

When temperature of remote sensor is higher than 127°C, the remote offset register including RT_OFT_MSB and RT_OFT_LSB should be set to a minus number and the remote temperature register including RT_MSB and RT_LSB reading should be interpreted with the same offset. For example, if the maximum remote temperature is 150°C then set the remote temperature offset register RT_OFT_MSB to -23(11101001b in 2's complement) (127+23=150). With this setting, if the RT_MSB and RT_LSB register reading is 100°C then add 23°C to it. The result of 123°C is the remote temperature. If reading is 120°C, then 143°C is the converted result by the chip.

Register Map (All registers are shown as below table.)

Table 3. Register Map

Register Address	Register Name	Attribution	Default Data	BIT							
				7	6	5	4	3	2	1	0
0x00	LT_MSB	RO	0x00	LT[10:3]							
0x01	RT_MSB	RO	0x00	RT[10:3]							
0x02	Alert_Status	RO	N/A	ADC_B	STS_ LTHA	Reserved	STS_ RTHA	STS_ RTLA	STS_ RTO	STS_ RTM	STS_ LTM
0x03	Configuration	R/W	0x25	ALERT_ MSK	STB	Reserved			EN_ RTM	EN_ CT	EN_ FQ
0x04	Conv_Rate	R/W	0x08	Reserved				Conv_rate[3:0]			
0x05	LT_HAT	R/W	0x46	LT_HAT[10:3]							
0x06	Reserved										
0x07	RT_HAT_MSB	R/W	0x46	RT_HAT[10:3]							
0x08	RT_LAT_MSB	R/W	0xD8	RT_LAT[10:3]							
0x09	Configuration	R/W	0x25	ALERT_ MSK	STB	Reserved			EN_ RTM	EN_ CT	EN_ FQ
0x0A	Conv_Rate	R/W	0x08	Reserved				Conv_rate[3:0]			
0x0B	LT_HAT	R/W	0x46	LT_HAT[10:3]							
0x0C	Reserved										
0x0D	RT_HAT_MSB	R/W	0x46	RT_HAT[10:3]							
0x0E	RT_LAT_MSB	R/W	0xD8	RT_LAT[10:3]							
0x0F	One_Shot_Con	WO	0x00								
0x10	RT_LSB	RO	0x00	RT[2:0]			Reserved				
0x11	RT_OFS_MSB	R/W	0x00	RT_OFS[10:3]							
0x12	RT_OFS_LSB	R/W	0x00	RT_OFS[2:0]			Reserved				
0x13	RT_HAT_LSB	R/W	0x00	RT_HAT[2:0]			Reserved				
0x14	RT_LAT_LSB	R/W	0x00	RT_LAT[2:0]			Reserved				
0x15	LT_LSB	R/W	0x00	LT[2:0]			Reserved				
0x16	ALERT_MASK	R/W	0x03	MSK_ LTH	Reserved		MSK_ RTH	MSK_ RTL	0	1	1
0x19	RT_THERM	R/W	0x55	RT_THERM[7:0]							
0x20	LT_THERM	R/W	0x55	LT_THERM[7:0]							
0x21	THERM_HYS	R/W	0x0A	Reserved			THERM_HYS[4:0]				
0xBF	ALERT_MODE	R/W	0x00								ALERT_ MODE
0xFD	Chip_ID	RO	0x50	0	1	0	1	0	0	0	0
0xFE	Manufacturer_ID	RO	0x59	0	1	0	1	1	0	0	1
0xFF	Device_ID	RO	0x8D	1	0	0	0	1	1	0	1

Register Description

LT_MSB, Local Temperature MSB Data

- Register Address: 0x00
- Register Attribution: Read only
- Default Data: 0x00in Standby mode after POR

BIT	7	6	5	4	3	2	1	0
Name	LT[10:3]							
Temperature Data	SIGN	64	32	16	8	4	2	1

RT_MSB, Remote Temperature MSB Data

- Register Address: 0x01
- Register Attribution: Read only
- Default Data: 0x00 in Standby mode after POR

BIT	7	6	5	4	3	2	1	0
Name	RT[10:3], it is MSB data, plus LSB data RT[2:0] forms complete RT Temperature Data							
Temperature Data	SIGN	64	32	16	8	4	2	1

Alert_Status, show the chip alert status

- Register Address: 0x02
- Register Attribution: Read Only
- Default Data: N/A

BIT	7	6	5	4	3	2	1	0
Name	ADC_B	STS_LTHA	Reserved	STS_RTHA	STS_RTLA	STS_RTO	STS_RTM	STS_LTM
Default	N/A							

BIT	Name	Description
7	ADC_B	1 - means ADC is busy for Data converting
6	STS_LTHA	1 - means temperature in local sensor is higher than local sensor set high limit
5	Reserved	
4	STS_RTHA	1 - means temperature in remote sensor is higher than remote sensor set high limit
3	STS_RTLA	1 - means temperature in remote sensor is lower than or equal to remote sensor set low limit
2	STS_RTO	1 -- means remote diode is open/disconnected
1	STS_RTM	1 -- means remote sensor THERM alarm active
0	STS_LTM	1 -- means local sensor THERM alarm active

Configuration, for configuring the chip

- Register Address: 0x03 and 0x09
- Register Attribution: Read/Write
- Default Data: 0x25

BIT	7	6	5	4	3	2	1	0
Name	ALERT_MSK	STB	Reserved			EN_RTM	EN_CT	EN_FQ
Default	0	0	1	0	0	1	0	1

BIT	Name	Description
7	ALERT_MSK	0 - Do not mask all ALERT interrupt function; 1 - Mask all ALERT interrupt function;
6	STB	0 - The chip is active and working normally; 1 - Stop monitoring both local and remote sensor temperature, the chip is going standby mode.
5	Reserved	
4	Reserved	
3	Reserved	
2	EN_RTM	0 - Disable remote sensor temperature monitor; 1 - Enable remote sensor temperature monitor.
1	EN_CT	0 - Disable to change THERM limit temperature of POR value; 1 - Enable to change THERM limit temperature of POR value.
0	EN_FQ	0 - Disable fault queue function, which means /ALERT pin will be active when monitoring any sensor is one time above set high point or below set low point; 1 - Enable fault queue function, which means /ALERT pin will be active when monitoring any sensor is three successive times above set high point or below set low point.

