Digital output Micro Differential Pressure Sensor

MMR940 Datasheet

DESCRIPTION

The MMR940 digitally outputs a micro differential pressure value which was corrected. Customers need no correction because it corrects and outputs the differences of sensors and temperature characteristics. It does not require complicated sensor drive or control circuit, and devices with high performance can be made only with this module and an external microcontroller which will be the host.

FEATURES

- Dual nozzle package:29(W) ×18(D) ×14.25(H)mm
- Operating pressure range
  C02 rank: -20~20cmH2O(-1.961~1.961kPa)
  C04 rank: -40~40cmH2O(-3.922~3.922kPa)
  C07 rank: -70~70cmH2O(-6.865~6.865kPa)
  C10 rank: -100~100cmH2O(-9.807~9.807kPa)
- Effective resolution: 0.002cmH2ORMS (0.196PaRMS) (at MODE4)
- Pressure measurement error
  C02 rank: ±2.0(TBD)[%FS]
  C04,C07,C10 rank: ±1.0(TBD) [%FS]
- It corrects the differences of sensors and temperature characteristics when shipped from our factory.
- It digitally outputs pressure value corrected in the module. (I2C)
  I2C slave address (7 bits) is 0x67
- Noise reduction is possible by a built-in Low Pass Filter.
- This product complies with RoHS.
- This product contains halogen.

rank		Pressure Unit Conversion Table						
	cmH2O	mbar	bar	psi	inchH2O	i.w.c	Pa	kPa
C02	±20	±19.61	±0.01961	±0.2845	±7.9402	±7.9402	±1961	±1.961
C04	±40	±39.23	±0.03923	±0.5689	±15.8804	±15.8804	±3922	±3.922
C07	±70	±68.65	±0.06865	±0.9956	±27.7907	±27.7907	±6865	±6.865
C10	±100	±98.07	±0.09807	±1.4223	±39.7010	±39.7010	±9807	±9.807

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BLOCK DIAGRAM

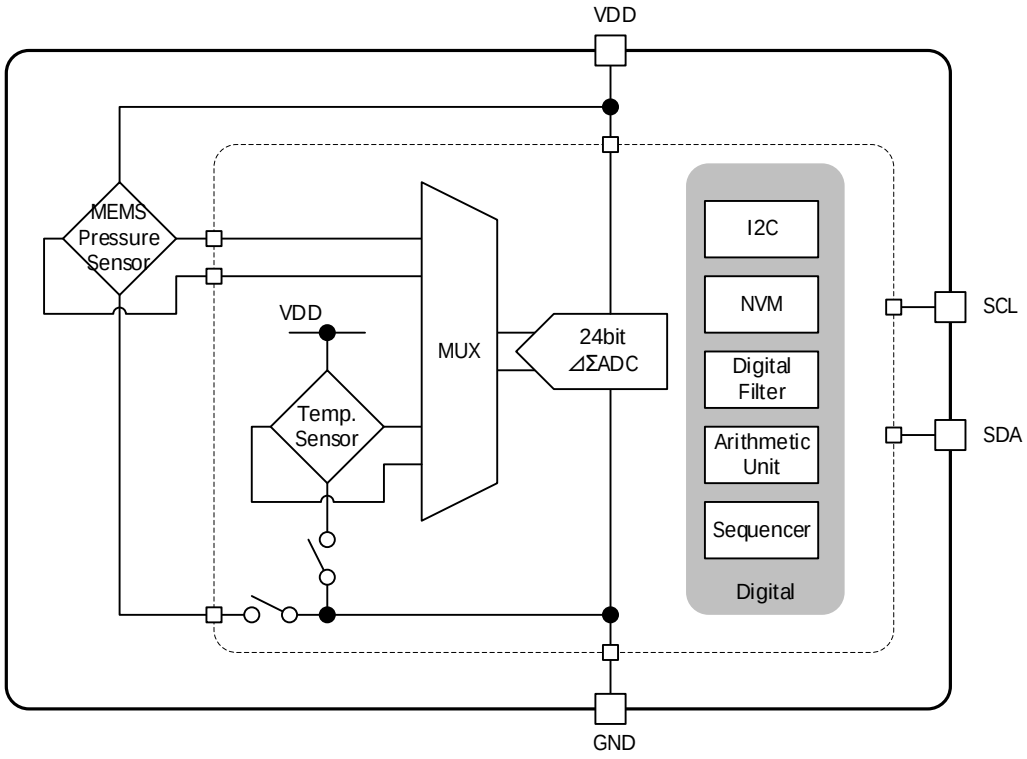


Fig. 1 Block diagram

PIN CONFIGURATION

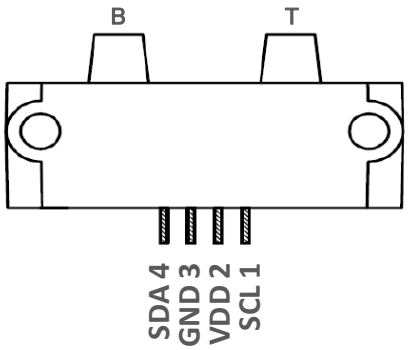


Fig. 2 Pin configuration (Top view)

note[1] B : Pressure opening to Bottom of MEMS sensor die
T : Pressure opening to Top of MEMS sensor die

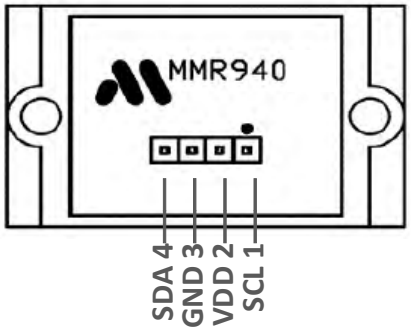


Fig. 3 Pin configuration (Bottom view)

TERMINAL EXPLANATIONS

Table 1 Pin table

No.	Pin Name	Type	Function
1	SCL	I/O	Serial clock for I2C communication (SCL)
2	VDD	I	Power-supply
3	GND	-	GND
4	SDA	I/O	Serial Data (Input and output) for I2C communication (SDA)
-	T	-	Pressure opening to Top of MEMS sensor die (T) Output value decreases when Pressure opening (T) is pressurized.
-	B	-	Output value increases when Pressure opening (B) is pressurized.

ABSOLUTE MAXIMUM RATINGS

(unless otherwise specified, Ta=25℃)

Item	Symbol	Min.	Max.	Unit
Storage temperature range	T_{STG}	-40	85	℃
Analog supply voltage	VDD_{MAX}	-0.3	4.0	V
Digital input voltage	$VDIN_{MAX}$	-0.3	VDD + 0.3	V
Overpressure (note[1])	P_{MAX}	-200 (-19.6)	200 (19.6)	cmH2O (kPa)
Burst pressure (note[2])	P_{Burst}	TBD	TBD	cmH2O (kPa)
Pressure medium (note[3])	-	Non-corrosive Gas (non-condensing)		-

note[1]: Overpressure is the maximum pressure to which the device can be taken and still meet specifications when return to the Operating pressure range.
note[2]: Burst pressure is the pressure at which the IC is damaged and leaks occur.
note[3]: Storage and operation in an environment of dry and non-corrosive gases.

RECOMMENDED OPERATING CONDITIONS

(unless otherwise specified, Ta=25℃)

Item		Symbol	Min.	Typ.	Max.	Unit
Operating temperature range		T_{OPR}	-40	-	85	℃
Supply voltage		VDD_{OPR}	3.0	3.3	3.6	V
Operating pressure range	C02 rank	P_{OPR}	-20 (-1.961)	-	20 (1.961)	cmH2O (kPa)
	C04 rank		-40 (-3.922)	-	40 (3.922)	
	C07 rank		-70 (-6.865)	-	70 (6.865)	
	C10 rank		-100 (-9.807)	-	100 (9.807)	
Full Scale	C02 rank	FS	-	20 (1.961)	-	cmH2O (kPa)
	C04 rank		-	40 (3.922)	-	
	C07 rank		-	70 (6.865)	-	
	C10 rank		-	100 (9.807)	-	

ELECTRICAL CHARACTERISTICS

Analog characteristics
(unless otherwise specified, Ta=25℃, VDD=3.3V)

Item	Symbol	Condition	Min.	Typ.	Max.	Unit.
VDD Current consumption	I_{VDDact}	Pressure measure active	640	800	960	μA
	I_{VDDsd}	Shutdown	-	0.1	1.0	
Conversion time (note[4])	t_{con1}	MODE1	0.385	0.395	0.405	msec
	t_{con2}	MODE2	0.770	0.790	0.810	
	t_{con3}	MODE3	1.54	1.58	1.62	
	t_{con4}	MODE4	3.08	3.16	3.24	

note[4]: The conversion time is longer when the temperature is measured once every 256 times and the characteristic correction is updated.

