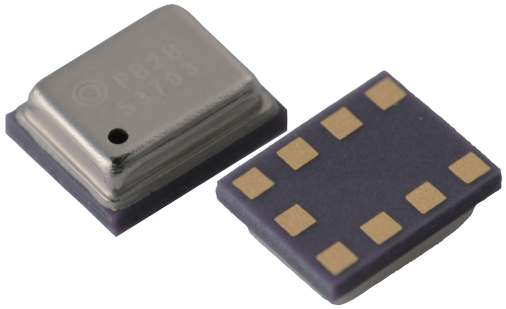
2SMPB-02B

Digital Barometric Pressure Sensor

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



- **Measure barometric pressure and temperature with high accuracy**
- **Built in low noise 24 bit 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
- Pedometer

Packaging Information

■ Standard Models with Surface Mounting Terminals

Structure	Packaging	Model	Minimum Packing Unit
LGA 9 pin	Tape and Reel	2SMPB-02B	3,500

Table of Contents

Ratings / Specifications / Function

■ Use conditions and recommended operating conditions

Type of Pressure	Absolute pressure
Medium	Air *
Operating Pressure Range	30 kPa to 110 kPa

* Never use corrosive gases.

■ Absolute Maximum Ratings

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

■ Operating Ratings

Item	Symbol	Min.	Typ.	Max.	Unit	Remark
Operating Voltage	Vopr	1.71	1.8	3.6	V	VDD
	Vio	1.20	1.8	3.6	V	VDDIO
Operating Temperature	Topr	-40	-	85	°C	

■ Electrical Characteristics (At Ta = 25°C, VDD = 1.8 V, unless otherwise noted)

Item	Symbol	Condition	Min.	Typ.	Max.	Unit
Average Current	Ihp	1 sample/s Forced 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	90 to 110 kPa, 0 to 40°C	-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	90 to 110 kPa, 0 to 40°C	-2	-	2	°C
Pressure Resolution	Pres		-	0.06	-	Pa
Temperature Resolution	Tres		-	0.0002	-	°C
Power Supply Rejection Ratio (DC)	Ppsrr	101.3 kPa, 0 to 40°C, 1.71 to 3.6 V Base on VDD = 1.8 V	-9.4	-	9.4	Pa

Note: 1. Typical specifications are not guaranteed.
Note: 2. The above table shows the characteristics of the Package before soldering.

■ Digital Interface Characteristics (At Ta = 25°C, VDD = 1.8 V, unless otherwise noted)

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	-	Vio+0.2	V
Digital Input Hysterisis Voltage	Vidhys		Vio×0.1	-	-	V
Digital Output Low Voltage (I²C)	Vol_d1	Io = 3 mA (SDI) *	0	-	Vio×0.2	V
Digital Output Low Voltage (SPI)	Vol_d2	Io = 1 mA (SDI, SDO) *	0	-	Vio×0.2	V
Digital Output High Voltage1 (SPI) (Vio >= 1.62 V)	Voh_d1	Io = 1 mA (SDI, SDO) *	Vio×0.8	-	-	V
Digital Output High Voltage2 (SPI) (Vio >= 1.2 V)	Voh_d2	Io = 1 mA (SDI, SDO) *	Vio×0.6	-	-	V
Leakage Current at Output OFF	Ioff	SDI, SDO	-10	-	10	µA
Internal Pullup Resistor	Rpullup	CSB	70	120	190	kΩ
I²C Load Capacitance	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

* "Io" is the load current of the 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.

■ Characteristics by Oversampling setting (Forced Mode)

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

Oversampling setting	Pressure oversampling	Temperature oversampling	Measurement time Typ.	ODR @ standby 1 ms Typ.	Average Current Typ. @ 1 sample/sec Forced 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	12.0	1.8
Ultra High accuracy	32	4	33.7	28	21.4	1.3

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

■ rms Noise by IIR Filter Selection (At Ta = 25°C, VDD = 1.8 V, unless otherwise noted)

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
Note 2: These characteristics are guaranteed by design.
Note 3: Initial setting of the IIR filter coefficient is “off”.

■ Bandwidth by IIR Filter Selection (At Ta = 25°C, VDD = 1.8 V, unless otherwise noted)

Oversampling setting	Typical Bandwidth [Hz]					
	IIR filter coefficient					
	off	2	4	8	16	32
High speed	153.0	35.3	14.7	6.8	3.3	1.6
Low power	121.0	28.0	11.6	5.4	2.6	1.3
Standard	86.0	19.9	8.3	3.8	1.8	0.9
High accuracy	51.0	11.8	4.9	2.3	1.1	0.5
Ultra High accuracy	28.0	6.5	2.7	1.2	0.6	0.3

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

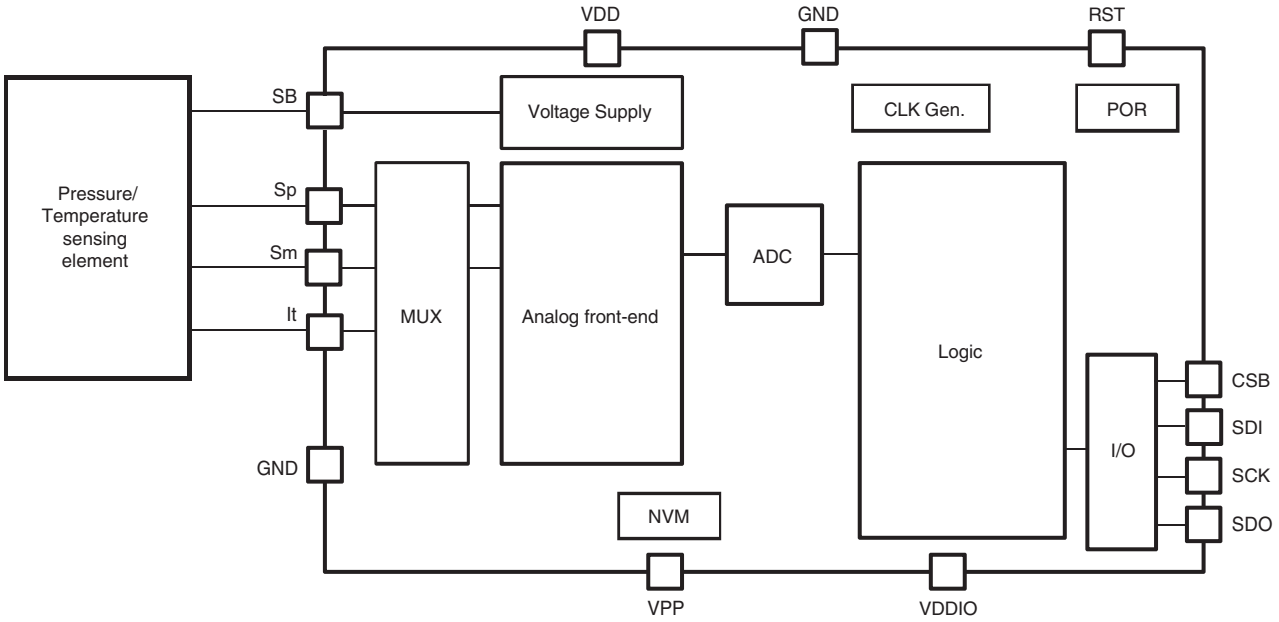
■ Filter selection based on use cases (At Ta = 25°C, VDD = 1.8 V, unless otherwise noted)

Example use case	Oversampling setting	Pressure over sampling times	Temp. over sampling times	Specification (Typ.)			
				IIR filter coefficient	Current consumption [μA]	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