Conv_Rate, Conversion Rate of ADC

- Register Address: 0x04 and 0x0A
- Register Attribution: Read/Write
- Default Data: 0x08

BIT	7	6	5	4	3	2	1	0
Name	Reserved				Conv_rate[3:0]			
Default	0	0	0	0	1	0	0	0

Data (HEX)	Conversion Rate Frequency (Hz)/Time(s)
0x00h	0.0625/16.00
0x01h	0.125/8.000
0x02h	0.250/4.000
0x03h	0.500/2.000
0x04h	1.000/1.000
0x05h	2.000/0.500
0x06h	4.000/0.250
0x07h	8.000/0.125
0x08h	16.00/0.0625
0x0Bh	13.70/0.073
Others	16.00/0.0625

LT_HAT, Local Sensor high ALERT Temperature for setup

- Register Address: 0x05 and 0x0B
- Register Attribution: Read/Write
- Default Data: 0x46, which means 70°C.

BIT	7	6	5	4	3	2	1	0
Name	LT_HAT[10:3]							
Data	SIGN	64	32	16	8	4	2	1
Default	0	1	0	0	0	1	1	0

RT_HAT_MSB, Remote Sensor high ALERT Temperature MSB Data for setup

- Register Address: 0x07 and 0x0D
- Register Attribution: Read/Write
- Default Data: 0x46, which stands for 70°C.

BIT	7	6	5	4	3	2	1	0
Name	RT_HAT_MSB[10:3]							
Data	SIGN	64	32	16	8	4	2	1
Default	0	1	0	0	0	1	1	0

RT_LAT_MSB, Remote Sensor low ALERT Temperature MSB Data for setup

- Register Address: 0x08 and 0x0E
- Register Attribution: Read/Write
- Default Data: 0xD8, which stands for -40°C.

BIT	7	6	5	4	3	2	1	0
Name	RT_LAT_MSB[10:3]							
Data	SIGN	64	32	16	8	4	2	1
Default	1	1	0	1	1	0	0	0

One_Shot_Con, one shot register used for one conversion cycle

- Register Address: 0x0F
- Register Attribution: Write only
- Default Data: 0x00, used to get one conversion cycle temperature data by writing any data into this register in send-byte communication format, when the chip enters into Standby mode.

RT_LSB, Remote Temperature LSB Data

- Register Address: 0x10
- Register Attribution: Read only
- Default Data: 0x00 after POR

BIT	7	6	5	4	3	2	1	0
Name	RT[2:0], it is LSB data, plus MSB data RT[10:3] forms complete RT Temperature Data							
Temperature Data (°C)	0.5	0.25	0.125	Reserved				

RT_OFS_MSB, Remote Sensor OFFSET Temperature MSB Data

- Register Address: 0x11
- Register Attribution: Read/Write
- Default Data: 0x00 after POR

BIT	7	6	5	4	3	2	1	0
Name	RT_OFS [10:3], it is Remote Sensor Offset Temperature MSB data, plus LSB data RT_OFS [2:0] forms complete Offset Temperature Data, this 11bit data is addition a temperature data used when Temperature is higher than 127°C. see "**Remote Sensor Higher than 127°C**"							
Temperature Data (°C)	SIGN	64	32	16	8	4	2	1

RT_OFS_LSB, Remote Sensor OFFSET Temperature LSB Data

- Register Address: 0x12
- Register Attribution: Read/Write
- Default Data: 0x00 after POR

BIT	7	6	5	4	3	2	1	0
Name	RT_OFS [2:0], it is Remote Sensor Offset Temperature LSB data, plus MSB data RT_OFS [10:3] forms complete Offset Temperature Data, this 12bit data is additional temperature data used when Temperature is higher than 127ºC. see "**Remote Sensor Higher than 127°C**"							
Temperature Data (°C)	0.5	0.25	0.125	Reserved				

RT_HAT_LSB, Remote Sensor high ALERT Temperature LSB Data for setup

- Register Address: 0x13
- Register Attribution: Read/Write
- Default Data: 0x00

BIT	7	6	5	4	3	2	1	0
Name	RT_HAT [2:0]			Reserved				
Temperature Data (°C)	0.5	0.25	0.125					
Default	0	0	0	0	0	0	0	0

RT_LAT_LSB, Remote Sensor low ALERT Temperature LSB Data for setup

- Register Address: 0x14
- Register Attribution: Read/Write
- Default Data: 0x00

BIT	7	6	5	4	3	2	1	0
Name	RT_LAT [2:0]			Reserved				
Temperature Data (°C)	0.5	0.25	0.125					
Default	0	0	0	0	0	0	0	0

LT_LSB, Local Temperature LSB Data

- Register Address: 0x15
- Register Attribution: Read/Write
- Default Data: 0x00

BIT	7	6	5	4	3	2	1	0
Name	LT [2:0], it is LSB data, plus MSB data LT [10:3] forms complete LT Temperature Data							
Temperature Data (°C)	0.5	0.25	0.125	Reserved				

