Air Pressure Digital Sensor

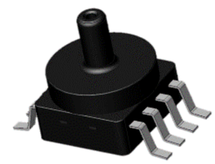
BM62S2201-1

Revision: V1.00 Date: November 30, 2021

www.holtek.com

Table of Contents

Features



- Pressure range: 0~1psi
- Accurate air pressure sensor
    - ♦ Resolution: 0.001psi
    - ♦ Accuracy: ±0.5%FS @ 25°C
- Factory-calibrated and temperature compensation output
- Optional digital interfaces: UART and I^2C
- Low current consumption
    - ♦ Operating Current: 3.3mA @5 V
    - ♦ Standby Currrent: 0.15μA @ 5V
- Wide operating voltage: 2.7V~5.5V

General Description

The BM62S2201-1 is a digital air pressure sensor which outputs relative air pressure values based on the atmosphere pressure. Compared with traditional analog sensors, this module needs no complicated external components and its feature of visual digital output provides great convenience in applications. The module includes a 24-bit ADC which has a high resolution and a temperature compensation mechanism to improve the overall accuracy. Since the module has been factory-calibrated, it does not require a secondary calibration.

Regarding the communication, the module has two standard interfaces, a UART interface and an I^2C interface. The module supports multiple output formats, making it more flexible in applications and numberical processing. The module is suitable for use in home appliance, consumer electronics, digital pressure meters, liquid level measurement products, etc.

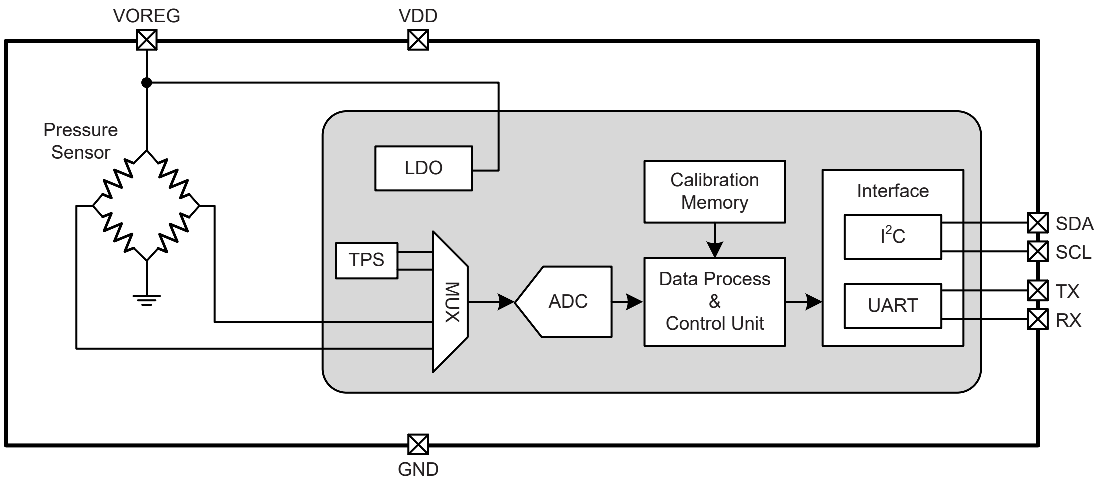
Applications

- Home appliance
- Consumer electronics
- Digital pressure meters
- Liquid level measurement products
- Air pressure switches
- Respirators

Selection Table

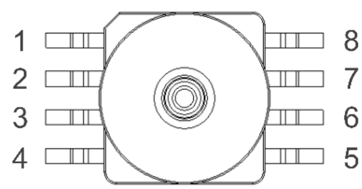
Part Number	Pressure Type	Range	Acuracy	Interface
BM62S2201-1	Gauge	0~1psi	±0.5%FS @ 25°C	UART, I^2C

Block Diagram



Note: TPS indicates Temperature Sensor.

Pin Assignment



Top View

Pin Description

Pin Number	Function	Type	Description
1	NC	—	—
2	GND	PWR	Negative power supply
3	TX	O	UART serial data output
4	RX	I	UART serial data input
5	SDA	I/O	I²C data line
6	SEL	I	Communication mode select pin
	SCL	I	I²C clock line
7	VDD	PWR	Positive power supply
8	VOREG	PWR	LDO output pin

Legend: PWR: Power I: Digital Input O: Digital Output I/O: Digital Input/Output

Absolute Maximum Ratings

Supply Voltage .... V_{SS}-0.3V to V_{SS}+6.0V

Input Voltage .... V_{SS}-0.3V to V_{DD}+0.3V

Storage Temperature .... 10˚C to 40˚C

Operating (Ambient) Temperature .... -40˚C to 85˚C

Total Power Dissipation 24.75mW

Maximum Overpressure 4psi

Note: These are stress ratings only. Stresses exceeding the range specified under "Absolute Maximum Ratings" may cause substantial damage to the device. Functional operation of this device at other conditions beyond those listed in the specification is not implied and prolonged exposure to extreme conditions may affect device reliability.