Digital I/O
(unless otherwise specified, Ta=25℃, VDD=3.0~3.6V)

Item	Symbol	Conditions	Min.	Typ.	Max.	Unit
High level input voltage	V_{IH}	-	0.8 × VDD	-	VDD +0.3	V
Low level input voltage	V_{IL}	-	-0.3	-	0.2 × VDD	V
Output voltage Low level	V_{OL}	I_{OL}=3mA	-	-	0.4	V

C02 rank Pressure sensor characteristics
(unless otherwise specified, Ta=25℃, VDD=3.3V)

Item	Symbol	Condition	Min.	Typ.	Max.	Unit
Operating pressure range	P_{OPR}	-	-20	-	20	cmH2O
Full Scale	FS	-	-	20	-	cmH2O
Pressure resolution	P_{Res}	-	-	0.00001	-	cmH2O
Pressure effective resolution	P_{Eres1}	MODE1 (tcon1 = Typ 0.395ms)	-	0.019	0.076	cmH2O RMS
	P_{Eres2}	MODE2 (tcon2 = Typ 0.790ms)	-	0.009	0.036	
	P_{Eres3}	MODE3 (tcon3 = Typ 1.58ms)	-	0.004	0.016	
	P_{Eres4}	MODE4 (tcon4 = Typ 3.16ms)	-	0.002	0.008	
Pressure measurement error	P_{Err}	-20 ~ 20cmH2O Ta = 0℃～50℃	-2.0(TBD)	-	2.0(TBD)	%FS (note[5])
		-20 ~ 20cmH2O Ta = -20℃～85℃	-6.0(TBD)	-	6.0(TBD)	
Pressure span accuracy	P_{Sacc}	-20 ~ 20cmH2O Ta = 0℃～50℃	-1.30	-	1.30	%FS (note[5])
		-20 ~ 20cmH2O Ta = -20℃～85℃	-4.00	-	4.00	
Pressure span accuracy Long term drift	P_{Sltd}	-20 ~ 20cmH2O Ta = 0℃～50℃ Test condition = 0～50℃ 1000h	-	-	±0.7	%FS (note[5])
Pressure linearity	P_L	-20 ~ 20cmH2O Ta = 0℃～50℃	-0.44	-	0.44	%FS (note[5])
		-20 ~ 20cmH2O Ta = -20℃～85℃	-1.20	-	1.20	

note[5]: Ratio to Full Scale (20cmH2O).

C04 rank Pressure sensor characteristics
(unless otherwise specified, Ta=25℃, VDD=3.3V)

Item	Symbol	Condition	Min.	Typ.	Max.	Unit
Operating pressure range	P_{OPR}	-	-40	-	40	cmH2O
Full Scale	FS	-	-	40	-	cmH2O
Pressure resolution	P_{Res}	-	-	0.00001	-	cmH2O
Pressure effective resolution	P_{Eres1}	MODE1 (tcon1 = Typ 0.395ms)	-	0.019	0.076	cmH2O RMS
	P_{Eres2}	MODE2 (tcon2 = Typ 0.790ms)	-	0.009	0.036	
	P_{Eres3}	MODE3 (tcon3 = Typ 1.58ms)	-	0.004	0.016	
	P_{Eres4}	MODE4 (tcon4 = Typ 3.16ms)	-	0.002	0.008	
Pressure measurement error	P_{Err}	-40 ~ 40cmH2O Ta = 0℃～50℃	-1.0(TBD)	-	1.0(TBD)	%FS (note[6])
		-40 ~ 40cmH2O Ta = -20℃～85℃	-3.0(TBD)		3.0(TBD)	
Pressure span accuracy	P_{Sacc}	-40 ~ 40cmH2O Ta = 0℃～50℃	-0.65	-	0.65	%FS (note[6])
		-40 ~ 40cmH2O Ta = -20℃～85℃	-2.00		2.00	
Pressure span accuracy Long term drift	P_{Sltd}	-40 ~ 40cmH2O Ta = 0℃～50℃ Test condition = 0～50℃ 1000h	-	-	±0.35	%FS (note[6])
Pressure linearity	P_L	-40 ~ 40cmH2O Ta = 0℃～50℃	-0.22	-	0.22	%FS (note[6])
		-40 ~ 40cmH2O Ta = -20℃～85℃	-0.60		0.60	

note[6]: Ratio to Full Scale (40cmH2O).

C07 rank Pressure sensor characteristics
(unless otherwise specified, Ta=25℃, VDD=3.3V)

Item	Symbol	Condition	Min.	Typ.	Max.	Unit
Operating pressure range	P_{OPR}	-	-70	-	70	cmH2O
Full Scale	FS	-	-	70	-	cmH2O
Pressure resolution	P_{Res}	-	-	0.00002	-	cmH2O
Pressure effective resolution	P_{Eres1}	MODE1 (tcon1 = Typ 0.395ms)	-	0.019	0.076	cmH2O RMS
	P_{Eres2}	MODE2 (tcon2 = Typ 0.790ms)	-	0.009	0.036	
	P_{Eres3}	MODE3 (tcon3 = Typ 1.58ms)	-	0.004	0.016	
	P_{Eres4}	MODE4 (tcon4 = Typ 3.16ms)	-	0.002	0.008	
Pressure measurement error	P_{Err}	-70 ~ 70cmH2O Ta = 0℃～50℃	-1.0(TBD)	-	1.0(TBD)	%FS (note[7])
		-70 ~ 70cmH2O Ta = -20℃～85℃	-3.0(TBD)	-	3.0(TBD)	
Pressure span accuracy	P_{Sacc}	-70 ~ 70cmH2O Ta = 0℃～50℃	-0.65	-	0.65	%FS (note[7])
		-70 ~ 70cmH2O Ta = -20℃～85℃	-2.00	-	2.00	
Pressure span accuracy Long term drift	P_{Sltd}	-70 ~ 70cmH2O Ta = 0℃～50℃ Test condition = 0～50℃ 1000h	-	-	±0.35	%FS (note[7])
Pressure linearity	P_L	-70 ~ 70cmH2O Ta = 0℃～50℃	-0.22	-	0.22	%FS (note[7])
		-70 ~ 70cmH2O Ta = -20℃～85℃	-0.60	-	0.60	

note[7]: Ratio to Full Scale (70cmH2O).

C10 rank Pressure sensor characteristics
(unless otherwise specified, Ta=25℃, VDD=3.3V)

Item	Symbol	Condition	Min.	Typ.	Max.	Unit
Operating pressure range	P_{OPR}	-	-100	-	100	cmH2O
Full Scale	FS	-	-	100	-	cmH2O
Pressure resolution	P_{Res}	-	-	0.00002	-	cmH2O
Pressure effective resolution	P_{Eres1}	MODE1 (tcon1 = Typ 0.395ms)	-	0.019	0.076	cmH2O RMS
	P_{Eres2}	MODE2 (tcon2 = Typ 0.790ms)	-	0.009	0.036	
	P_{Eres3}	MODE3 (tcon3 = Typ 1.58ms)	-	0.004	0.016	
	P_{Eres4}	MODE4 (tcon4 = Typ 3.16ms)	-	0.002	0.008	
Pressure measurement error	P_{Err}	-100 ~ 100cmH2O Ta = 0℃～50℃	-1.0(TBD)	-	1.0(TBD)	%FS (note[8])
		-100 ~ 100cmH2O Ta = -20℃～85℃	-3.0(TBD)	-	3.0(TBD)	
Pressure span accuracy	P_{Sacc}	-100 ~ 100cmH2O Ta = 0℃～50℃	-0.65	-	0.65	%FS (note[8])
		-100 ~ 100cmH2O Ta = -20℃～85℃	-2.00	-	2.00	
Pressure span accuracy Long term drift	P_{Sltd}	-100 ~ 100cmH2O Ta = 0℃～50℃ Test condition = 0～50℃ 1000h	-	-	±0.35	%FS (note[8])
Pressure linearity	P_L	-100 ~ 100cmH2O Ta = 0℃～50℃	-0.22	-	0.22	%FS (note[8])
		-100 ~ 100cmH2O Ta = -20℃～85℃	-0.60	-	0.60	

note[8]: Ratio to Full Scale (100cmH2O).

