Security Level: 3

Document# 13-52-13	Title: QMP6988 Datasheet	Rev: C
Originator: ASIC/ Bill Chen		

REVISION RECORD

Rev.	Date	Originator	Change Description
A	4/10/2018	Bill Chen	Initial Release
B	12/13/2018	Bill Chen	1:Update New Format&New Logo; 2: Add 1.2 Absolute Maximum Ratings form remark; 3: Update 1.3 Operating Ratings form. 4. update 4.3 Compensation of pressure and temperature
C	11/17/2020	Bill Chen	1. Add HS definition for I2C in page 20 2. Add notes in page 4 and page 5

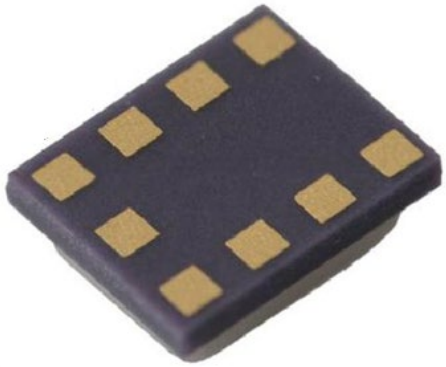
Digital Barometric Pressure Sensor QMP6988

Advanced Information

High accuracy and small size barometric pressure sensor with low current consumption

- Measure barometric pressure and temperature with high accuracy
- Built-in low noise 24bit ADC
- Digital control and output via I²C/SPI interface
- Automatically power down non-working circuit to minimize power consumption
- Individual calibration parameters stored in OTP*
  (*One Time Programmable ROM)

RoHS compliant



Application Example

- Indoor navigation (floor detection)
- Car navigation (to distinguish highway and frontage road)
- Altimeter
- Activity monitor (to detect up and down of stairs)
- Life log
- Weather forecast

Target Devices Example

- Smart Phones / Tablet PCs
- Wearable devices, such as watch type, band type, clip type or glasses type
- GPS devices
- Healthcare devices such as pedometer

Packaging Information

■Standard Models with Surface Mounting Terminals

Structure	Packaging	Model	Miminum Packing Unit
LGA 9pin	Tape and Reel	QMP6988	3500

Table of Contents

1. Ratings, Specifications and Functions

1.1 Use conditions and recommended operating conditions

Type of Pressure	Absolute Pressure
Medium	Air (*1)
Operating Pressure Range	30kPa to 110kPa

Note. *1: Never use corrosive gases.

1.2 Absolute Maximum Ratings

Item	Symbol	Rating	Unit	Remark
Power Supply Voltage	Vddmax	4.0	V	
Input Voltage (other than power)	Vmax	-0.2~Vopr+0.2	V	
Maximum Pressure	Pmax	800	kPa	
Storage Temperature	Tstr	-40~85	℃	with no condensation or icing
Storage Humidity	Hstr	10~95	%RH	with no condensation or icing
ESD(HBM)	Vhbm	±2000	V	
ESD(MM)	Vmm	±200	V	
ESD(CDM)	Vcdm	±500	V	

1.3 Operating Ratings

Item	Symbol	Min	Typ	Max	Unit	Remark
Operating Voltage	Vopr	1.71	1.8	3.6	V	VDD
	Vio	1.2	1.8	3.6	V	VDDIO
Operating Temperature	Topr	-40		85	℃	

1.4 Electrical Characteristics

Item	Symbol	Condition	Min	Typ	Max	Unit
Average Current *	Ihp	1sample/s force-mode Ultra High Accuracy	-	21.4	-	μA
Operating Current Consumption	Iddp	Pressure mode	-	640	800	μA
	Iddt	Temperature mode	-	410	520	μA
Sleep Mode Current Consumption	Isleep		-	1.1	2.3	μA
Measureable Pressure Range	Popr		30	-	110	kPa
Absolute Pressure Accuracy	Pabs1	30-110kPa, -20℃ - 65℃	-100	-	100	Pa
Relative Pressure Accuracy *	Prel1	Ultra High Accuracy	-	±3.9	-	Pa
rms Noise *	Pnois	Ultra High Accuracy	-	1.3	-	Pa
Absolute Temperature Accuracy	Tabs	30-110kPa, -20℃ - 65℃	-2	-	2	℃
Pressure Resolution *	Pres		-	0.06	-	Pa
Temperature Resolution *	Tres		-	0.0002	-	℃
Power Supply Rejection Ratio (DC)	Ppsrr	101.3kPa, 0-40℃ 1.71-3.6V Base on Vdd=1.8V	-9.4	-	9.4	Pa

(At Ta=25℃, VDD=1.8V, unless otherwise noted)

Note * Above characteristics are guaranteed by design.

Note2: The above table shows the characteristics of the package before soldering

1.5 Digital Interface Characteristics

Item	Symbol	Condition	Min	Typ	Max	Unit
Digital Input Low Voltage	Vil_d		-	-	Vio*0.2	V
Digital Input High Voltage	Vih_d		Vio*0.8	-	-	V
Digital Input Hysterisis	Vidhys		Vio*0.1	-	-	V
Digital Output Low Voltage(I2C)	Vol_d1	Io=3mA (SDI) *1)	0	-	Vio*0.2	V
Digital Output Low Voltage(SPI)	Vol_d2	Io=1mA (SDI, SDO) *1)	0	-	Vio*0.2	V
Digital Output High Voltage1 (SPI) (Vio>=1.62V)	Voh_d1	Io=1mA (SDI, SDO) *1)	Vio*0.8	-	-	V
Digital Output High Voltage2 (SPI) (Vio>=1.2V)	Voh_d2	Io=1mA (SDI, SDO) *1)	Vio*0.6	-	-	V
Leakage Current at Output OFF	Ioff	SDI, SDO	-10	-	10	μA
Internal Pullup Resistor	Rpullup	CSB	70	120	190	kohm
I2C Load Capacitor	Cb	SDI, SCK	-	-	400	pF
Load Capacitance of Reset Terminal	Crst		-	-	20	pF
Pulse Width of Asynchronous Reset	Trst		100	-	-	μsec
Power On Startup Time	Tstart		-	-	10	msec

(At Ta=25℃, VDD=1.8V, unless otherwise noted)

* "Io" is the load current of output terminal.

Note: Undescribed items are compliant with the I2C specification.

About detailed I2C bus information, please refer to the I2C bus specification and user manual presented by NXP

1.6 Characteristics by Oversampling setting (force mode)

Oversampling setting	Pressure Oversampling	Temperature Oversampling	Measurement time Typ	ODR @standby 1ms Typ	Average Current Typ @1sample/sec force-mode	rms Noise Typ.
unit	-	-	msec	Hz	μA	Pa
High speed	2	1	5.5	153	4.1	5.2
Low power	4	1	7.2	121	5.2	3.7
Standard	8	1	10.6	86	7.3	2.6
High accuracy	16	2	18.3	51	12	1.8
Ultra High accuracy	32	4	33.7	28	21.4	1.3

（At Ta=25 degC, VDD=1.8V, CPU Clock Frequency=300kHz, unless otherwise noted）

Note. *1) These characteristics are guaranteed by design.
*2) ODR is defined as Output data rate at standby time 1msec.

1.7 rms Noise by IIR Filter Selection

Oversampling setting	Typical rms Noise in Pressure [Pa]					
	IIR filter coefficient					
	off	2	4	8	16	32
High speed	5.2	2.5	1.6	1.1	0.8	0.5
Low power	3.7	1.8	1.1	0.8	0.5	0.4
Standard	2.6	1.3	0.8	0.5	0.4	0.3
High accuracy	1.8	0.9	0.6	0.4	0.3	0.3
Ultra High accuracy	1.3	0.6	0.4	0.3	0.3	0.2

Note. *1) IIR: Infinite Impulse Response.
*2) These characteristics are guaranteed by design.
*3) Initial setting of the IIR filter coefficient is “off”

1.8 Bandwidth by IIR Filter Selection

Oversampling setting	Typical Bandwidth [Hz]					
	IIR filter coefficient					
	off	2	4	8	16	32
High speed	133	30.7	12.8	5.9	2.9	1.4
Low power	108	24.9	10.4	4.8	2.3	1.1
Standard	79	18.2	7.6	3.5	1.7	0.8
High accuracy	49	11.3	4.7	2.2	1.1	0.5
Ultra High accuracy	28	6.5	2.7	1.2	0.6	0.3

Note. *1) These characteristics are guaranteed by design
*2) Initial setting of the IIR filter coefficient is “off”

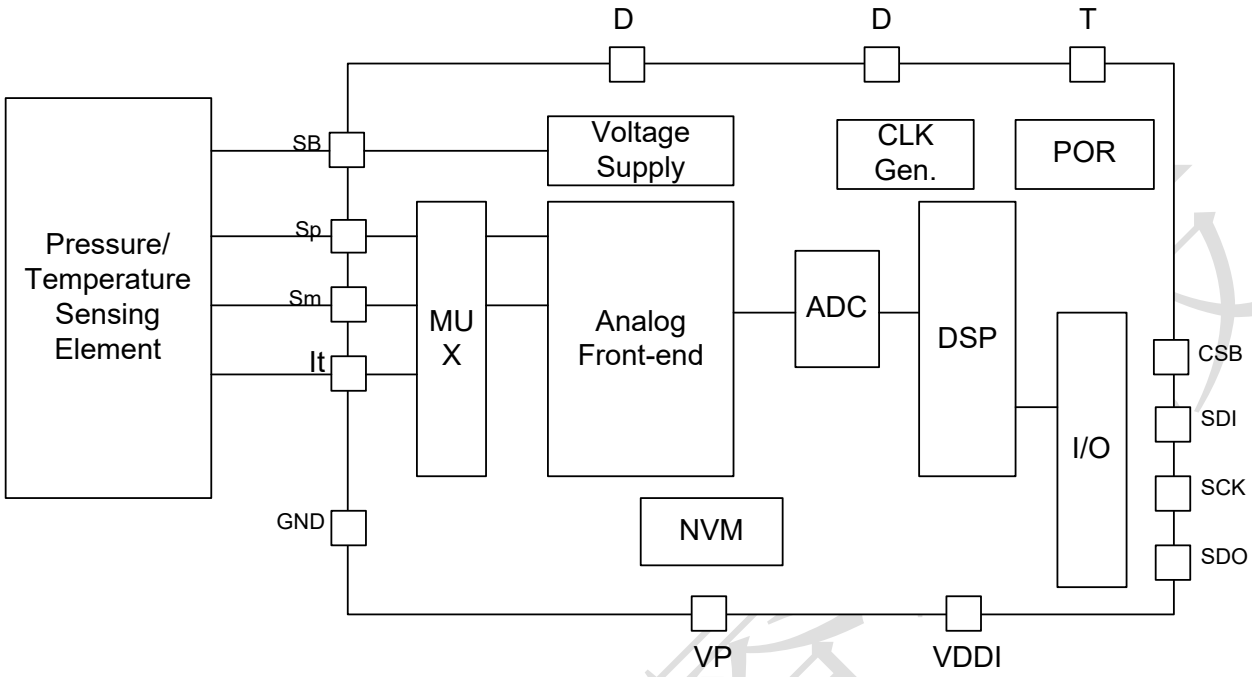
1.9 Filter selection based on use cases

Example use case	Oversampling Setting	Pressure oversampling times	Temp oversampling times	Specification (Typ.)			
				IIR filter coefficient	Current consumption [uA]	ODR [Hz] (Example)	rms Noise [Pa]
Weather monitoring	High speed	2	1	off	1.2	0.05	5.2
Drop detection	Low power	4	1	off	407	100	3.7
Elevator detection	Standard	8	1	4	63.4	10	0.8
Stair detection	High accuracy	16	2	8	219	20	0.4
Indoor navigation	Ultra high accuracy	32	4	32	570	28	0.2

