Thermocouple Module

BM42S3021-1

Revision: V1.10 Date: May 09, 2024

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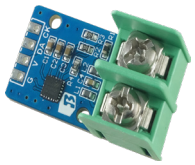
Features



- Operating voltage: 2.6V~5.5V
- Operating current: 1.5mA @ 3.3V
- Supports thermocouple types: K, N, E, J, R
- Thermocouple sensor
  - Resolution: 0.1℃
  - Measurement range: -270℃~1370℃ (K type)
- Accuracy:
  - -100℃~100℃: ±2℃
  - <-100℃ or >100℃: ±2%
- Low power consumption, sleep current < 3μA
- Communication interface: I²C
- Factory-calibrated
- Module size: 29.1mm×15mm×14.2mm

General Description

The BM42S3021-1 is a thermocouple temperature measurement module. The module uses a 24-bit A/D converter chip, the BH66F5355, which is specially designed for high accuracy measurement and has a resolution of 0.1°C.

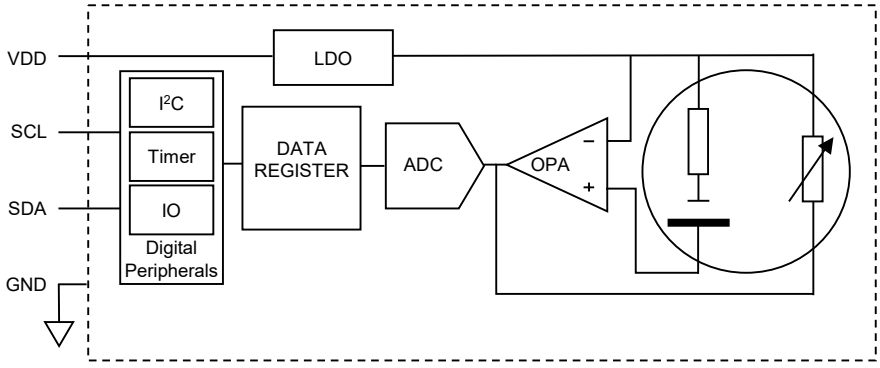
The measurement range of different thermoelectric types are different. All BM42S3021-1 modules are calibrated before they leave the factory. The calibration data is stored in internal memory to ensure that the sensor can be used directly or replaced without software correction.

For communication, the I²C communication method is provided. The module is suitable for applications such as contact thermometers, roti machines, industrial boiler incubators, etc.

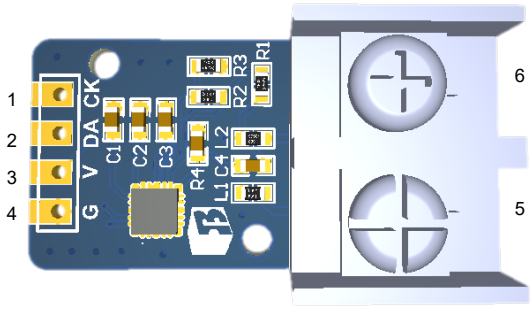
Applications

- Contact thermometers
- Roti machines
- Industrial boiler incubators

Block Diagram



Pin Assignment



Pin Description

Pin	Function	Type	Description
1	SCL	DI	I²C clock line
2	SDA	DI/DO	I²C data line
3	VDD	PWR	Positive power supply
4	GND	PWR	Negative power supply, ground
5	TC+	AI	Connect the thermocouple positive
6	TC-	AI	Connect the thermocouple negative

