Pressure Sensor

BM45ADA

Bestow Mascot

General Description:

The BM45ADA is the pressure sensor which measures absolute pressures. It consists of a silicon micro-machined sensing element chip and a signal conditioning ASIC. The ASIC is equipped with a 24-bit resolution Σ-Δ ADC and outputs a highly precise pressure value as a digital value. The pressure sensor element and the ASIC are mounted inside a system-in-package and wire-bonded to appropriate contacts. The BM45ADA provides the digital output data with the format of I^2C/SPI interface. It can achieve ESD robustness, fast response time, high accuracy and linearity as well as long-term stability. All measurement data is fully calibrated and temperature compensated. In addition, it allows for easy system integration.

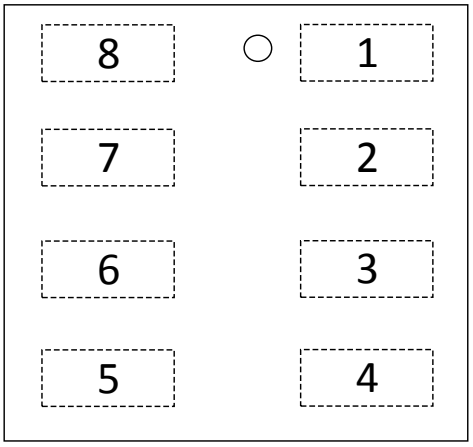
Features:

- Piezo-resistive silicon micro-machined sensor
- Absolute type pressure sensor
- Pressure range : 260 to 1260 mBar
- 24-bit data output access I^2C/SPI(3-wire/4-wire) interface
- Supply voltage：1.7 to 3.6V
- Embedded temperature compensation
- Fast power up to first data ready : 15ms
- Fast data update rate : 200Hz
- QFN-8 pin package (2.5*2.5*1mm)
- RoHS compliant and Halogen-free Package

Applications:

- Altitude and Barometer for portable device
- GPS application
- Air Conditioning
- Weather stations
- Pneumatic control

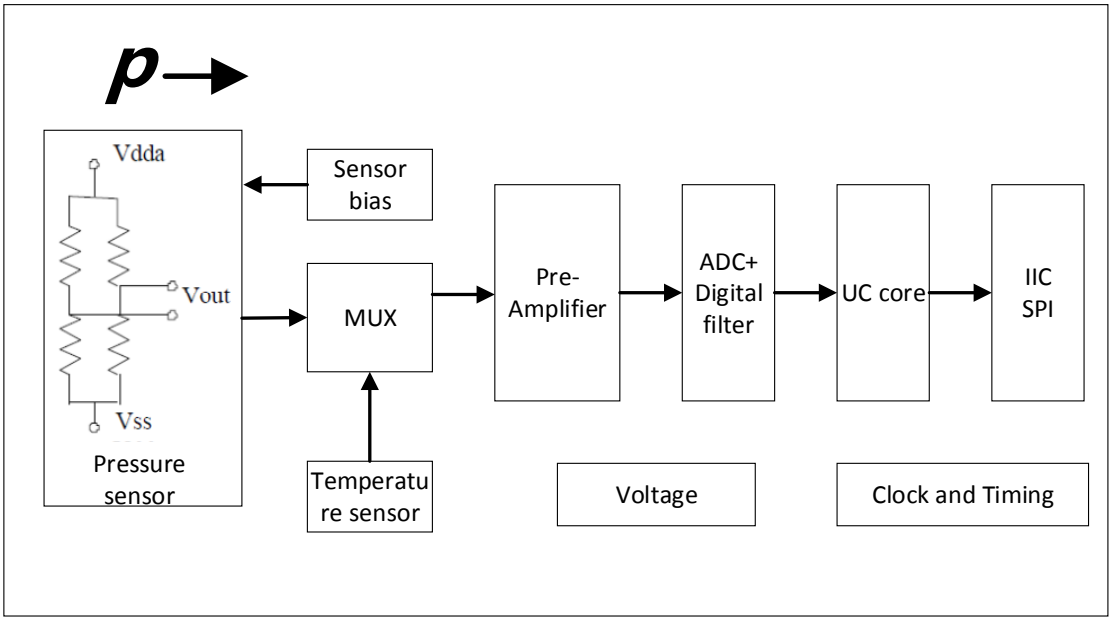
Pin Configuration:



Top View

Pin No.	Pin Name	I/O	Function description
1	GND	P	Connected to GND
2	CSB	I	SPI chip select; active low. When it is high, chip is in I^2C mode. Otherwise, chip is in SPI mode
3	SDA/SDI/SDIO	I/O	I^2C SDA/SPI SDI in 4-wire mode/SPI SDIO in 3-wire mode
4	SCL/SCK	I	I^2C SCL/SPI SCK
5	I^2C_AOPT/SDO	I/O	I^2C address bit 0 select in I^2C mode/SDO in SPI mode
6	VDD_IO	P	Digital I/O power
7	GND	P	Connected to GND
8	GND	P	Positive supply voltage

Block Diagram



Maximum Ratings

V_{DD} ..... -0.3 V to +4.1 V

Voltage at Digital IO Pins..... ..... -0.3 V to V_{DD}+0.3 V

Operating Temperature Range ..... -40°C to +85°C

Storage Temperature Range..... .... -40°C to +125°C

Voltage (with respect to GND unless otherwise noted)

Electrical Characteristics

Symbol	Parameter	Test Conditions		Min.	Typ.	Max.	Unit
		V_{DD}	Conditions				
V_{DD}	Operating Voltage	---	---	1.7	3.0	3.6	V
I_{DD}	Operating Current	3.0V	---	---	1.6	---	mA
		1.8V	---	---	0.7	---	mA
I_{STB1}	Standby Current	3.0V	Sleep state at 25℃	---	5	---	μA
T_{OP}	Full accuracy temperature range	---	---	-20	---	85	℃
P_{PRO}	Proof pressure	---	---	---	---	3000	mBar
P_{OP}	Operating pressure range	3.0V	---	260	---	1260	mBar
D_R	Data Resolution	---	---	---	24	---	bit
P_{senty}	Pressure sensitivity	---	---	---	0.001	---	mBar/LSB
Pacc	Accuracy pressure over temperature	3.0V	T:25℃ P:900~1260mBar	-3	---	+3	mBar
			T:25℃ P:260~1260mBar	-5	---	+5	mBar
			T:0℃~50℃ P:260~1260mBar	-10	---	+10	mBar
			T:-20℃~85℃ P:260~1260mBar	-17	---	+17	mBar
t_{ADC}	AD conversion	3.0V	T=25℃,F_{SYS}(8MHz)	---	4.12	----	mS
F_{SYS}	System Frequency	2.5~3.6V	T:0℃~85℃	7.96	8.00	8.04	MHz
$F_{c.I^2C}$	I^2C clock frequency	3.0V	---	---	400	3400	KHz
F_{scp}	SPI bus speed	3.0V	except bit to bit delay	---	---	10	MHz
ESD	Human Body Mode	---	MIL-STD-883E Method 3015.7	-2	---	+2	kV

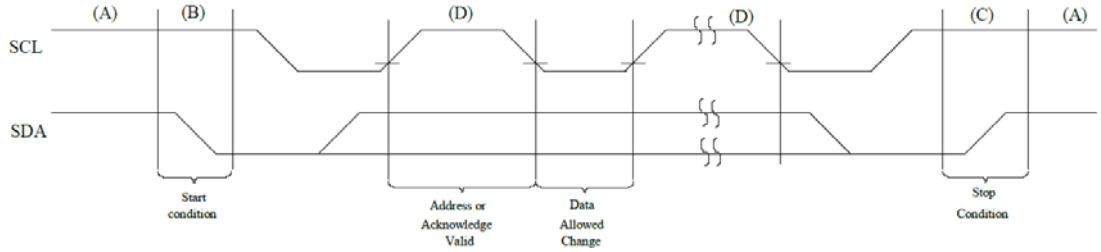
I²C operation

BM45ADA supports a bi-direction two wire bus and data transmission protocol to output data. A processor sends data onto the bus is defined as transmitter, BM45ADA receives data is defined receiver. The bus must be controlled by a master processor which generates the serial clock(SCL), controls the bus access, and generates the START and STOP conditions, while the BM45ADA works as slave.