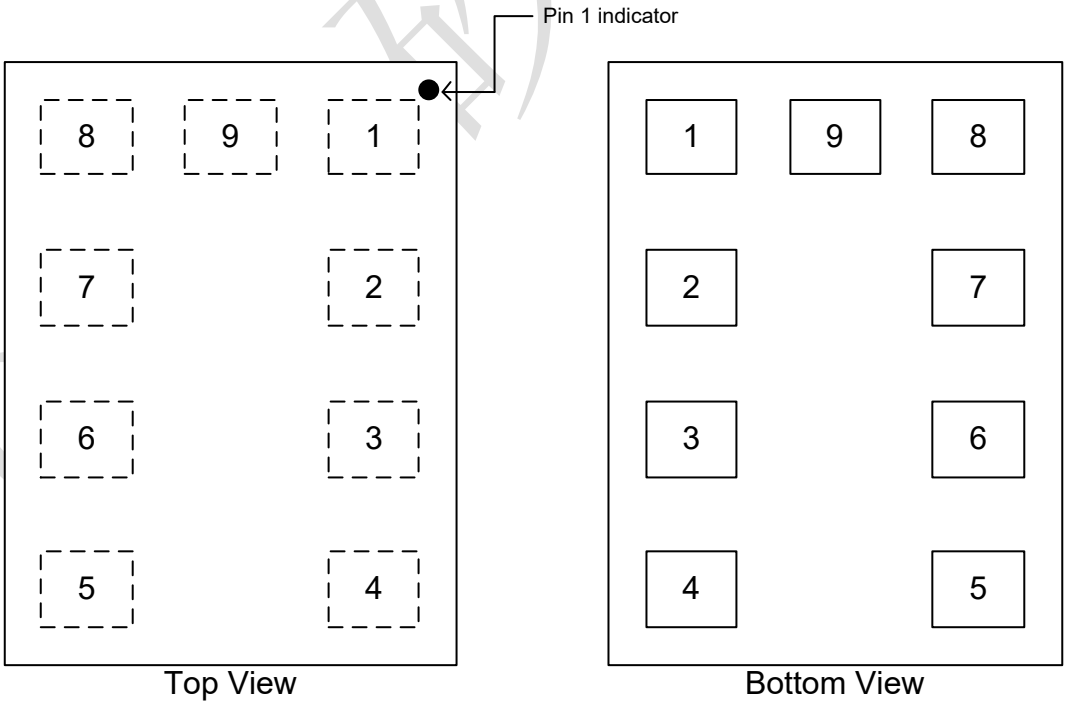
Note. These characteristics are guaranteed by design.

2. Connection

2.1 Block Diagram



2.2 Pin Description and Layout



Pin Description

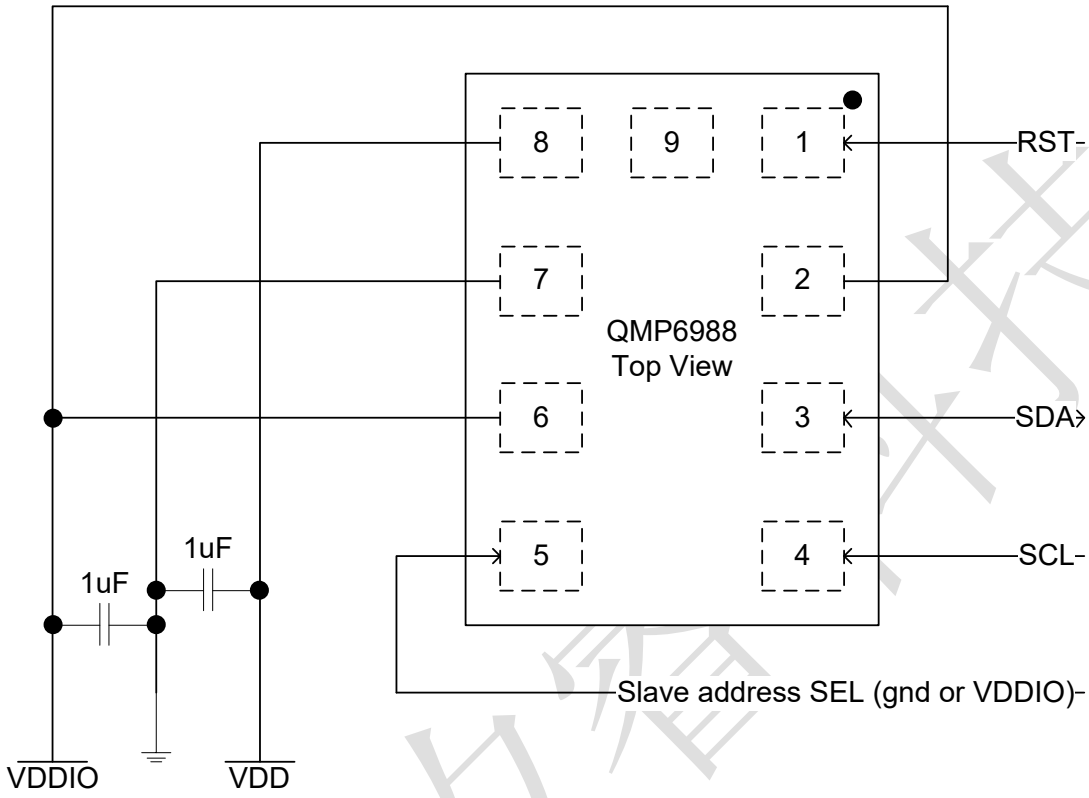
No.	Symbol	Description	
		SPI	I2C
1	RST	Asynchronous Reset *1	
2	CSB	CSB	VDDI0
3	SDI	SDI/SD0	SDA
4	SCK	SCK	SCL
5	SD0	SD0	ADDR
6	VDDIO	Power Supply to Digital IO	
7	GND	Ground	
8	VDDIO	Power Supply	
9	VPP	Power Supply to NVM Programing *2	

Note. *1) If you do not need the reset function, please just have the layout design of PCB of connecting both No.1 (RST) pin and No.7 (GND) pin into the ground of PCB.

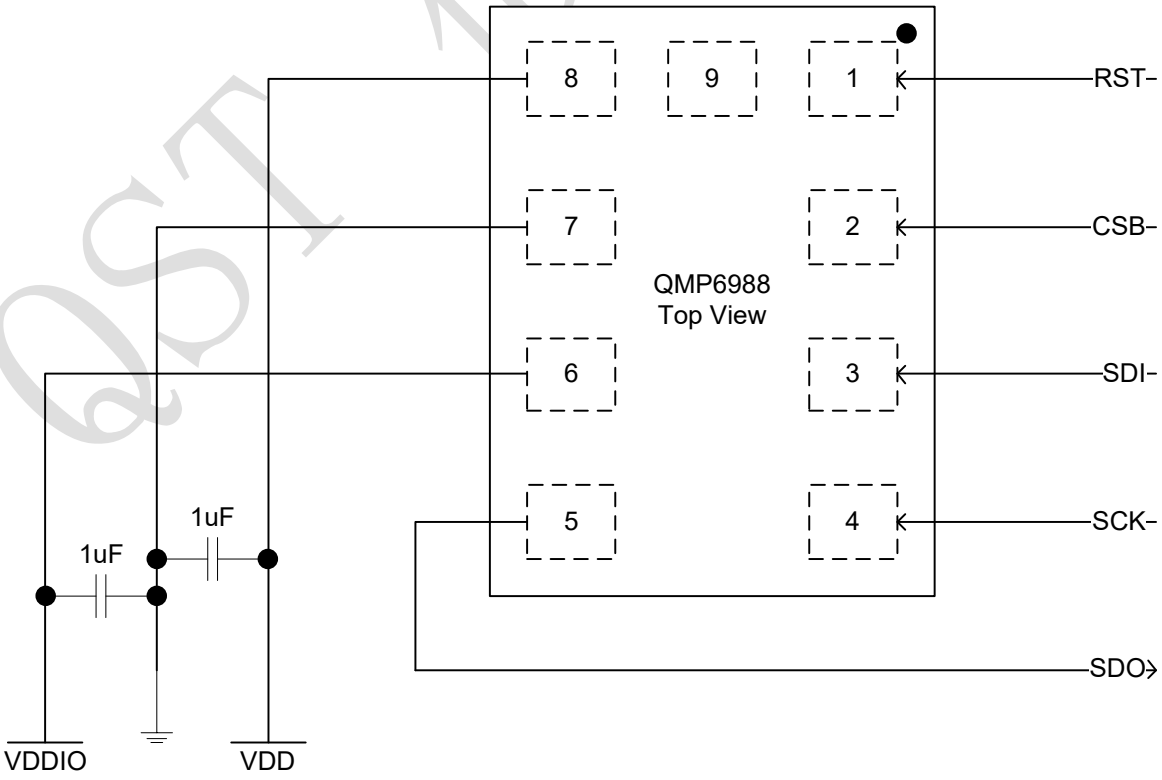
*2) Pin 9 is only used internally. Please leave this pin disconnected. If Pin 9 is connected with any other Pin electrically, the sensor will not work properly.