D.C. Characteristics

Ta=25°C

Symbol	Parameter	Test Conditions		Min.	Typ.	Max.	Unit
		V_{DD}	Conditions				
V_{DD}	Supply Voltage	—	—	2.7	5.0	5.5	V
I_{DD}	Average Current	3.3V	Measurement period: 1s; duty: operating mode – 0.25s / sleep mode – 0.75s	—	0.60	0.75	mA
		5V		—	0.83	1.00	
	Measurement Peak Current	3.3V	Operating mode	—	2.40	3.60	mA
		5V		—	3.30	4.95	
	Standby Current	3.3V	Sleep mode, SEL pin floating	—	0.10	0.15	μA
		5V		—	0.15	0.29	
V_{IL}	Input Low Voltage	2.7V~5.5V	—	0	—	$0.2V_{DD}$	V
V_{IH}	Input High Voltage	2.7V~5.5V	—	$0.8V_{DD}$	—	V_{DD}	V
V_{LVR}	Low Voltage Reset Voltage	—	—	-5%	2.55	+5%	V
V_{LVD}	Low Voltage Detect Voltage	—	—	-5%	2.7	+5%	V

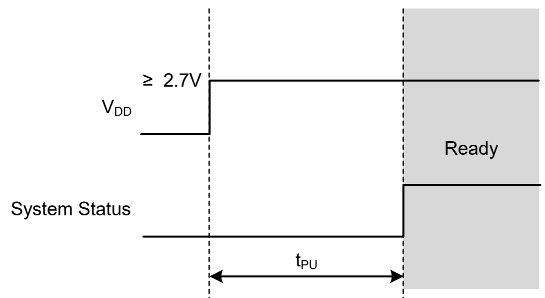
A.C. Characteristics

System Timming

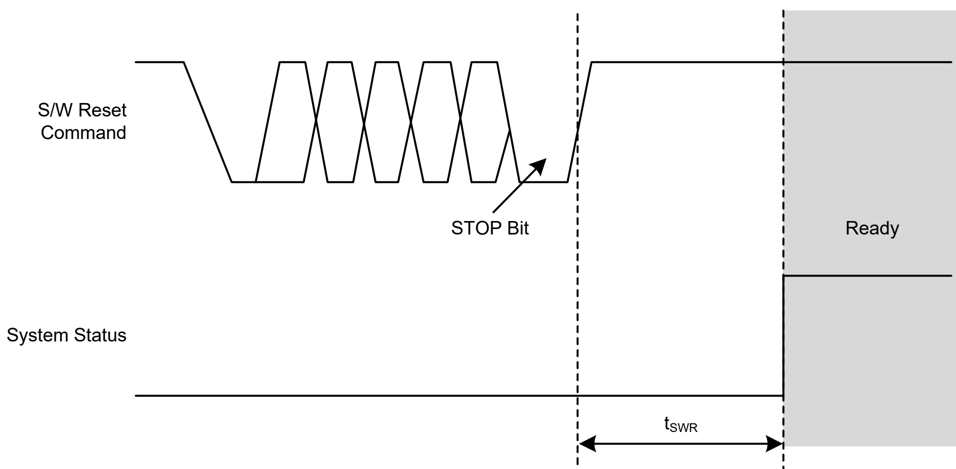
Ta=-40°C~85°C, V_{DD}=2.7V~5.5V, V_{SS}=0V

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
t_{PU}	Power-up Time	From V_{DD}≥2.7V to the point when the first communication is available	—	202	—	ms
t_{SWR}	Software Reset Time	—	—	208	—	ms
t_{PDR}	Pressure Data Ready Time	From System Ready signal to the completion of the first pressure measurement	—	70	—	ms
t_{TDR}	Temperature Data Ready Time	From System Ready signal to the completion of the first temperature measurement	—	35	—	ms
t_{RSP}	Temperature/Pressure Response Time	—	—	2.6	—	ms
t_{WU}	System Wake-up Time	—	—	15	—	μs
t_{CI}	Command Interval Time	READ Command	5.6	—	—	ms
		WRITE/SETUP Command	5	—	—	ms

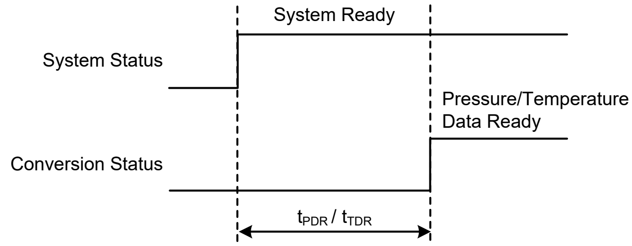
Note: The System Ready signal indicates that the system initialisation has completed and the sensor is ready to receive commands sent by the master device.