The following bus protocol has been defined:

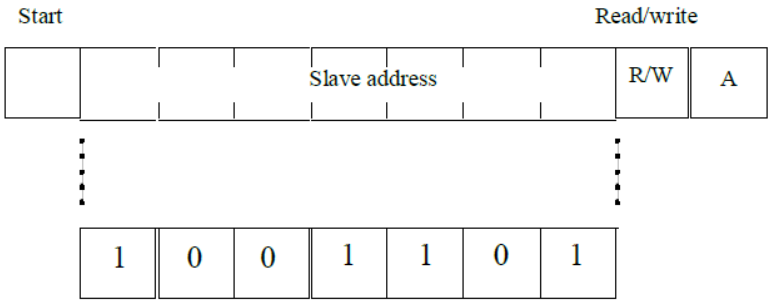
- Data transfer may be initiated only when the bus is not busy.
- During data transfer, the data line must remain stable whenever the clock is HIGH level. Changes in the data line while the clock line is HIGH will be interpreted as a START or STOP condition.

Following bus conditions have been defined



- Bus not busy as condition(A)
  Both data and clock lines remain HIGH.
- Start data transfer as condition(B)
  A HIGH to LOW transition of the SDA line while the clock (SCL) is HIGH determines as START condition. Reading data must be begun by START condition.
- Stop data transfer as condition(C)
  A LOW to HIGH transition of the SDA line while the clock (SCL) is HIGH determines as STOP condition.
- Data valid as condition(D)
  After a START condition, the data line is stable for the duration of the HIGH period of the clock signal. The data on the line must be changed during the LOW period of the clock signal. There is one clock pulse per bit of data. The number of valid data bytes transferred between the START and STOP conditions.
- Acknowledge signal
  Each BM45ADA receiving, when addressed, is obliged to generate an acknowledge bit after the reception of each byte. The processor must generate an extra clock pulse which is associated with this acknowledge bit. The BM45ADA has to pull down the SDA line during the acknowledge clock pulse. The way is the SDA line is stable LOW during the HIGH period of acknowledge related clock pulse. A processor must signal an end of data to the slave by not generating an acknowledge bit on the last byte.
- BM45ADA I²C slave address
  The seven bit is as slave address after START condition. The BM45ADA slave address is 1001101B (7 bits). The eighth bit of control address is read or written bit that processor wants. The processor

read data sequence refers as below :



I²C Read/Write Format

Notation

S	Start
P	Stop
SAD+W	Slave Address (1001 101) + Write bit (0)
SAD+R	Slave Address (1001 101) + Read bit (1)
REG	Register Address
DATA	Data
A	Master acknowledge
~A	Master non-acknowledge
SAK	Slave acknowledge

Master is writing one Byte to slave

Master	S	SAD+W		REG		DATA		P
Slave			SAK		SAK		SAK	

Master is writing Multiple Bytes to slave

Master	S	SAD+W		REG		DATA		DATA		DATA		P
Slave			SAK		SAK		SAK		SAK		SAK	

Master is reading one Byte from slave

Master	S	SAD+W		REG		S	SAD+R			~A	P
Slave			SAK		SAK		SAK	SAK	DATA		

Master is reading Multiple Bytes from slave

Master	S	SAD+W		REG		S	SAD+R			A		A		~A	P
Slave			SAK		SAK		SAK	SAK	DATA		DATA		DATA		

Read pressure data Format (I²C Interface)