2.3 Typical Connection Diagram

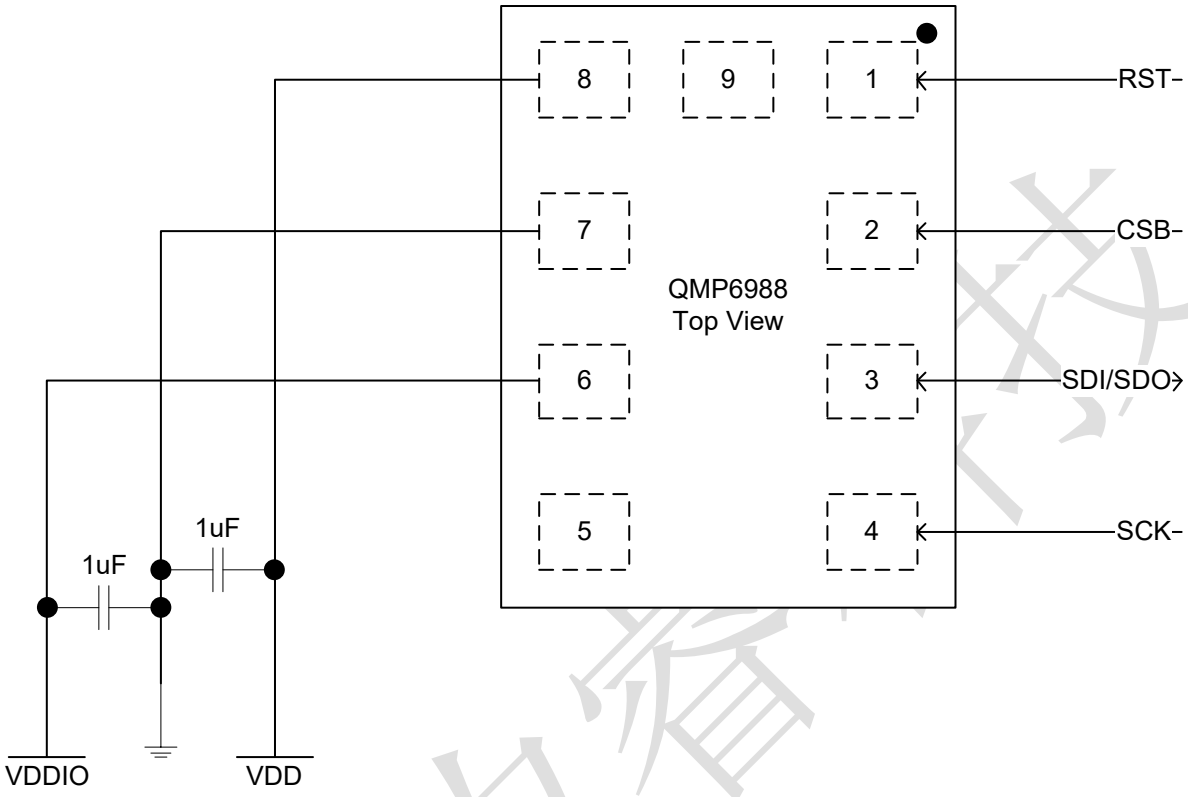
(1) I²C mode
Corresponding to 100Kbit/s (at Standard Mode), 400Kbit/s (at Fast Mode) and 3.4Mbit/s (at High Speed Mode)



(2) 4-wire SPI mode (Corresponding to 10Mbit/s)

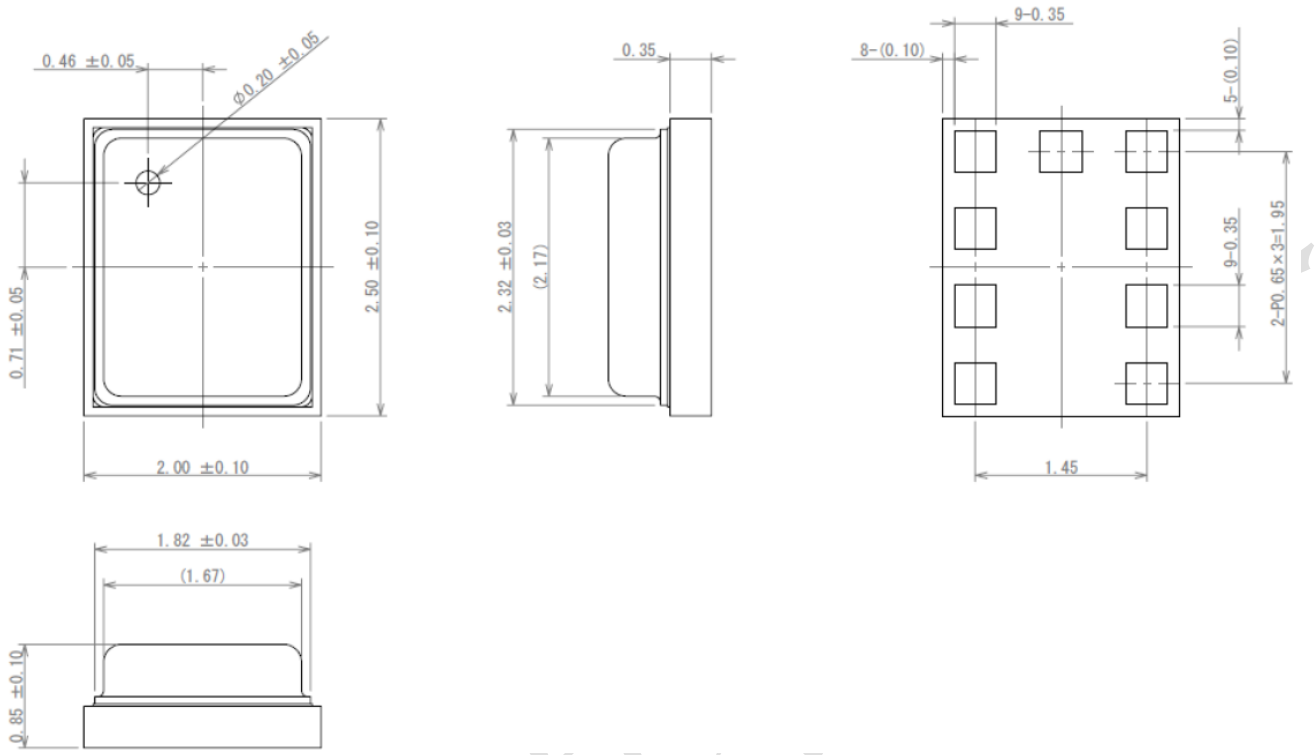


(3) 3-wire SPI mode (Corresponding to 10Mbit/s)



3. Dimensions

3.1 Package

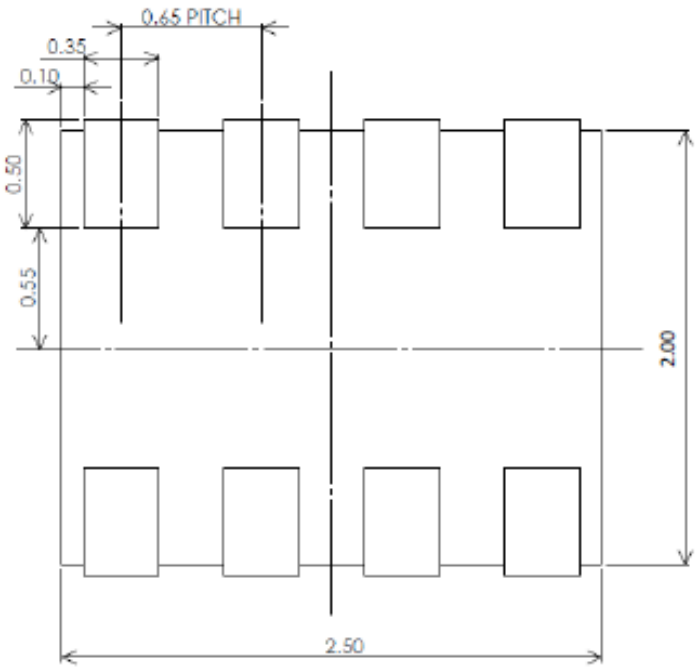


Package Type：LGA (Land Grid Array) 9pin

Package Size：2.00×2.50×0.85 mm

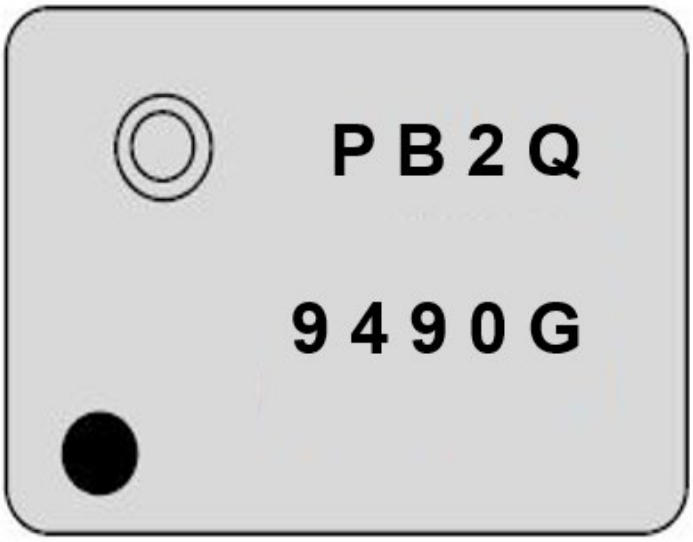
Material of the terminal surface: Au

3.2 Mounting PAD Dimensions



(Top View) : Recommended

3.3 Marking structure



4. Operations

4.1 Communication Mode

This sensor is corresponding to I²C and SPI communication.
Digital interface terminal functions for each communication mode are as below.

Communication Mode	CSB	SDI	SCK	SDO	Remark
I2C	VDDIO	SDA	SCL	0/1	SDO=0→70h, SDO=1→56h
SPI 3 wires	CSB	SDI/SDO	SCK	-	spi3w register = 1
SPI 4 wires	CSB	SDI	SCK	SDO	spi3w register = 0

When changing the communication mode, also see Typical Connection Diagram section.