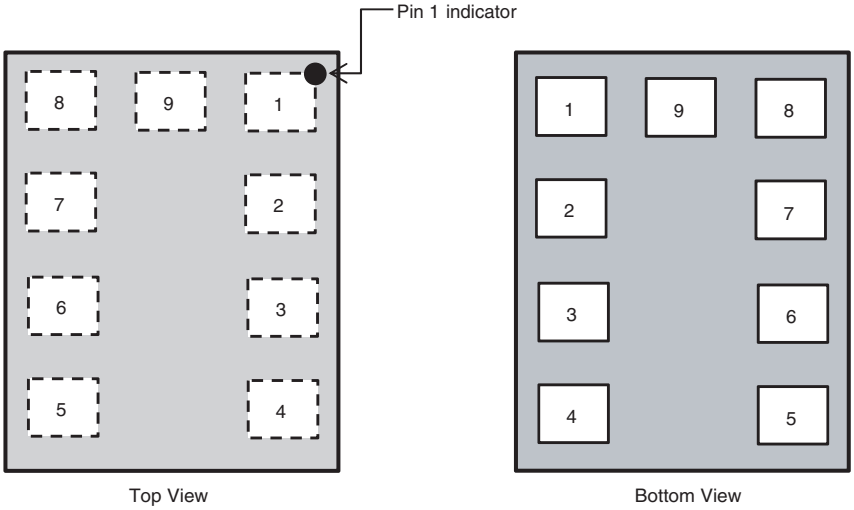
Note: These characteristics are guaranteed by design.

Connection

■ Block Diagram



■ Pin Description and Layout



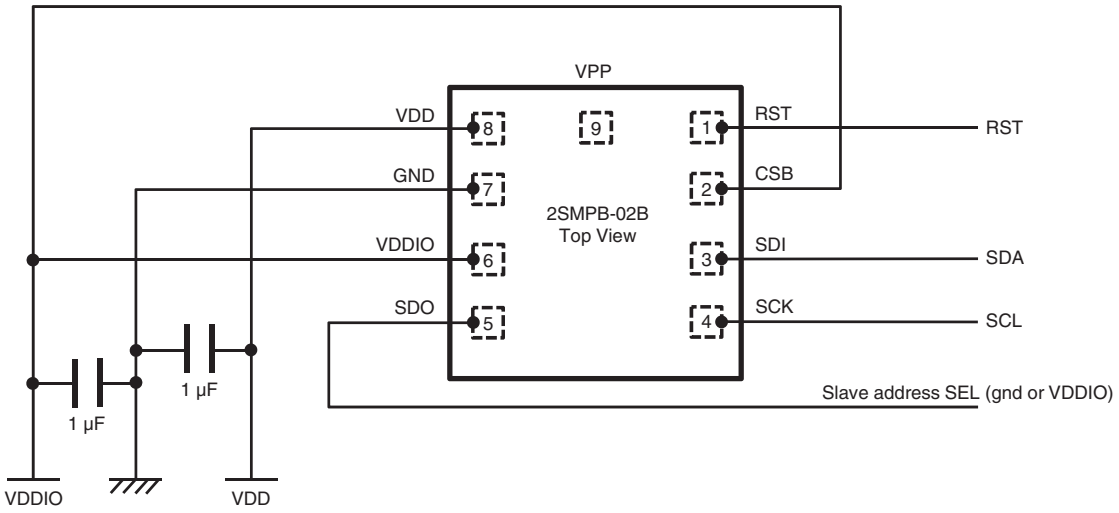
Pin No.	Symbol	Description	
		SPI	I²C
1	RST	Asynchronous Reset *1	
2	CSB	CSB	VDDIO
3	SDI	SDI/SDO	SDA
4	SCK	SCK	SCL
5	SDO	SDO	ADDR
6	VDDIO	Power Terminal for Digital IO	
7	GND	Ground Terminal	
8	VDD	Power Terminal	
9	VPP	NVM Writing Terminal *2	

*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. Please refer "■Reset Function" for the case of using the reset function.

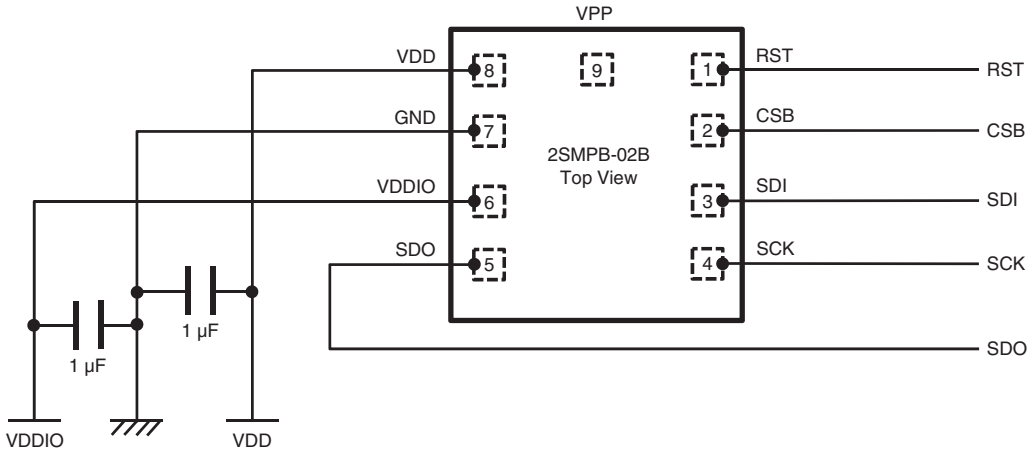
*2. Pin 9 is only used internally in OMRON. Please leave the pin disconnected. If Pin 9 is connected with any other Pin electrically, the sensor will not work properly.

■ Typical Connection Diagram

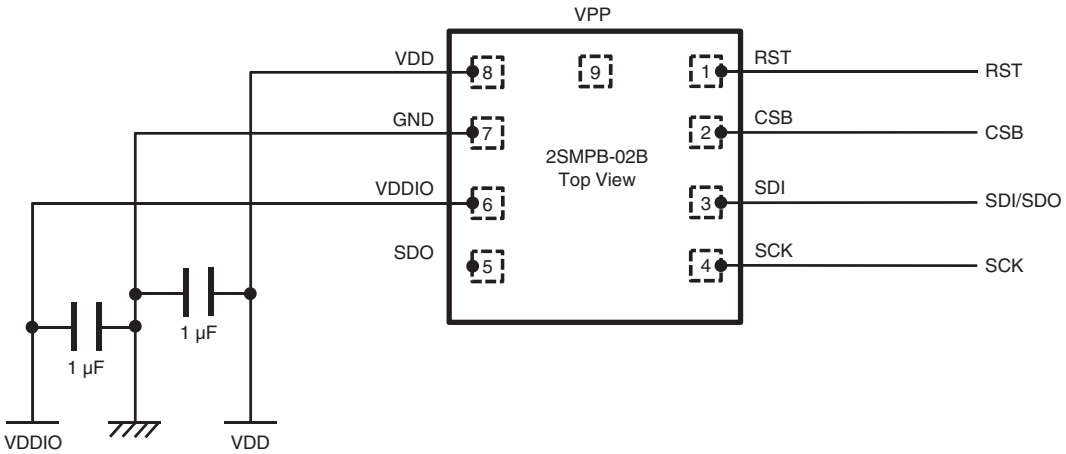
I²C mode (Corresponding to 100 Kbit/s (at Standard Mode), 400 Kbit/s (at Fast Mode) and 3.4 Mbit/s (at High Speed Mode))