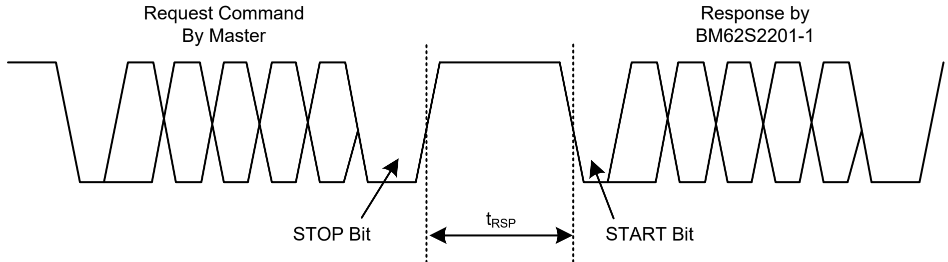
System Power-up Timming Chart



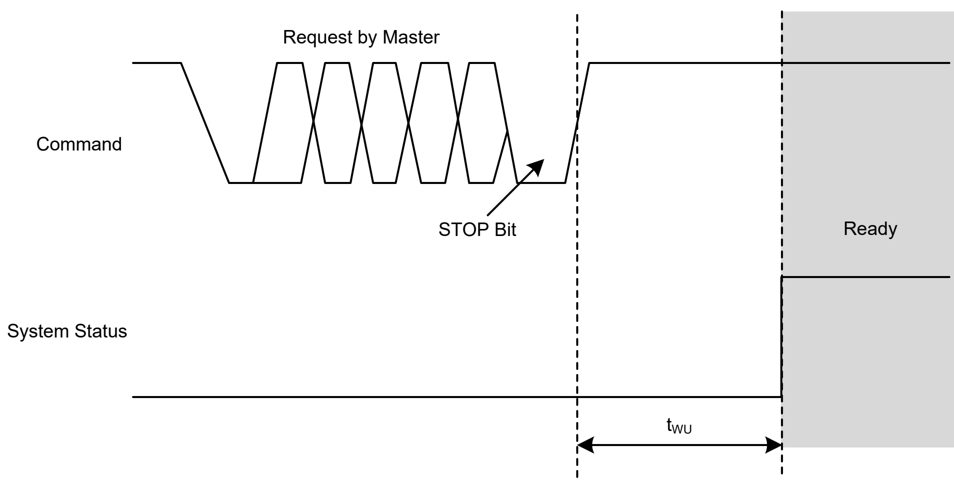
Software Reset Timming Chart



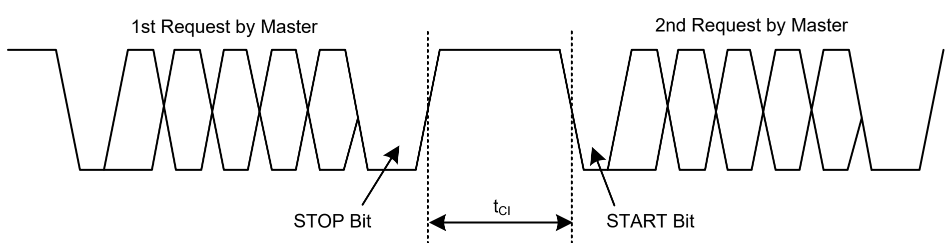
Pressure / Tempearture Data Ready Time



Response Time



System Wake-up Time



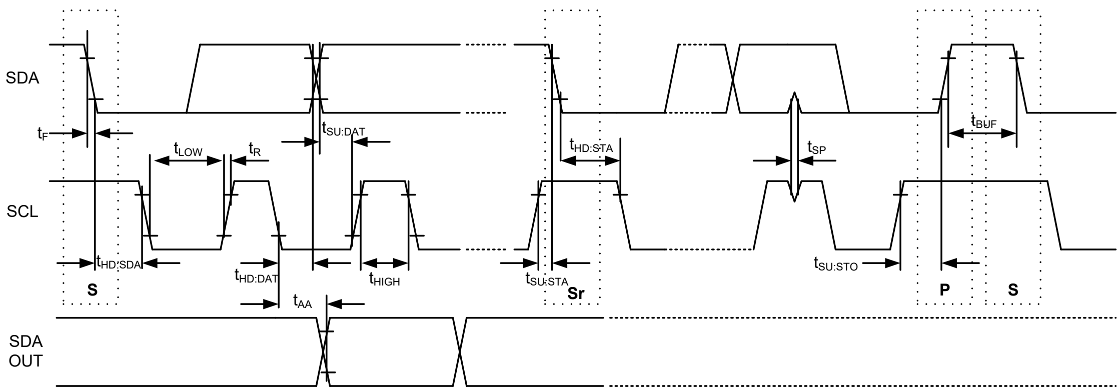
Command Interval Time

I²C Interface

Ta=-40°C~85°C, V_{DD}=2.7V~5.5V, V_{SS}=0V

Symbol	Parameter	Test Conditions	Min	Typ.	Max.	Unit
f_{SCL}	Clock Frequency	—	5	—	100	kHz
t_{BUF}	Bus Free Time	Time in which the bus must be free before a new transmission can start	4.7	—	—	μs
$t_{HD:STA}$	START Condition Hold Time	After this period, the first clock pulse is generated	4	—	—	μs
t_{LOW}	SCL Low Time	—	4.7	—	—	μs
t_{HIGH}	SCL High Time	—	4	—	—	μs
$t_{SU:STA}$	START Condition Setup Time	Time only relevant to repeated START condition	4.7	—	—	μs
$t_{HD:DAT}$	Data Hold Time	—	0	—	—	ns
$t_{SU:DAT}$	Data Setup Time	—	250	—	—	ns
t_R	SDA and SCL Rising Time (Note)	—	—	—	1	μs
t_F	SDA and SCL Falling Time (Note)	—	—	—	0.3	μs
$t_{SU:STO}$	STOP Condition Setup Time	—	4	—	—	μs
t_{AA}	Output Valid from Clock	—	—	—	3.45	μs
t_{SP}	Input Filter Time Constant (SDA and SCL Pins)	Noise suppression time	—	—	50	ns

Note: These parameters are periodically sampled but not 100% tested.