ALERT_MASK, Mask ALERT setup option

- Register Address: 0x16
- Register Attribution: Read/Write
- Default Data: 0x03

BIT	7	6	5	4	3	2	1	0
Name	MSK_LTH	Reserved		MSK_RTH	MSK_RTL	0	1	1
Default	0	0	0	0	0	0	1	1

BIT	Name	Description
7	MSK_LTH	0 - Disable local temperature high ALERT mask; 1 - Enable local temperature high ALERT mask
6	Reserved	
5	Reserved	
4	MSK_RTH	0 - Disable remote temperature high ALERT mask; 1 - Enable remote temperature high ALERT mask
3	MSK_RTL	0 - Disable remote temperature low ALERT mask; 1 - Enable remote temperature low ALERT mask
2	Reserved	
1	Reserved	
0	Reserved	

RT_THERM, Remote Sensor THERM limit Temperature setup

- Register Address: 0x19
- Register Attribution: Read/Write
- Default Data: 0x55. This register cannot be written with any data until EN_CT bit (bit1 of Configuration Register 0x03) is set '1'.

LT_THERM, Local Sensor THERM limit Temperature setup

- Register Address: 0x20
- Register Attribution: Read/Write
- Default Data: 0x55. This register cannot be written with any data until EN_CT bit (bit1of Configuration Register 0x03) is set '1'.

THERM_HYS, THERM Temperature Hysteresis Window Temperature

- Register Address: 0x21
- Register Attribution: Read/Write
- Default Data: 0x0A, stands for 10°C

BIT	7	6	5	4	3	2	1	0
Name	Reserved			THERM_HYS [4:0], range can be set from 0 to 32°C				
Data				16	8	4	2	1
Default				0	1	0	1	0

ALERT_MODE, ALERT Mode Selection

- Register Address: 0xBF
- Register Attribution: Read/Write
- Default Data: 0x00.

BIT	7	6	5	4	3	2	1	0
Name	Reserved							ALERT_MODE
Default	0	0	0	0	0	0	0	0

BIT	Name	Description
Bit [7:1]	Reserved	
0	ALERT_MODE	0 - Interrupt Mode 1 - Comparator Mode

Chip ID

- Register Address: 0xFD
- Register Attribution: Read Only
- Default Data: 0x50.

Manufacturer ID

- Register Address: 0xFE
- Register Attribution: Read Only
- Default Data: 0x59.

Device ID

- Register Address: 0xFF
- Register Attribution: Read Only
- Default Data: 0x8D.

Remote and Local Temperature Sensor Channel

For remote sensor channel, 300μV of voltage offset forced between DXP and DXN will cause about 1°C error. And equivalent ESR in series with the remote diode connection will cause about +0.6°C error per ohm.

Operating Mode, Active and Standby

The chip has 2 operation modes.

(1). Active (Run, by setting bit6 of Configuration Register as '0'): In this mode, the ADC is doing conversion on all temperature sensor channels at the programmed conversion rate. The temperature data is updated and limitation is checked at the end of every conversion cycle. In this mode, writing to the one-shot register will do nothing.

(2). Standby (Stop, by setting bit6 of Configuration Register as '1'): In this mode, most circuit blocks are powered down to reduce operation current. The SMBus is fully active and the chip will return requested data. Writing to the one-shot register will enable all temperature sensor channels only one time. Once all the sensor channels are updated, the chip will return to standby mode.

One Shot Register

One shot register is used to perform one shot command. When the chip is in Standby mode, writing any data to one shot register will cause ADC to update both temperature sensor measurements. In active mode, writing to one shot register does no effect to the chip.

This register is Write Only. Data written to this register is not stored and is always read as 0x00.

SMBus Digital Interface

Slave Address

The SMBus or I^2C slave address of this device is 10011000b (0x98h in HEX) in write mode, and 10011001b (0x99h in HEX) in read mode. If 3 or more of these devices in one SMBus are used, Please contact Panjit sales for more information.

	A6	A5	A4	A3	A2	A1	A0	R/W
Read	1	0	0	1	1	0	0	1
Write	1	0	0	1	1	0	0	0

SMBus Protocol

The chip supports four standard SMBus protocols Send Byte, Read Byte, Write Byte and Receive Byte, shown as below tables.

Write Byte

S	Slave Add	R/W	ACK	Reg Add	ACK	Reg Data	ACK	P
	1001100	0	0	XXh	0	XXh	0	

Read Byte

S	Slave Add	R/W	ACK	Reg Add	ACK	S	Slave Add	R/W	ACK	Reg Data	NACK	P
	1001100	0	0	XXh	0		1001100	1	0	XXh	1	

Send Byte

S	Slave Add	R/W	ACK	Reg Add	ACK	P
	1001100	0	0	XXh	0	

Receive Byte

S	Slave Add	R/W	ACK	Reg Add	NACK	P
	1001100	1	0	XXh	1	

Here S means SMBus Start to communication with master; P, means communication STOP.

Slave Add, means the chip's SMBus address.

Reg Add, means pointed Register Address.

Reg Data, means data to be written into register or read from register.

Compatible with I²C

The chip is compatible with both SMBus and I²C. And the major difference between SMBus and I²C are shown as below. For more information, refer to SMBus specification v2.0 and I²C specification v2.1.

(1). This chip supports I²C fast mode (400kHz) and standard mode (100kHz), which can cover SMBus maximum frequency 100kHz.