Master	S	SAD+W (100110		REG (28H)		S	SAD+R (100110			A		A		~A	P
Slave			SAK		SAK		SAK	SAK	P_DATA <7:0>		P_DATA <15:8>		P_DATA <23:16>		

Read-out data format represents

Pressure Value	Reading Data		
	<23:16>	<15:8>	<7:0>
260mBar	0x03	0xF7	0xA0
500mBar	0x07	0xA1	0x20
1000mBar	0x0F	0x42	0x40
1260mBar	0x13	0x39	0xE0

I²C Operation sequence

Step 1:

- First, DRDY enable. Writing register address 21H as 0x2cH to BM45ADA access I²C interface.
- Second, Control REG1 setting. Writing register address 20H as 0x98H to BM45ADA access I²C interface.
- Third, I²C Page Enable Register enable. Writing register address 3FH as 0x80H to BM45ADA access I²C interface.

Step 2:

- Fourth, I²C Page 0 setting. Writing register address 3EH as 0x00H to BM45ADA access I²C interface.
- Fifth, Measurement Mode setting. Writing register address 46H as 0x0010H to BM45ADA access I²C interface.

Step 3:

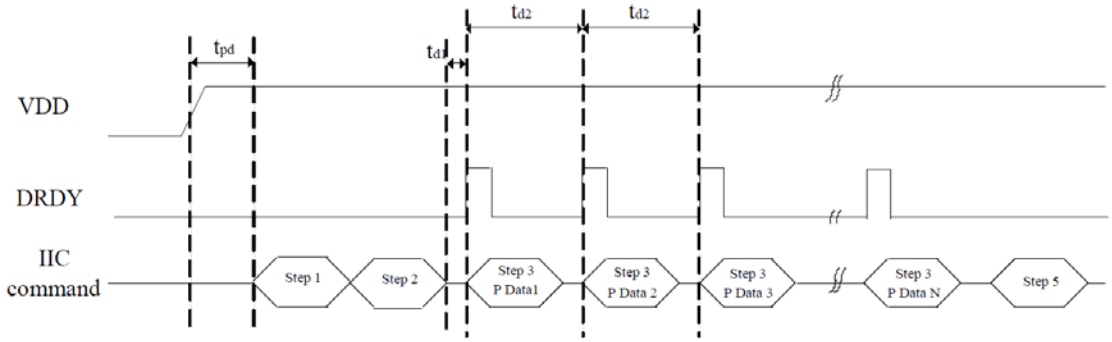
- -1186Sixth, read-out digital pressure value after detecting rising edge of DRDY (Bit 6 Of STATUS Register).

  Reading 24-bit pressure data in register address 28H from BM45ADA access I²C interface.

  Repeat step 3 to continue reading 24-bit pressure data from BM45ADA access I²C interface.

  After pressure measurement completely, write register address 20H as 18H to BM45ADA going to standby mode.

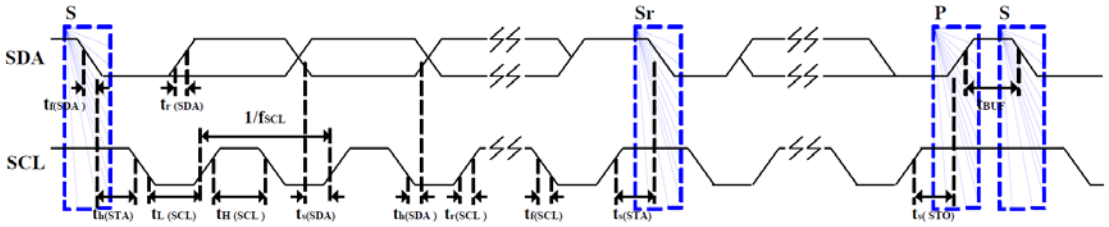
System reading data diagram



*DRDY(Bit 6 Of STATUS Register) switches to low form high while host read out the pressure data.