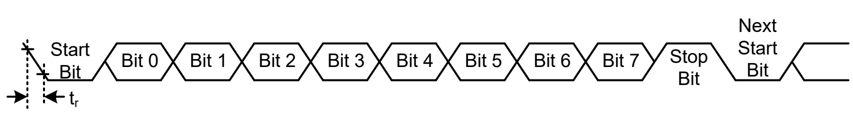


I²C Timming Chart

UART Interface

Ta=-40°C~85°C, V_{DD}=2.7V~5.5V, V_{SS}=0V

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
BDR	UART Buad Rate	—	—	38400	—	bps
t_r	Rising or Falling Time	—	—	—	0.3	μs



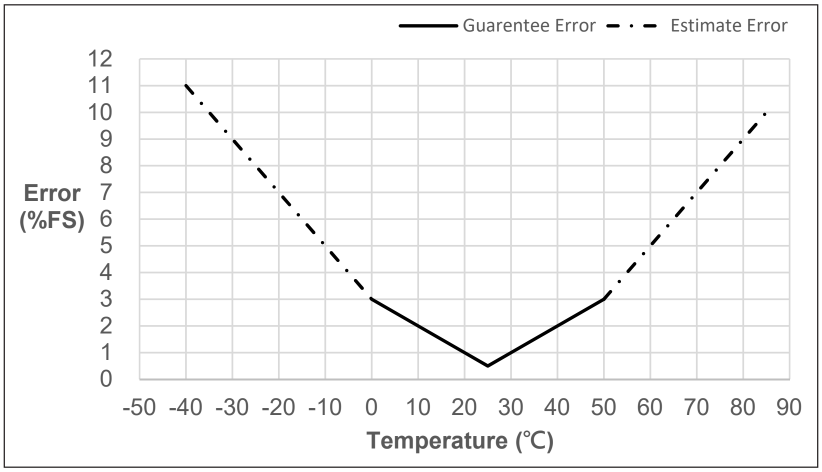
UART Timming Chart

Sensor Characteristics

Air Pressure Sensor

Ta=25°C, unless otherwise specified

Parameter	Test Conditions		Min.	Typ.	Max.	Unit
	V_{DD}	Conditions				
Sensing Range	2.7V~5.5V	—	0	—	1	psi
Resolution	2.7V~5.5V	—	—	0.001	—	psi
Accuracy	5V	Ta=25°C	—	±0.5	—	%FS
		Ta=20°C~30°C	—	±1	—	%FS
		Ta=10°C~40°C	—	±2	—	%FS
		Ta=0°C~50°C	—	±3	—	%FS
Linearity	5V	—	—	0.3	—	%FS
Media Compatibility	Clean, dry air and noncorrosive gases					



Pressure Measurement Accuracy

Temperature Sensor

Parameter	Test Conditions		Min.	Typ.	Max.	Unit
	V_{DD}	Conditions				
Sensing Range	2.7V~5.5V	—	-40	—	88	°C
Resolution	2.7V~5.5V	—	—	0.1	—	°C
Accuracy (Note)	5V	0°C~60°C, C_{VOREG}=4.7μF	—	±1	—	°C
		-20°C~0°C, 60°C~80°C, C_{VOREG}=4.7μF	—	±3	—	°C

Note: The temperature accuracy will vary with the capacitance of C_{VOREG}. It is not recommended to use capacitance values outside the recommended specifications for C_{VOREG}. Refer to the Application Circuits section for more circuit details.

Functional Description

System Description

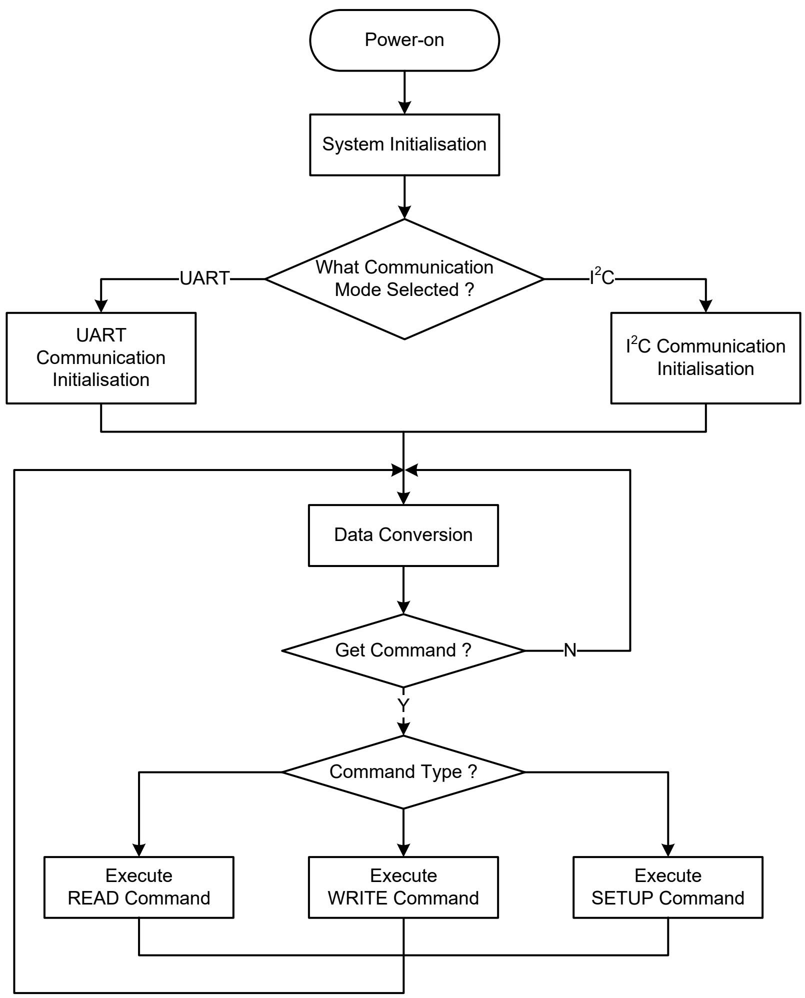
The BM62S2201-1 is a digital-output type air pressure sensor supporting I^2C and UART communication modes. After power-on and initialisation, the system will determine the communication mode immetiately by checking the SEL pin status. The I^2C mode is selected if the SEL pin is externally pulled high, in which condition the No.6 pin will be switched to the SCL function as the clock line for I^2C communication. The UART mode is selected if the SEL pin is pulled low. Immediately after the communication mode selection, the system will execute the first pressure and temperature measurement and waite for the master device to access.