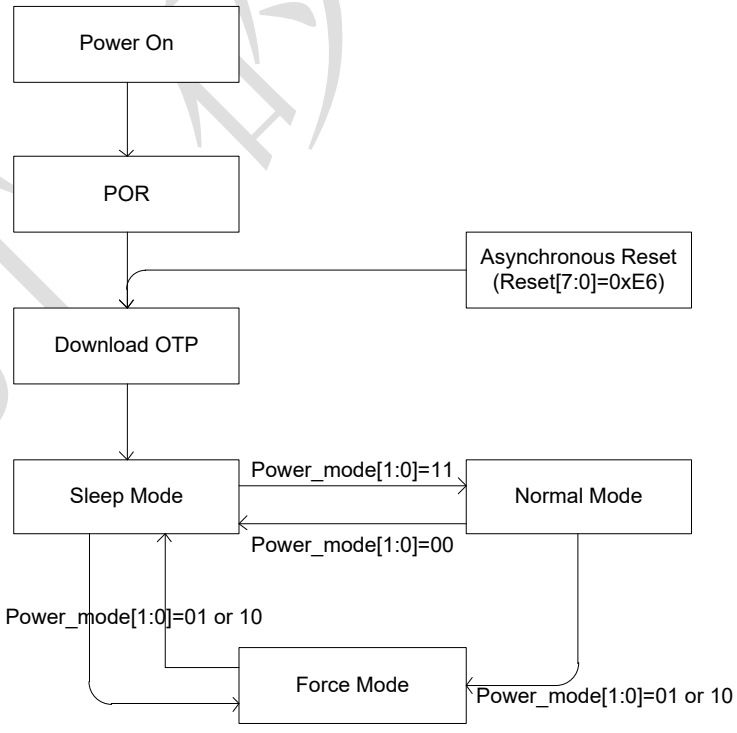
1) I²C mode becomes effective by pulling CSB up to VDDIO.
2) SPI mode becomes effective by pulling CSB down to GND.
3) Once CSB is pulled down, SPI mode would not be changed unless otherwise Power on Reset (POR) or Asynchronous Reset. Switching between SPI 3-Wire mode and SPI 4-Wire mode can be configured with the register value of "spi3w". Refer to IO_SETUP register section for more detail.
4) Default mode after POR or Asynchronous Reset will be I²C mode.

4.2 Power Mode

This sensor has three power modes and it can be switched by setting CTRL_MEAS register. Refer to the "CTRL_MEAS" register section for more detail.

- Sleep mode
- Normal mode
- Forced mode

Transition diagram for each mode is as follows.



1) Sleep Mode (Power Reduction Mode)
No measurements are performed.
I²C/SPI interface and each register can be accessed even if the sensor is in sleep mode.

2) Forced Mode

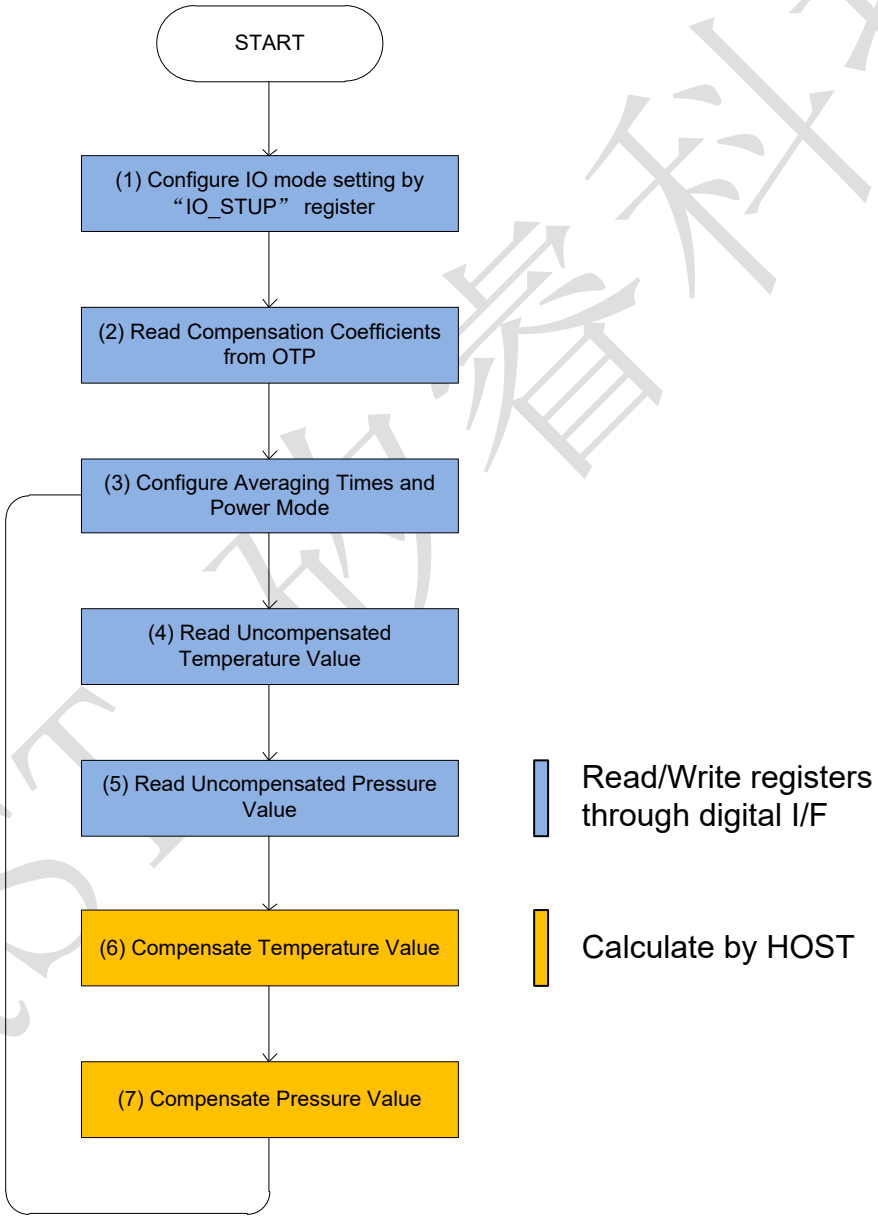
In the case of Force Mode, a single measurement is performed. When the set up measurement is finished, the sensor returns to Sleep Mode after storing the measurement data to the registers

3) Normal Mode

In the case of Normal Mode, the measurements are performed repeatedly between a measurement period and a standby period. The standby time can be configured by "t_standby[1:0]" register. Be sure to consider that the data must be read from the master side after a Normal Mode.

4.3 Compensation of Pressure and Temperature

This section describes a typical measurement procedure and a calculation method after POR. This sensor has compensation coefficients in internal Non Volatile Memory (NVM). The compensated pressure can be calculated by using these values.



① Configure IO mode setting. Refer to IO_SETUP register section for more detail.
② Read compensation coefficients which are stored in NVM. This procedure is sufficient just once after POR. These values are used for a compensation calculation at the step ⑥ and ⑦.
③ Configure averaging times and power mode. Refer to CTRL_MEAS register section for more detail.
④ Read raw temperature data which are stored in TEMP_TXDx registers.

⑤ Read raw pressure data which are stored in PRESS_TXDx registers.
⑥ Compensated temperature can be calculated by using the below formula and the values of the step ② and ④.

$$Tr = a0 + a1 \bullet Dt + a2 \bullet Dt^2$$

Tr Calculation Result of Temperature [256 degreeC]
Dt Raw Temperature Data [digit] (20-24bits measurement value of TEMP_TXDx Reg.)
a0 Compensation Coefficient of PTAT (NVM resister: COE_a0_ex, COE_a0_0, COE_a0_1)
a1 Compensation Coefficient of PTAT (NVM resister: COE_a1_0, COE_a1_1)
a2 Compensation Coefficient of PTAT (NVM resister: COE_a2_0, COE_a2_1)

⑦ Correction pressure without temperature compensation can be calculated by using the below formula and the values of the step ② and ⑥.

$$\Pr = b00 + bt1 \bullet Tr + bp1 \bullet Dp + b11 \bullet Tr \bullet Dp + bt2 \bullet Tr^2 + bp2 \bullet Dp^2$$
$$+ b12 \bullet Dp \bullet Tr^2 + b21 \bullet Dp^2 \bullet Tr + bp3 \bullet Dp^3$$

Pr Calculation Result of Pressure [Pa]
Tr Calculation Result of Temperature [256 degreeC]
Dp Raw Pressure Data [digit] (20-24bits measurement value of PRESS_TXDx Reg.)
b00 Compensation Coefficient of Pressure (NVM resister: COE_b00_ex, COE_b00_0, COE_b00_1)
bt1 Compensation Coefficient of Pressure (NVM resister: COE_bt1_0, COE_bt1_1)
bp1 Compensation Coefficient of Pressure (NVM resister: COE_bp1_0, COE_bp1_1)
b11 Compensation Coefficient of Pressure (NVM resister: COE_b11_0, COE_b11_1)
bt2 Compensation Coefficient of Pressure (NVM resister: COE_bt2_0, COE_bt2_1)
bp2 Compensation Coefficient of Pressure (NVM resister: COE_bp2_0, COE_bp2_1)
b12 Compensation Coefficient of Pressure (NVM resister: COE_b12_0, COE_b12_1)
b21 Compensation Coefficient of Pressure (NVM resister: COE_b21_0, COE_b21_1)
bp3 Compensation Coefficient of Pressure (NVM resister: COE_bp3_0, COE_bp3_1)

How to get compensation coefficients

Each compensation coefficients can be calculated by using the below formula and conversion factors.