(2). For SMBus protocol, the minimum frequency is 10kHz. There is no such limitation for I²C.

(3). For SMBus protocol, slave device will reset if hold clock at '0' longer than 30ms. There is no timeout for I²C.

(4). ARA (Alert Response Address) general call is only valid interrupt in SMBus, not valid in I²C.

General Call

The PJ85718 device responds to a two-wire general-call address (0000 000) if the eighth bit is 0. The device acknowledges the general-call address and responds to commands in the second byte. If the second byte is 0000 0110, the PJ85718 internal registers are reset to power-up values.

High-Speed (Hs) Mode

If the master needs to run at frequencies above 400 kHz in I²C, the master device must issue an Hs-mode master code (0000 1xxx) as the first byte after a START condition to switch the bus to high-speed operation. After the Hs-mode master code has been issued, the master transmits a slave address to initiate a data-transfer operation. The bus continues to operate in Hs-mode until a STOP condition occurs on the bus. Upon receiving the STOP condition, the PJ85718 device will return to fast-mode operation. Below is the example for reading operation in high speed mode.

S	Hs-mode code	NACK	S	Slave Add	ACK	Reg Add	ACK	S	Slave Add	ACK	Reg Data	NACK	P
	0000 1xxx	1		0x98	0		0		0x99	0	xx	1	

ALERT Output

/ALERT pin is active-low output with open drain, which is triggered when measured temperature exceeds the limitation setup in the limit registers. Bit6 of Status Register [0x02] will be set ‘1’ once local temperature exceeds the temperature setup in LT_HAT [0x05]. Bit4 of Status Register [0x02] will be set ‘1’ once remote temperature exceeds the temperature setup in RT_HAT[0x07, 0x13] and bit3 of Status Register [0x02] will be set ‘1’ once remote temperature drops below the temperature setup in RT_LAT [0x08, 0x14]. All above situations are called ALERT trigger. Once ALERT trigger happened, /ALERT pin can be active and released with three types of output mode: comparator mode, interrupt mode, and SMBus ALERT Response mode

Comparator Mode

Below Figure 11 shows the mechanism of the /ALERT output in comparator mode. In this mode, the /ALERT pin will be asserted (active low) by writing ‘0’ into bit7 (ALERT_MSK) of Configuration register [0x03] during ALERT trigger. And /ALERT pin can be released by any of below 2 conditions: (1) Temperature is kept between higher and lower limitations. (2) Set bit7 of Configuration register [0x03] as ‘1’. In this mode, for bit7 of Configuration register [0x03] readout value is same as written value.

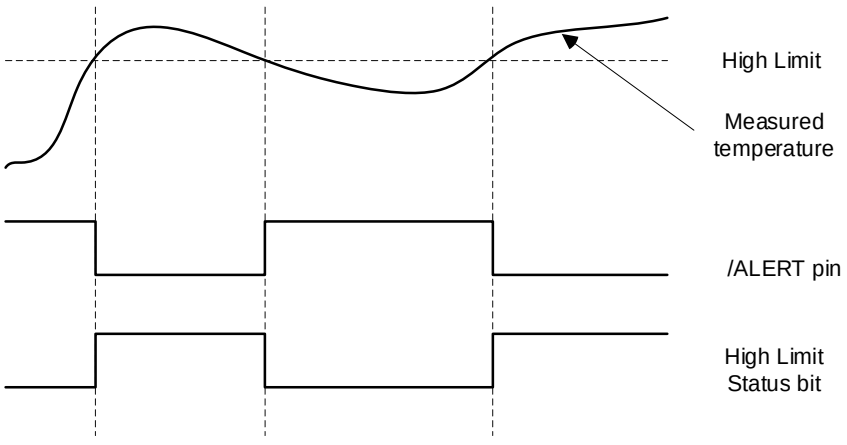


Figure 11. /ALERT pin output in comparator mode

Interrupt Mode

Below Figure12 shows the mechanism of the /ALERT pin output in interrupt mode. In this mode, the /ALERT pin will be asserted (active low) by writing '0' into bit7 of Configuration register [0x03] during ALERT trigger. Once ALERT trigger happens, the /ALERT pin will be asserted (active low). And /ALERT pin can be released by reading STATUS registers [0x02] or SMBus Alert response happened

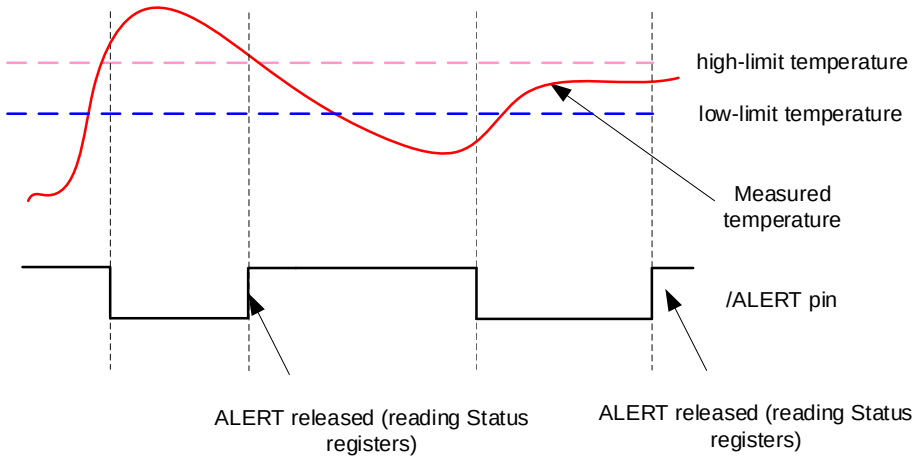


Figure 12. /ALERT pin output in interrupt mode

SMBus Alert Response Mode

It can be used as a processer interrupt or as SMBus ALERT. When the master detects that /ALERT pin is asserted, it will send Alert Response Address (ARA) to general address (00011001b). All devices with active interrupts will respond with client address.