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



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

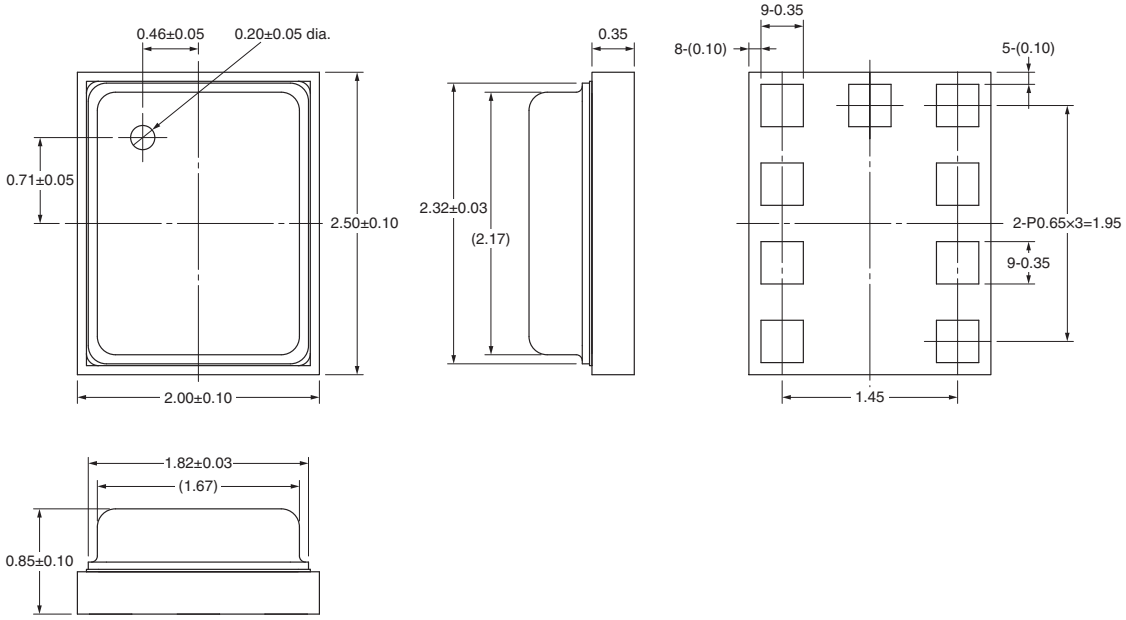


Dimensions (Unit: mm)

■ Package

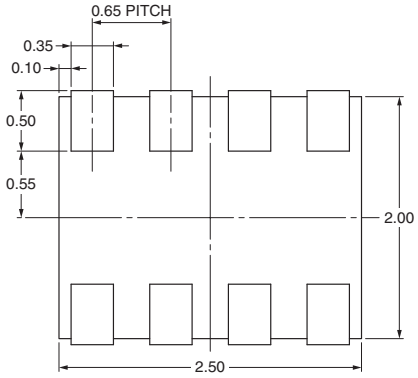
Package Type: LGA (Land Grid Array) 9 pin
Package Size: 2.00 × 2.50 × 0.85 mm
Material of the terminal surface: Au

■ Outline Dimension

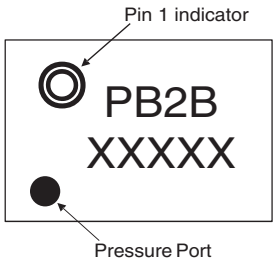


■ Mounting PAD Dimensions

Recommended (Top View)



■ Marking structure



Operations

■ 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	GND/VDDIO	SDO = GND → 70h, SDO = VDDIO → 56h
SPI 3 Wires	CSB	SDI/O	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.

- I²C mode becomes effective by pulling CSB up to VDDIO.
- SPI mode becomes effective by pulling CSB down to GND.
- 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.
- Default mode after POR or Asynchronous Reset will be I²C mode.

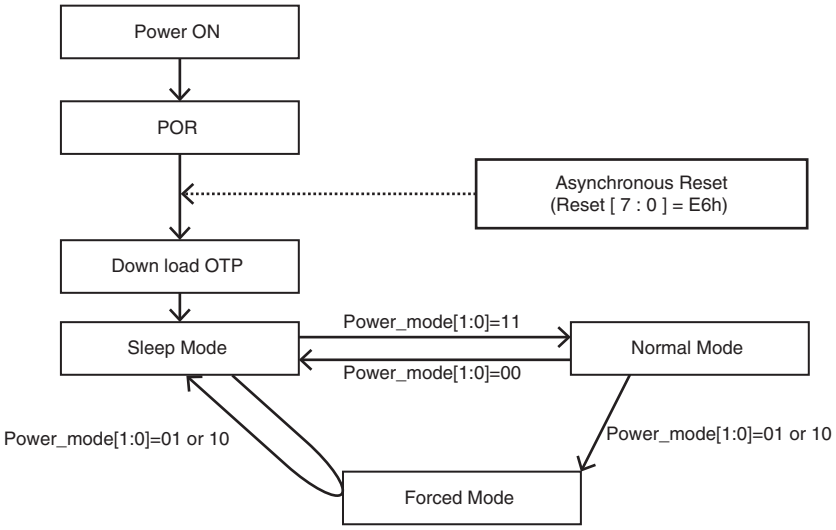
■ Power Mode

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.



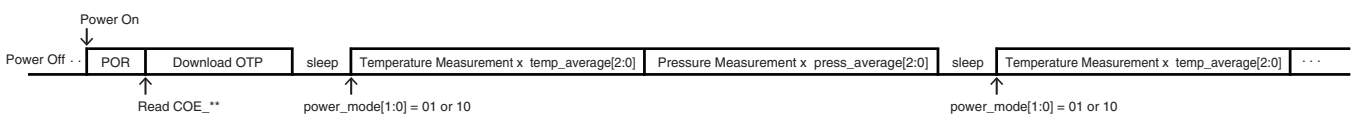
Sleep Mode (Power Reduction Mode)

No measurements are performed.

I²C/SPI interface and each register can be accessed even if the sensor is in Sleep Mode.

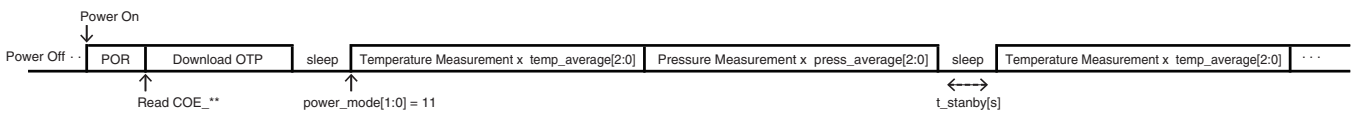
Forced Mode

In case of Forced 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 register.