Temperature sensor characteristics
(unless otherwise specified, Ta=25℃, VDD=3.3V)

Item	Symbol	Conditions	Min.	Typ.	Max.	Unit
Temperature measurement error	T_{acc}	0℃~ 50℃ Initial temperature ADC value (Timing Chart Temperature n=1st)	-2.0	-	2.0	℃

Definition of characteristics

Pressure measurement value P_{result}
It is the device output value obtained by Read Pressure Result Command.

Pressure resolution P_{Res}
This Value is equivalent to 1LSB of output digital value.

Pressure effective resolution P_{Eres}
Measure 16 points after the pressure output is stable, and it is the standard deviation of the 16 points.

Pressure measurement error P_{Err}
It is the deviation amount of the Pressure measurement value from the ideal line. (Refer to Fig. 4)
Fig. 5 shows source of error included in the pressure measurement error.

Pressure linearity P_L
It is the amount of deviation from the Ref. line connecting measurement value –FS cmH2O with FS cmH2O.
(Refer to Fig. 4)

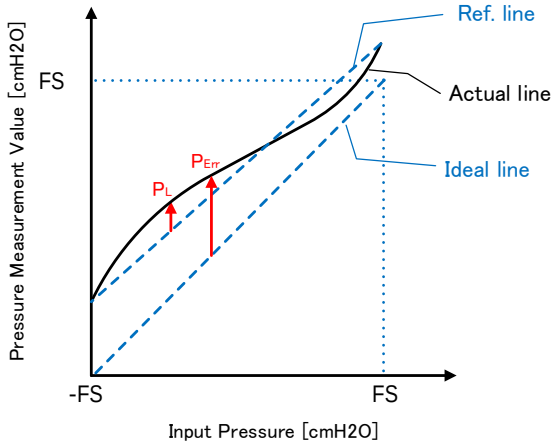


Fig. 4 Definition of Characteristics

Pressure span accuracy P_{Sacc}

It is the accuracy removing the error caused by the offset from the pressure measurement error. (Refer to Fig. 5)

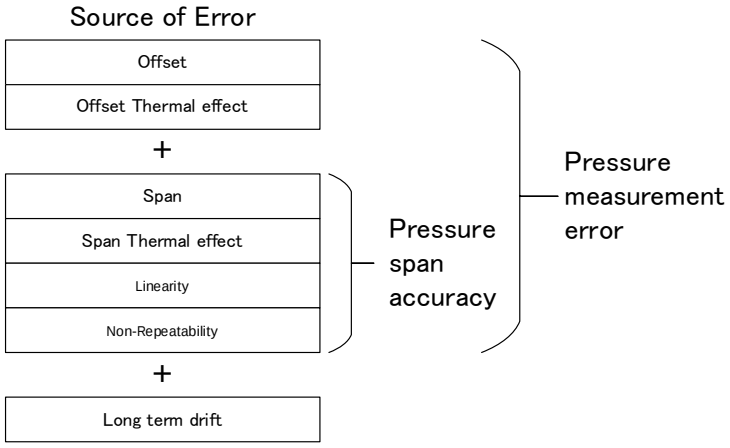


Fig. 5 Source of Error

Pressure span accuracy Long term drift P_{Sltd}

The amount of fluctuation in Pressure span accuracy over a long term.

FUNCTION EXPLANATION

Function Outline

The MMR940 is consists of piezo resistive pressure sensor and an analog front end IC.

It converts analog output voltage from piezo resistive pressure sensor to digital value of 24 bits, and corrects and outputs variations of sensor characteristics due to variations of temperature and process.

Conversion time and Pressure effective resolution are selectable with the mode of different four. Conversion time and Pressure effective resolution are in the relationship of trade-off.

Noise reduction is possible by a built-in Low Pass Filter. Cutoff frequency of Low Pass Filter can be changed.

State transition table

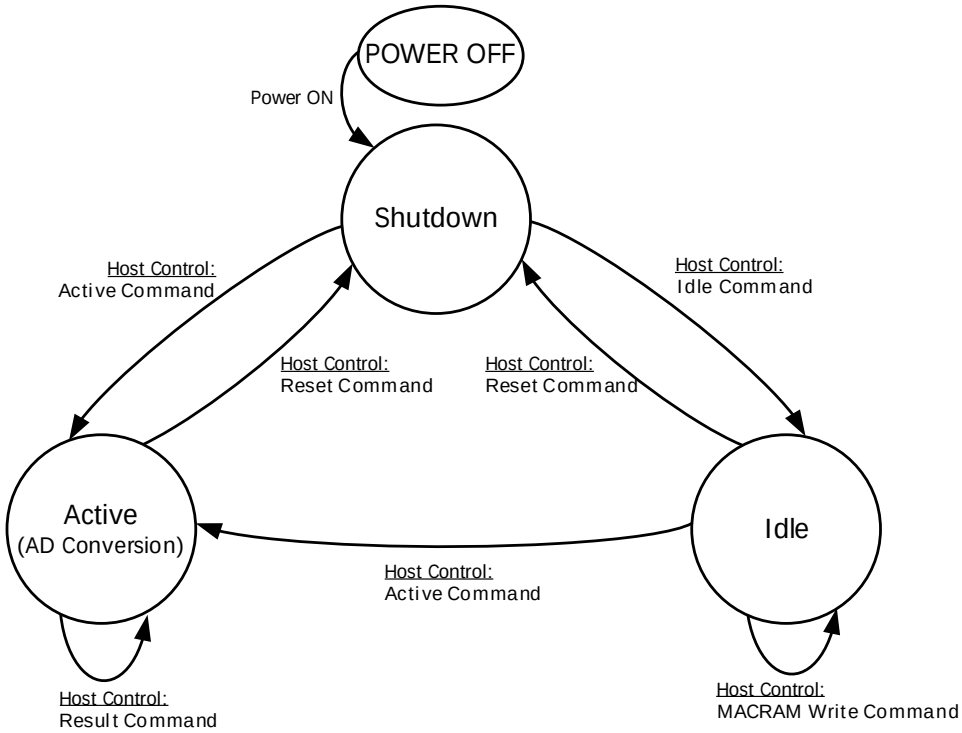


Fig. 6 State transition diagram

Table 2 State transition table

State / Command	Shutdown	Active	Idle
Reset	Power on Reset & Initial Boot =>Shutdown	Power on Reset & Initial Boot =>Shutdown	Power on Reset & Initial Boot =>Shutdown
Active	Reset & Boot Load =>Active state(AD conversion)	Ignore(note[9]) =>Keep state	=>Active state (AD conversion)
Result	Ignore(note[9]) =>Keep state	Output result =>Keep state	Do not issue(note[10]) =>Keep state
Idle	Reset & Boot Load =>Idle state	Do not issue(note[11]) =>Idle state	=>Keep state
MACRAM Write	Ignore(note[9]) =>Keep state	Do not issue(note[11]) =>Keep state	Change cutoff frequency =>Keep state
Status	Output code =>Keep state	Output code =>Keep state	Output code =>Keep state

note[9]: NACK is returned to the command.
note[10]: The correct result isn't output. Additionally, ACK is returned to the command.
note[11]: Although command is acceptable, it goes unintended behavior since sequence is running.

Command code

Table 3 Command code list

Command Name		Command Code									Applicable format
		HEX.	BIN.								
			C7	C6	C5	C4	C3	C2	C1	C0	
Reset		0x72	0	1	1	1	0	0	1	0	I2C Write format
		Reset and Return to Shutdown state. It becomes busy for the maximum 1.8msec.									
Idle		0x94	1	0	0	1	0	1	0	0	I2C Write format
		Start up the internal circuit and put it in the idle state.									
Active	Measure at MODE 1	0xA0	1	0	1	0	0	0	0	0	I2C Write format
	Measure at MODE 2	0xA2	1	0	1	0	0	0	1	0	
	Measure at MODE 3	0xA4	1	0	1	0	0	1	0	0	
	Measure at MODE 4	0xA6	1	0	1	0	0	1	1	0	
		Start AD conversion.									