Legend: PWR: Power; DI: Digital input; DO: Digital output; AI: Analog input

Technical Specifications

Absolute Maximum Ratings

Power Supply Voltage ..... 2.6V ~ 5.5V

Storage Temperature..... -20℃ ~ 80℃

Storage Relative Humidity ..... 30% ~ 70% RH

Operating (Ambient) Temperature ..... 0℃ ~ 50℃

Operating (Ambient) Humidity ..... 30% ~ 70% RH

D.C. Electrical Characteristics

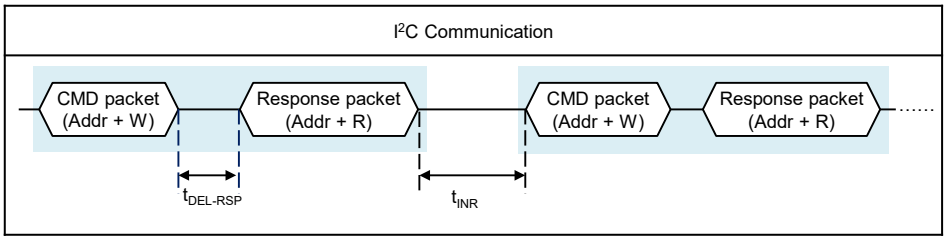
Ta=25°C

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
V_{DD}	Operating Voltage	—	2.6	—	5.5	V
I_{DD}	Operating Current	V_{DD}=3.3V	—	1.5	2.4	mA
I_{STA}	Sleep Current	V_{DD}=3.3V	—	1	3	μA
Ta	Operating Temperature	—	0	—	50	°C
	Measurement Range	V_{DD}=3.3V, K type thermocouple	-270	—	1370	°C
		V_{DD}=3.3V, N type thermocouple	-270	—	1300	°C
		V_{DD}=3.3V, E type thermocouple	-270	—	1000	°C
		V_{DD}=3.3V, J type thermocouple	-210	—	1190	°C
		V_{DD}=3.3V, R type thermocouple	-50	—	1760	°C
	Accuracy	V_{DD}=3.3V, -100°C~100°C	—	—	±2	°C
		V_{DD}=3.3V, >100°C or <-100°C	—	—	±2	%
	Resolution	V_{DD}=3.3V	—	0.1	—	°C

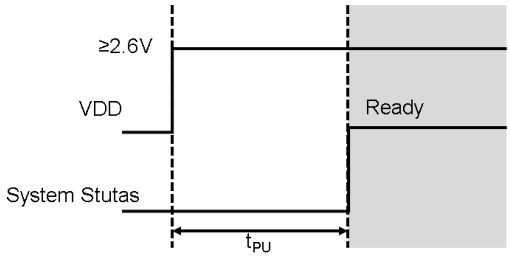
A.C. Electrical Characteristics

System Timing

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
t_{PU}	Power-up Time	Start from V_{DD} ≥ 2.6V to prepare for conversion and communication	—	—	1	s
t_C	Temperature Conversion Time	V_{DD}=3.3V	—	1	—	s
$t_{DEL-RSP}$	Response Delay Time	V_{DD}=3.3V	10	—	—	ms
t_{INR}	Interval Time	V_{DD}=3.3V	10	—	—	ms



Communication timing



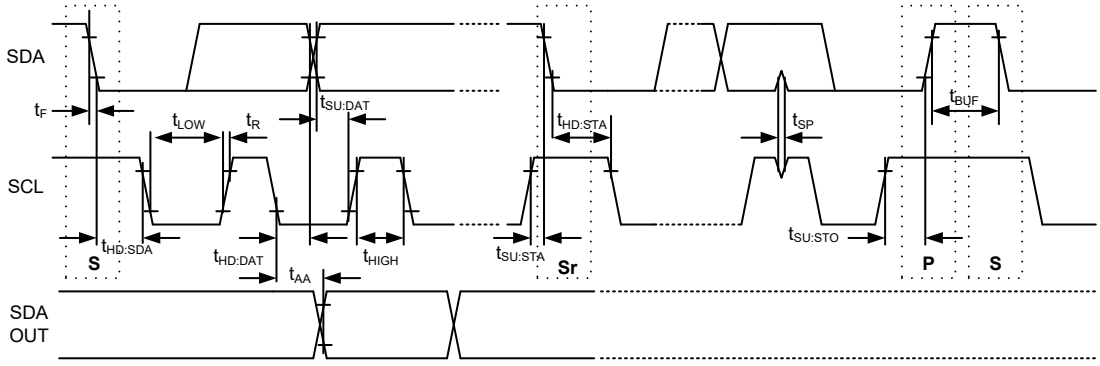
Power-up timing

I²C Interface

Ta=25°C, V_{DD}=5V

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
f_{SCL}	Clock Frequency	—	0.03	—	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	4.0	—	—	μs
t_{LOW}	SCL Low Time	—	4.7	—	—	μs
t_{HIGH}	SCL High Time	—	4.0	—	—	μs
$t_{SU: STA}$	START Condition Setup Time	Time only relevant for repeated START signal	4.7	—	—	μs
$t_{HD: DAT}$	Data Hold Time	—	0	—	—	ns
$t_{SU: DAT}$	Data Setup Time	—	250	—	—	ns
t_R	SDA and SCL Rise Time (Note)	—	—	—	1	μs
t_F	SDA and SCL Fall Time (Note)	—	—	—	0.3	μs
$t_{SU: STO}$	STOP Condition Setup Time	—	4.0	—	—	μs
t_{AA}	Output Valid from SCL Low	—	—	—	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 Timing