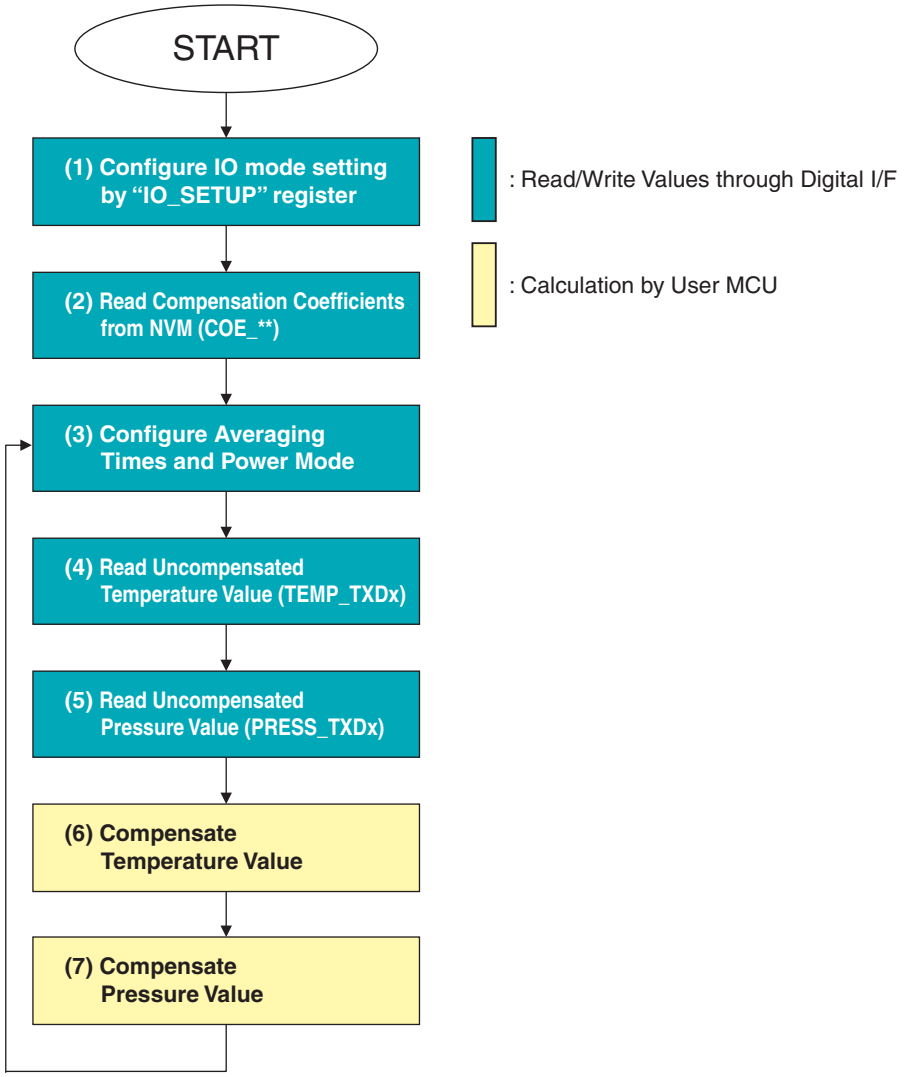
Normal Mode

In 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_stanby[2:0]” register. Be sure to consider that the data must be read from the master side after a Normal Mode.



■ 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.



MSB of PRESS_TXDx, TEMP_TXDx and COE_** are sign bit.

(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).

$$Tr = \frac{-ba - \sqrt{ba^2 - 4aa\,(ca - Dt)}}{2aa}$$

Tr : Calculation Result of Temperature (Tr/256 = Temperature [degree C])
e.g.) If Tr Value is 6400 LSB,

$$\text{Temperature (degree C)} = \frac{\text{Tr Value (LSB)}}{\text{Scaling Factor}} = \frac{\text{6400 LSB}}{\text{256 LSB/degree C}} = 25.00 \text{ degree C}$$

Dt : Raw Temperature Data [digit] (22-24bits measurement value of TEMP_TXDx Reg.)
aa : Compensation Coefficient of PTAT (Coefficient made from COE_PTAT31 and COE_PTAT32 Reg.)
ba : Compensation Coefficient of PTAT (Coefficient made from COE_PTAT21 and COE_PTAT22 Reg.)
ca : Compensation Coefficient of PTAT (Coefficient made from COE_PTAT11, COE_PTAT12 and COE_PTAT13 Reg.)

(7)① Correction pressure without temperature compensation can be calculated by using the below formula and the values of the step (2) and (5).

$$Pl = \frac{-bp + \sqrt{bp^2 - 4ap\,(cp - Dp)}}{2ap}$$

Pl : Calculation result of Pressure [Pa]
Dp : Raw Pressure Data [digit] (22-24bits measurement value of PRESS_TXDx Reg.)
ap : Compensation Coefficient of Pressure (Coefficient made from COE_PR31 and COE_PR32 Reg.)
bp : Compensation Coefficient of Pressure (Coefficient made from COE_PR21 and COE_PR22 Reg.)
cp : Compensation Coefficient of Pressure (Coefficient made from COE_PR11, COE_PR12 and COE_PR13 Reg.)

② The compensated pressure for temperature can be calculated by using the below formula and the results of step (3), (6) and (7)①.

$$Po = \frac{Pl}{at \times Tr^2 + bt \times Tr + (ct + 1)}$$

Po : Final compensated Pressure. This result is an absolute pressure value. [Pa]
at : Compensation Coefficient of Temperature (Coefficient made from COE_TEMP31 and COE_TEMP32 Reg.)
bt : Compensation Coefficient of Temperature (Coefficient made from COE_TEMP21 and COE_TEMP22 Reg.)
ct : Compensation Coefficient of Temperature (Coefficient made from COE_TEMP11 and COE_TEMP12 Reg.)

How to get compensation coefficients

Each compensation coefficients (ap, bp, at, bt, ct, aa, ba) can be calculated by using the below formula and conversion factors. The other coefficients (cp, ca) are 24 bits offset value, so raw digit stored in registers can be used.

$$K = A + \frac{S \times OTP}{32767}$$

K	Conversion factor		OTP		
	A	S	23-16 bit	15-8 bit	7-0 bit
aa	0.00E+00	4.20E-04		COE_PTAT31	COE_PTAT32
ba	-1.60E+02	8.00E+00		COE_PTAT21	COE_PTAT22
ca	Offset value with 24 bits length		COE_PTAT11	COE_PTAT12	COE_PTAT13
ap	0.00E+00	3.00E-05		COE_PR31	COE_PR32
bp	3.00E+01	1.00E+01		COE_PR21	COE_PR22
cp	Offset value with 24 bits length		COE_PR11	COE_PR12	COE_PR13
at	0.00E+00	8.00E-11		COE_TEMP31	COE_TEMP32
bt	-6.60E-06	1.60E-06		COE_TEMP21	COE_TEMP22
ct	4.00E-02	8.50E-03		COE_TEMP11	COE_TEMP12

