Temperature Sensor

BM43TND-S2

Bestow Mascot

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CONTENT

1. Description

1.1 General Description

The BM43TND-S2 is the BM digital Far Infrared Thermopile sensor with read-out IC that measures the temperature of an object without the need to contact. This sensor uses a compound thermopile to measure the Far Infrared energy emitted from the object being measured and uses the corresponding change in thermopile voltage to determine the object temperature. This sensor detects the object temperature from -40 to +125 to enable use in a wide range of application. An I^2C interface is used to communicate with this device for various applications.

1.2 Features

- Fully Integrated Digital Far Infrared Thermopile sensor
- Different size of SMD package
- 1.68V to 3.6V single supply continuous operation
- Current consumption: 1.0mA (operating mode)
- Sleep state current: 20nA (typical)
- I^2C Interface
- Temperature resolution
  - 3mK/LSB for body temperature sensing
  - ±0.1 K for Object temperature sensing
- Operating temperature: -40 ~85
- Optical Option: Infrared Optical Band-pass filter / Infrared Fresnel lens

1.3 Applications

- Non-contact Temperature sensing:
  - Temperature monitoring
  - Mobile phone
  - Comfort index measurement
  - Power management system
- Human Body Detection:
  - Interactive Power control
  - Notebook monitor control
  - Lighting unit control
  - Display panel control

1.4 Package

2. Block Diagram

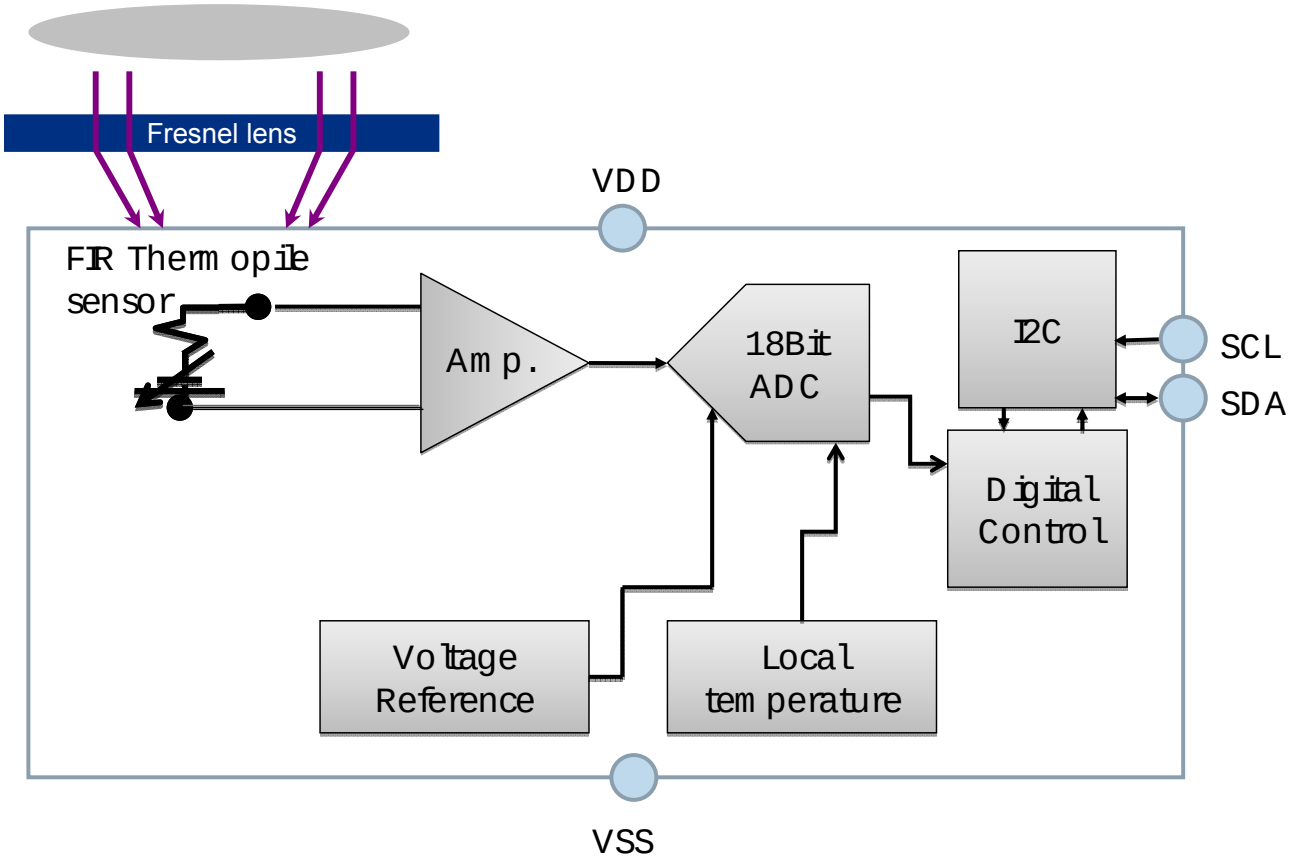


Figure1 Block Diagram

3. Signal Conditioning

3.1 Signal Conditioning Circuit

The BM43TND-S2 is a thermopile sensor module with a sensor signal conditioner (SSC) integrated circuit for high-accuracy amplification and analog-to-digital conversion of a differential or pseudo-differential input signal. Designed for variety high-resolution sensor module applications, the integrated signal conditioner of a BM43TND-S2 can perform offset, span, and 1st and 2nd order temperature compensation of the measured signal. The module is developed for correction of absolute voltage sensors, it can also provide a corrected temperature output measured with an internal sensor.

The measured and corrected sensor values are provided at the digital output pins, which can be configured as I^2C. Digital compensation of signal offset, sensitivity, temperature, and non-linearity is accomplished via a 26-bit internal digital signal processor (DSP) running a correction algorithm. Calibration coefficients are stored on-chip in a highly reliable, non-volatile, multiple-time programmable (MTP) memory. Programming the BM43TND-S2 is simple via the serial interface. The interface is used for the PC-controlled calibration procedure, which programs the set of calibration coefficients in memory. The BM43TND-S2 provides accelerated signal processing, increased resolution, and Improved noise immunity in order to support high-speed control, safety, and real-time sensing applications with the highest requirements for energy efficiency.