Table 4 Command code list (continued)

<table>
<tr><th colspan="2" rowspan="2">Command Name</th><th colspan="9">Command Code</th><th rowspan="2">Applicable format</th></tr>
<tr><th>HEX.</th><th colspan="8">BIN.</th></tr>
<tr><th></th><th></th><th>C7</th><th>C6</th><th>C5</th><th>C4</th><th>C3</th><th>C2</th><th>C1</th><th>C0</th><th></th></tr>
<tr><td rowspan="3"></td><td>Normal</td><td>0xC0</td><td>1</td><td>1</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td rowspan="2">I2C Combined format</td></tr>
<tr><td>With Low Pass Filter</td><td>0xC4</td><td>1</td><td>1</td><td>0</td><td>0</td><td>0</td><td>1</td><td>0</td><td>0</td></tr>
<tr><td colspan="11">Read compensated pressure result.
It outputs the result of pressure measurement at 24bits, MSB first.
A negative number is expressed by 2's complement.
About output range, in case of positive output : 000000 h ~ 7FFFFF h (in decimal number : 0 ~ 8388607), in case of negative output : FFFFFF h ~ 800000 h (in decimal number : -1 ~ -8388608)
However, the result of measurement when being used beyond a recommended operating condition can't be guaranteed.

C02 rank, C04 rank
Pressure value = DEC. / 10^5

Output example:
<table><tr><th>HEX.</th><th>DEC.</th><th>Pressure</th></tr><tr><td>800000 h</td><td>-8388608</td><td>-83.88608 cmH2O</td></tr><tr><td>C2F700 h</td><td>-4000000</td><td>-40.00000 cmH2O</td></tr><tr><td>E17B80 h</td><td>-2000000</td><td>-20.00000 cmH2O</td></tr><tr><td>FFFFFF h</td><td>-1</td><td>-0.00001 cmH2O</td></tr><tr><td>000000 h</td><td>0</td><td>0.00000 cmH2O</td></tr><tr><td>000001 h</td><td>1</td><td>0.00001 cmH2O</td></tr><tr><td>1E8480 h</td><td>2000000</td><td>20.00000 cmH2O</td></tr><tr><td>3D0900 h</td><td>4000000</td><td>40.00000 cmH2O</td></tr><tr><td>7FFFFF h</td><td>8388607</td><td>83.88607 cmH2O</td></tr></table>

C07 rank, C10 rank
Pressure value = DEC. x 2 / 10^5

Output example:
<table><tr><th>HEX.</th><th>DEC.</th><th>Pressure</th></tr><tr><td>800000 h</td><td>-8388608</td><td>-167.77216 cmH2O</td></tr><tr><td>B3B4C0 h</td><td>-5000000</td><td>-100.00000 cmH2O</td></tr><tr><td>CA9820 h</td><td>-3500000</td><td>-70.00000 cmH2O</td></tr><tr><td>FFFFFF h</td><td>-1</td><td>-0.00002 cmH2O</td></tr><tr><td>000000 h</td><td>0</td><td>0.00000 cmH2O</td></tr><tr><td>000001 h</td><td>1</td><td>0.00002 cmH2O</td></tr><tr><td>3567E0 h</td><td>3500000</td><td>70.00000 cmH2O</td></tr><tr><td>4C4B40 h</td><td>5000000</td><td>100.00000 cmH2O</td></tr><tr><td>7FFFFF h</td><td>8388607</td><td>167.77214 cmH2O</td></tr></table></td><td>Read Pressure Result</td></tr>
</table>

Table 5 Command code list (continued)

<table>
<tr><th rowspan="3">Command Name</th><th colspan="9">Command Code</th><th rowspan="3">Applicable format</th></tr>
<tr><th rowspan="2">HEX.</th><th colspan="8">BIN.</th></tr>
<tr><th>C7</th><th>C6</th><th>C5</th><th>C4</th><th>C3</th><th>C2</th><th>C1</th><th>C0</th></tr>
<tr><td rowspan="2">Read Temperature Result</td><td>0xC2</td><td>1</td><td>1</td><td>0</td><td>0</td><td>0</td><td>0</td><td>1</td><td>0</td><td>I2C Combined format</td></tr>
<tr><td colspan="10">Read compensated temperature result.
It outputs the result of pressure measurement at 24bits, MSB first.
A negative number is expressed by 2's complement.
About output range, in case of positive output : 000000 h ~ 7FFFFF h (in decimal number : 0 ~ 8388607), in case of negative output : FFFFFF h ~ 800000 h (in decimal number : -1 ~ -8388608)
However, the result of measurement when being used beyond a recommended operating condition can't be guaranteed.

Temperature value = DEC. / 2^7

Output example:
<table>
<tr><th>HEX.</th><th>DEC.</th><th>Temperature</th></tr>
<tr><td>000000 h</td><td>0</td><td>0.000 ℃</td></tr>
<tr><td>000C80 h</td><td>3200</td><td>25.000 ℃</td></tr>
<tr><td>001900 h</td><td>6400</td><td>50.000 ℃</td></tr>
</table></td></tr>
<tr><td rowspan="2">Status</td><td>0x80</td><td>1</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>I2C Combined format</td></tr>
<tr><td colspan="10">Output 8bits data depending on the IC conditions
<table>
<tr><th>D7</th><th>D6</th><th>D5</th><th>D4</th><th>D3</th><th>D2</th><th>D1</th><th>D0</th><th>State</th></tr>
<tr><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>Shutdown</td></tr>
<tr><td>1</td><td>1</td><td>1</td><td>0</td><td>0</td><td>1</td><td>0</td><td>1</td><td>Idle</td></tr>
<tr><td>1</td><td>1</td><td>1</td><td>0</td><td>1</td><td>1</td><td>0</td><td>1</td><td>Active</td></tr>
</table></td></tr>
<tr><td rowspan="2">MACRAM Write</td><td>0xE4</td><td>1</td><td>1</td><td>1</td><td>0</td><td>0</td><td>1</td><td>0</td><td>0</td><td>I2C MACRAM Write format
(special format)</td></tr>
<tr><td colspan="10">It is used for writing filter coefficient. For the filter coefficient, refer to 10-6. LowPassFilter.</td></tr>
</table>