■ Implementing Register List

Register Name	Address		R/W	Data								Descriptions	Initial
	I²C	SPI		bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0		
TEMP_TXD0	FCh	7Ch	R/-	t_txd0[7:0]								Temperature DATA [8:1] in 24 bits	00h
TEMP_TXD1	FBh	7Bh	R/-	t_txd1[7:0]								Temperature DATA [16:9] in 24 bits	00h
TEMP_TXD2	FAh	7Ah	R/-	t_txd2[7:0]								Temperature DATA [24:17] in 24 bits *	00h
PRESS_TXD0	F9h	79h	R/-	p_txd0[7:0]								Pressure DATA [8:1] in 24 bits	00h
PRESS_TXD1	F8h	78h	R/-	p_txd1[7:0]								Pressure DATA [16:9] in 24 bits	00h
PRESS_TXD2	F7h	77h	R/-	p_txd2[7:0]								Pressure DATA [24:17] in 24 bits *	00h
IO_SETUP	F5h	75h	R/W	t_stanby[2:0]			-		spi3_sdim	-	spi3w	t_stanby[2:0] : Standby time setting spi3w : SPI mode setting (4 or 3 wire) spi3_sdim : Select output type of SDI terminal	00h
CTRL_MEAS	F4h	74h	R/W	temp_average[2:0]			press_average[2:0]			power_mode[1:0]		temp_average[2:0] : Temperature Averaging Times press_average[2:0] : Pressure Averaging Times power_mode[1:0] : Power mode setting	00h
DEVICE_STAT	F3h	73h	R/-	-	-	-	-	measure	-	-	otp_update	measure : Status of measurement otp_update : Status of OTP data access	00h
I²C_SET	F2h	72h	R/W	-	-	-	-	-	master_code[2:0]			Master code setting at I²C HS mode	01h
IIR_CNT	F1h	71h	R/W	-	-	-	-	-	filter[2:0]			IIR filter co-efficient setting	00h
RESET	E0h	60h	-/W	reset[7:0]								When inputting "E6h", a software reset will be occurred.	00h
CHIP_ID	D1h	51h	R/-	chip_id[7:0]								CHIP_ID1 : 5C	5Ch
COE_PTAT32	B4h	34h	R/-	coe_ptat32[7:0]								Compensation Coefficient	–
COE_PTAT31	B3h	33h	R/-	coe_ptat31[7:0]								Compensation Coefficient *	–
COE_PTAT22	B2h	32h	R/-	coe_ptat22[7:0]								Compensation Coefficient	–
COE_PTAT21	B1h	31h	R/-	coe_ptat21[7:0]								Compensation Coefficient *	–
COE_PTAT13	AFh	2Fh	R/-	coe_ptat13[7:0]								Compensation Coefficient	–
COE_PTAT12	AEh	2Eh	R/-	coe_ptat12[7:0]								Compensation Coefficient	–
COE_PTAT11	ADh	2Dh	R/-	coe_ptat11[7:0]								Compensation Coefficient *	–
COE_TEMP32	ACh	2Ch	R/-	coe_temp32[7:0]								Compensation Coefficient	–
COE_TEMP31	ABh	2Bh	R/-	coe_temp31[7:0]								Compensation Coefficient *	–
COE_TEMP22	AAh	2Ah	R/-	coe_temp22[7:0]								Compensation Coefficient	–
COE_TEMP21	A9h	29h	R/-	coe_temp21[7:0]								Compensation Coefficient *	–
COE_TEMP12	A8h	28h	R/-	coe_temp12[7:0]								Compensation Coefficient	–
COE_TEMP11	A7h	27h	R/-	coe_temp11[7:0]								Compensation Coefficient *	–
COE_PR32	A6h	26h	R/-	coe_pr32[7:0]								Compensation Coefficient	–
COE_PR31	A5h	25h	R/-	coe_pr31[7:0]								Compensation Coefficient *	–
COE_PR22	A4h	24h	R/-	coe_pr22[7:0]								Compensation Coefficient	–
COE_PR21	A3h	23h	R/-	coe_pr21[7:0]								Compensation Coefficient *	–
COE_PR13	A2h	22h	R/-	coe_pr13[7:0]								Compensation Coefficient	–
COE_PR12	A1h	21h	R/-	coe_pr12[7:0]								Compensation Coefficient	–
COE_PR11	A0h	20h	R/-	coe_pr11[7:0]								Compensation Coefficient *	–

* MSB of PRESS_TXDx, TEMP_TXDx and COE_** are sign bit.

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
22 bits output	D21	D20	D19	...	D2	D1	D0	0	0	Temp/Press_ave = 001
23 bits output	D22	D21	D20	...	D3	D2	D1	D0	0	Temp/Press_ave = 010
24 bits output	D23	D22	D21	...	D4	D3	D2	D1	D0	Temp/Press_ave = 011 to 111

Note: 1. Dn (D23 to D0) : Sensor Data ……The value of n bit (1 or 0)
Note: 2. The raw measurement values are unsigned 24 bits values. The values need to do subtraction with 2^{23} at 24 bits 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)

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	F5h	75h	8bits	R/W	t_stanby[2:0]			–	–	spi3_sdim	–	spi3w	00h

it7 to 5 t_stanby[2:0] : Standby time setting

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

bit3 to 4 Reserved : keep these bits at 0
bit2 spi3_sdim : Select output type of SDI terminal
0 : Lo / Hi-z output (Default)
1 : Lo / Hi output
bit1 Reserved : keep this bit at 0
bit0 spi3w : 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	F4h	74h	8bits	R/W	temp_average[2:0]			press_average[2:0]			power_mode[1:0]		00h

bit7 to 5 temp_average[2:0] Averaging 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 to 2 press_average[2:0] Averaging 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 : Forced 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	F3h	73h	8bits	R	–	–	–	–	measure	–	–	otp_update	00h

bit7 to 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 NVM data access. This value automatically changes.
0: No accessing NVM data
1: While accessing NVM 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	F2h	72h	8bits	R/W	–	–	–	–	–	master_code[2:0]			01h

bit7 to 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
08h	09h	0Ah	0Bh	0Ch	0Dh	0Eh	0Fh

IIR_CNT : IIR filter co-efficient setting Register

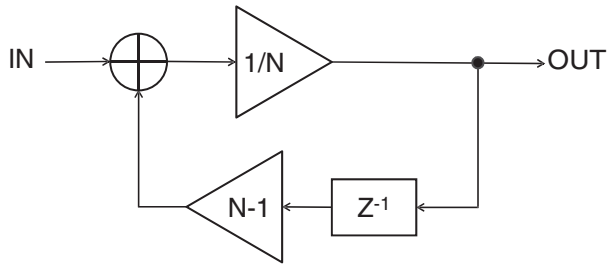
Register Name	I²C Addr.	SPI Addr.	Length	R/W	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0	initial
IIR_CNT	F1h	71h	8bits	R/W	–	–	–	–	–	filter[2:0]			00h

bit7 to 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	E0h	60h	8bits	W	reset[7:0]								00h

bit7 to 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	D1h	51h	8bits	R	chip_id[7:0]								5Ch

bit7 to 0 chip_id[7:0] 5Ch

■ I²C Protocol

(1) I²C Slave Address

The 2SMPB-02 module I²C slave address is shown below.

SDO	I²C Slave Address (7 bits)	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))

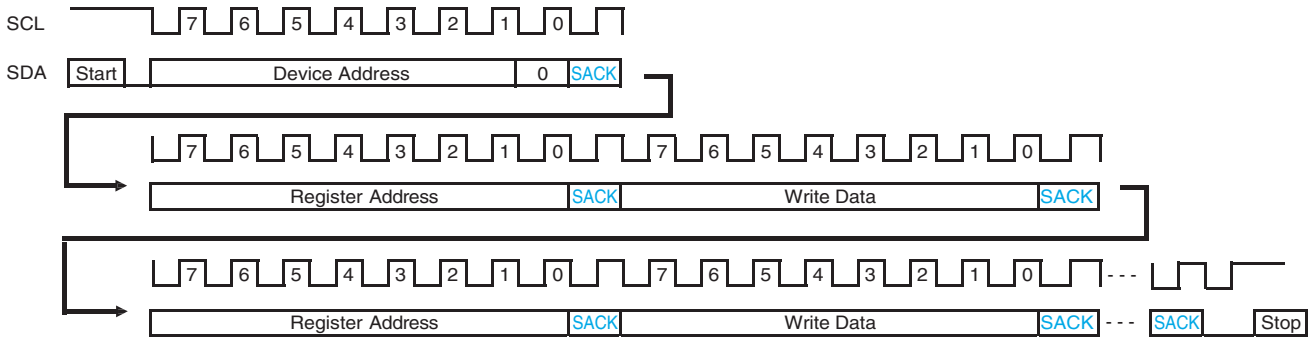
Read Access : Please set LSB of slave address as "1", then the address is E1h (1110_0001b). (70h<<1+RD(1))

(2) I²C Access Protocol Examples

Symbol	Condition
START	START condition
STOP	STOP condition
SACK	Acknowledge by Slave
MACK	Acknowledge by Master
MNACK	Not Acknowledge by Master