3.2 Features

- An integrated high accuracy thermopile with its signal conditioning circuits
- Flexible, programmable analog front-end design; up to 18-bit analog-to-digital converter (ADC)
- Fully programmable gain amplifier for optimizing sensor signals: gain range 6.6 to 216 (linear)
- Internal auto-compensated temperature sensor
- Digital compensation of individual sensor offset; 1st and 2nd order digital compensation of sensor gain as well as 1st and 2nd order temperature gain and offset drift
- Programmable interrupt operation (Option)
- High-speed sensing: e.g. 16-bit conditioned sensor signal measurement rate >500s-1
- Typical sensor elements can achieve accuracy of better than ±0.10%FSO at -40 to 85°C

3.3 Benefits

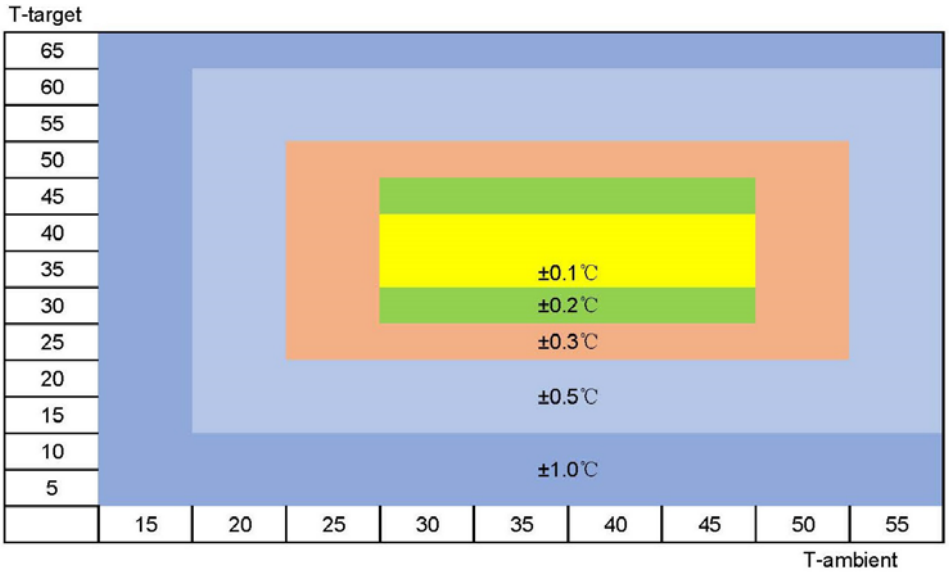
- Integrated 26-bit calibration math digital signal processor (DSP)
- Fully corrected signal at digital output
- One-pass calibration minimizes calibration costs
- No external trimming, filter, or buffering components required
- Highly integrated CMOS design with cutting edge MEMS technology
- Integrated reprogrammable non-volatile memory
- Excellent for low-voltage and low-power battery applications

3.4 Physical Characteristics

- Supply voltage range: 1.68V to 3.6V
- Current consumption: 1.0mA (operating mode)
- Sleep State current: 20nA (typical)
- Temperature resolution: <0.003K/LSB
- Best-in-class energy-efficiency with 16-bit resolution: <140pJ/step with 18-bit resolution: <50pJ/step
- Operation temperature: –40°C~+85°C
- Delivery options: SMD package

4. Characteristics

4.1 Accuracy of Measurement



4.2 Electrical Characteristics

Parameter	Min.	Typ.	Max.	Units
Operating Voltage Range	1.68	2.8	3.6	V
Supply Current	-	-	1.0mA	mA
Measuring Accuracy	-	0.2	-	
Operating Temperature Range	-40	-	+85	
Storage Temperature Range	-50	-	+125	
Junction Temperature (TJ max)	-	-	+150	
VDD Rise Time	-	-	200	us
ESD Rating: Human Body Model	-	-	4000	V

4.3 IC Characteristics

Absolute Maximum Ratings: The absolute maximum ratings are stress ratings only. The BM43TND-S2 might not function or be operable above the recommended operating conditions. Stresses exceeding the absolute maximum ratings might also damage the device. In addition, extended exposure to stresses above the recommended operating conditions might affect device reliability. BM does not recommend designing to the “Absolute Maximum Ratings.”

Table1 Maximum Ratings

Parameter	Symbol	Min.	Typ.	Max.	Units
Voltage Reference	VSS	0	-	0	V
Analog Supply Voltage	VDD	-0.4	-	3.63	V
Input Current into any Pin except RES, SS [1), 2)]	IIN	100	-	100	mA
Electrostatic Discharge Tolerance – Human Body Model (HBM1) [3)]	VHBM1	±4000	-	-	V

Storage Temperature	TSTOR	-50	-	125	°C
1)Latch-up current limit for RES, BM-test and SS: ±70mA. 2)Latch-up resistance; reference for pin is 0V. 3)HBM1: C = 100pF charged to VHBM1 with resistor R=1.5kin series based on MIL 883, Method 3015.7. ESD protection referenced to the Human Body Model is tested with devices in ceramic dual in-line packages (CDIP) during product qualification.					

Table2 Operating Conditions

Parameter	Symbol	Min.	Typ.	Max.	Units
Supply Voltage	VDD	1.68	-	3.6	V
VDD Rise Time	tVDD	-	-	200	μs
Operation Temperature Range	TAMB	-40	-	85	°C
External (Parasitic) Capacitance between VDDB and VSS	CL	0.01		50	nF
Note: The reference for all voltages is Vss.					

A dynamic power-on-reset circuit is implemented in order to achieve minimum current consumption in idle mode. The VDD low level and the subsequent rise time and VDD rising slope must meet the requirements in Table 1.1 to guarantee an overall IC reset; lower VDD low levels allow slower rising of the subsequent on-ramp of VDD. Other combinations might also be possible. For example, the reset trigger can be influenced by increasing the power-down time and lowering the VDD rising slope requirement. Alternatively, the RES pin can be connected and used to control safe resetting of the BM43TND-S2. RES is active-low; a VDD-VSS-VDD transition at the RES pin leads to a complete IC reset. (Option).

4.4 MTP Memory Content Assignments

Table 3 MTP Memory Content Assignments

MTP Address	Word / Bit Range	Default Setting	Description	Notes
00_{HEX}	15:0	0000_{HEX}	Cust_ID0	Customer ID byte 0 (combines with memory word 01_{HEX} to form customer ID).
01_{HEX}	15:0	0000_{HEX}	Cust_ID1	Customer ID byte 1 (combines with memory word 00_{HEX} to form customer ID).
Interface Configuration				
02_{HEX}	6:0	$000\ 0000_{BIN}$	Slave_Addr	I^2C slave address; valid range: 00_{HEX} to $7F_{HEX}$ (default: 00_{HEX}). Note: address codes 04_{HEX} to 07_{HEX} are reserved for entering the I^2C High Speed Mode.
	8:7	00_{BIN}	INT_setup	Interrupt configuration, EOC pin functionality: . 00 End-of-conversion signal . 01 0-1 transition if threshold1 (TRSH1) is exceeded and 1-0 transition if threshold1 is underrun again . 10 0-1 transition if threshold1 is underrun and 1-0 transition if threshold1 is exceeded again