$K = A + \frac{S \cdot OTP}{32767}$ ...a1, a2, bt1, bt2, bp1, b11, bp2, b12, b21, bp3 $K = \frac{OTP}{16}$ ... a0, b00

K	Conversion factor		OTP		
	A	S	23-16bit	15-8bit	7-0bit
a1	-6.30E-03	4.30E-04	-	C0E_a1_1	C0E_a1_1
a2	-1.90E-11	1.20E-10	-	C0E_a2_1	C0E_a2_0
bt1	1.00E-01	9.10E-02	-	C0E_bt1_1	C0E_bt1_0
bt2	1.20E-08	1.20E-06	-	C0E_bt2_1	C0E_bt2_0
bp1	3.30E-02	1.90E-02	-	C0E_bp1_1	C0E_bp1_0
b11	2.10E-07	1.40E-07	-	C0E_b11_1	C0E_b11_0
bp2	--6.30E-10	3.50E-10	-	C0E_bp2_1	C0E_bp2_0
b12	2.90E-13	7.60E-13	-	C0E_bp12_1	C0E_bp12_0
b21	2.10E-15	1.20E-14	-	C0E_bp21_1	C0E_bp21_0
bp3	1.30E-16	7.90E-17	-	C0E_bp3_1	C0E_bp3_0

K	Conversion factor	OTP		
		19-21bit	11-4bit	3-0bit
a0	Offset value (20Q16)	C0E_a0_1	C0E_a0_0	C0E_a0_ex
b00	Offset value (20Q16)	C0E_b00_1	C0E_b00_0	C0E_b00_ex

TEMP(PRESS)_TXDx : Temperature and Pressure data : TXD0, TXD1 or TXD2

This sensor holds ADC data with 22 to 24 bits accuracy. It can be obtained as each 24 bits data. If there are redundant data, the low order positions will be filled by zero (0). The shaded regions as shown below are valid data area.

bit	24	23	22	…	5	4	3	2	1	Note
22bits output	D21	D20	D19	…	D2	D1	D0	0	0	Temp/Press_ave=001
23bits output	D22	D21	D20	…	D3	D2	D1	D0	0	Temp/Press_ave=010
24bits output	D23	D22	D21	…	D4	D3	D2	D1	D0	Temp/Press_ave=011~111

※Dn(D23～D0) : Sensor Data ……The value of n bit (1 or 0)

※The raw measurement values are unsigned 24bits values. The values need to do subtraction with 2^{23} at 24bits output mode. Here is a programing example for Dt and Dp calculation.

$$Dt = ((TEMP\_TXD2) << 16) + ((TEMP\_TXD1) << 8) + (TEMP\_TXD0) - pow(2,23)$$

$$Dp = ((PRESS\_TXD2) << 16) + ((PRESS\_TXD1) << 8) + (PRESS\_TXD0) - pow(2,23)$$

4.4 Implementing Register List

Register Name	Address I2C	Address SPI	Length	R/W	Data b7	b6	b5	b4	b3	b2	b1	b0	Description	Default
TEMP_TXD0	0xFC	0x7C	8bit	R/-	t_txd0[7:0]								Temperature Data[8:1] in 24bit	00h
TEMP_TXD1	0xFB	0x7B	8bit	R/-	t_txd1[7:0]								Temperature Data[16:9] in 24bit	00h
TEMP_TXD2	0xFA	0x7A	8bit	R/-	t_txd2[7:0]								Temperature Data[24:17] in 24bit	00h
PRESS_TXD0	0xF9	0x79	8bit	R/-	p_txd0[7:0]								Pressure Data[8:1] in 24bit	00h
PRESS_TXD1	0xF8	0x78	8bit	R/-	p_txd1[7:0]								Pressure Data[16:9] in 24bit	00h
PRESS_TXD2	0xF7	0x77	8bit	R/-	p_txd2[7:0]								Pressure Data[24:17] in 24bit	00h
IO_SETUP	0xF5	0x75	8bit	R/W	t_standby[3:0]				-	spi3_sdim	-	spi3w	t_standby[3:0]: Standby time setting spi3w: SPI mode setting (4 or 3 wire) spi3_sdim: Select output type of SDI terminal	00h
CTRL_MEAS	0xF4	0x74	8bit	R/W	temp_average[2:0]			press_average[2:0]			power_mode[1:0]		temp_average[2:0]: Temerature Averaging times press_average[2:0]: Pressure Averaging times power_mode[2:0]: Power mode setting	00h
DEVICE_STAT	0xF3	0x73	8bit	R/-	-	-	-	-	measure	-	-	otp_update	measure: Status of measurement otp_update: Status of OTP data access	00h
I2C_SET	0xF2	0x72	8bit	R/W	-	-	-	-	-	master_code[2:0]			Master code setting at I2C HS mode	01h
IIR_CNT	0xF1	0x71	8bit	R/W	-	-	-	-	-	filter[2:0]			IIR filter co-efficient setting	00h
RESET	0xE0	0x60	8bit	W	reset[7;0]								When inputting "E6h", a soft-reset will be occurred	00h
CHIP_ID	0xD1	0x51	8bit	R/-	chip_id[7:0]								CHIP_ID: 5Ch	5ch
COE_b00_a0_ex	0xB8	0x38	8bit	R/-	b00[3:0]				a0[3:0]				Compensation Coefficient	-
COE_a2_0	0xB7	0x37	8bit	R/-	a2[7:0]								Compensation Coefficient	-
COE_a2_1	0xB6	0x36	8bit	R/-	a2[15:8]								Compensation Coefficient	-
COE_a1_0	0xB5	0x35	8bit	R/-	a1[7:0]								Compensation Coefficient	-
COE_a1_1	0xB4	0x34	8bit	R/-	a1[15:8]								Compensation Coefficient	-
COE_a0_0	0xB3	0x33	8bit	R/-	a0[11:4]								Compensation Coefficient	-
COE_a0_1	0xB2	0x32	8bit	R/-	a0[19:2]								Compensation Coefficient	-
COE_bp3_0	0xB1	0x31	8bit	R/-	bp3[7:0]								Compensation Coefficient	-
COE_bp3_1	0xB0	0x30	8bit	R/-	bp3[15:8]								Compensation Coefficient	-
COE_b21_0	0xAF	0x2F	8bit	R/-	b21[7:0]								Compensation Coefficient	-
COE_b21_1	0xAE	0x2E	8bit	R/-	b21[15:8]								Compensation Coefficient	-
COE_b12_0	0xAD	0x2D	8bit	R/-	b12[7:0]								Compensation Coefficient	-
COE_b12_1	0xAC	0x2C	8bit	R/-	b12[15:8]								Compensation Coefficient	-
COE_bp2_0	0xAB	0x2B	8bit	R/-	bp2[7:0]								Compensation Coefficient	-
COE_bp2_1	0xAA	0x2A	8bit	R/-	bp2[15:8]								Compensation Coefficient	-
COE_b11_0	0xA9	0x29	8bit	R/-	b11[7:0]								Compensation Coefficient	-
COE_b11_1	0xA8	0x28	8bit	R/-	b11[15:8]								Compensation Coefficient	-
COE_bp1_0	0xA7	0x27	8bit	R/-	bp1[7:0]								Compensation Coefficient	-
COE_bp1_1	0xA6	0x26	8bit	R/-	bp1[15:8]								Compensation Coefficient	-
COE_bt2_0	0xA5	0x25	8bit	R/-	bt2[7:0]								Compensation Coefficient	-
COE_bt2_1	0xA4	0x24	8bit	R/-	bt2[15:8]								Compensation Coefficient	-
COE_bt1_0	0xA3	0x23	8bit	R/-	bt1[7:0]								Compensation Coefficient	-
COE_bt1_1	0xA2	0x22	8bit	R/-	bt1[15:8]								Compensation Coefficient	-
COE_b00_0	0xA1	0x21	8bit	R/-	b00[11:4]								Compensation Coefficient	-
COE_b00_1	0xA0	0x20	8bit	R/-	b00[19:12]								Compensation Coefficient	-

IO_SETUP : IO SETUP Register

Register Name	I²C Addr.	SPI Addr.	Length	R/W	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0	initial
IO_SETUP	0xF5	0x75	8bits	R/W	t_standby[2:]			-	-	Spi3_sdim	-	Spi3w	0x00

Bit7~5 t_standby[2:0]: Standby time setting

000	001	010	011	100	101	110	111
1ms	5ms	50ms	250ms	500ms	1s	2s	4s

Bit3~4 Reserved: keep these bits at 0
Bit2 spi3_sdim[2]: select output type of SDI terminal
0: Lo / Hiz output
1: Lo / Hi output
Bit1 Reserved: keep this bit at 0
Bit0 spi3w[0]: Change mode between SPI 4-wire and SPI 3-wire
0: 4-wire (default)
1: 3-wire

CTRL_MEAS : Measurement Condition Control Register

Register Name	I²C Addr.	SPI Addr.	Length	R/W	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0	initial
CTRL_MEAS	0xF4	0x74	8bits	R/W	Temp_average[2:0]			Press_average[2:0]			Power_mode[1:0]		0x00

Bit7~5 temp_average[2:0] Average times setting for temperature measurement (skip means no measurement)

000	001	010	011	100	101	110	111
Skip	1	2	4	8	16	32	64

Bit4~2 press_average[2:0] Average times setting for pressure measurement (skip means no measurement)

000	001	010	011	100	101	110	111
Skip	1	2	4	8	16	32	64

Bit1,0 power_mode[1:0] Operation mode setting
00: sleep mode
01,10: force mode
11: normal mode

DEVICE_STAT : Device Status Register

Register Name	I²C Addr.	SPI Addr.	Length	R/W	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0	initial
DEVICE_STAT	0xF3	0x73	8bits	R	-	-	-	-	Measure	-	-	Otp_update	0x00

Bit7~4 Reserved: Keep these bits at 0
Bit3 measure Device operation status. This value automatically changes
0: finish a measurement – waiting for next measurement
1: on a measurement – waiting for finishing the data store
Bit2~1 Reserved: Keep these bits at 0
Bit0 otp_update the status of OTP data access. This value automatically changes
0: no accessing OTP data
1: while accessing OTP data

I²C_SET : Master code setting

Register Name	I²C Addr.	SPI Addr.	Length	R/W	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0	initial
I2C_SET	0xF2	0x72	8bits	R/W	-	-	-	-	-	Master_code[2:0]			0x00

bit7~3 Reserved: Keep these bits at 0
bit2,1,0 master_code[2:0] Master code setting at I2C high-speed mode.

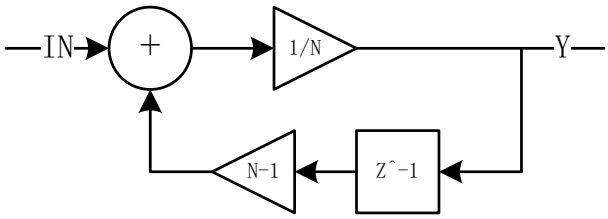
000	001	010	011	100	101	110	111
0x08	0x09	0x0A	0x0B	0x0C	0x0D	0x0E	0x0F

IIR: IIR filter co-efficient setting Register

Register Name	I²C Addr.	SPI Addr.	Length	R/W	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0	initial
IIR	0xF1	0x71	8bits	R/W	-	-	-	-	-	Filter[2:0]			0x00

bit7～3 Reserved : keep these bits at 0

bit2,1,0 filter[2:0] IIR filter co-efficient setting
Write access to this register address, IIR filter will be initialized.
Note. Initial setting of the IIR filter coefficient is “OFF”



000	001	010	011	100	101	110	111
Off	N=2	N=4	N=8	N=16	N=32	N=32	N=32

RESET: Reset Control Register

Register Name	I²C Addr.	SPI Addr.	Length	R/W	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0	initial
RESET	0xE0	0x60	8bits	W	Reset[7:0]								0x00

Bit7~0 reset[7:0] When input “E6h”, the software reset will be effective.
Except for that, nothing is to happen.