Symbol	Parameter	Min.	Typ.	Max.	Unit
tpd	Power on delay time	11	-	-	ms
td1	Delay time for 1st data ready	4	-	-	ms
Td2	Data update rate time	-	5	-	ms

I²C interface timing



Symbol	Parameter	Fast mode		High speed mode		Unit
		Min	Max	Min	Min	
f_{SCL}	SCL clock frequency	---	400	---	3400	Hz
$t_{L(SCL)}$	SCL clock low time	1.3	---	0.16	---	us
$t_{H(SCL)}$	SCL clock high time	0.6	---	0.06	---	us
$t_{r(SCL)}$ / $t_{r(SDA)}$	SCL and SDA rise time	---	300	---	10	ns
$t_{f(SCL)}$ / $t_{f(SDA)}$	SCL and SDA fall time	---	300	---	10	ns
$t_{s(SDA)}$	SDA setup time	100	---	10	---	ns
$t_{h(SDA)}$	SDA hold time	0	---	0	---	ns
$t_{s(STA)}$	Setup time for START condition	0.6	---	0.16	---	us

Command table description

Register	Address	Bit	Command	Description
CTRL_1	0x20	7:0	Write 0x98	Start measurement, ODR: 200Hz
			Write 0x18	System Stand by
CTRL_2	0x21	CTRL_2	Write 0x24	Disable DRDY function
			Write 0x2c	Enable DRDY (Active High).
CTRL_3	0x46	15:0	Write 0x0010	Measurement Mode Enable
Pressure Output Data L	0x28	7:0	Read	Pressure Output Low Byte Data
Pressure Output Data M	0x29	7:0	Read	Pressure Output Medium Byte Data
Pressure Output Data H	0x2A	7:0	Read	Pressure Output High Byte Data
I^2C Page Register	0x3E	7:0	Write 0x00	Changed to I^2C Page 0 *The I^2C page is changeable while I^2C Page Enable Register = 0x80.
I^2C Page Enable Register	0x3F	7:0	Write 0x80	After enable, user can change I^2C Page number.

CTRL_1

CTRL_REG1(0x20)			
Bit	Description Attr Default	Attr	Default
7	PC1: Stand-by or Active mode 0 = Stand-by –mode (default after POR) 1 = Active-mode	R/W	0
6:5	Reserved	R/W	0
4:3	ODR12: Pressure measurement Output Data Rates 11 = ODR3 =200 Hz 10 = ODR2 = 50 Hz 00 = ODR1 =5 Hz (default after POR) 01 = ODR0 = 1 Hz	R/W	0
2	Reserved	R	0
1	FS1: Functional State 0 = Normal -Mode 1 = Normal –Mode Disable (default after POR)	R/W	1
0	Reserved	R	0

STATUS Register

STAT(0x27)			
Bit	Description Attr Default	Attr	Default
7	Reserved	R	0
6	DRDY: Data ready status 0 = data not ready, 1 = data ready valid - data ready signal is following stream data ODR selection - Data ready physical signal disabled/enabled in register /CNTL2, bit DREN	R	0
5	Reserved	R	0
4	Reserved	R	0
3	Reserved	R	0
2	Reserved	R	0
1	Reserved	R	0
0	Reserved	R	0