MTP Address	Word / Bit Range	Default Setting	Description	Notes
				. 11 EOC is determined by threshold settings (see section 3.3): If (TRSH1 > TRSH2) then EOC/INT (interrupt level) = 0 if (TRSH1 > MEAS ≥ TRSH2) where MEAS is the conditioned measure- ment result. Otherwise EOC/INT=1. If (TRSH1 ≤ TRSH2) then EOC = 1 if (TRSH1 ≤ MEAS < TRSH2). Otherwise EOC = 0.
	9	0BIN	SS_polarity	Determines the polarity of the Slave Select pin (SS) for SPI operation: 0 Slave Select is active low (SPI and BM43TND-S2 are active if SS==0) 1 Slave Select is active high (SPI and BM43TND-S2 are active if SS==1)
	11:10	00BIN	CKP_CKE	Clock polarity and clock-edge select—determines polarity and phase of SPI interface clock with the following modes: 00 01 10 11 SCLK is low in idle state, data latch with rising edge and data output with falling edgeSCLK is low in idle state, data latch with falling edge and data output with rising edge SCLK is high in idle state, data latch with falling edge and data output with rising edge SCLK is high in idle state, data latch with rising edge and data output with falling edge
	14:12	000BIN	CYC_period	Update period (BM43TND-S2 sleep time, except oscillator) in cyclic operation: 000 not assigned 001 125ms010 250ms 011 500ms 100 1000ms101 2000ms110 4000ms 111 not assigned
	15	0BIN	SOT_curve	Type/shape of second-order curve correction for the sensor signal. 0 parabolic curve 1 s-shaped curve
Signal Conditioning Parameters				
03HEX	15:0	0000HEX	Offset_S[15:0]	Bits [15:0] of the 24-bit-wide sensor offset correction coefficient Offset_S. (The MSBs of this coefficient including sign are Offset_S[23:16], which is bits [15:8] in $0D_{HEX}$.)
04HEX	15:0	0000HEX	Gain_S[15:0]	Bits [15:0] of the 24-bit-wide value of the sensor gain coefficient Gain_S. (The MSBs of this coefficient including sign are Gain_S[23:16], which is bits [7:0] in $0D_{HEX}$.)
05HEX	15:0	0000HEX	Tcg[15:0]	Bits [15:0] of the 24-bit-wide coefficient Tcg for the temperature correction of the sensor gain. (The MSBs of this coefficient including sign are Tcg[23:16], which is bits [15:8] in $0E_{HEX}$.)
06HEX	15:0	0000HEX	Tco[15:0]	Bits [15:0] of the 24-bit-wide coefficient Tco for temperature correction of the sensor offset. (The MSBs of this coefficient including sign are Tco[23:16], which is bits [7:0] in $0E_{HEX}$.)
07HEX	15:0	0000HEX	SOT_tco[15:0]	Bits [15:0] of the 24-bit-wide 2nd order term

MTP Address	Word / Bit Range	Default Setting	Description	Notes
				SOT_tco applied to Tco. (The MSBs of this term including sign are SOT_tco[23:16], which is bits[15:8] in $0F_{HEX}$.)
08_{HEX}	15:0	0000_{HEX}	SOT_tcg[15:0]	Bits [15:0] of the 24-bit-wide 2nd order term SOT_tcg applied to Tcg. (The MSBs of this term including sign are SOT_tcg[23:16], which is bits[7:0] in $0F_{HEX}$.)
09_{HEX}	15:0	0000_{HEX}	SOT_sens[15:0]	Bits [15:0] of the 24-bit-wide 2nd order term SOT_sens applied to the sensor readout. (The MSBs of this term including sign are SOT_sens[23:16], which is bits[15:8] in 10_{HEX}.)
$0A_{HEX}$	15:0	0000_{HEX}	Offset_T[15:0]	Bits [15:0] of the 24-bit-wide temperature offset correction coefficient Offset_T. (The MSBs of this coefficient including sign are Offset_T[23:16], which is bits[7:0] in 10_{HEX}.)
$0B_{HEX}$	15:0	0000_{HEX}	Gain_T[15:0]	Bits [15:0] of the 24-bit-wide absolute value of the temperature gain coefficient Gain_T.(The MSBs of this coefficient including sign are Gain_T[23:16], which is bits[15:8] in 11_{HEX}.)
$0C_{HEX}$	15:0	0000_{HEX}	SOT_T[15:0]	Bits [15:0] of the 24-bit-wide 2nd-order term SOT_T applied to the temperature reading.(The MSBs of this coefficient including sign are SOT_T[23:16], which is bit[7:0] in 11_{HEX}.)
$0D_{HEX}$	7:0	00_{HEX}	Gain_S[23:16]	Bits [23:16] including sign for the 24-bit-wide sensor gain correction coefficient Gain_S. (The LSBs of this coefficient are Gain_S[15:0] in register 04_{HEX}.)
	15:8	00_{HEX}	Offset_S[23:16]	Bits [23:16] including sign for the 24-bit-wide sensor offset correction coefficient Offset_S. (The LSBs are Offset_S[15:0] in register 03_{HEX}.)
$0E_{HEX}$	7:0	00_{HEX}	Tco[23:16]	Bits [23:16] including sign for the 24-bit-wide coefficient Tco for temperature correction for the sensor offset. (The LSBs are Tco[15:0] in register 06_{HEX}.)
	15:8	00_{HEX}	Tcg[23:16]	Bits [23:16] including sign for the 24-bit-wide coefficient Tcg for the temperature correction of the sensor gain. (The LSBs are Tcg[15:0] in register 05_{HEX}.)
$0F_{HEX}$	7:0	00_{HEX}	SOT_tcg[23:16]	Bits [23:16] including sign for the 24-bit-wide 2nd order term SOT_tcg applied to Tcg. (The LSBs are SOT_tcg[15:0] in register 08_{HEX}.)
	15:8	00_{HEX}	SOT_tco[23:16]	Bits [23:16] including sign for the 24-bit-wide 2nd order term SOT_tco applied to Tco. (The LSBs are SOT_tco[15:0] in register 07_{HEX}.)
10_{HEX}	7:0	00_{HEX}	Offset_T[23:16]	Bits [23:16] including sign for the 24-bit-wide temperature offset correction coefficient Offset_T. (The LSBs are Offset_T[15:0] in register $0A_{HEX}$.)
	15:8	00_{HEX}	SOT_sens[23:16]	Bits [23:16] including sign for the 24-bit-wide 2nd order term SOT_sens applied to the sensor readout. (The LSBs are SOT_sens[15:0] in register 09_{HEX}.)