Below Figure shows the mechanism of the ALERT output SMBus Alert mode. In this mode, the ALERT output is connected to the SMBus Alert line which has more than one device connected to it. Through such and implementation, SMBus Alert mode can assist the master in resolving which salve generates an interrupt. When the measured temperature falls outside of the allowed range, the /ALERT pin will be pulled low and the corresponding Alert flags in Status Register will be set to 1. The ALERT mask bit will just be set if there is a SMBus ALERT Response Address (ARA) occurs from master (ALERT Response Address is 00011001b). Meanwhile, the chip will generate and return its own address to the master. If the temperature never falls outside of the allowed range, the latched /ALERT pin can be released by the reset ALERT mask bit and the latched corresponding alert flags in Status Register can release by reading command for Status Register.

S	General Add	R/W	ACK	Slave Add	ACK	P
	0001100	1	0	1001 100xb	1	

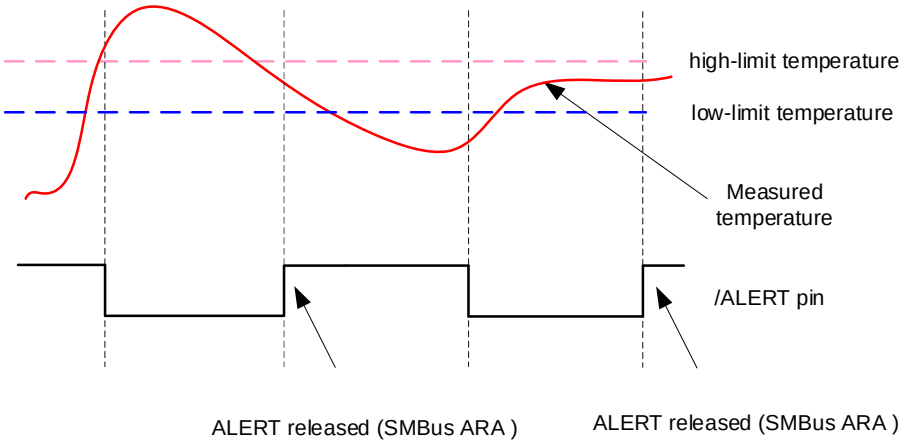


Figure 13. /ALERT pin in SMBus ALERT Response mode

THERM Output

/THERM pin is also an active low output with open drain. The THERM is asserted and pulled low when any of the measured temperatures exceeds the THERM limitation temperature programmed by user in Register 0x19, 0x20. Once /THERM pin outputs low, it will remain asserted and will not be set high until all measured temperature is lower than THERM limit minus THERM Hysteresis (also programmable in register add 0x21). When the /THERM pin is asserted, THERM Status bits of Status Registers will be set respectively and will not be cleared until the /THERM pin is de-asserted. Below Figure shows this mechanism.

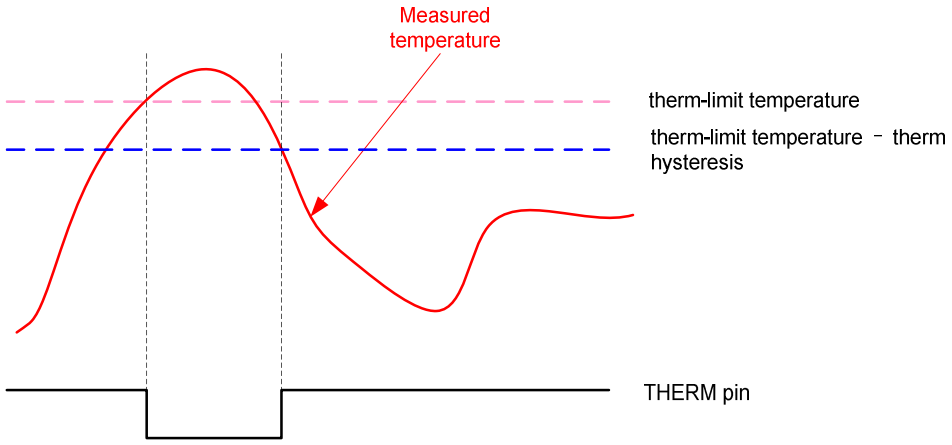


Figure 14. /THERM pin output

Diode Fault Alarm

The chip can detect an open on DP and DN pin (e.g. no external diode connection) or a short between DP and DN pin. In each temperature measurement cycle, the chip checks diode fault for external diode channel. When a diode short is detected, the /ALERT pin is asserted (unless masked by user's program) and the temperature data is 0xC0h (MSB) and 0x00 (LSB) read from RT_MSB register [0x01] and RT_LSB register [0x10], which means the temperature is -64°C. Also, STS_RTLA bit of Alert_Status register is set '1'. If the chip detects an open before power-on reset, temperature will show 0 °C, also STS_RTO bit of Alert_Status register is set '1'. If open is detected after power-on reset, however, the temperature data shown represents the result that was converted in the last cycle, and it will NOT get updated. Also STS_RTO bit of Alert_Status register will be set '1'.

External Diode Selection

The chip is designed to measure both local and remote temperatures. For remote temperature sensing, the chip needs connection to an external diode, which could be a discrete diode or a discrete BJT (PNP type or NPN type) transistor with diode-connected. The external diode also can be substrate parasitic BJT transistor inside CPU or other GPU chips.