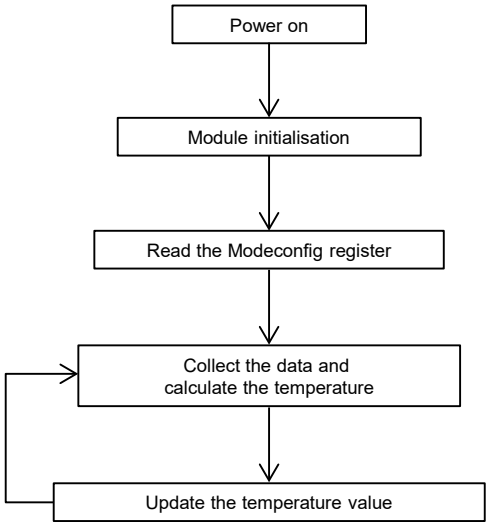
Functional Description

System Description

The BM42S3021-1 is a thermocouple temperature measurement module. The module uses a 24-bit A/D converter chip, the BH66F5355, which has a resolution of 0.1°C.

Operating Principle

After the system is powered on and module initialisation, read the Modeconfig register value to determine the thermocouple type for the module, and then collect data continuously to generate the latest temperature through algorithm calculation.



Flow Chart of Generating Temperature after Module Power-on

Sleep Mode

To save the system power consumption, the system enters Sleep mode when receiving the I²C Sleep command. At this time, the measurement function is temporarily disabled and the system wakes up after receiving the I²C communication instruction which matches the address.

Communication interface

The BM42S3021-1 supports I²C communication method. In the I²C communication method, the module is used as a slave, the master can read measurement values (temperature) from the BM42S3021-1 and select the thermocouple type. Refer to the I²C Interface section for communication mode details.

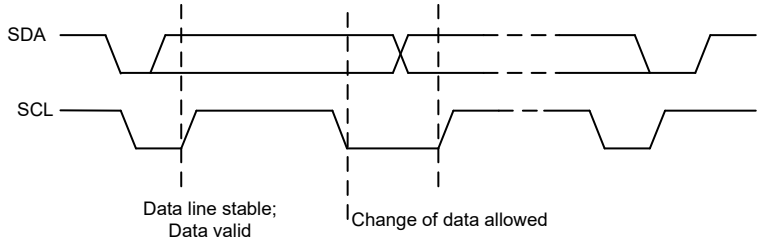
I²C Interface

I²C Operation

The BM42S3021-1 supports an I²C serial interface. The I²C bus is for bidirectional, two-line communication between ICs or modules. The two lines are a serial data line, SDA, and a serial clock line, SCL. 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.

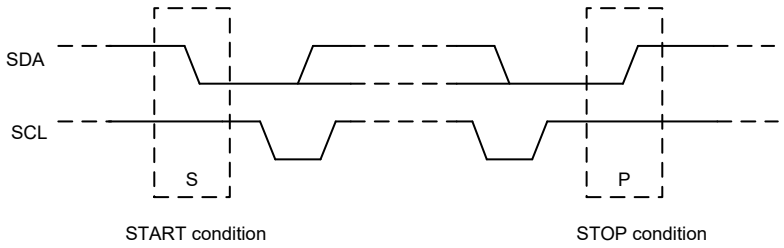
Data Validity

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.



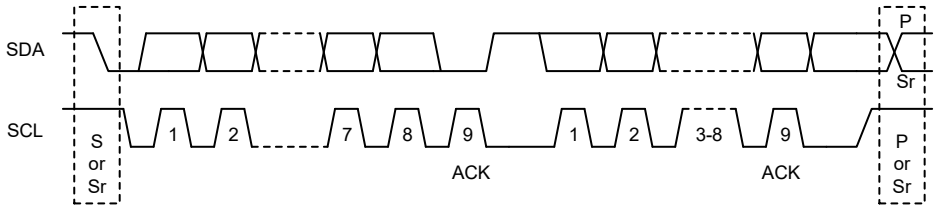
START and STOP Conditions

- 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.