(3) Register Write Access Protocol

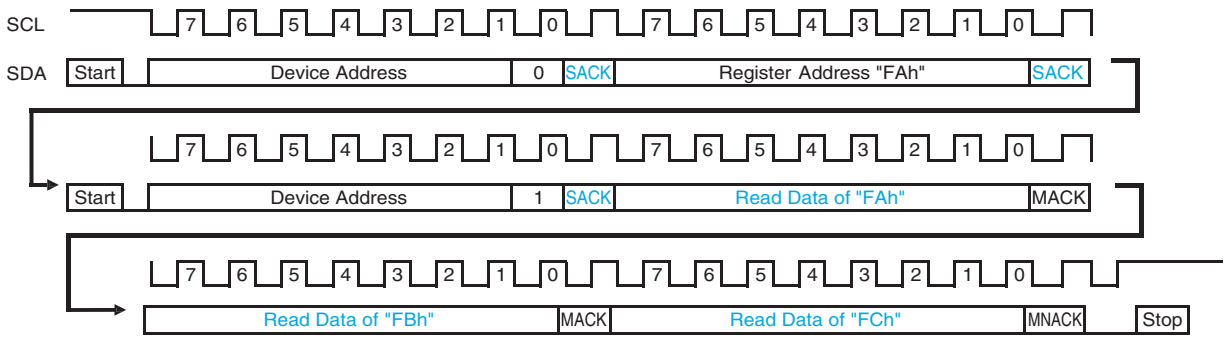
After the START condition, a Device Address is sent. This address is seven bits long followed by an eighth bit which is a data direction bit. A 'zero' indicates a transmission "WRITE". After that, the register address and the writing data shall be one set and it should be continuously transmitted until 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

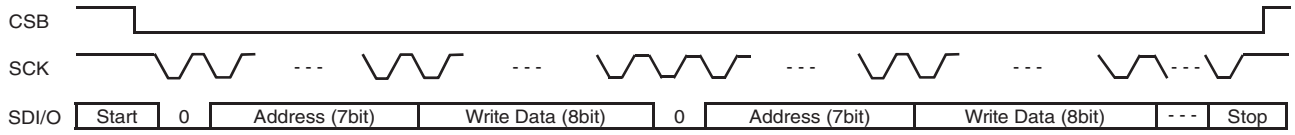
After a START condition, the Device Address with WRITE sign ("0") and Word Address intended to read a first data are transmitted. Next, "STOP-START" or "Re-START" condition are transmitted by the master. After that, Device Address with READ sign ("1") is transmitted by the master. Then, the slave will output the first data that is intended to read. In case of incrementing Register Address automatically, the slave will output the data repeatedly until NACK is input by the master. If Register Address becomes "FFh", please continue to output "00h". Below example shows 3 bytes reading method from "FAh" register.



■ 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)



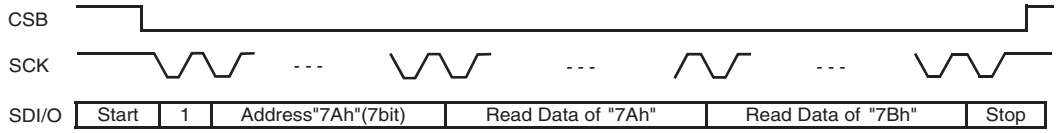
(2) SPI read

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 "FAh" register.



■ Interface specifications

(1) I²C timings

All timings apply to 100 kbps (at Standard Mode), 400 kbps (at Fast Mode) and 3.4 Mbps (at High Speed Mode).

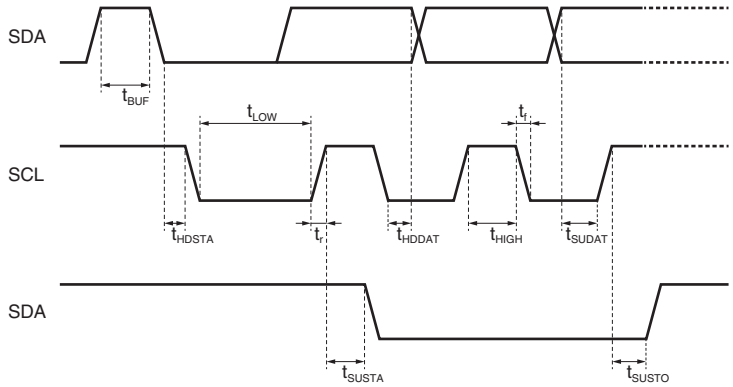
For I²C timings, the following abbreviations are used :

S&F Mode = Standard and Fast Mode

Cb = bus capacitance on SDI line

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	t_{SUDAT}	S&F Mode		160	–	–	ns	
		HS Mode	Vio = 1.62 V	30	–	–	ns	
		HS Mode	Vio = 1.2 V	55	–	–	ns	
SDI hold time	t_{HDDAT}	S&F Mode, Cb ≤ 100 pF		80	–	–	ns	
		S&F Mode, Cb ≤ 400 pF		90	–	–	ns	
		HS Mode, Cb ≤ 100 pF	Vio = 1.62 V	18	–	115	ns	
			Vio = 1.2 V	25	–	140	ns	
		HS Mode, Cb ≤ 400 pF	Vio = 1.62 V	24	–	150	ns	
			Vio = 1.2 V	45	–	170	ns	
SCK low pulse	t_{LOW}	HS Mode, Cb ≤ 100 pF	Vio = 1.62 V	160	–	–	ns	
			Vio = 1.2 V	210	–	–	ns	

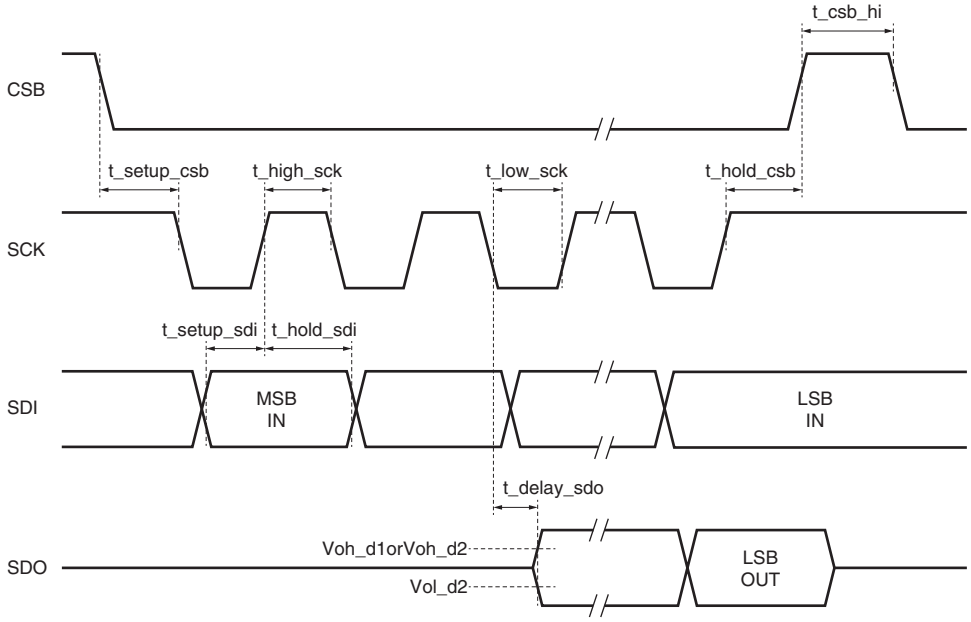
(2) SPI timings

All timings are applied both to 4-wire and 3-wire SPI.

To reduce external noise in High-Z state, we recommend the following;

- In 4-wire mode, SDO terminal is pulled up to Vio via the resister.
- In 3-wire mode, SDI terminal is pulled up to Vio via the resister.

e.g.) Rpullup = 3.6kΩ @Vio=1.8V.