This sensor is a slave device which executes actions according to the commands sent from the master device. The commands are divided into three types, READ, WRITE and SETUP. For more command details refer to the Command Table.

READ: Read sensor data such as air pressure value, temperature value, register status, etc.

WRITE: Modifiy register configuration.

SETUP: Control the sensor operations, including sleep mode entry and system reset.



System Flow Chart

Low Volatage Monitoring

The module has Low Voltage Detect (LVD) and Low Voltage Reset (LVR) mechanisms for low voltage conditions. The master device can poll the LVDO flag in the STATUS register for low voltage monitoring. The LVDO flag is set high when V_{DD}<2.7V and cleared to zero after the master device reads the STATUS register. The LVR function will reset the system when V_{DD} is less than the 2.55V voltage threshold.

Function	Condition	Reaction
LVD	V_{DD}<2.7V	LVDO=1
LVR	V_{DD}<2.55V	System Reset

Device Operation

The module provides the I²C and UART communication modes which are selected by the SEL pin level, refer to the Application Circuits section for detailed communication mode circuit connection. To change the SEL pin status for communication mode switching, power off the system first, change the pin level when power off and then power on again. Otherwise some unpredicated system states may occur.

The communication commands of the module are listed in the following command table. The module adopts a slave architecture of one request and one response and the communication directions are defined as follows.

Request: Master → Slave

Response: Slave → Master

Command Table

No.	Command Type	Command Code	Direction	Functional Description	Data Length (Byte)
1	READ	0x01	Request	Request to read pressure data	—
			Response	Respond with pressure data (unit: mpsi)	2
2	READ	0x02	Request	Request to read temperature data	—
			Response	Respond with temperature data (unit: °C)	2
3	READ	0x03	Request	Request to read the pressre A/D code	—
			Response	Respond with the pressre A/D code	3
4	READ	0x04	Request	Request to read the temperature A/D code	—
			Response	Respond with temperature A/D code	3
5	READ	0x05	Request	Request to read device information (device ID)	—
			Response	Respond with device information (device ID)	8
6	READ	0x06	Request	Request to read I²C slave address	—
			Response	Respond with I²C slave address	1
7	WRITE	0x07	Request	Setup I²C slave address	1
8	READ	0x0A	Request	Request to read device STATUS register	—
			Response	Respond with device STATUS register	1
9	SETUP	0x0B	Request	Request device to enter sleep mode	—
10	SETUP	0x0C	Request	Reset the device	—
11	SETUP	0x0D	Request	Restore the I2CADR register to factory setting	—

Format

The following figures show the Request and Response formats of the module.

1 Byte	1 Byte	1 Byte	0~1 Byte	1 Byte
Header (0xFA)	Command	Data Length	Data	Checksum

Request Format (Master → Slave)

1 Byte	1 Byte	1 Byte	1~8 Bytes	1 Byte
Header (0xFA)	Command	Data Length	Data	Checksum

Response Format (Slave → Master)

Header (1 Byte): Start code, fixed at 0xFA

Command (1 Byte): Command code, refer to the command table above.

Data Length (1 Byte):

- Request Format
  READ/SETUP: Fixed at 0x00
  WRITE: Fill in according to the required data length (unit: byte)
  For example, data length is 0x01 for 1 byte of data.
- Response Format
  READ: Fill in according to the actual data length
  WRITE/SETUP: No response (1)

Data:

- Request Format (0~1 Byte)
  READ/SETUP: Do not fill in (2)
  WRITE: Fill in the data to be written
- Response Format (1~8 Bytes)
  READ: Respond according to the command
  WRITE/SETUP: No response

Checksum (1 Byte): Checksum = Command + Data Length + Data

Note: 1. If the master device sends a WRITE or SETUP command, the sensor will write data or execute relevant action according to the command without any response.
2. The Data field needs to be omitted if the master device sets the Data Length of the request to 0x00, thereby the packet length of the request is 4-byte.

Response Data

Pressure Data

The pressure value output is in a form of HEX code. Each transfer includes 2 bytes with the low byte first and the high byte last. Its calculation is shown below.

Pressure Value = PHEXH×256 + PHEXL (Unit: mpsi)

Legend: PHEXH = Pressure Hex Code High Byte
PHEXL = Pressure Hex Code Low Byte

bit7 bit0	
PHEXL	PHEXH

Pressure Data HEX Output Format

Temperature Data

The temperature value output is in a form of HEX code. Each transfer includes 2 bytes with the low byte first and the high byte last. Its calculation is shown below.

Temperature Value = (THEXH×256+THEXL)÷10 (Unit: °C)

Legend: THEXH = Temperature Hex Code High Byte
THEXL = Temperature Hex Code Low Byte

bit7 bit0	
THEXL	THEXH

Temperature HEX Output Format

Pressure A/D Code

The pressure A/D code is composed of 3 bytes. Each transfer includes 3 bytes with the lowest byte first and the highest byte last.