For Remote sensor channel, temperature accuracy depends on external PN junction. It is better to select small-signal BJT transistor of proper performance with diode-connected. Proper performance includes below,

(1). Vbe is between 250mV at 10uA and 950mV at 300uA;

(2). Beta or current DC gain, is equal or larger than 30;

(3). base resistance is below 100ohm.

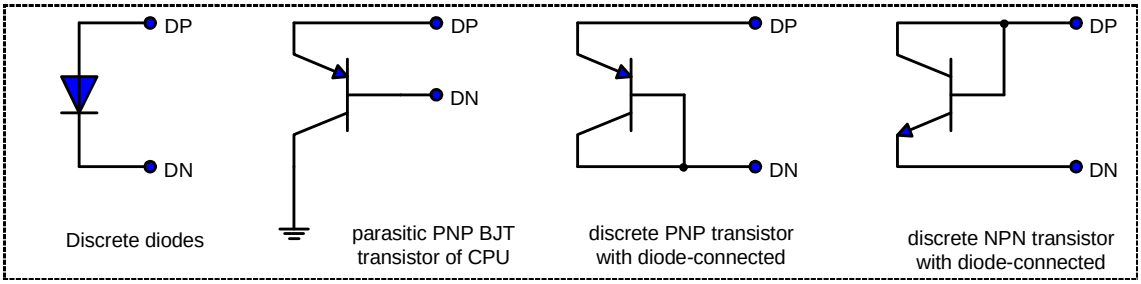


Figure 15. External Diode Connection

POR

The chip uses volatile memory. To prevent unclean power-supply conditions, which could happen in system application, from corrupting the data in memory and causing an unexpected situation, a POR voltage detector monitors Vcc and clears the memory if Vcc falls below threshold voltage (1.2V in typical). When Vcc rises above threshold voltage, the logic blocks begin operating. Then the chip block will work normally along with Vcc rising high enough gradually.

Applications Information

How to Improve Temperature Accuracy

The temperature measurement of the chip is based on semiconductor physics principle. Forward voltage of diode is a function of temperature. The formula is shown as below.

$$V_F = \frac{kT}{q} \ln\left(\frac{I_F}{I_S}\right)$$

Here,

V_F - *forward voltage*
I_F - *forward current*
I_S - *reverse saturation current*
k - Boltzmann constant
T - Temperature in K
*q - Electric charge con*stant

To cover wide temperature range, i.e. -40°C to 125°C, a very small voltage variation is corresponding to every degree C temperature change. For this chip, 200μV voltage between DP and DN pin stands for about1°C. Panjit has applied many ways to improve measurement accuracy in chip circuits design, such as compensation, trimming etc. In real system design, however, some factors that can increase measurement error need to be considered. Most issues that usually occur are highlighted as below.

Parasitic ESR of Remote Diode

Parasitic series resistance in the remote diode will cause about +0.60°C error per ohm. So it is very necessary to place the chip as close as possible to the external remote diode in PCB layout. If the remote diode channel is NOT used, it is better to short DP and DN pins together.

Noise between DP and DN

Since 200uV stands for about 1°C, any common-mode noise between DP and DN pin will cause temperature measurement error. So it is very necessary to place a low ESR ceramic cap across DP and DN pin to filter noise. The recommended capacitance is 2200pF.

Thermal Response Time

It is very necessary to wait enough time for obvious temperature changing of target due to thermal time constant, e.g. taking food out of refrigerator, temperature changes from -20°C to 20°C, which could take over ten minutes to reach thermal equilibrium eventually. Enough time is still needed for the target to reach thermal equilibrium, even forcing temperature transient into target object. For example, changing 100°C suddenly around this chip, it will take about 15minutes to reach thermal equilibrium on this chip die under 1°C accuracy.

Self-heating

For local sensor, self-heating could affect temperature measurement accuracy. It always brings positive error. It could be estimated as below steps.

Step 1, Estimating the chip power consumption, caused by average operating current and sink current at /ALERT pin, /THERM pin.

$Pd1 = V_{CC} \times I_{AOC} = 5.0V \times 45uA = 225uW$

(Assuming Vcc is 5.0V, conversion rate is 1Hz.)

$Pd2 = V_{OL} \times I_{SINK} = 0.1V \times 0.5mA \times 2 = 0.1mW$

(Assuming in normal operating, both /ALERT pin and /THERM pins are active, and pull-up resistors are 10k)

Pdtotal = Pd1 + Pd2 = 225uW + 0.1mW = 325uW

Step 2, Estimating junction temperature error caused by power consumption,

Δ Tj = Pdtotal x Theta J-A = 325uW x 140°C/W = 0.04°C, which is too small to be ignored.

Setup by System Software

It is necessary to properly setup/optimize system software to improve reliability and consistency of the temperature data. Below is the guideline for reading temperature data with 1Hz frequency.

(1). Setup conversion rate register (0x0A) as 4Hz;

(2). Read the temperature data 4 times in one second;

(3). Average out the above 4 temperature data

(4). Do moving-average repeatedly for the last 4 average temperature readings

(5). Compensate positive temperature error caused by self-heating, which could be estimated by the calculation in "**Self-heating**";

(6). Compensate error caused by environment temperature around the chip, which could be obtained by another local sensor;

(7). Output above temperature data once every second.

Select proper external Diode

See "**External Diode Selection**".

PCB Layout

Cautions below are important to improve temperature measurement in PCB layout design.