Flow chart of pressure/temperature measurement

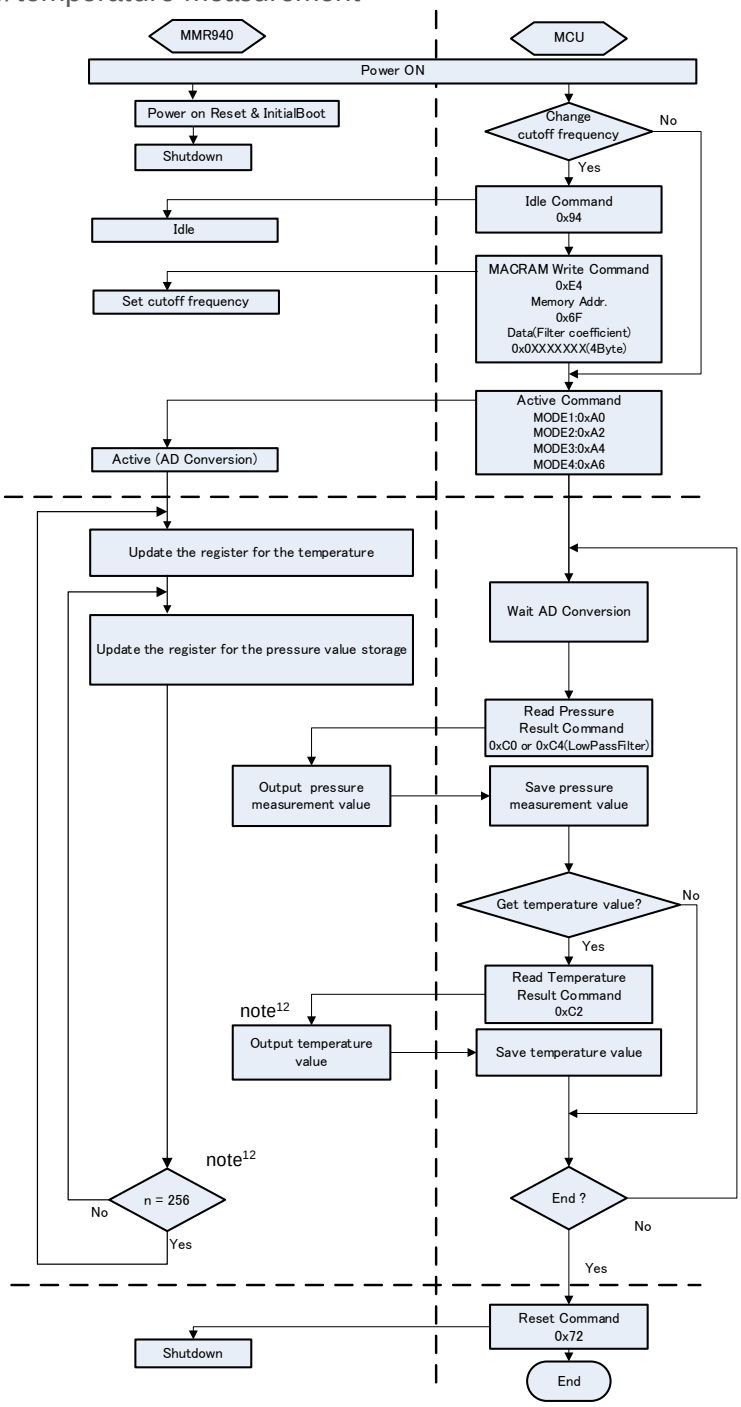


Fig. 7 Flow chart of pressure/temperature measurement

note[12]:Temperature is measured once every 256 times and the pressure characteristic correction is updated. Conversion time will be longer at this timing.

Timing Chart

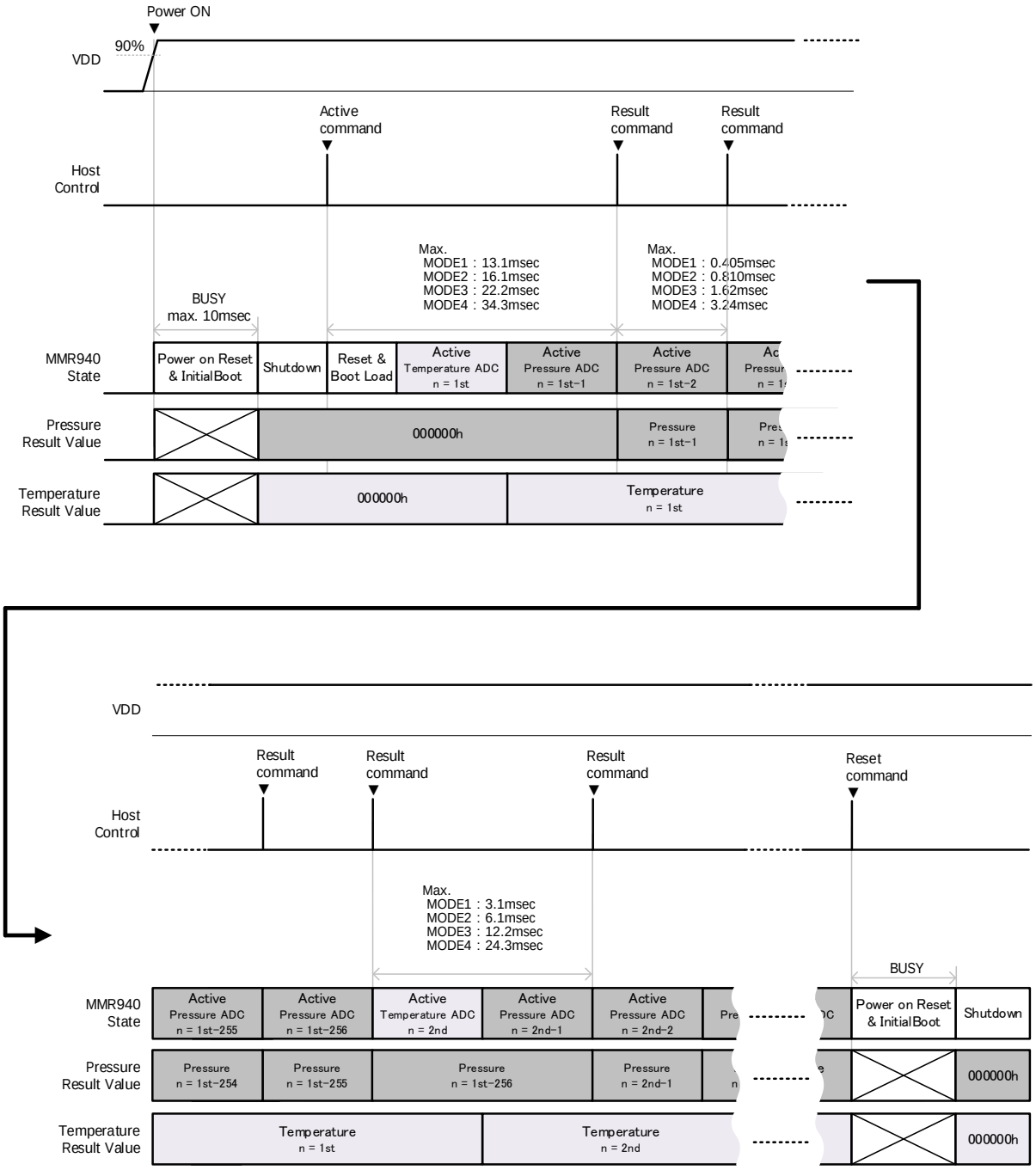


Fig. 8 Timing Chart

Low Pass Filter

Noise reduction is possible by a built-in Low Pass Filter. Pressure value with Low Pass Filter applied can be got using command code 0xC4. Cutoff frequency fc can be changed by filter coefficient 4Bytes calculated by the equation (1). Filter coefficient is written to the IC using the MACRAM Write command in the idle state. Filter coefficient is cleared to the default value in the shutdown state.

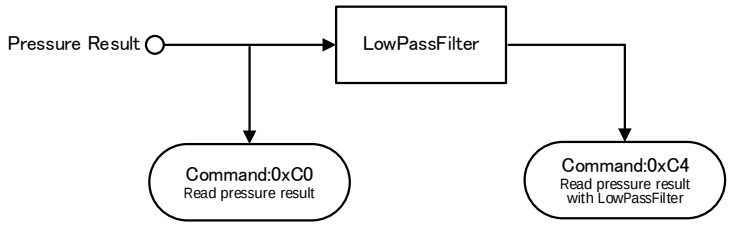


Fig. 9 Low Pass Filter Configuration

Table 6 example of character with Low Pass Filter

Cutoff frequency		No filter	fc=100Hz	fc=10Hz
Pressure effective resolution example [cmH2O RMS]	MODE1	0.019	0.012	0.0068
	MODE2	0.008	0.0064	0.0034
	MODE3	0.0044	0.0036	0.0022
	MODE4	0.0025	0.0023	0.0013

Filter coefficient equation

$$\text{Filter coefficient(4Bytes)} = 2^{27} \times \exp(-2\pi \times f_c \times t_{con}) \cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots (\text{Eq1})$$

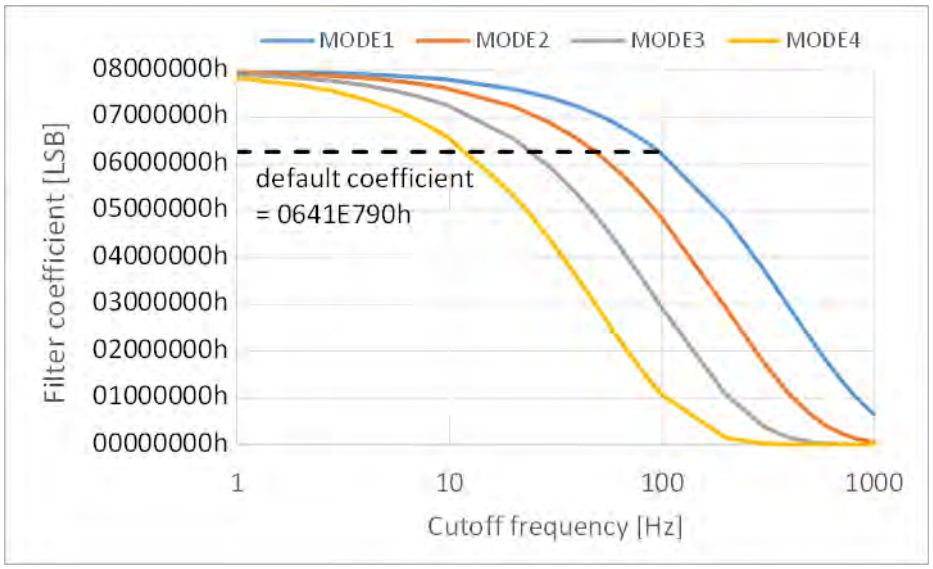


Fig. 10 Filter coefficient example

SERIAL COMMUNICATION INTERFACE

It supports I2C (max.3.4Mbps) as an interface for serial communication.