MTP Address	Word / Bit Range	Default Setting	Description	Notes
11_{HEX}	7:0	00_{HEX}	SOT_T[23:16]	Bits [23:16] including sign for the 24-bit-wide 2nd - order term SOT_T applied to the temperature reading. (The LSBs are SOT_T[15:0] in register $0C_{HEX}$.)
	15:8	00_{HEX}	Gain_T[23:16]	Bits [23:16] including sign for the 24-bit-wide absolute value of the temperature gain coefficient Gain_T. (The LSBs are Gain_T[15:0] in register $0B_{HEX}$.)
Measurement Configuration Register 1 (SM_config1)				
12_{HEX}	2:0	000_{BIN}	Gain_stage1	Gain setting for the 1st PREAMP 1ststage with Gain_stage1 $Gain_{amp1}$: 000 6 001 12 010 20 011 30 100 40 101 60 110 80 111 120 (Might affect noise and accuracy specifications depending on sensor setup)
	5:3	000_{BIN}	Gain_stage2	Gain setting for the 2ndPREAMP stage with Gain_stage2 $Gain_{amp2}$: 000 1.1 001 1.2 010 1.3 011 1.4 100 1.5 101 1.6 110 1.7 111 1.8
	6	0_{BIN}	Gain_polarity	Set up the polarity of the sensor bridge's gain (inverting of the chopper) with 0 positive (no polarity change)1 negative (180° polarity change)
	10:7	0000_{BIN}	Adc_bits	Absolute number of bits for the ADC conversion ADC_bits: 0000 0001 0010 0011 0100 0101 0110 0111 to 1111 not assigned
	11	0_{BIN}	AbsV_enable	Enable bit for thermopile input selection (INN connected to AGND, INP connected to absolute voltage source) with AbsV_enable: 0 absolute voltage input disabled (default) 1 absolute voltage input enabled (e.g. for a thermopile)
	14:12	000_{BIN}	Offset	Differential signal's offset shift in the ADC; compensation of signal offset by x% of input signal: 000 no offset compensation 001 6.75% offset 010 12.5% offset 011 19.25% offset 100 25% offset 101 31.75% offset 110 38.5% offset 111 43.25% offset Note: Bit 15 below must be set to 1 to enable the offset shift.
	15	0_{BIN}	Shift_method	Offset shift method switch:0 No offset shift. Offset (bits [14:12] in 12_{HEX}) must be set to 000_{BIN}; $Gain_{ADC}$ = 1 1⇔Offset shift ADC; $Gain_{ADC}$=2
13_{HEX}	15:0	0000_{HEX}	TRSH1[15:0]	Bits [15:0] of the 24-bit-wide interrupt threshold1, TRSH1. (The MSB bits for this threshold are TRSH1[23:16], which is bits [7:0] of register 15_{HEX}.)
14_{HEX}	15:0	0000_{HEX}	TRSH2[15:0]	Bits [15:0] of the 24-bit-wide interrupt threshold2, TRSH2. (The MSB bits for this threshold are

MTP Address	Word / Bit Range	Default Setting	Description	Notes
				TRSH2[23:16], which is bits[15:8] of register 15_{HEX}.)
15HEX	7:0	00_{HEX}	TRSH1[23:16]	Bits [23:16] of the 24-bit-wide interrupt threshold1, TRSH1. (The LSB bits for this threshold are TRSH1[15:0], which is bits[15:0] of register 13_{HEX}.)
	15:8	00_{HEX}	TRSH2[23:16]	Bits [23:16] of the 24-bit-wide interrupt threshold2, TRSH2. (The LSB bits for this threshold are TRSH2[15:0], which is bits[15:0] of register 14_{HEX}.)
Measurement Configuration Register 2 (SM_config2)				
16HEX	2:0	000_{BIN}	Gain_stage1	Gain setting for the 1st PREAMP stage with Gain_stage1 $Gain_{amp1}$: 000 6 001 12 010 20 011 30 100 40 101 60 110 80 111 120 (Might affect noise and accuracy specifications depending on sensor setup)
	5:3	000_{BIN}	Gain_stage2	Gain setting for the 2nd PREAMP stage with Gain_stage2 $Gain_{amp2}$: 000 1.1 001 1.2 010 1.3 011 1.4 100 1.5 101 1.6 110 1.7 111 1.8
	6	0_{BIN}	Gain_polarity	Set up the polarity of the sensor bridge's gain (inverting of the chopper) with 0 positive (no polarity change)1 negative (180° polarity change)
	10:7	0000_{BIN}	Adc_bits	Absolute number of bits for the ADC conversion ADC_bits: 0000 0001 0010 0011 0100 0101 0110 0111 to 1111 not assigned
	11	0_{BIN}	AbsV_enable	Enable bit for thermopile input selection (INN connected to AGND, INP connected to absolute voltage source) with AbsV_enable: 0 absolute voltage input disabled (default) 1 absolute voltage input enabled (e.g. for a thermopile)
	14:12	000_{BIN}	Offset	Differential signal's offset shift in the ADC; compensation of signal offset by x% of input signal: 000 no offset compensation 001 6.75% offset 010 12.5% offset 011 19.25% offset 100 25% offset 101 31.75% offset 110 38.5% offset 111 43.25% offset Note: Bit 15 below must be set to 1 to enable the offset shift.
	15	0_{BIN}	Shift_method	Offset shift method switch:0 No offset shift. Offset (bits[14:12] in 16_{HEX}) must be set to 000_{BIN}; $Gain_{ADC}$ = 1 1 ⇔Offset Shift ADC, $Gain_{ADC}$=2
Post-Calibration Offset Correction Coefficients				
17HEX	15:0	0000_{HEX}	SENS_Shift[15:0]	Bits [15:0] of the post-calibration sensor offset shift coefficient SENS_Shift. (The MSB bits of

MTP Address	Word / Bit Range	Default Setting	Description	Notes
				SENS_Shift are bits [7:0] of register 19HEX.)
18HEX	15:0	0000HEX	T_Shift[15:0]	Bits [15:0] of the post-calibration temperature offset shift coefficient T_Shift. (The MSB bits of T_Shift are bits [15:8] of register 19HEX.)
19HEX	7:0	00HEX	SENS_Shift[23:16]	Bits [23:16] of the post-calibration sensor offset shift coefficient SENS_Shift. (The LSB bits of SENS_Shift are in register 17HEX.)
	15:8	00HEX	T_Shift[23:16]	Bits [23:16] of the post-calibration temperature offset shift coefficient T_Shift. (The LSB bits of T_Shift are in register 18HEX.)
Free Memory – Arbitrary Use				
20HEX	15:0	0000HEX		Not assigned (e.g., can be used for Cust_IDx customer identification number)
21HEX	15:0	0000HEX		Not assigned (e.g., can be used for Cust_IDx customer identification number)
...				Not assigned (e.g., can be used for Cust_IDx customer identification number)
37HEX	15:0	0000HEX		Not assigned (e.g., can be used for Cust_IDx customer identification number)
38HEX	15:0	0000HEX		Not assigned (e.g., can be used for Cust_IDx customer identification number)
39HEX	15:0	-	Checksum	Generated (checksum) for the entire memory through a linear feedback shift register (LFSR); signature is checked on power-up to ensure memory content integrity

The memory integrity checksum (referred to as CRC) is generated through a linear feedback shift register with the following polynomial:

$g(x) = x^{16} + x^{15} + x^2 + 1$ with the initialization value: FFFFHEX. If the CRC is valid, then the "Memory Error" status bit is set to 0.

4.5 I²C

I²C Mode will be selected if the very first interface activity after BM43TND-S2 power-up is an I²Ccommand.