CHIP_ID: Chip ID confirmation Register

Register Name	I²C Addr.	SPI Addr.	Length	R/W	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0	initial
CHIP_ID	0xD1	0x51	8bits	R	Chip_id[7:0]								0x5c

Bit7~0 chip_id[7:0] 5C

4.5 I2C Protocol

(1) I²C Slave Address

The QMP6988 modules I²C slave address is show below.

SDO	I2C Slave Address (7bits)	bit	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
			Add[6]	Add[5]	Add[4]	Add[3]	Add[2]	Add[1]	Add[0]	R/W
High(1)	56h + R/W	Value	1	0	1	0	1	1	0	1/0
Low(0)	70h + R/W	Value	1	1	1	0	0	0	0	1/0

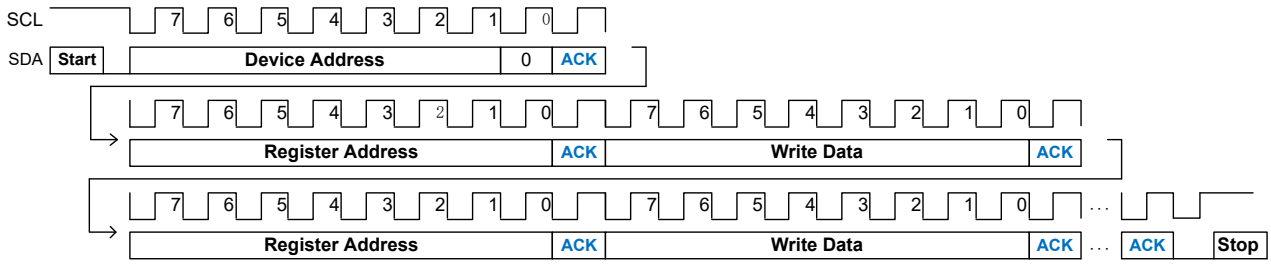
For example, in case of SDO=Low (0),
Write Access：Please set LSB of slave address as “0”, then the address is E0h(1110_0000b). (70h<<1+WR(0)) Read Access：Please set LSB of slave address as “1”, then the address is E1h(1110_0001b). (70h<<1+RD(1))

(2) I²C Access Protocol Examples

Symbol
START: Start condition
STOP: Stop condition
RE-START: Re-START condition for Read
SACK: Acknowledge by Slave
MACK: Acknowledge by Master
MNACK: Not Acknowledge by Master

(3) Register Write Access Protocol

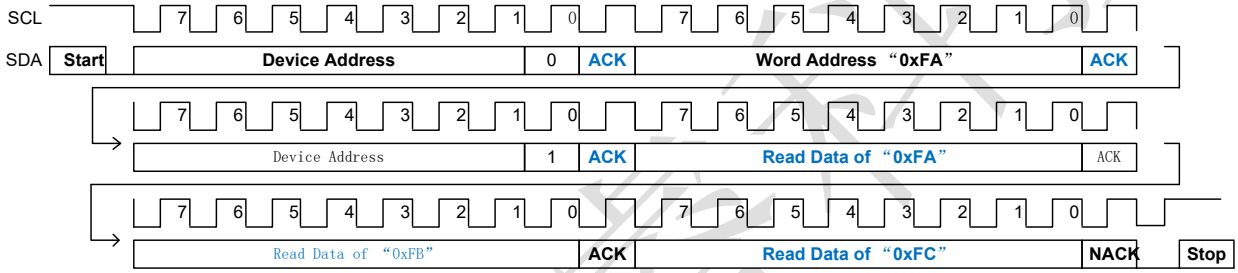
After the START condition, a Device Address is sent. This address is seven bits long followed by an eighth bit which is a data direction bit. A ‘zero’ indicates a transmission “WRITE”. After that, the register address and the writing data shall be one set and it should be continuously transmitted until a STOP condition. A data transfer is always terminated by a STOP condition generated by the master.



※**Black characters : Master → Slave / Blue characters : Slave → Master**

(4) Register Read Access Protocol

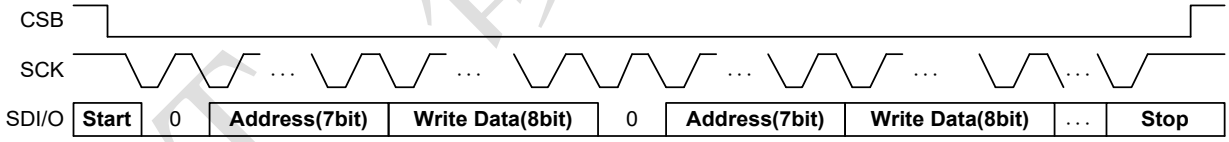
After a START condition, the Device Address with WRITE sign (“0”) and Word Address intended to read a fir st data are transmitted. Next, “STOP–START” or “Re-START” condition are transmitted by the master. After th at, Device Address with READ sign (“1”) is transmitted by the master. Then, the slave will output the first dat a that is intended to read. In case of incrementing Register Address automatically, the slave will output the d ata repeatedly until NACK is input by the master. If Register Address becomes "0xFF", please continue to out put "0xFF." Below example shows 3 bytes reading method from "0xFA" register.



4.6 SPI Protocol

(1) SPI write

“SPI Write” needs to transmit the one set data of Register Address(Ctl.=”0”+Address) and a writing data in the situation where CSB is "L". Two or more writing can be possible during CSB is “L”. If CSB becomes "H", SPI communication will finish. (as well as I²C write)

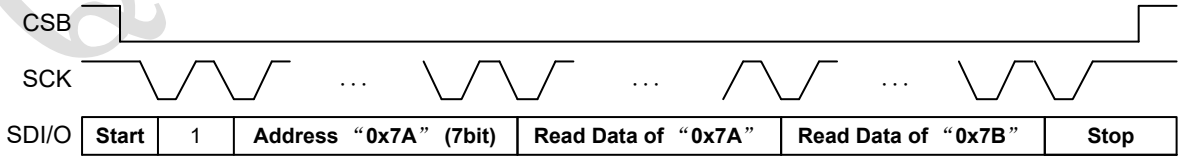


(2) SPI read

First, “SPI read” needs to transmit Register Address(Ctl.=”1”+Address) in a situation where CSB is "L".

Next, the data of the requested register address will be output from SDO. (in case of 3-wire mode, the data will be output from SDI). After that, the register address is automatically incremented by one until CSB becomes “H”, the device will output the data repeatedly. (as well as I²C read)

Below shows an example of the 2 bytes reading from "0xFA" register.



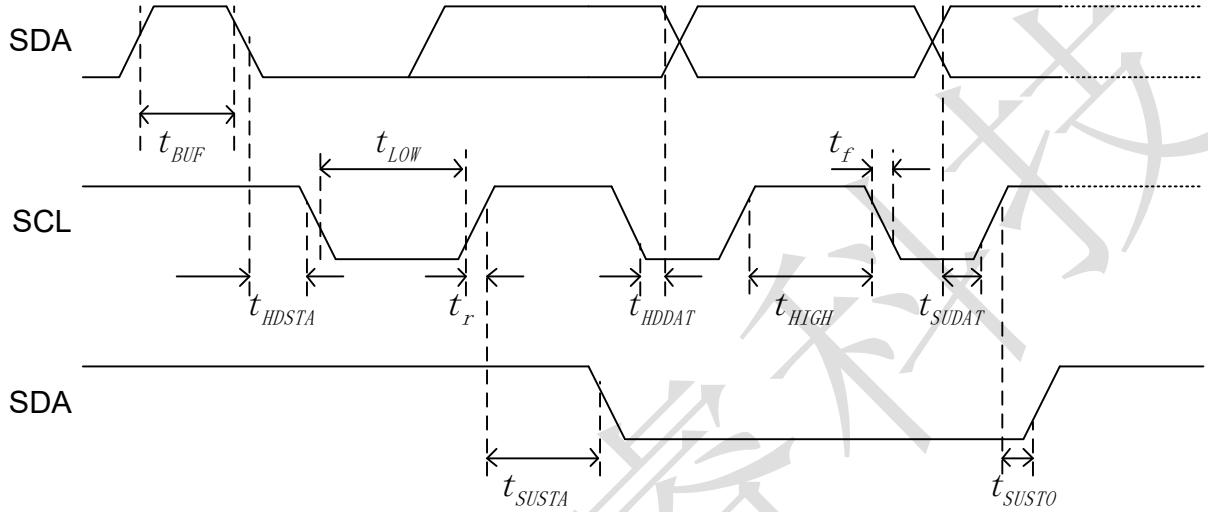
4.7 Interface specifications

(1) I²C timings

All timings apply to 100kbps（at Standard Mode），400kbps (at Fast Mode) and 3.4Mbps(at High Speed Mode). For I²C timings, the following abbreviations are used :

*1) S&F Mode = standard and fast mode
*2) Cb = bus capacitance on SDI line
*3) HS Mode = High Speed Mode

All other naming refers to I²C specification 2.1 (January 2000).