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 setup time	t_setup_sdi		20	–	–	ns	
SDI hold time	t_hold_sdi		20	–	–	ns	
SDO output delay	t_delay_sdo	Cb = 25 pF, Vio = 1.62 V min	–	–	30	ns	
		Cb = 25 pF, Vio = 1.2 V 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	

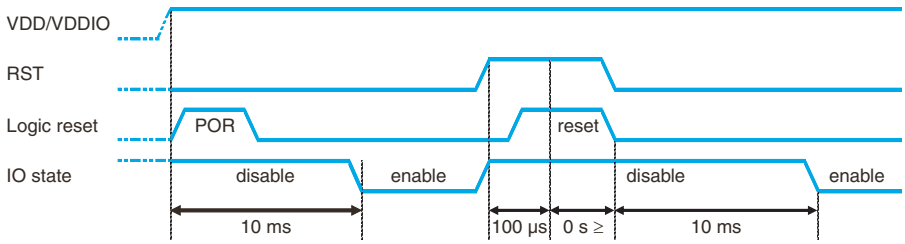
■ Reset Function

The sensor is capable of resetting the operation with “Asynchronous Reset Terminal (RST pin)”.

The procedure is as follows: Input high voltage to RST pin. (100 µs ≥)

Turn off (input low voltage) and wait 10 ms.

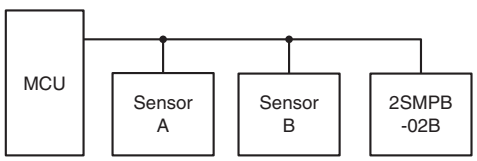
Reset sequence



■ 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 400 kbit/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

Packaging

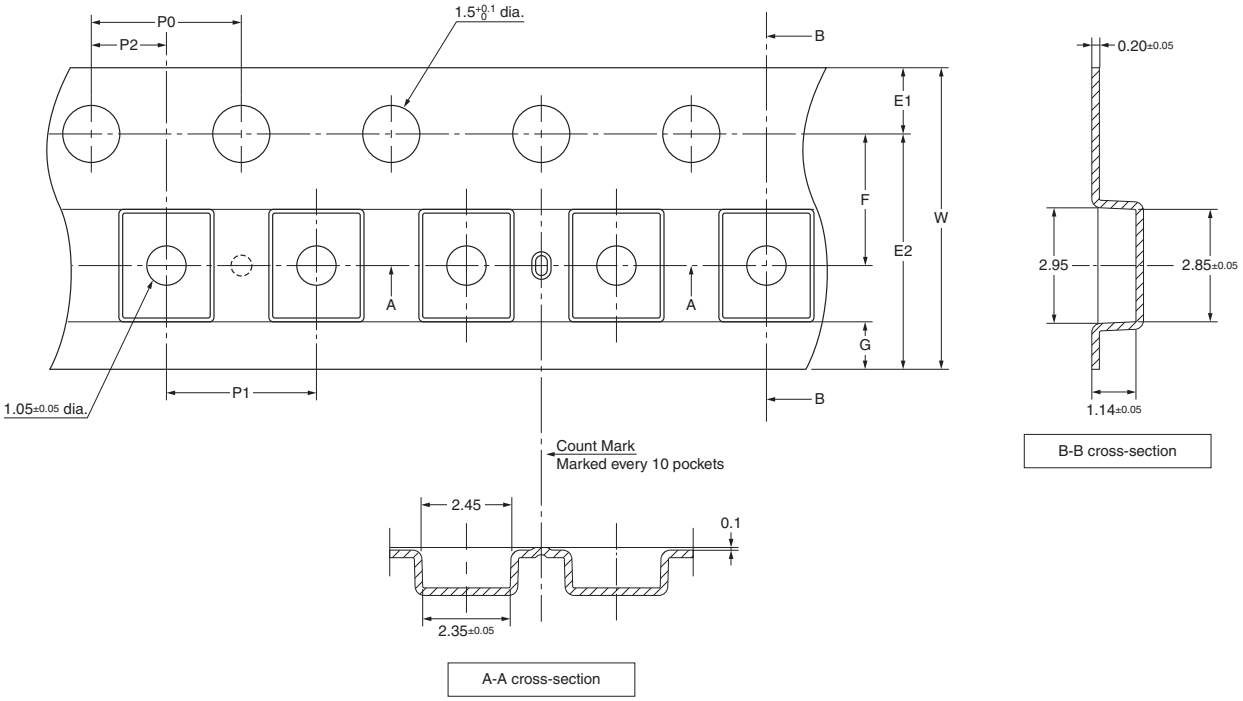
■ Configuration of shipment

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

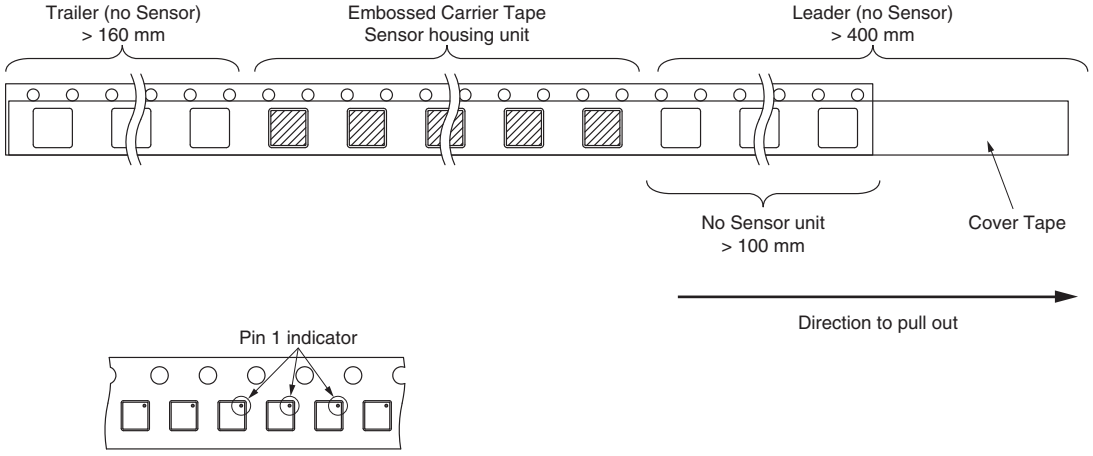
Note: Specification of taping & reel comply with JIS C 0806-3 (IEC 60286-3).

■ Taping

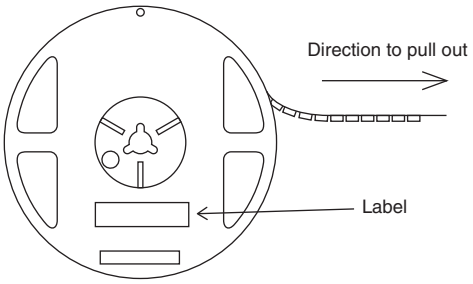
Emboss pitch 4 mm type & tape width 8 mm type.