Device placement

It is better to place the chip away from any thermal source (e.g. power device in board), high speed digital bus (e.g. memory bus), coil device (e.g. inductors) and wireless antenna (e.g. Bluetooth, WiFi, RF). It is recommended to place the chip close to the remote diode.

DP, DN Route in PCB

It is better to draw the traces of DP and DN net list as a pair trace and to make sure that the two are always kept with the same distance and the same layer in PCB board. Also it is better NOT to change PCB layer for this pair trace, which means to keep trace to the same layer as the chip and remote diode.

The recommended trace width of DP, DN pair trace is 5mil.

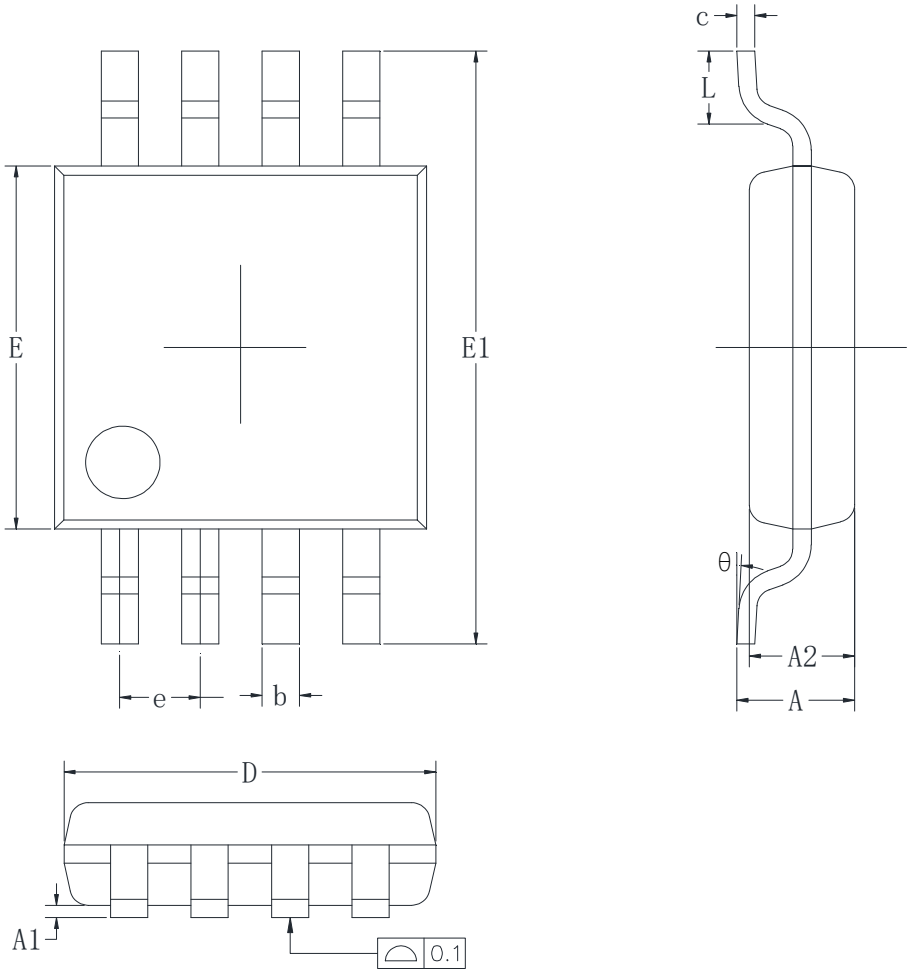
Twisted cable and shield

Another method is to use ground shield around the DP, DN pair trace, which could reduce digital noise.

Twisted cable with shield is recommended for long distance temperature measurement that uses a discrete diode as the remote sensor. Shield is shorted to ground.

PACKAGE OUTLINE DIMENSION (MSOP-8)

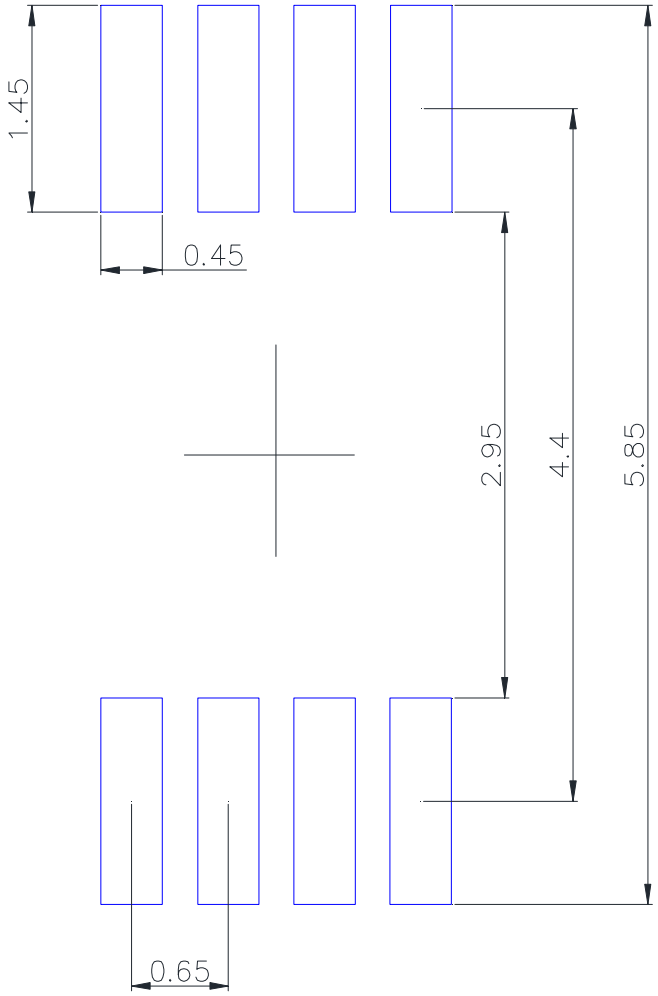
MSOP-8 Unit (mm)