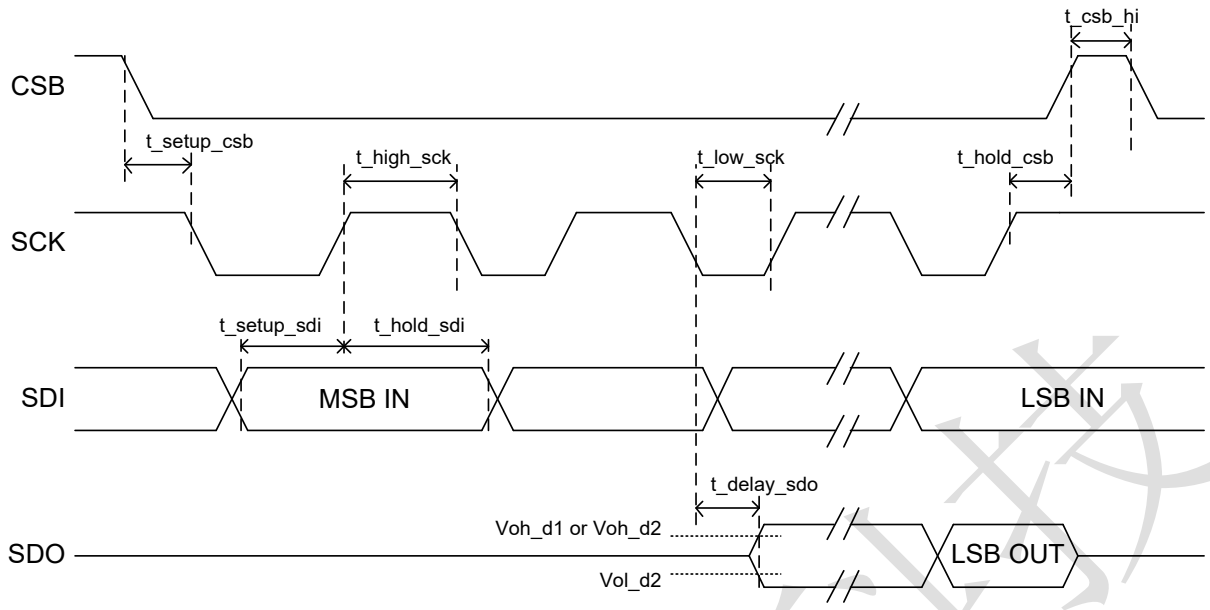


Undescribed items and symbols are compliant with the I²C specification.

Items	Symbol	Condition		min	typ	max	Units	Remark
SDI Setup time	tSUDAT	S&F Mode *1)		160	-	-	ns	
		HS Mode *2)	vio=1.62V	30	-	-	ns	
		HS Mode	Vio=1.2V	55	-	-	ns	
SDI hold time	tHDDAT	S&F Mode, Cb<=100pF		80	-	-	ns	
		S&F Mode, Cb<=400pF		90	-	-	ns	
		HS Mode, Cb<=100pF	Vio=1.62V	18	-	115	ns	
			Vio=1.2V	25	-	140	ns	
		HS Mode, Cb<=400pF	Vio=1.62V	24	-	150	ns	
			Vio=1.2V	45	-	170	ns	
SCK low pulse	tLOW	HS Mode, Cb<=100pF	Vio=1.62V	160	-	-	ns	
			Vio=1.2V	210	-	-	ns	

(2) SPI timings

All timings apply both to 4- and 3-wire SPI.
In 4-wire mode, SDO terminal has to be pull up to Vio via the resister.
On the other hand, in 3-wire mode, SDI has to be pull up to Vio.

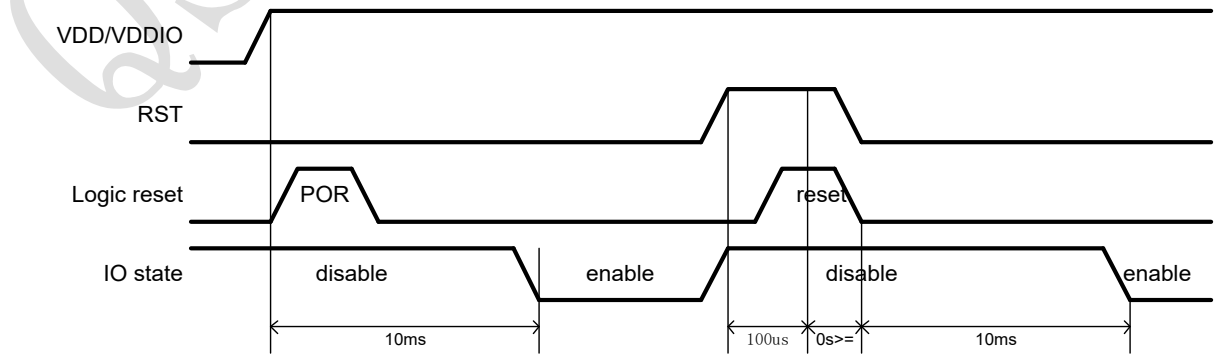


Items	Symbol	Condition	min	typ	max	Units	Remark
SCK frequency	f_spi		-	-	10	MHz	
SCK low pulse	t_low_sck		40	-	-	ns	
SCK high pulse	t_high_sck		40	-	-	ns	
SDI setupt time	t_setup_sdi		20	-	-	ns	
SDI hold time	t_hold_sdi		20	-	-	ns	
SDO output delay	t_delay_sdo	Cb=25pF, Vio=1.62V min	-	-	30	ns	
		Cb=25pF, Vio=1.2V min	-	-	40	ns	
CSB setup time	t_setup_csb		40	-	-	ns	
CSB hold time	t_hold_csb		40	-	-	ns	
CSB_HI time	t_csb_hi		100	-	-	ns	

4.8 Reset Function

The sensor is capable of resetting the operation with "Asynchronous Reset Terminal (RST pin)".
The procedure is as follows:
(1) Input high voltage to RST pin. (>=100us)
(2) Turn off (input low voltage) and wait for 10ms.

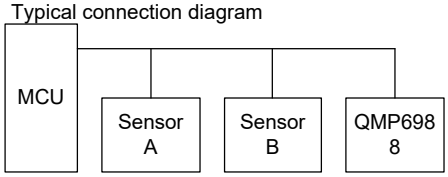
◆Reset sequence



4.9 Recommended conditions of communication

In case that this sensor and other sensors are connected with a common bus line, if you use this sensor at a communication speed more than 400kbit/s,
after finishing the communication with other sensors, we recommend to provide 1 ms or more waiting time
before starting the communication with this sensor in order to ensure a stable communication (see diagram below).

Typical connection diagram



Example of communication

5. Packaging

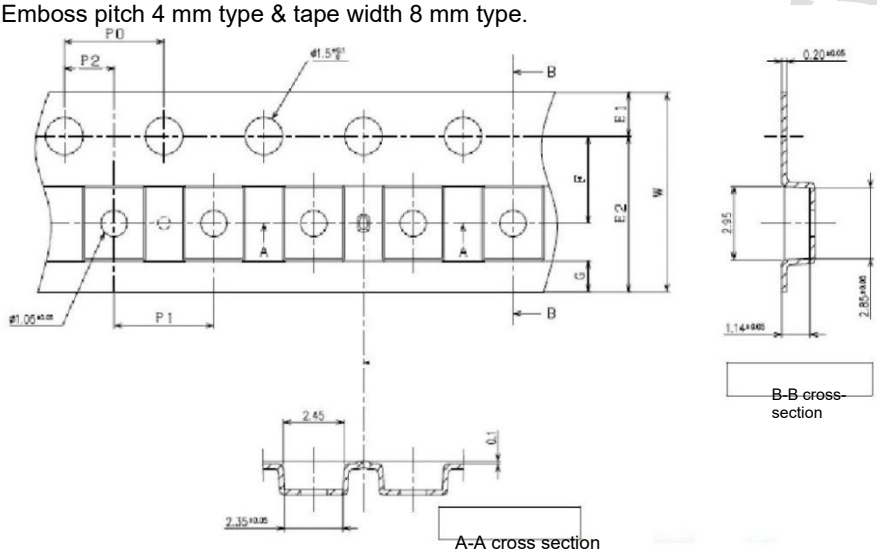
5.1 Configuration of shipment

Packaging	Embossed Carrier Tape
Quantity	3,500 pcs / 1 reel 1 reel / 1 Interior box Max. 20 Interior boxes / 1 exterior box
Reel	180 mm dia.
Insert method	see below

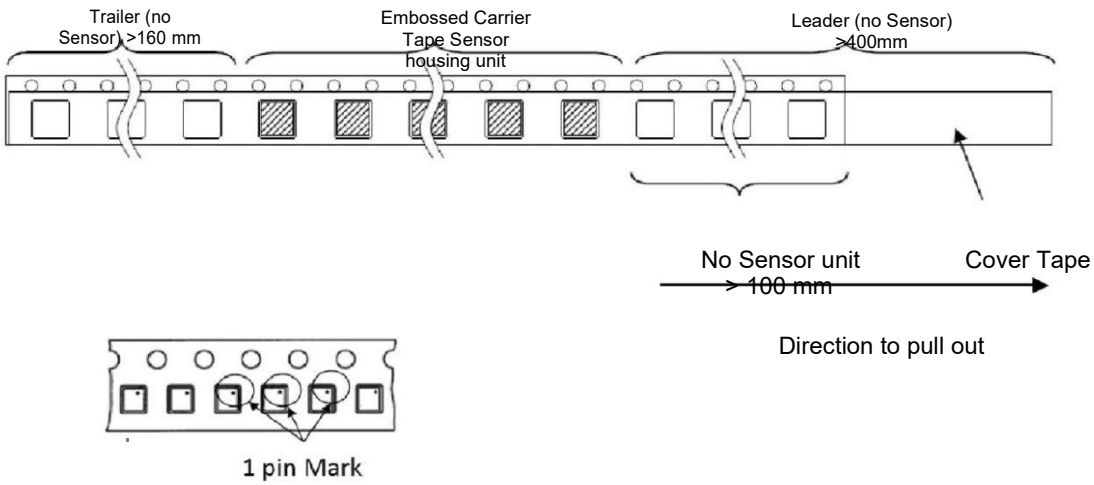
Specification of taping & reel comply with JIS C 0806-3 (IEC 60286-3).

5.2 Taping

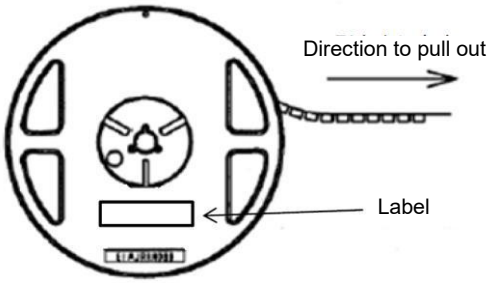
Emboss pitch 4 mm type & tape width 8 mm type.