Baud rate

※This item is not inspected at the time of shipment.

(unless otherwise specified, Ta=25℃, VDD=3.0~3.6V)

Item	Symbol	Conditions	Min.	Typ.	Max.	Unit
I2C communication speed	BR_{I2C1}	Cb≦100pF	-	-	3.4	Mbps
	BR_{I2C3}	Cb≦400pF	-	-	1.7	

I2C AC Characteristics

※This item is not inspected at the time of shipment

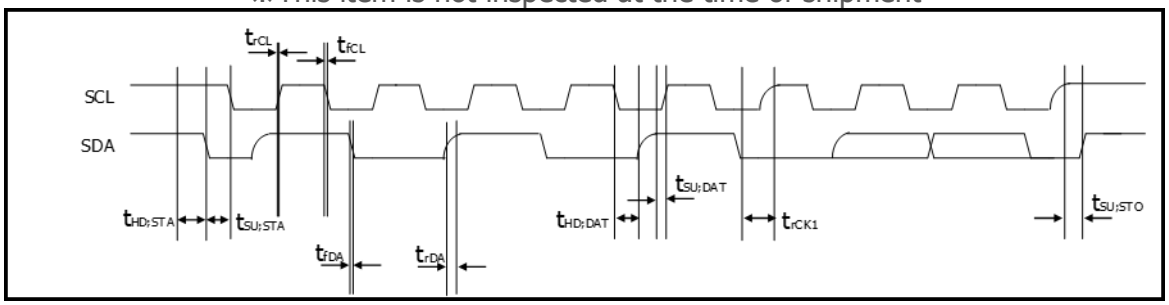


Fig. 11 I2C AC timing chart

Table 7 I2C AC Characteristics

Items	Symbol	Hsmode				
		Cb=100pF		Cb=400pF		
		min.	max.	min.	max.	
SCL frequency	f_{SCL}	0	3.4	0	1.7	MHz
Start condition setup time	$t_{SU;STA}$	160	-	160	-	ns
Start condition hold time	$t_{HD;STA}$	160	-	160	-	ns
Stop condition setup time	$t_{SU;STO}$	160	-	160	-	ns
Data setup time	$t_{SU;DAT}$	20	-	20	-	ns
Data hold time (note[13])	$t_{HD;DAT}$	20	70	20	150	ns
SCL rise time	t_{rCL}	10	40	20	80	ns
Rise time of SCL after ACK (When clock stretch is released.)	t_{rCL1}	10	80	20	160	ns
SCL fall time	t_{fCL}	10	-	20	80	ns
SDA rise time	t_{rDA}	10	80	20	160	ns
SDA fall time	t_{fDA}	10	80	20	160	ns

note[13]: This product does not have the function to retain data in SDA.
Please ensure the hold of SDA with 20nsec for the area where SCL falling edge is not defined.

I2C format

It conforms to I2C protocol except some special formats. I2C address is the total of 8 bits. The first 7 bits are slave address and the rest of 1 bit is R/W bit. Slave address of MMR940 (7 bits) is 0x67. I2C address (8 bits) will be 0xCE (Write) and 0xCF (Read) by combining with R/W bit.

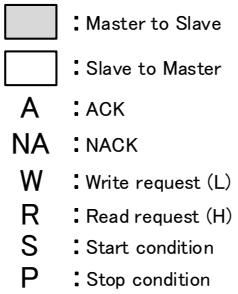
Table 8 I2C address

	I2C Address (8 bit)							
	Slave address (7 bit)							R/W bit
HEX.	A6	A5	A4	A3	A2	A1	A0	
0xCE	1	1	0	0	1	1	1	0
0xCF	1	1	0	0	1	1	1	1

I2C Write format

Please send I2C address of 8 bits (0xCE) by Write Mode. Then please send command code.

Fig. 12 I2C Write format



Combined format

Please send I2C address (0xCE) and the command code by Write Mode. Then please send I2C address (0xCF) by Read Mode. It outputs the data MSB first

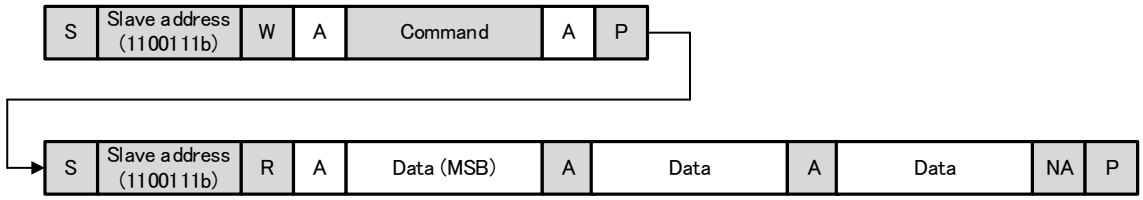


Fig. 13 I2C Combined format

I2C MAC Write format (special format)

It is a format unique to this product that does not partially conform to I2C protocol. Please send I2C address (0xCE), the command (0xE4), and memory address (0x6F) by Write Mode. Then send the data of 4Bytes Filter coefficient. At this time, please be careful that NACK is returned after transmitting LSB. After receiving data, it becomes busy for the maximum 15msec in order to data- writing. During this time, SCL is put in clock stretch. When data- writing is completed, SCL is released.