I²C Page Register

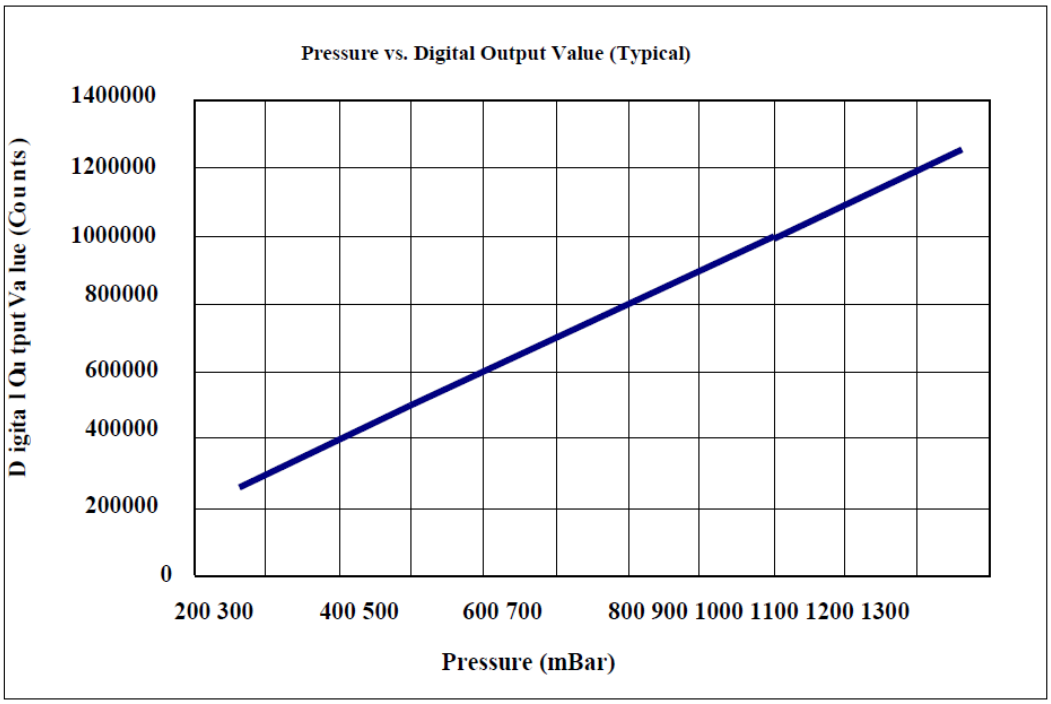
I²C Page Register (0x3E)			
Bit	Description Attr Default	Attr	Default
7:4	**I²C PAGE:** I²C page number *This 4 bits are changeable while I²C_PAGE_CHANGE_EN= 1	R/W	0xF
3	**SPI_BANK_BIT:** SPI_PAGE/BANK = { **I²C_PAGE, SPI_BANK_BIT**} *This bit is changeable while **I²C_PAGE_CHANGE_EN** = 1	R/W	0x0
2:0	Reserved	R	0

I²C_PAGE_EN Register

I²C_Page_EN Register 1 (0x3F)			
Bit	Description Attr Default	Attr	Default
7	**I²C(SPI)_PAGE_CHANGE_EN** When this bit is set, user can change the **I²C_PAGE**. Once user writes the I²C_PAGE/**SPI_BANK_BIT/SPI_3_WIRE,** this bit will be cleared.	R/W	0
6:0	**Reserved**	0	0