Symbol	Dimensions in Millimeters		Dimensions in Inches	
	Min.	Max.	Min.	Max.
A	0.820	1.100	0.032	0.043
A1	0.020	0.150	0.001	0.006
A2	0.750	0.950	0.030	0.037
b	0.250	0.380	0.010	0.015
c	0.090	0.250	0.004	0.010
D	2.900	3.100	0.114	0.122
E	2.900	3.100	0.114	0.122
E1	4.700	5.100	0.185	0.201
e	0.650（BSC）		0.026（BSC）	
L	0.400	0.800	0.016	0.031
θ	0°	8°	0°	8°

Recommend Land Pattern Layout (MSOP-8)

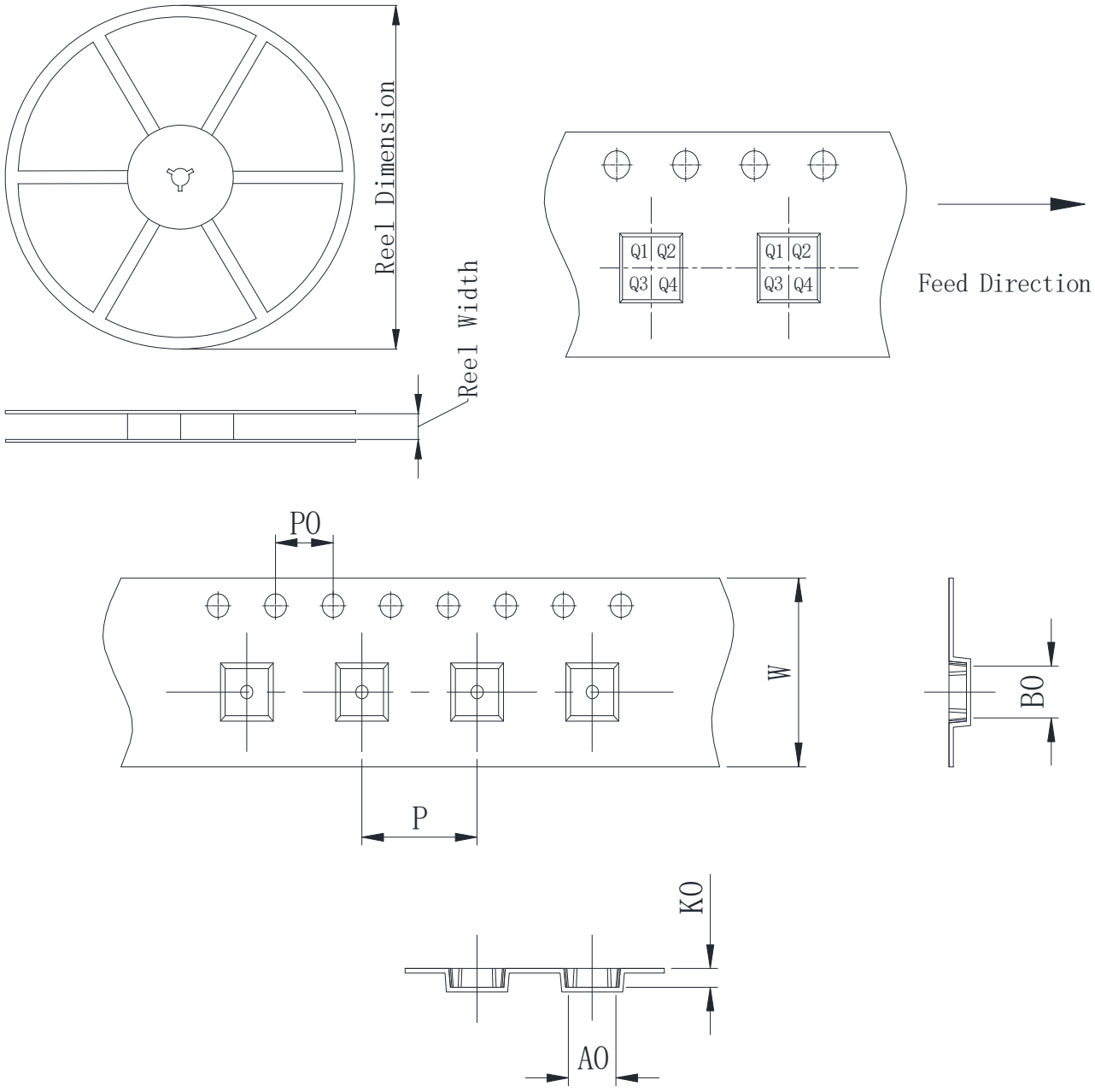
MSOP-8 Unit (mm)



Note:

1. All dimensions are in millimeter
2. Recommend tolerance is within ±0.1mm
3. Change without notice

Packing information (MSOP-8)



Package type	Reel size	Reel dimension (±3.0mm)	Reel width (±1.0mm)	A0 (±0.1mm)	B0 (±0.1mm)	K0 (±0.1mm)	P (±0.1mm)	P0 (±0.1mm)	W (±0.3mm)	Pin1
MSOP-8	13'	330	12.4	5.4/5.2	3.4/3.3	1.4/1.5	8.0	4.0	12.0	Q1

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