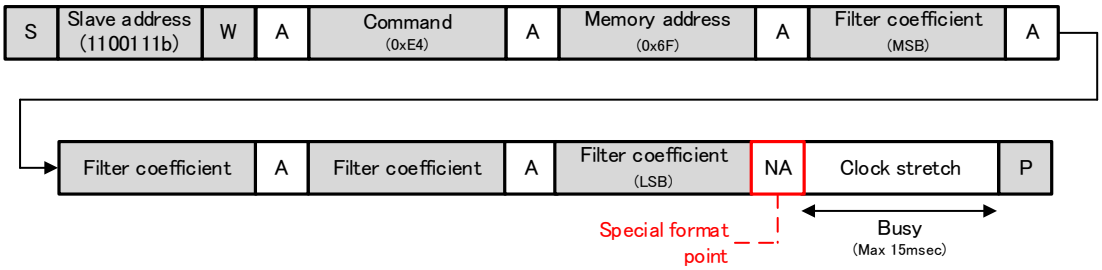


Fig. 14 I2C MACRAM Write format

TYPICAL APPLICATION CIRCUIT

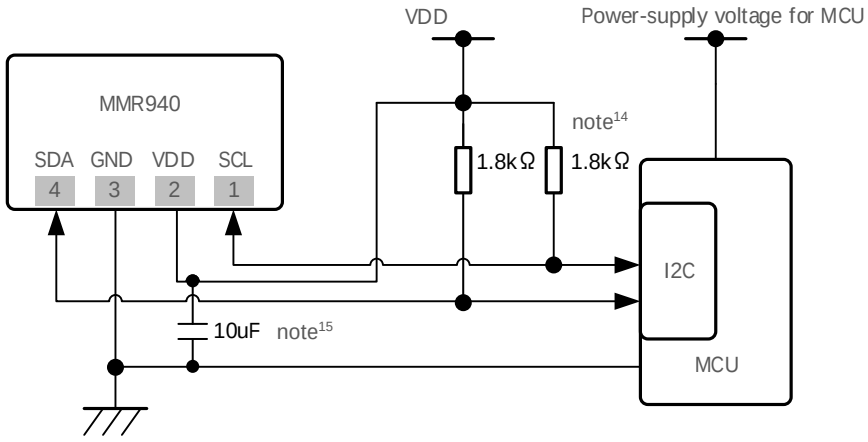


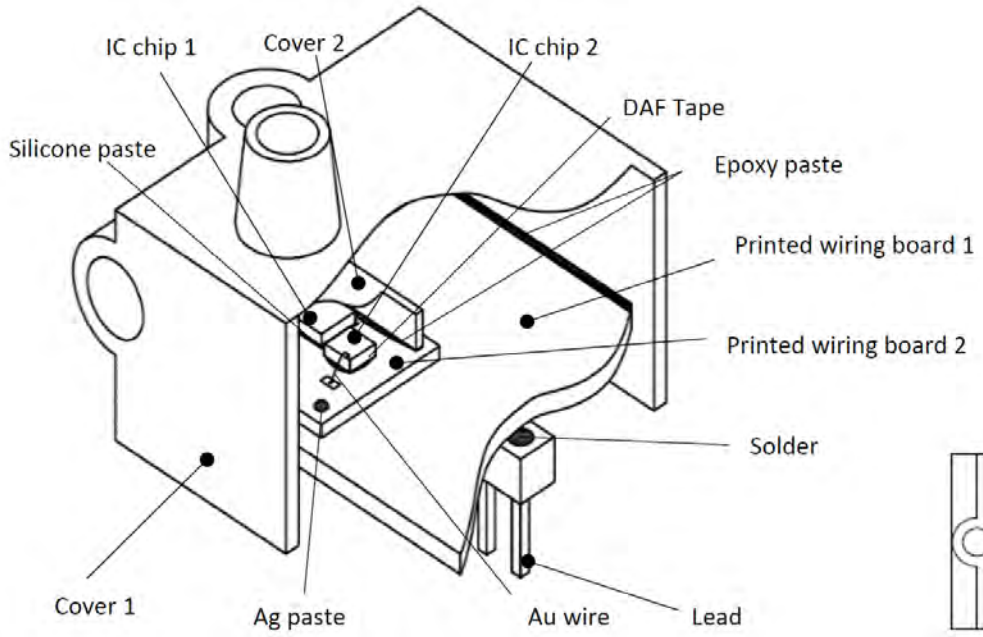
Fig. 15 Typical Electrical Connection

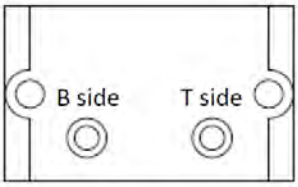
note[14]: The longer the bus line on the board, the larger the parasitic capacitance and communication waveform rounding becomes.
In this case, reduce the pull-up resistor to improve the communication waveform. (Min 1.2k ohm)
※It should be designed in accordance with "NXP's UM10204: I2C-bus specification and user manual".
note[15]: Place the bypass capacitor for the power supply as close to the IC as possible.

TYPICAL PERFORMANCE CHARACTERISTICS

TBD

PACKAGE STRUCTURE



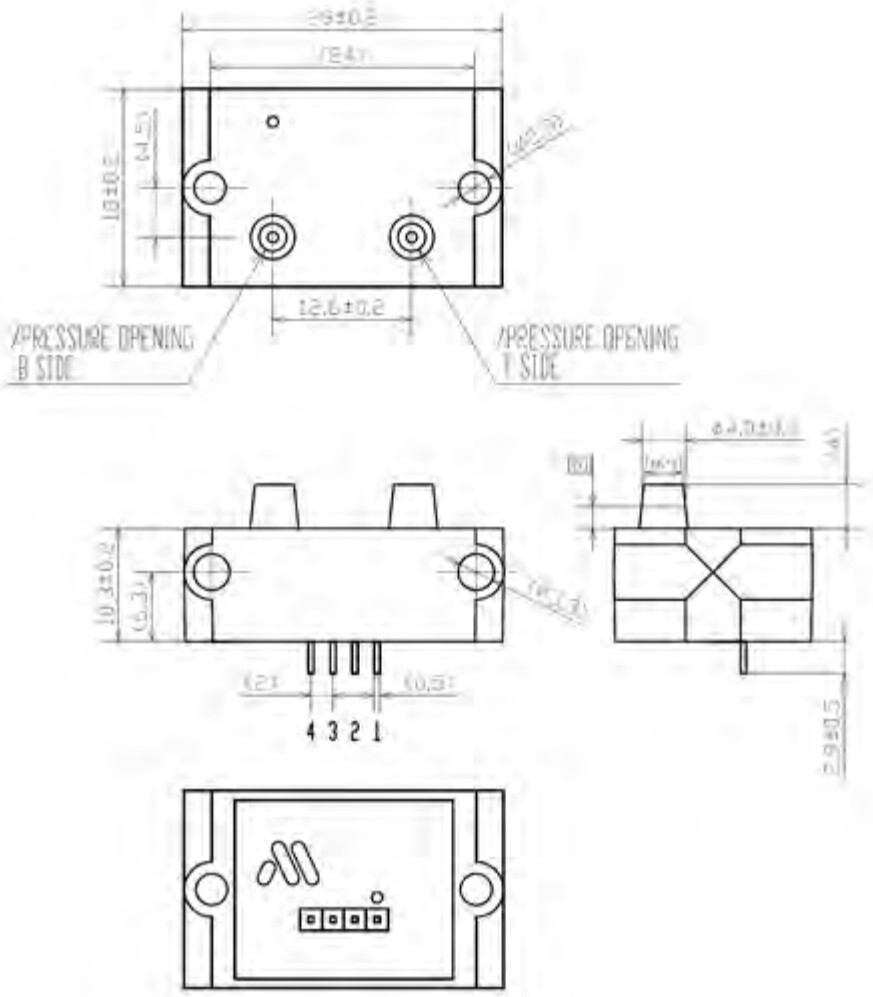


		Wetted Material		
Part Name	Material	B Side	T Side	Remarks
IC chip 1	Silicon (Si)	✓	✓	
	Aluminium (Al), Tungsten (W)		✓	
IC chip 2	Si, Al, W, Copper (Cu), Tantalum (Ta)		✓	
Printed wiring board 1	Epoxy resin, Glass fiber, Acrylic resin, Gold (Au)		✓	
	Cu, Nickel (Ni)			
Printed wiring board 2	Epoxy resin, Glass fiber, Acrylic resin	✓	✓	
	Au, Cu, Ni		✓	
Cover 1	PBT, Glass fiber	✓	✓	
Cover 2	PPS, Glass fiber, Carbon black	✓	✓	
Au wire	Au		✓	
Lead	Tin (Sn)		✓	
	Cu, Ni, LCP			
Silicone paste	Silicone, SiO2	✓	✓	
DAF Tape	Epoxy resin		✓	
Epoxy paste	Epoxy resin, SiO2, Carbon Black	✓	✓	
Ag paste	Silver (Ag), Epoxy resin		✓	
Solder	Sn, Ag, Cu		✓	

DIMENSIONS

PACKAGE MEMS-4A

UNIT	mm



Terminal list

PIN No.	Name
1	SCL
2	VDD
3	GND
4	SDA

MARKING CONTENTS

TBD

PRODUCT NAME

MMR940□□□□

Package type
A：MEMS-12B
Rank(Pressure range)
C02：-20~+20cmH2O(-1.961~+1.961kPa) Full scale 20cmH2O
C04：-40~+40cmH2O(-3.922~+3.922kPa) Full scale 40cmH2O
C07：-70~+70cmH2O(-6.865~+6.865kPa) Full scale 70cmH2O
C10：-100~+100cmH2O(-9.805~+9.805kPa) Full scale 100cmH2O
Model name
MMR940：Micro differential pressure sensor

PRODUCT LINEUP

Product Name	Rank	Pressure Range	Packing	Status
MMR940C02A	C02	-20~20cmH2O(-1.961~1.961kPa)	Tray	Planning
MMR940C04A	C04	-40~40cmH2O(-3.922~3.922kPa)	Tray	Developing
MMR940C07A	C07	-70~70cmH2O(-6.865~6.865kPa)	Tray	Planning
MMR940C10A	C10	-100~100cmH2O(-9.807~9.807kPa)	Tray	Planning