Pressure A/D Code Value = PADH×65536+PADM×256+PADL (Unit: Count)

Legend: PADH = Pressure A/D Code High Byte
PADM = Pressure A/D Code Midium Byte
PADL = Pressure A/D Code Low Byte

bit7 bit0		
PADL	PADM	PADH

Pressure A/D Code Output Format

Temperature A/D Code

The temperature A/D code is composed of 3 bytes. Each transfer includes 3 bytes with the lowest byte first and the highest byte last.

Temperature A/D Code Value = TADH×65536+TADM×256+TADL (Unit: Count)

Legend: TADH = Temperature A/D Code High Byte
TADM = Temperature A/D Code Middle Byte
TADL = Temperature A/D Code Low Byte

bit7 bit0		
TADL	TADM	TADH

Temperature A/D Code Output Format

Device Information

When reading the sensor's device information, an 8-byte data as shown below will be returned.

Part Number	B	M	62	S	220		1	-1
Value	42	4D	3E	53	00	DC	01	01

B: 42h (ASCII Code)　M: 4Dh (ASCII Code)　62: 3Eh (HEX)　S: 53h (HEX)
220: 00DCh (HEX)　1: 01h (HEX)　-1: 01h (HEX)

Registers

When reading the sensor's register status (not temperature or pressure value), the sensor will return the current status of the register with a data length of 1 byte. Note that only one register is allowed for each READ command.

Sleep Mode

To make the sensor enter the sleep mode, the master device should send a command based on the corresponding request format to the sensor. When entering the sleep mode, the sensor system will disable the measurement, conversion and communication functions until it is woken up.

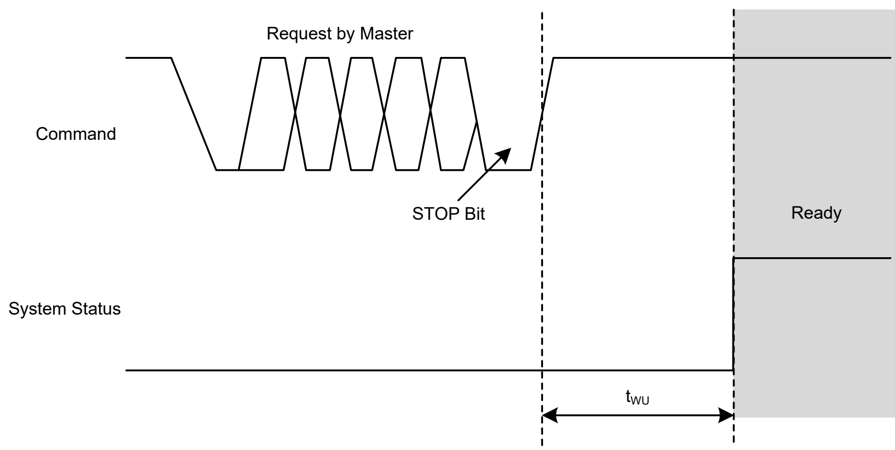
Wake-Up

The sensor can be woken up via I^2C or UART communication. The system is woken up by a START bit falling edge on the SDA pin when in the I^2C mode or by a START bit falling edge received on the RX pin when in the UART mode. After the sensor completes the command reception, a time of t_{WU}, as specified below, is required before it is ready for command execution. Note that the t_{WU} counting starts from the STOP bit rising edge.

Steps to Read Pressure/Temperature after Wake-up

After the sensor is woken up from the sleep mode, the CCF flag should be checked before reading the pressure or temperature value. CCF=1 means the pressure/temperature conversion is in process. CCF=0 means the pressure or temperature conversion is completed and the data is available to read.

Symbol	Parameter	Min.	Typ.	Max.	Unit
t_{WU}	System Wake-up Time	—	15	—	μs



System Wake-up Time

Reset System

The module provides a software reset function which allows the master device to reset the sensor using a Reset command. Refer to the command table for relevant request format.

Status Monitoring

The module includes a STATUS register for sensor status monitoring.

- **STATUS Register**

Bit	7	6	5	4	3	2	1	0
Name	CRCF	LVDO	DSF	CCF	—	—	—	—
R/W	R	R	R	R	—	—	—	—
POR	0	0	1	1	—	—	—	—

Bit 7 **CRCF**: Command received correct flag
0: Command correct
1: Command incorrect
The CRCF flag will be set high if the sensor receives an incorrect command or a communication time-out situation occurs and cleared to zero after the master device reads the STATUS register.

Bit 6 **LVDO**: Low voltage detect output flag
0: No low voltage detected
1: Low voltage detected
The LVDO flag will be set high when the system voltage is less than 2.7V and cleared to zero after the master device reads the STATUS register.

Bit 5 **DSF**: Device setup status flag
0: Busy
1: Standby
The DSF flag is normally “1” and is cleared to “0” when the system receives a WRITE command and starts execution. The flag will be automatically restored to high when the WRITE command execution is completed.

Bit 4 **CCF**: Pressure and temperature data conversion complete flag
0: Conversion is completed
1: Conversion is in progress
The CCF flag will be set high when a POR, sowftwre reset or wake-up from sleep mode condition occurs. It will be cleared to zero automatically by the system after the measurement data is ready.

Device Setting

I²C Slave Address Setting

The BM62S2201-1 adopts the standard I²C 7-bit addressing. The I²C slave address of the sensor can be modified using the ADR6~ADR0 bits of the I2CADR register.