Command Request (I²CWrite)

S	SlaveAddr	0	A	Command	A	P

S	SlaveAddr	0	A	Command	A	CmdDat <15:8>	A	CmdDat	A	P

I²C Read Status

Read Status (I²C Read)

S	SlaveAddr	1	A	Status	N	P

Read Data (I²C Read)

(a) Example: after the completion of a Memory Read command

S	SlaveAddr	1	A	Status	A	MemDat <15:8>	A	MemDat <7:0>	N	P

(b) Example: after the completion of a Full Measurement command (AAHEX)

S	SlaveAddr	1	A	Status	A	SensorDat <23:16>	A	SensorDat <15:8>	A	SensorDat <7:0>	A	TempDat <23:16>	A	TempDat <15:8>	A	TempDat <7:0>	N	P

I^2CCommands

The I^2Ccommands supported by the BM43TND-S2 are listed in Table4. The command to read an address in the user memory is the same as its address. The command to write to an address in user memory is the address plus 40HEX.

There is a BM-reserved section of memory that can be read but not over-written by the user.

Table4I^2C Commands

Command (Byte)	Return	Description	Normal Mode	Command Mode
00HEX to 39HEX	16-bit user data	Read data in the user memory address (00HEX to 39HEX) matching the command (might not be using all addresses).	Yes	Yes
3AHEX to 3FHEX	16-bit BM-reserved memory data	Read data in BM-reserved memory at address (3AHEX to 3FHEX).	Yes	Yes
40HEX to 79HEX followed by data (0000HEX to FFFFHEX)	—	Write data to user memory at address specified by command minus 40HEX (addresses 00HEX to 39HEX respectively; might not be using all addresses).	Yes	Yes
90HEX	—	Calculate and write memory checksum (CRC).	Yes	Yes
A0HEX to A7HEX followed by XXXXHEX (see Table 3.2)	24-bit formatted raw data	Get_Raw This command can be used to perform a measurement and write the raw ADC data into the output register. The LSB of the command determines how the AFE configuration register is loaded for the Get_Raw measurement (see Table 3.2).	Yes	Yes
A8HEX	—	Start_NOM Exit Command Mode and transition to Normal Mode (Sleep or Cyclic).	No	Yes
A9HEX	—	Start_CM Exit Normal Mode and transition to Command Mode (as very first command after power-up).	Yes	No
AAHEX	24-bit formatted fully corrected sensor meas-urement data + 24-bit corrected temperature data	Measure Trigger full measurement cycle (AZSM, SM, AZTM, and TM, as described in section 3.2) and calculation and storage of data in the output buffer using the configuration from MTP.	Yes	Yes
ABHEX	24-bit formatted	Measure Cyclic This command	Yes	Yes

Command (Byte)	Return	Description	Normal Mode	Command Mode
	fully corrected sensor meas- urement data + 24-bit corrected temperature data	triggers a continuous full measurement cycle (AZSM, SM, AZTM, and TM; see section 3.2) and calculation and storage of data in the output buffer using the configuration from MTP followed by a pause determined by CYC_period (bits[14:12] in memory register 02HEX).		
ACHEX	24-bit formatted fully corrected sensor meas- urement data + 24-bit corrected temperature data	Oversample-2 Measure Mean value gen- eration: 2 full measurements are conducted (as in command AAHEX), the measurements' mean value is calculated, and data is stored in the output buffer using the configuration from MTP; no power down or pause between the 2 measurements	Yes	Yes
ADHEX	24-bit formatted fully corrected sensor meas- urement data + 24-bit corrected temperature data	Oversample-4 Measure Mean value generation: 4 full measurements (as in command AAHEX) are conducted, the measurements' mean value is calculated, and data is stored in the output buffer using the configuration from MTP; no power down or pause between the 4 measurements	Yes	Yes
AEHEX	24-bit formatted fully corrected sensor meas- urement data + 24-bit corrected temperature data	Oversample-8 Measure Mean value gen- eration: 8 full measurements (as in command AAHEX) are conducted, the measurements' mean value is calculated, and data is stored in the output buffer using the configuration from MTP; no power down or pause between the 8 measurements	Yes	Yes
AFHEX	24-bit formatted fully corrected sensor meas- urement data + 24-bit corrected temperature data	Oversample-16 Measure Mean value generation: 16 full measurements (as in command AAHEX) are conducted, the measurements' mean value is calculated, and data is stored in the output buffer using the configuration from MTP; no power down or pause between the 16 measurements	Yes	Yes
B0HEX	—	Select SM_config1 register (12HEX in memory) For any measurement using the memory contents for the analog front-end and sensor setup, the respective setup is loaded from the SM_config1 register; status bit[1]==0 (default)	Yes	Yes
B1HEX	—	Select SM_config2 register (16HEX in memory) For any measurement using the memory contents for the analog front-end and sensor setup, the respective setup is loaded from	Yes	Yes

Command (Byte)	Return	Description	Normal Mode	Command Mode
		the SM_config2 register, status bit[1]==1		
BFHEX	—	STOP_CYC This command causes a power- down halting the update / cyclic measure- ment operation and causing a transition to Normal-Sleep operation	Yes	Yes
FXHEX	Status followed by last 24-bit data	NOP Only valid for SPI (see sections 3.5.1 and 3.5.2)	Yes	Yes
Note: Every return starts with a status byte followed by the data word as described in section				

Table5 Get_Raw Commands

Command	Measurement	AFE Configuration Register
A0HEX followed by 0000HEX	SM – Sensor Measurement	SM_config1 register or SM_config2 register.
A1HEX followed by ssssHEX	SM – Sensor Measurement	ssss is the user's configuration setting for the measure- ment provided via the interface. The format and pur- pose of configuration bits must be according to the definitions for SM_config (see Table 3.5).
A2HEX followed by 0000HEX	SM-AZSM – Auto-Zero Corrected Sensor Measurement 1)	SM_config
A3HEX followed by ssssHEX	SM-AZSM – Auto-Zero Corrected Sensor Measurement 2)	ssss is the user's configuration setting for the measure- ment provided via the interface. The format and pur- pose of configuration bits must be according to the definitions for SM_config.
A4HEX followed by 0000HEX	TM – Temperature Measurement	BM-defined register
A5HEX followed by ssssHEX	TM – Temperature Measurement	ssss is the user's configuration setting for the measure- ment provided via the interface. The format and pur- pose of configuration bits must be according to the definitions for SM_config and valid for temperature measurement in this case (bits [15:12] will be ignored).
A6HEX followed by 0000HEX	TM-AZTM – Auto-Zero Corrected Temperature Measurement 1)	BM-defined register
A7HEX followed by ssssHEX	TM-AZTM – Auto-Zero Corrected Temperature Measurement 2)	ssss is the user's configuration setting for the measure- ment provided via the interface. The format and pur- pose of these configuration bits must be according to the definitions for SM_config and valid for temperature measurement in this case (bits [15:12] will be ignored).
1)Recommended for raw data collection during calibration coefficient determination using the measurement setups pre-programmed in MTP.2)Recommended for raw data collection during		

calibration coefficient determination using un-programmed (not in MTP), external measurement setups; e.g., for evaluation purposes.

Table6 General Status Byte

Status [4:3]	Mode
00	Normal Mode (sleep and cyclic operations)
01	Command Mode
10	BM reserved
11	BM reserved

4.6 Sensor Data Output Format

Regardless ADC resolution, both thermopile and temperature outputs are 24bit format. The values are either in two's complement or sign-absolute format.