Symbol	Rating
W	8.0 +0.03/-0.1
E1	1.75 +/- 0.1
F	3.50 +/- 0.05
P0	4.0 +/- 0.1
P1	4.0 +/- 0.1
P2	2.00 +/- 0.05

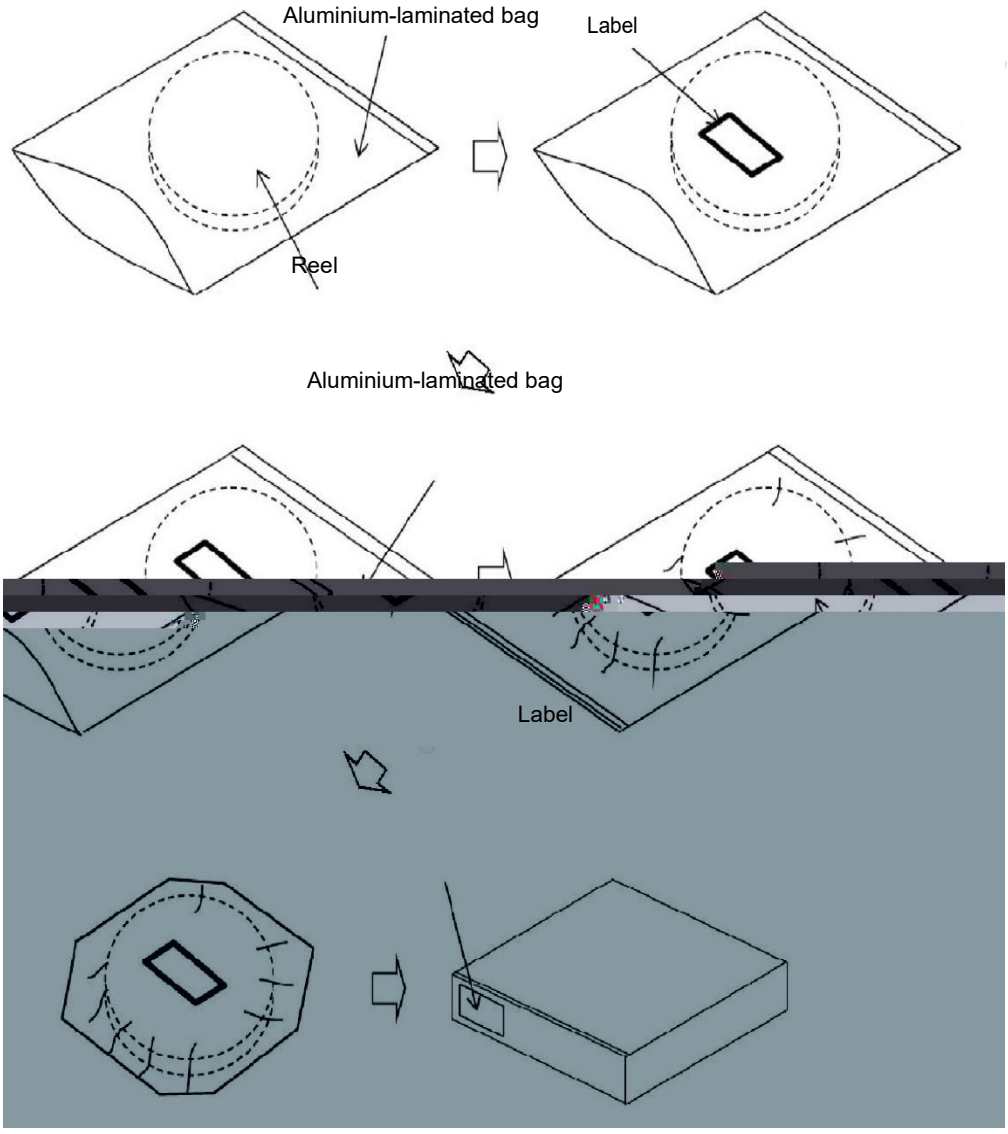


5.3 Reel



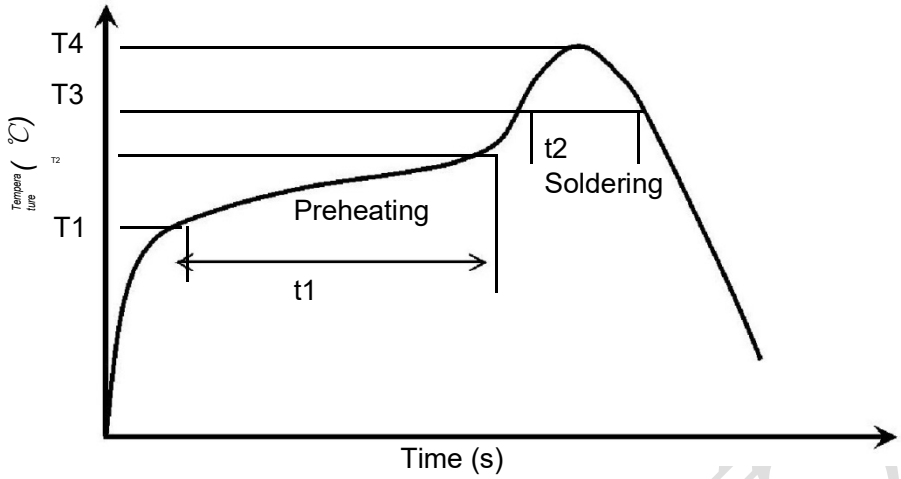
Reel 180 mm dia.
comply with JIS C 0806-3 requirements

5.4 Individual packaging



6. Recommended Soldering Method

■ **Soldering method** : Air Reflow (Max 2 times)
■ **Condition of Temperature** : Max.260 degreeC, within 40seconds
■ **Recommended Soldering Method** :



Temperature profile conditions of reflow soldering should set the temperature condition as shown in the below table and then confirm that actual conditions are met them in the table.

Item	Preheating (T1 to T2, t1)	Soldering (T3, t2)	Peak Value (T4)
Terminal	150 degreeC to 200 degreeC 60sec to 180sec.	217degreeC min. 60sec to 150sec.	260 degreeC 20sec to 40sec..

- Since the pressure sensor chip is exposed to atmosphere, cleaning fluid shall not be allowed to enter inside the sensor's case.
- We recommend that it should be used the recommended mounting PAD dimensions for the land pattern.

7. Precautions

(1) General

1) Please use QST products in compliance with usage conditions including rating and performance.
2) Please confirm fitness of QST products in your application and use your own judgment to determine the appropriateness of using them in such application. QST shall not warrant the fitness of QST products in customer application.
3) Please confirm that QST products are properly wired and installed for their intended use in your ove rall system.
4) When using QST products, please make sure to (i) maintain a margin of safety vis-à-vis the publish ed rated and performance values, (ii) design to minimize risks to customer application in case of failur e of QST products, such as introducing redundancy, (iii) introduce system-wide safety measures to n otify risks to users, and (iv) conduct regular maintenance on QST products and customer application.
5) QST products are designed and manufactured as general-purpose products for use in general indust rial products. They are not intended to be used in the following applications. If you are using QST products in the following applications, QST shall not provide any warranty for such QST products.
   a) Applications with stringent safety requirements, including but not limited to nuclear power control e quipment, combustion equipment, aerospace equipment, railway equipment, elevator/lift equipment, amusement park equipment, medical equipment, safety devices and other applications that could cause danger/harm to people's body and life
   b) Applications that require high reliability, including but not limited to supply systems for gas, water and electricity, etc., 24 hour continuous operating systems, financial settlement systems and other applications that handle rights and property
   c) Applications under severe condition or in severe environment, including but not limited to outdoor equipment, equipment exposed to chemical contamination, equipment exposed to electromagnetic i nterference and equipment exposed to vibration and shocks
   d) Applications under conditions and environment not described in specification
6) In addition to the applications listed from (a) to (d) above, QST products are not intended for use in automotive applications (including two wheel vehicles). Please do NOT use QST products for autom otive applications. Please contact QST sales staff for products for automotive use.

(2) Handling

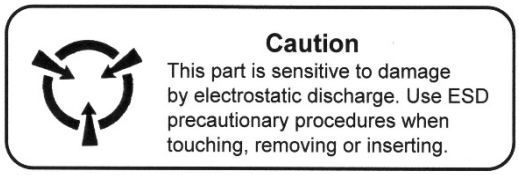
1) Only air can be used as pressure media on the product directly. It is prohibited to use pressure media including corrosive gases (e.g. organic solvents gases, sulfur dioxide and hydrogen sulfide gases), fluid and any other foreign materials.
2) The products are not water proof. The product shall be kept dry in use excluding the sensor port.
3) The product shall not be used under dew-condensing conditions. Frozen fluid on sensor chips may cause fluctuation of sen-sor output and other troubles.
4) The product shall be used within rated pressure. Usage at pressure out of the range may cause breakage.
5) The product may be damaged by static electricity. Charged materials (e.g. a workbench and a floor) and workers should pro-vide measures against static electricity, including ground connection.
6) The product shall not be dropped and handled roughly.
7) The product shall not be used under dusty or damp condition.
8) Do not wash the print circuit board after the pressure sensor is mounted using solvent. It may cause a mal-function.
9) Please connect the sensor terminals according to the connection diagram.
10) The product shall not be used under high-frequency vibration including ultrasonic wave.
11) This product uses the elastic adhesive for bonding the lid, so do not add excessive stress to the lid.
12) If soldering is not fit, then this product may catch fire or get hot.
13) There is a possibility that the peripheral circuit board or some electronic part generates heat while driving this product. Please handle with care.
14) Do not tear down this product.
15) Please do not use the sensor after following case;
    - excessive shock added to the terminal of the sensor
    - the sensor lid decapped
    - the sensor dropped
16) If you use other conditions described in this document, please check yourself in advance.

(3) Environmental conditions for transport and storage

1) The product shall not be kept with corrosive gases (e.g. organic solvents gases, sulfur dioxide and hydrogen sulfide gases).
2) The products are not water proof. The product shall be kept dry during storage.
3) The outer box strength may be degraded depending on the storage conditions. Please use the product in order.
4) For this product, please keep away from direct sunlight or ultraviolet rays.
5) The product shall be kept in appropriate conditions of temperature and humidity.
6) The product shall not be kept under dusty or damp condition.

ORDERING INFORMATION

Ordering Number	Temperature Range	Package	Package
QMP6988-TR	-40℃~85℃	LGA	Tape and Reel: 3.5k pieces/reel



CAUTION: ESDS CAT. 1B

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ISO9001 : 2008

China Patents 201510000399.8, 201510000425.7, 201310426346.3, 201310426677.7, 201310426729.0, 201210585811.3 and 201210553014.7 apply to the technology described.