- **I2CADR Register**

Bit	7	6	5	4	3	2	1	0
Name	ADR6	ADR5	ADR4	ADR3	ADR2	ADR1	ADR0	—
R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	—
Factory Initial	1	0	1	0	0	0	0	—

Bit 7~1 **ADR6~ADR0**: I²C slave address

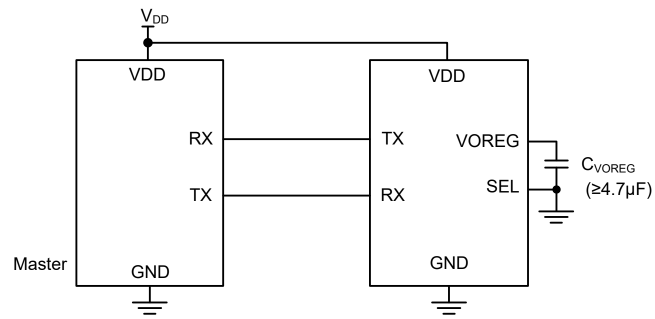
Bit 0 Reserved. In order to meet the I²C 7-bit addressing principle, the bit 0 of the I2CADR register must be cleared to “0”.

Restore to Factory Setting

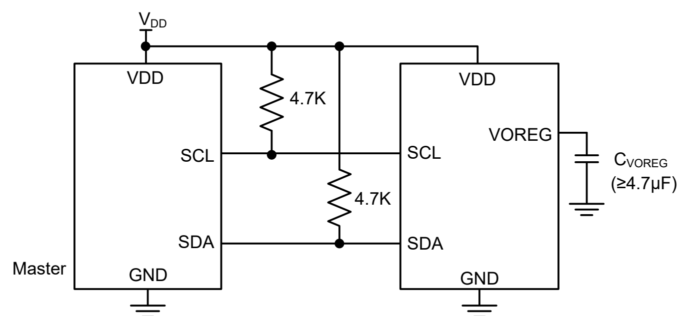
The sensor provides a function of restoring to factory setting. When such a command is received by the sensor, the system will restore the I2CADR register to its factory setting followed by a software reset. Refer to the Command Table for more details.

Application Circuits

UART Mode



I²C Mode



Interface

The module supports the UART and I²C communication methods. In the UART communication mode, the TX and RX pins are connected to the RX and TX pins of the master device respectively, refer to the UART Interface section for more information. In the I²C communication mode, the sensor acts as a slave device that can be accessed by the master device through the standard I²C interface, refer to the I²C Interface section for more information.

Time-out

When a communication time-out situation occurs, either by UART or I²C interface, the CRCF flag in the STATUS register will be set high.

Communication	Time-out Value	Unit
UART	10	ms
I²C	10	ms

I²C Interface

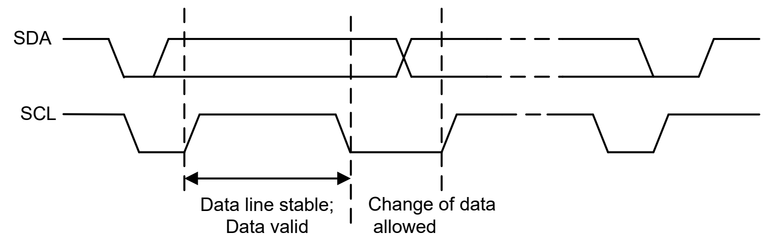
I²C Operation

The device supports the I²C serial interface.

The I²C bus is for bidirectional, two-line communication between different ICs or modules. The two lines are a serial data line, SDA, and a serial clock line, SCL. Both lines are connected to the positive supply via a pull-up resistor with a typical value of 4.7kΩ. When the bus is free, both lines are high. Devices connected to the bus must have open-drain or open-collector outputs to implement a wired-and function. Data transfer is initiated only when the bus is not busy.

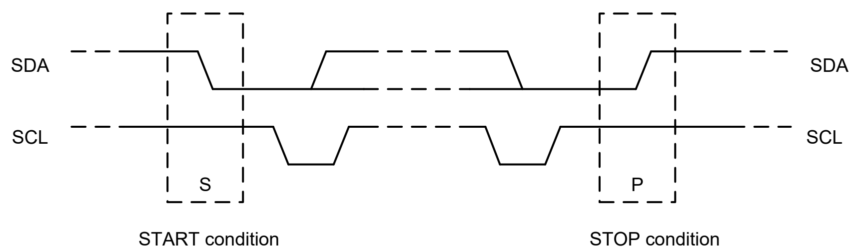
Data Validity

The data on the SDA line must be stable during the high period of the serial clock. The high or low state of the data line can only change when the clock signal on the SCL line is low as shown in the diagram.



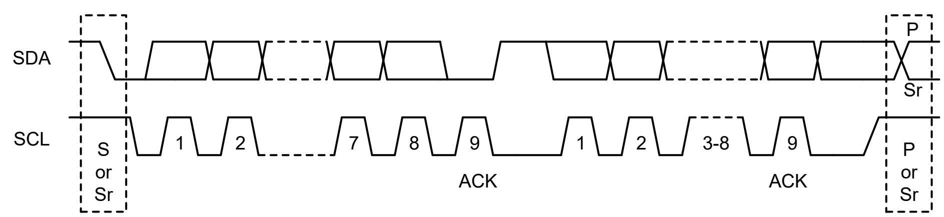
START and STOP Conditions

- A high to low transition on the SDA line while SCL is high defines a START condition.
- A low to high transition on the SDA line while SCL is high defines a STOP condition.
- START and STOP conditions are always generated by the master. The bus is considered to be busy after the START condition. The bus is considered to be free again a certain time after the STOP condition.
- The bus stays busy if a repeated START (Sr) is generated instead of a STOP condition. In some respects, the START(S) and repeated START (Sr) conditions are functionally identical.