If you use raw data output, the data format should be 2' complement

RAW Data Reading

Bit	23	22	21	20	…	3	2	1	0
Meaning,Weight	-2^0	2^{-1}	2^{-2}	2^{-3}	…	2^{-20}	2^{-21}	2^{-22}	2^{-23}

Bit	7	6	5	4	3	2	1	0
Meaning,Weight	Meaning	0	Powered ?	Busy?	Mode	Memory error?	Meaning	0

Calibration Coefficients(Factors and Summands) in Memory(sing-magnitude)

Bit	23	22	21	20	…	3	2	1	0
Meaning,Weight	0:Positive 1:Negative	2^1	2^0	2^{-1}	…	2^{-18}	2^{-19}	2^{-20}	2^{-21}

Output Results from SSC-Correction Math or DSP – Sensor and Temperature

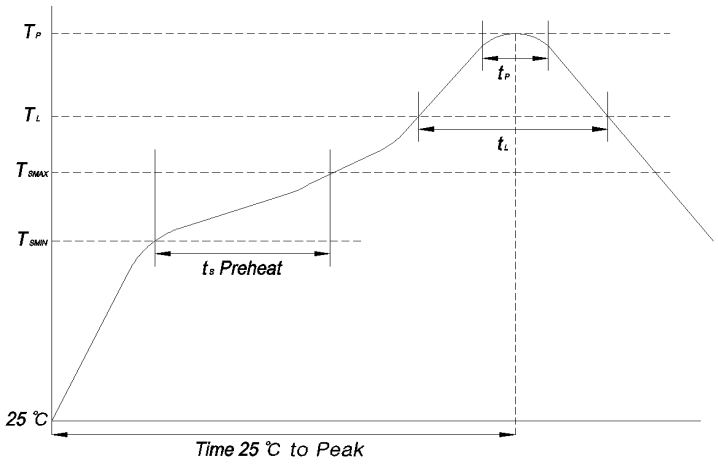
Bit	23	22	21	20	…	3	2	1	0
Meaning,Weight	2^0	2^{-1}	2^{-2}	2^{-3}	…	2^{-20}	2^{-21}	2^{-22}	2^{-23}

Interrupt Thresholds TRSH1 and TRSH2 –Format as for SSC-Correction Math Output

Bit	23	22	21	20	…	3	2	1	0
Meaning,Weight	2^0	2^{-1}	2^{-2}	2^{-3}	…	2^{-20}	2^{-21}	2^{-22}	2^{-23}

5. Application Note

5.1 Reflow Profile for BM43TND



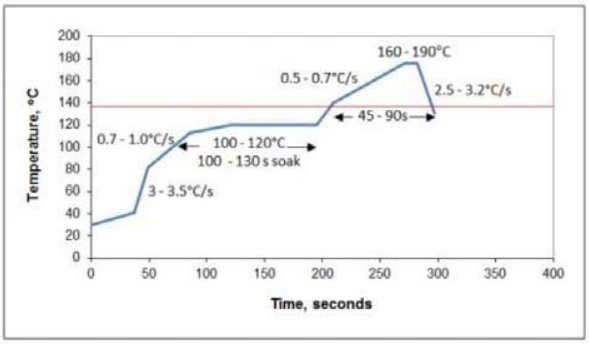
Profile Feature		Lead(Pb) Free Solder
Preheat	Temperature min.(T_{SMIN})	150
	Temperature max.(T_{SMAX})	200
	Time (t_S)	60-120 Seconds
Liquidous	Temperature (T_L)	217
	Time (t_L)	60-150 Seconds
Peak	Temperature (T_P)	260
	Time within 5 of actual peak temperature (t_P)	30 Seconds Max.
Ramp up	Average ramp up rate T_{SMAX} to T_P	3 / Second Max.
Ramp down	Average ramp down rate T_P to T_{SMAX}	6 / Second Max.
Time 25 to Peak temperature		8 Minutes Max.

5.2 SMD Reflow Suggestion for Application

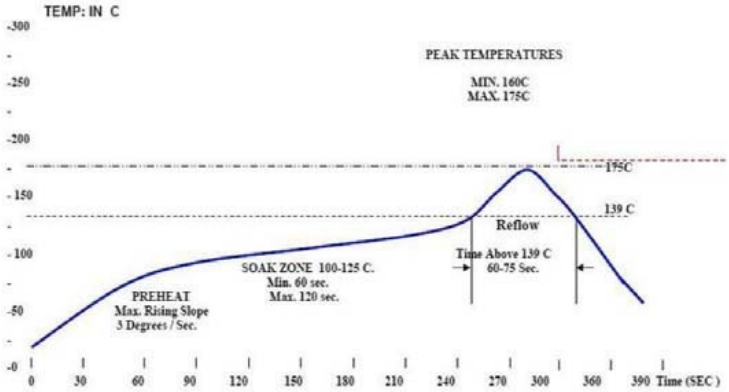
BM43TND is temperature sensitive component in terms of package and thermopile sensor, Therefore, normal SMD temperature could damage BM43TND package and sensor. BM would like to suggest customer to proceed secondary SMD reflow for BM43TND with lower temperature which is not higher than 180°C in order to guarantee the best performance. The followings are some example of low temperature SMD profile and low temperature solder paste for your reference.