PRESSURE SENSOR LINEUP

Function	Product Name	Size [mm] (L x W x H)	Pressure Range [Pa]	Full Scale [Pa]	Pressure Measurement error [%FS]	Span Accuracy [%FS]	Effective Resolution [PaRMS]	Packing	Halogen	Status
Gage Pressure Sensor	MMR920C02A	7 x 7 x 7.2	-1,961 ～ 1,961	1,961	2.0	1.30	0.2	Tray	Contain	Planning
	MMR920C02ARE	7 x 7 x 7.2	-1,961 ～ 1,961	1,961	2.0	1.30	0.2	Taping (R)	Contain	Planning
	MMR920C04A	7 x 7 x 7.2	-3,922 ～ 3,922	3,922	1.0	0.65	0.2	Tray	Contain	Developing
	MMR920C04ARE	7 x 7 x 7.2	-3,922 ～ 3,922	3,922	1.0	0.65	0.2	Taping (R)	Contain	Developing
	MMR920C07A	7 x 7 x 7.2	-6,865 ～ 6,865	6,865	1.0	0.65	0.2	Tray	Contain	Planning
	MMR920C07ARE	7 x 7 x 7.2	-6,865 ～ 6,865	6,865	1.0	0.65	0.2	Taping (R)	Contain	Planning
	MMR920C10A	7 x 7 x 7.2	-9,807 ～ 9,807	9,807	1.0	0.65	0.2	Tray	Contain	Planning
	MMR920C10ARE	7 x 7 x 7.2	-9,807 ～ 9,807	9,807	1.0	0.65	0.2	Taping (R)	Contain	Planning
	MMR906XAN	6 x 5 x 7.2	-1,000 ～ 40,000	40,000	-	0.66	1.0	Tray	Free	MP
	MMR906XARE	6 x 5 x 7.2	-1,000 ～ 40,000	40,000	-	0.66	1.0	Taping (R)	Free	Developing
	MMR902A34A	7 x 7 x 7.2	-1,000 ～ 40,000	40,000	2.3	0.66	0.7	Tray	Free	MP
	MMR902A34ABE	7 x 7 x 7.2	-1,000 ～ 40,000	40,000	2.3	0.66	0.7	Taping (B)	Free	Developing
	MMR902A34ARE	7 x 7 x 7.2	-1,000 ～ 40,000	40,000	2.3	0.66	0.7	Taping (R)	Free	Developing
Differential Pressure Sensor	MMR940C02A	29 x 18 x 14.25	-1,961 ～ 1,961	1,961	(2.0)	1.30	0.2	Tray	Contain	Planning
	MMR940C04A	29 x 18 x 14.25	-3,922 ～ 3,922	3,922	(1.0)	0.65	0.2	Tray	Contain	Developing
	MMR940C07A	29 x 18 x 14.25	-6,865 ～ 6,865	6,865	(1.0)	0.65	0.2	Tray	Contain	Planning
	MMR940C10A	29 x 18 x 14.25	-9,807 ～ 9,807	9,807	(1.0)	0.65	0.2	Tray	Contain	Planning

NOTES

Safety Precautions

- Though Mitsumi Electric Co., Ltd. (hereinafter referred to as "Mitsumi") works continually to improve our product's quality and reliability, semiconductor products may generally malfunction or fail. Customers are responsible for complying with safety standards and for providing adequate designs and safeguards for their hardware, software and systems which minimize risk and avoid situations in which a malfunction or failure of this product could cause loss of human life, bodily injury, or damage to property, including data loss or corruption. Before customers use this product, create designs including this product, or incorporate this product into their own applications, customers must also refer to and comply with (a) the latest versions or all of our relevant information, including without limitation, product specifications, data sheets and application notes for this product and (b) the user's manual, handling instructions or all relevant information for any products which is to be used, or combined with this products. Customers are solely responsible for all aspects of their own product design or applications, including but not limited to (a) determining the appropriateness of the use of this product in such design or applications; (b) evaluating and determining the applicability of any information contained in this document, or in charts, diagrams, programs, algorithms, sample application circuits, or any other referenced documents; and (c) validating all operating parameters for such designs and applications. Mitsumi assumes no liability for customers' product design or applications.
- This product is intended for applying to computers, OA units, communication units, instrumentation units, machine tools, industrial robots, AV units, household electrical appliances, and other general electronic units.
- If you have any intentions to apply this product to the units related to the control and safety of transportation units (vehicles, trains, etc.), traffic signaling units, disaster-preventive & burglar-proof units, or the like, contact our sales representatives in advance.
- Don't apply this product to any aeronautical & space systems, submarine repeaters, nuclear power controllers, medical units involving the human life, or the like.
- Before using this product, even when it is not used for the usage written above, notify and present us beforehand if special care and attention are needed for its application, intended purpose, environment of usage, risk, and the design or inspection specification corresponding to them.
- If any damage to our customer is objectively identified to be caused by the defect of this product, Mitsumi is responsible for it. In this case, Mitsumi is liable for the cost limited to the delivery price of this product.

Application considerations during actual circuit design

- The outline of parameters described herein has been chosen as an explanation of the standard parameters and performance of the product. When you actually plan to use the product, please ensure that the outside conditions are reflected in the actual circuit and assembling designs.
- Before using this product, please evaluate and confirm the actual application with this product mounted and embedded.
- To investigate the influence by applied transient load or external noise, It is necessary to evaluate and confirm them with mounting this product to the actual application.
- Any usage above the maximum rating may destroy this product or shorten the lifetime. Be sure to use this product under the maximum rating.
- If you continue to use this product highly-loaded (applying high temperature, large current or high voltage; or variation of temperature) even under the absolute maximum rating and even in the operating range, the reliability of this product may decrease significantly. Please design appropriate reliability in consideration of power dissipation and voltage corresponding to the temperature and designed lifetime after confirming our individual reliability documents (such as reliability test report or estimated failure rate). It is recommended that, before using this product, you appropriately derate the maximum power dissipation (typically, 80% or less of the maximum value) considering parameters including ambient temperature, input voltage, and output current.

Precautions for Foreign Exchange and Foreign Trade Control Act

- If you export or take products and technologies in this document which are subject to security trade control based on the Foreign Exchange and Foreign Trade Act to overseas from Japan, permission of the Japanese government is required.

Prohibitions for Industrial Property Rights

- Since this document contains the contents related to our copyright and know-how, you are requested not to use this document for any purpose other than the application of this product.
- If a use of this product causes a dispute related to the industrial property rights of a third party, Mitsumi has no liability for any disputes except those which arise directly from the manufacturing and manufacturing method of our products.

Precautions for Product Liability Act

- No responsibility is assumed by us for any consequence resulting from any wrong or improper use or operation, etc. of this product.

Others

- Any part of the contents contained herein must not be reprinted or reproduced without our prior permission.
- In case of any question arises out of the description in this specification, it shall be settled by the consultation between both parties promptly.

ATTENTION

- This product is designed and manufactured with the intention of normal use in general electronics. No special circumstance as described below is considered for the use of it when it is designed. With this reason, any use and storage under the circumstances below may affect the performance of this product. Prior confirmation of performance and reliability is requested to customers.
  - Environment with strong static electricity or electromagnetic wave
  - Environment with high temperature or high humidity where dew condensation may occur
- This product is not designed to withstand radioactivity, and must avoid using in a radioactive environment.

ADDTTIONAL NOTES

- The pressure medium which can use directly is only air. Please do not use other media, especially corrosive gases (organic solvent gas, sulfurous acid gas, hydrogen sulfide gas, etc.) and media which include moisture and foreign substance, since they could cause damages or malfunctions.
- Please handle it noting the foreign body mixing with the pressure opening and atmospheric pressure opening after opening packing.
- When cut folding the PCB after mounting this product, take measures to prevent stress to the package. Also, when you insert the tube in this product, please note that plugging it vertically. Load in the lateral direction of the cover of the nozzle is up to 1kg or less. (Load condition: position of height 4mm from the marking surface.) Excessive load could cause damages of cover, or air leak by peeling from the interface of the cover and the substrate, or malfunctions.
- The light that enters from the pressure entrance reaches the semiconductor chip. Please avoid use in the environment that light enters into the pressure entrance directly, because the semiconductor chip might malfunction because of light.

PACKING SPECIFICATIONS (TRAY)

TBD

CONDITION FOR PACKAGE MOUNTING

TBD

MITSUMI ELECTRIC CO., LTD.
Strategy Engineering Department Semiconductor Business Division
Tel: +81-46-230-3470 / https://www.mitsumi.co.jp/profile/contact.html

Notes:
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