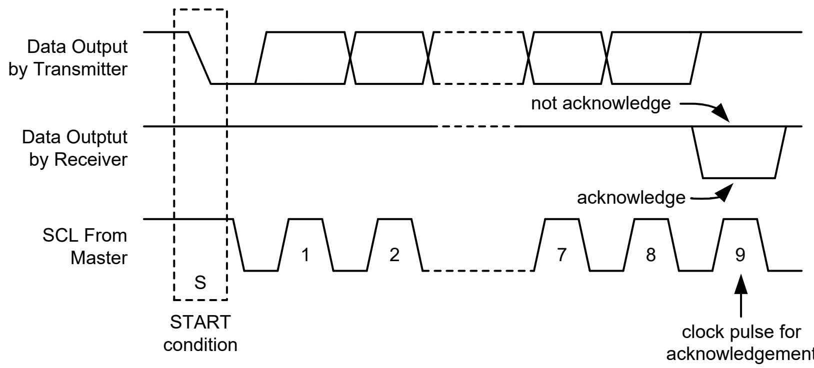
Byte Format

Every byte put on the SDA line must be 8-bit long. The number of bytes that can be transmitted per transfer is unrestricted. Each byte has to be followed by an acknowledge bit. Data is transferred with the most significant bit, MSB, first.



Acknowledge

- Each byte of eight bits is followed by one acknowledge bit. This Acknowledge bit is a low level placed on the bus by the receiver. The master generates an extra acknowledge related clock pulse.
- The slave receiver which is addressed must generate an Acknowledge, ACK, after the reception of each byte.
- The device that acknowledges must pull low the SDA line during the acknowledge clock pulse so that it remains stable low during the high period of this clock pulse.
- A master receiver must signal an end of data to the slave by generating a not-acknowledge, NACK, bit on the last byte that has been clocked out of the slave. In this case, the master receiver must leave the data line high during the 9th pulse to not acknowledge. The master will generate a STOP or repeated START condition.



Slave Addressing – 1010000

- The slave address byte is the first byte received following the START condition from the master device. The first seven bits of the first byte make up the slave address. The 8th bit (the lowest bit) defines whether a read or write operation is to be performed. When the R/W bit is "1", a read operation is selected. When the R/W bit is "0", a write operation is selected.
- The BM62S2201-1 device address bits are "1010000". When an address byte is sent, the device compares the first seven bits after the START condition. If they match, the device outputs an Acknowledge on the SDA line.

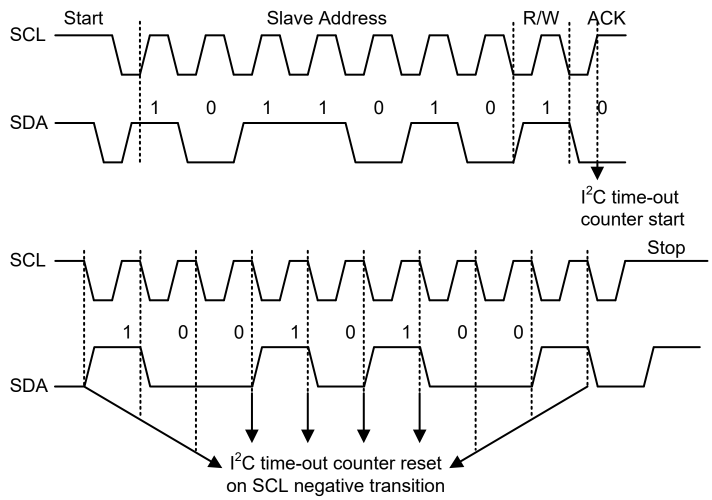
Sleave Address

MSB							LSB
1	0	1	0	0	0	0	R/W

I^{2}C Address Format

Time-out Control

In order to reduce the problem of I²C lockup due to reception of erroneous clock sources, a time-out function is provided. If the clock source to the I²C is not received for a while, then the I²C circuitry and register will be reset after a certain time-out period. The time-out conter starts counting on an I²C bus "START" & "address match" condition, and is cleared by an SCL falling edge. Before the next SCL falling edge arrives, if the time elapsed is greater than the 10ms time-out, then a time-out condition will occur. The time-out function will stop when and I²C "STOP" condition occurs.



I²C Time-out

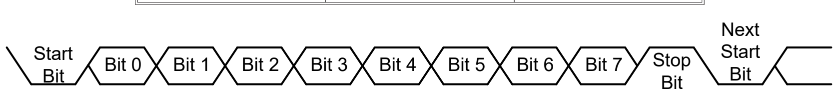
UART Interface

The module contains an integrated full-duplex asynchronous serial communications UART interface that enables communication with external devices that contain a serial interface. The UART function has many features and can transmit and receive data serially by transferring a frame of data with eight data bits per transmission.

The integrated UART function contains the following features:

- Full-duplex, asynchronous communication
- 8 bits character length
- No parity function
- One stop bit
- Fixed baud rate of 38400bps
- RX pin wake-up function

Baud Rate	Real Rate	Miss Rate (%)
38400	38461	0.16



8-bit Data Format

UART External Pins

To communicate with an external serial interface, the internal UART has two external pins known as TX and RX, which are the UART transmitter and receiver pins respectively.

Dimensions

(Unit: mm)