REFLOW

OM-535 SBX02, SnBi0.4Ag Typical Reflow Profile



Sn42/Bi58 Profile

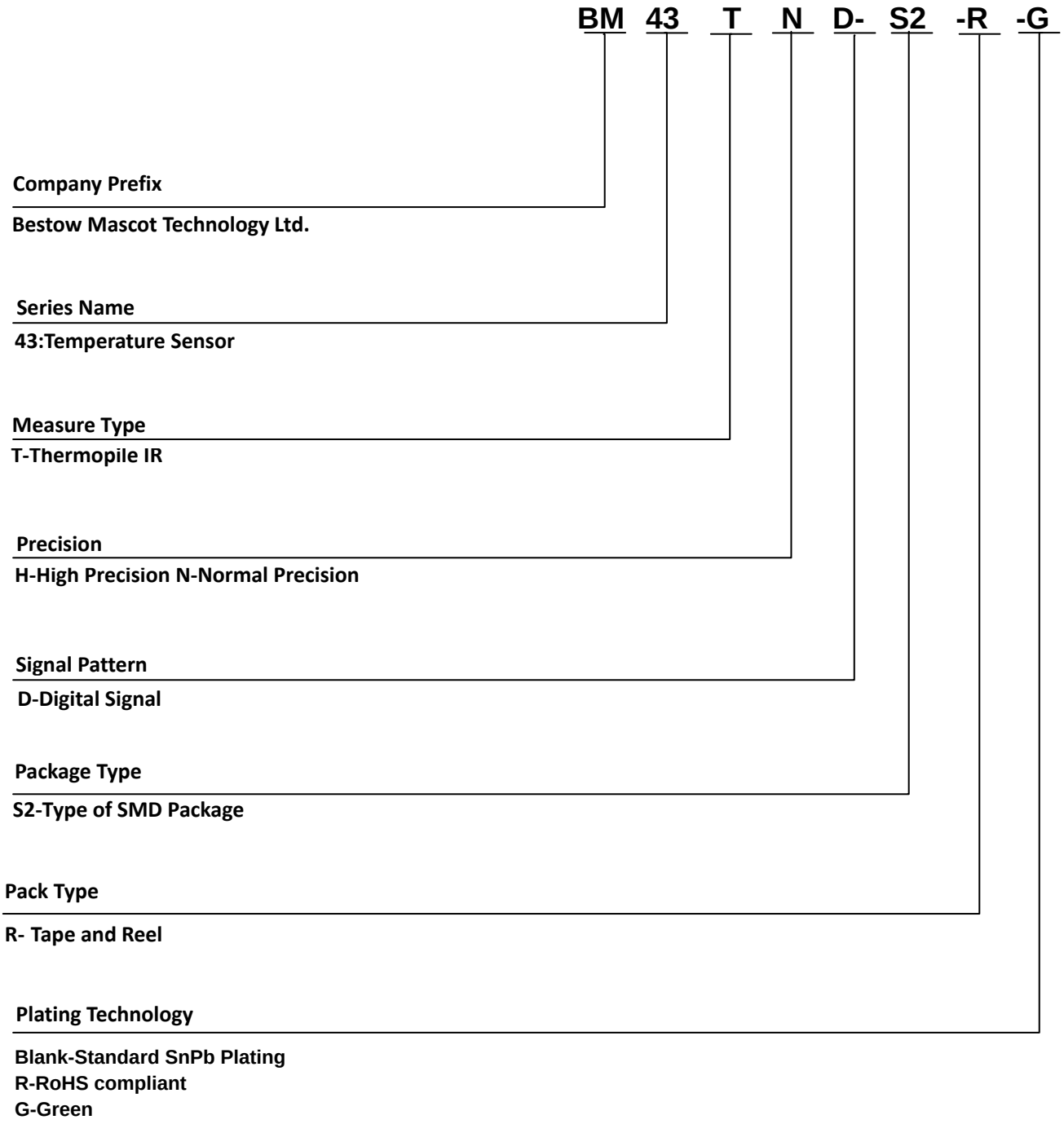


5.3 Typical Reliability Test Items

No	Tested Item	Condition	Standard
1	Humidity	+85±2 , 85±2%RH 120h, 2V	JESD 22-A 101A-B
2	Low Temperature	-40±2 200h	IEC 68-2-2 Test Aa
3	High Temperature	+105±2 200h	IEC 68-2-2 Test Ba
4	Thermal Shock	(-40±2 →+85 ±2)×20Cycle 2h	IEC 60068-2-4
5	Drop	Drop 12 times onto thick steel plate from height 1.52m (installed in JIG)	IEC 60068-2-32
6	Vibration	Frequency sweep: 10~55Hz/min → 2h Direction : X, Y, X (1.52mm distance for each direction)	MIL 883E, Method 2007.2.A
7	ESD(Contact)	5 discharges at ±8 direct contact to lid when unit is grounded. 5 discharges at ±2 direct contact to I/O pins.	IEC 61000-4-2
8	Tumbling	Steel chamber length = 1m, 6.5rpm, 300 times.	SANICO specification
9	Reflow	Peak = 260 / 30sec, Repeat 3 times	IPC-JEDEC J-STD-020D.1

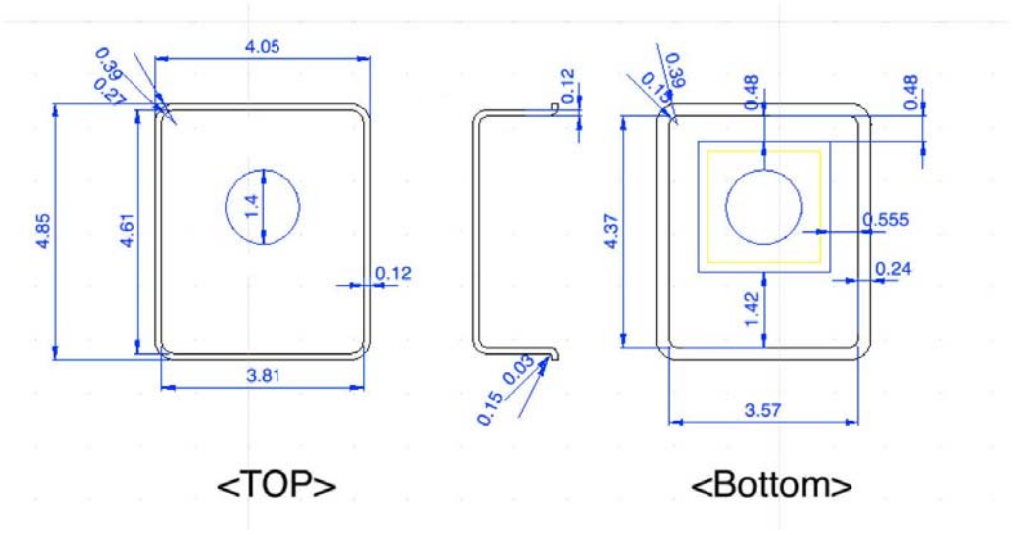
6. Ordering Information

6.1 Part Numbering

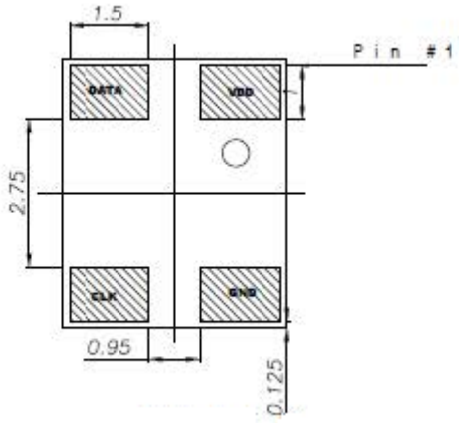


Package Type	Temperature Range	HSF	Pack Type	Order Code
S2	-40 to +125	Green	Tape and Reel	BM43TND-S2-R-G

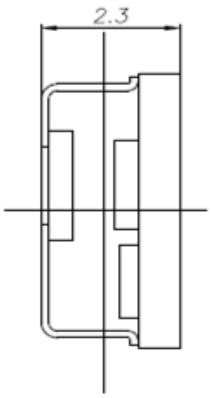
6.2 SMD Package Outline Dimensions (in mm)