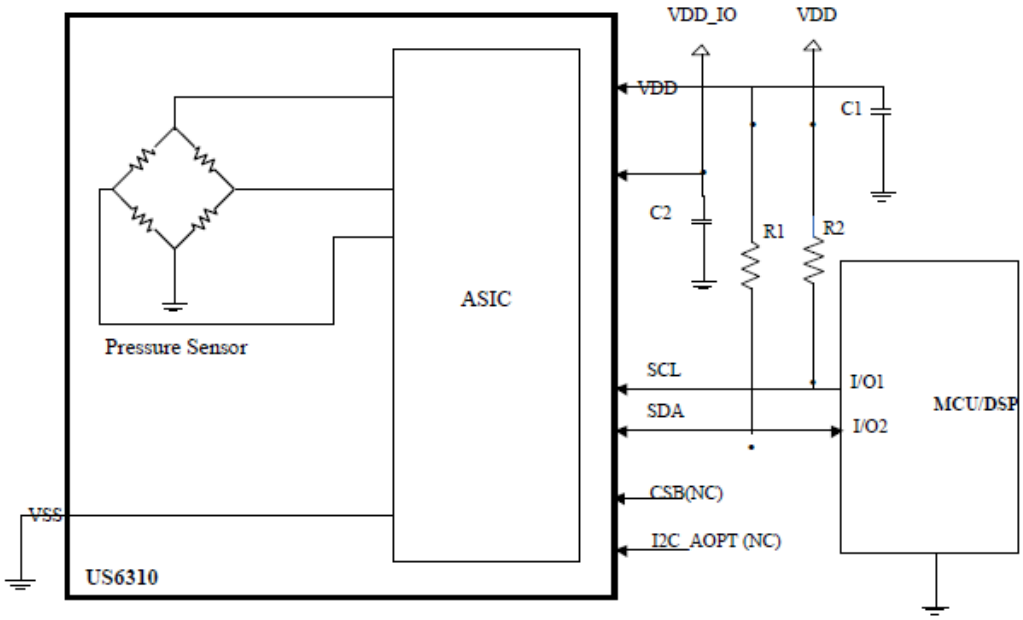
Pressure versus digital out value

The relationship between digital output value and pressure is given as show below:

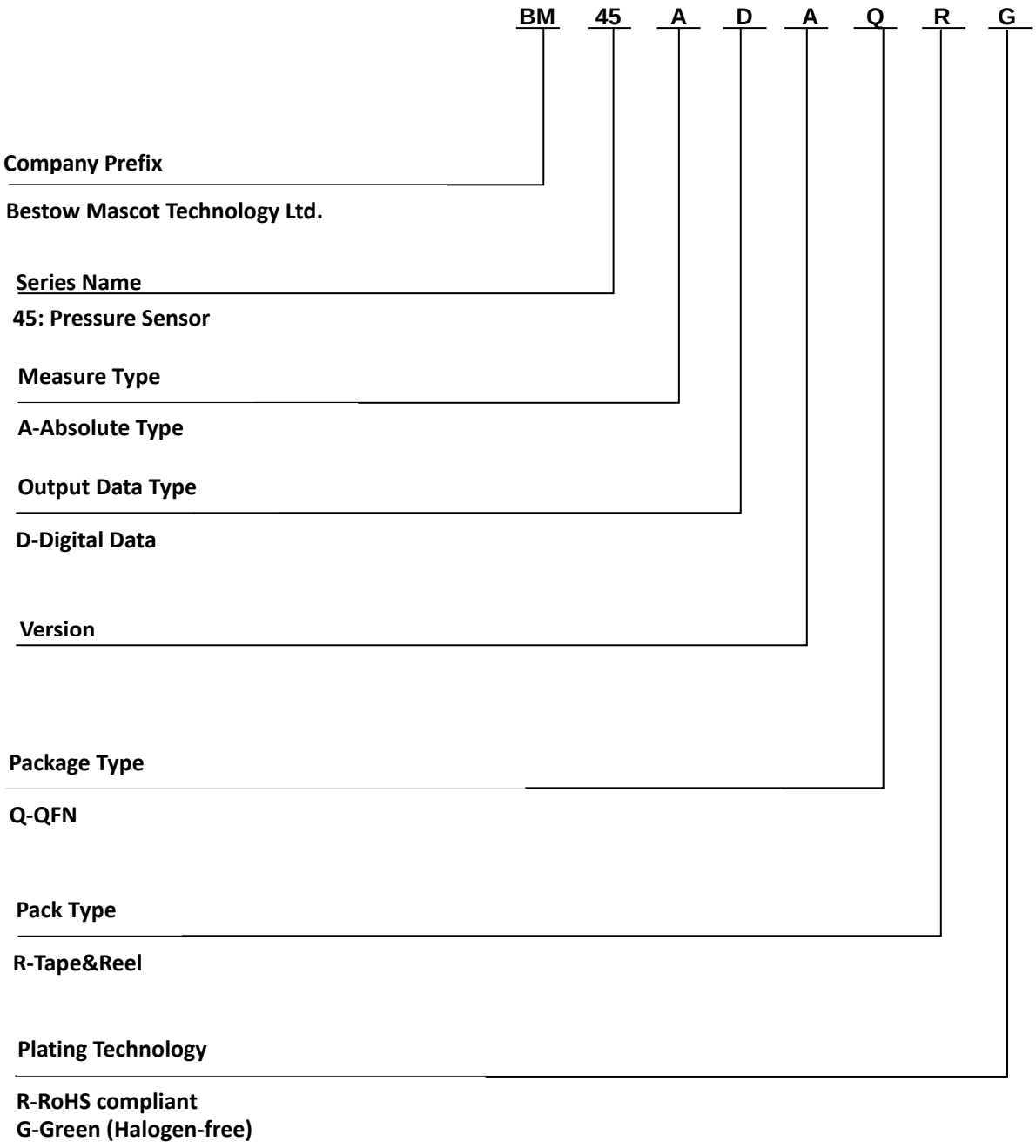


* Pressure (mBar)=(Output Value)/1000

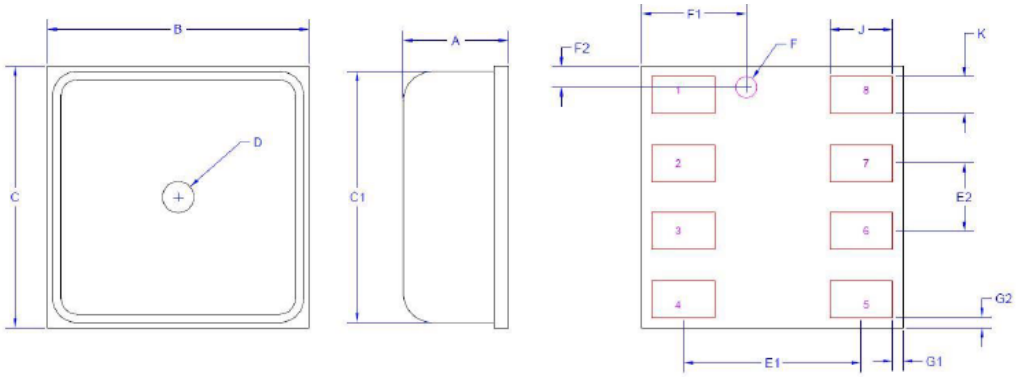
Application Circuit (I²C Interface)



Notice:
(1) R1,R2: Pull-Up Resister (If needed). Ex:4.7K
(2) C1,C2: 0.1uF
(3) CSB: No Connected (Internal Pull-Up)
(4) I²C_AOPT: No Connected (Internal Pull-Up)


BM 45 A D A Q R G
Company Prefix
Bestow Mascot Technology Ltd.
Series Name
45: Pressure Sensor
Measure Type
A-Absolute Type
Output Data Type
D-Digital Data
Version
Package Type
Q-QFN
Pack Type
R-Tape&Reel
Plating Technology
R-RoHS compliant
G-Green (Halogen-free)

Package Information (Unit：mm)



	Min.	Nominal	Max.
A	0.90	1.00	1.10
B	2.40	2.50	2.60
C	2.40	2.50	2.60
B1	2.35	2.40	2.45
C1	2.35	2.40	2.45
D	ø0.25	ø0.30	ø0.35
E1	1.65	1.70	1.75
E2	0.60	0.65	0.70
F	ø0.15	ø0.20	ø0.25
F1	0.95	1.00	1.05
F2	0.15	0.20	0.25
G1	0.05	0.10	0.15
G2	0.05	0.10	0.15
J	0.55	0.60	0.65
K	0.30	0.35	0.40

QFN Package Outline Dimension

●General Precaution

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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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Version	Publication date	Pages	Revise Description
1.0	Jan.2015	19	Initial Document Release
1.1	Feb.2015	13	Update ordering information