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

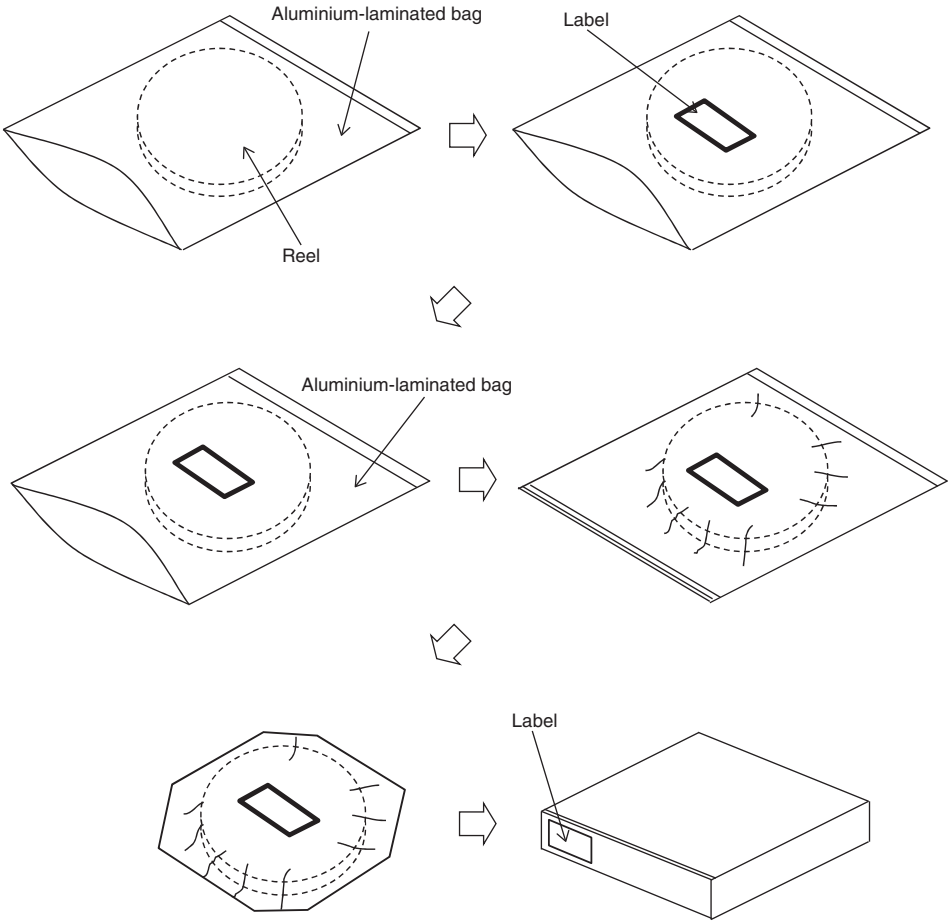


■ Reel



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

■ Individual packaging



Recommended Soldering Method

■ Soldering method

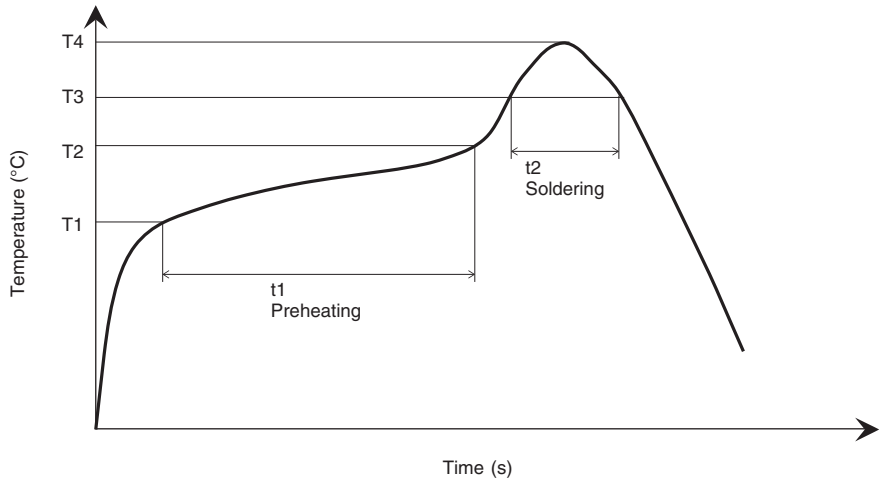
Air Reflow (Max. 2 times)

■ Condition of Temperature

Max. 260°C, within 40 seconds

■ 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°C to 200°C 60 sec to 180 sec.	> 217°C 60 sec to 150 sec.	260°C 20 sec to 40 sec.

- 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.

Safety Precautions

Precautions for Correct Use

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 sensor 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 provide 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.

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.

Warranty and Limited Warranty

Definition

The definition of terms used in these Terms and Conditions are as follows:

(1) Usage conditions: Usage conditions, rating, performance, operating environment, handling instructions, cautions, prohibited use, etc. of Omron products described in specifications, documentations or manuals.

(2) Customer application: Application of Omron products by customers which include embedding and/or using Omron products in their parts/components, electronic substrates, devices, equipment or systems manufactured by customers.

(3) Fitness: (a) performance, (b) non-infringement of third-party intellectual property, (c) compliance with laws and regulations and (d) conformity to various standards.

Caution on Descriptions

Attention is required to the following points on descriptions in specifications.

(1) Rated values and performance values are the product of tests performed for separate single conditions, including but not limited to temperature and humidity. It is not intended to warrant rated values and performance values for multiple combined conditions.

(2) Reference data are provided for reference only. Omron does NOT warrant that Omron products work properly at all time in the range of reference data.

(3) Application examples are provided for reference only. Omron does NOT warrant the Fitness of Omron products under such application.

(4) Omron may discontinue the production of Omron products or change the specifications of them for the purpose of improving such products or other reasons entirely at its own discretion.

Precautions

Please be aware of and accept the following when you introduce or use Omron products:

(1) Please use Omron products in compliance with usage conditions including rating and performance.

(2) Please confirm fitness of Omron products in your application and use your own judgment to determine the appropriateness of using them in such application. Omron shall not warrant the fitness of Omron products in customer application.

(3) Please confirm that Omron products are properly wired and installed for their intended use in your overall system.

(4) When using Omron products, please make sure to (i) maintain a margin of safety vis-à-vis the published rated and performance values, (ii) design to minimize risks to customer application in case of failure of Omron products, such as introducing redundancy, (iii) introduce system-wide safety measures to notify risks to users, and (iv) conduct regular maintenance on Omron products and customer application.

(5) Omron products are designed and manufactured as general-purpose products for use in general industrial products. They are not intended to be used in the following applications. If you are using Omron products in the following applications, Omron shall not provide any warranty for such Omron products.

- (a) Applications with stringent safety requirements, including but not limited to nuclear power control equipment, 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 interference 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, Omron products are not intended for use in automotive applications (including two wheel vehicles). Please do NOT use Omron products for automotive applications. Please contact Omron sales staff for products for automotive use.

Warranty Terms and Conditions

The terms and conditions for warranty of Omron products are as follows:

(1) Warranty period: One year after the purchase.

(2) Coverage: Omron will provide free replacement of the malfunctioning Omron products with the same number of replacement/alternative products

(3) Exceptions: Omron will not cover Omron products under its warranty if the cause of the malfunction falls under any of the following.

- (a) Usage in a manner other than the original intended use for the Omron product.
- (b) Usage outside of the usage conditions.
- (c) Cause which could not have been foreseen with the level of science and technology at the time of shipping from Omron.
- (d) Causes originating from other than Omron or Omron products (including force majeure such as but not limited to natural disasters).

Limitation of Liability

The warranty set out in these Terms and Conditions is the whole and sole liability for Omron products. There are no other warranties, expressed or implied. Omron and the distributors of Omron products are not liable for any damages which may arise from or be related to Omron products.

Export Controls

Customers of Omron products shall comply with all applicable laws and regulations of other relevant countries with regard to security export control, when exporting Omron products and/or technical documents or providing such products and/or documents to a non-resident. Omron may not provide customers with Omron products and/or technical documents should they fail to comply with such laws and regulations

Please check each region's Terms & Conditions by region website.

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China
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Japan
https://www.omron.co.jp/ecb/

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