<TOP> <Bottom>

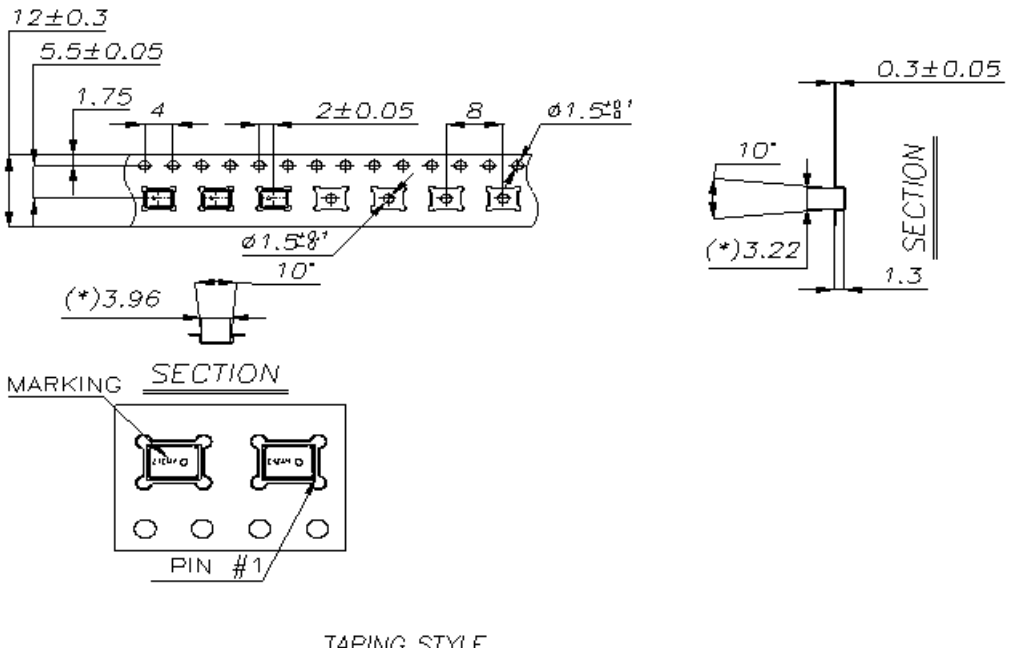


PCB layout



CAN+PCB

6.3 Tape and Reel Information (2500pcs/reel)



TAPING STYLE

7. Notice

●General Precaution

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2) All information contained in this document is current as of the issuing date and subject to change without any prior notice. Before purchasing or using BM's Products, please confirm the latest information with a BM sales representative.

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[a] Installation of protection circuits or other protective devices to improve system safety

[b] Installation of redundant circuits to reduce the impact of single or multiple circuit failure

3) Our Products are designed and manufactured for use under standard conditions and not under any special or extraordinary environments or conditions, as exemplified below. Accordingly, BM shall not be in any way responsible or liable for any damages, expenses or losses arising from the use of any BM's Products under any special or extraordinary environments or conditions. If you intend to use our Products under any special or extraordinary environments or conditions (as exemplified below), your independent verification and confirmation of product performance, reliability, etc, prior to use, must be necessary:

[a] Use of our Products in any types of liquid, including water, oils, chemicals, and organic solvents

[b] Use of our Products outdoors or in places where the Products are exposed to direct sunlight or dust

[c] Use of our Products in places where the Products are exposed to sea wind or corrosive gases, including Cl_2, H_2S, NH_3, SO_2, and NO_2

[d] Use of our Products in places where the Products are exposed to static electricity or electromagnetic waves

[e] Use of our Products in proximity to heat-producing components, plastic cords, or other flammable items

[f] Sealing or coating our Products with resin or other coating materials

[g] Use of our Products without cleaning residue of flux (even if you use no-clean type fluxes, cleaning residue of flux is recommended); or Washing our Products by using water

or water-soluble cleaning agents for cleaning residue after soldering

[h] Use of the Products in places subject to dew condensation

4) The Products are not subject to radiation-proof design.

5) Please verify and confirm characteristics of the final or mounted products in using the Products.

6) In particular, if a transient load (a large amount of load applied in a short period of time, such as pulse) is applied, confirmation of performance characteristics after on-board mounting is strongly recommended. Avoid applying power exceeding normal rated power; exceeding the power rating under steady-state loading condition may negatively affect product performance and reliability.

7) De-rate Power Dissipation (Pd) depending on Ambient temperature (Ta). When used in sealed area, confirm the actual ambient temperature.

8) Confirm that operation temperature is within the specified range described in the product specification.

9) BM shall not be in any way responsible or liable for failure induced under deviant condition from what is defined in this document.

●Precaution for Mounting / Circuit board design

1) When a highly active halogen us (chlorine, bromine, etc.) flux is used, the residue of flux may negatively affect product performance and reliability.

2) In principle, the reflow soldering method must be used; if flow soldering method is preferred, please consult with the BM representative in advance. For details, please refer to BM Mounting specification

●Precautions Regarding Application Examples and External Circuits

1) If change is made to the constant of an external circuit, please allow a sufficient margin considering variations of the characteristics of the Products and external components, including transient characteristics, as well as static characteristics.

2) You agree that application notes, reference designs, and associated data and information contained in this document are presented only as guidance for Products use. Therefore, in case you use such information, you are solely responsible for it and you must exercise your own independent verification and judgment in the use of such information contained in this document. BM shall not be in any way responsible or liable for any damages, expenses or losses incurred by you or third parties arising from the use of such information.

●Precaution for Electrostatic

This Product is electrostatic sensitive product, which may be damaged due to electrostatic discharge. Please take proper caution in your manufacturing process and storage so that voltage exceeding the Products maximum rating will not be applied to Products. Please take special care under dry condition (e.g. Grounding of human body / equipment / solder iron, isolation from charged objects, setting of Ionizer, friction prevention and temperature / humidity control).

●Precaution for Storage / Transportation

1) Product performance and soldered connections may deteriorate if the Products are stored in the places where:

[a] the Products are exposed to sea winds or corrosive gases, including Cl_2, H_2S, NH_3, SO_2, and NO_2

[b] the temperature or humidity exceeds those recommended by BM

[c] the Products are exposed to direct sunshine or condensation

[d] the Products are exposed to high Electrostatic

2) Even under BM recommended storage condition, solder ability of products out of recommended storage time period may be degraded. It is strongly recommended to confirm solder ability before using Products of which storage time is exceeding the recommended storage time period.

3) Store / transport cartons in the correct direction, which is indicated on a carton with a symbol. Otherwise bent leads may occur due to excessive stress applied when dropping of a carton.

4) Use Products within the specified time after opening a humidity barrier bag. Baking is required before using Products of which storage time is exceeding the recommended storage time period.

●Precaution for Product Label

QR code printed on BM Products label is for BM's internal use only.

●Precaution for Disposition

When disposing Products please dispose them properly using an authorized industry waste company.

●Precaution for Foreign Exchange and Foreign Trade act

Since our Products might fall under controlled goods prescribed by the applicable foreign exchange and foreign trade act, please consult with BM representative in case of export.

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8. Revision History

Version	Publication Date	Pages	Revise Description
1.0	Dec.2015	25	Initial Document Release
1.1	Mar. 2016	25	Update Package Information
1.2	Apr. 2016	25	Update some English words, sentences' descriptions, grammar and formatting
1.2.1	Jun. 2016	25	Update Package Information
1.3	Jul. 2016	25	Add Accuracy of Measurement Add height of product
1.4	Oct.2016	24	Update Reflow Information