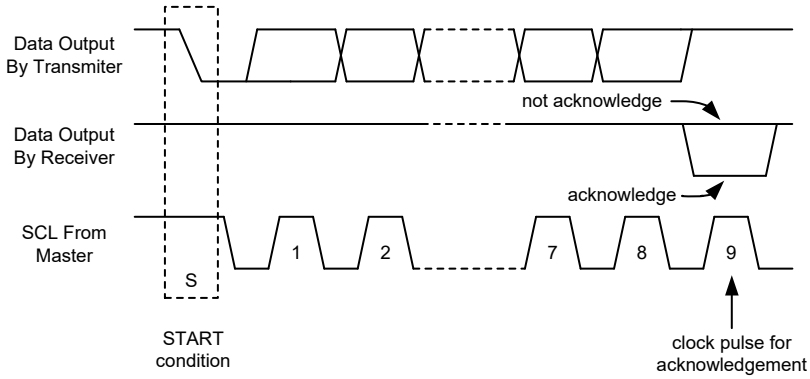
Byte Format

Every byte put on the SDA line must be 8-bits 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.
- A slave receiver which is addressed must generate an Acknowledge, ACK, after the reception of each byte.
- The device that acknowledges must pull down 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 - 1011100

- 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 eighth 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 BM25S2021-1 device address bits are “0101000”. 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.

MSB LSB

A6	A5	A4	A3	A2	A1	A0	R/W
0	1	0	1	0	0	0	

Slave address(0x28)

I²C Communication Protocol

- I²C communication rate: 30Hz~100kHz
- The module internal SCL/SDA pins have no pull-up resistors
- There are two instruction frame formats, known as data write instruction frame and data read instruction frame.

  Data write instruction frame format:

Start	Addr+W	CMD	D_1~D_2	CheckSum1	Stop
1-bit	1-byte	1-byte	2-byte	1-byte	1-bit

  Frame content introduction:

  - Start: Start bit signal
  - Addr+W：I²C address ＋write
  - CMD: Command code, each command code corresponds to a different function
  - D_1~D_2: Data
  - CheckSum1: Check code, CheckSum1 = (CMD + D1 + D2) & 0xff
  - Stop: Stop bit signal

  Data read instruction frame format:

Start	Addr+W	CMD	Start	Addr+R	D_1~D_2	CheckSum2	Stop
1-bit	1-byte	1-byte	1-bit	1-byte	2-byte	1-byte	1-bit

  Frame content introduction:

  - Addr+R: I²C address + read
  - CheckSum2: Check code, CheckSum2 = (D1 + D2) & 0xff

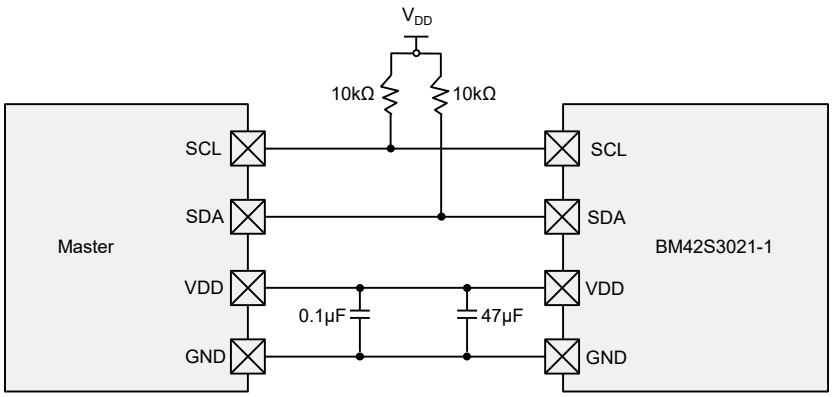
Data Write Instruction Set

No.	Functional Description	CMD	Data (D_1~D_2)	Note
1	Set the thermocouple type	0x28	D_1: Mode configuration register low 8 bits bit3 ~ bit0: Set the thermocouple type 000: K type thermocouple 001: N type thermocouple 010: E type thermocouple 011: J type thermocouple 100: R type thermocouple D2: Register high 8 bits, default is 0x00	This setting will not be lost when the power is off
2	Set the module to enter the Sleep mode	0xff	D_1: 0x34 D_2: 0x12	

Data Read Instruction Set

No.	Functional Description	CMD	Response Data (D_1~D_2)	Note
1	Obtain the temperature	0x09	D_1: Ambient temperature low 8 bits D_2: Ambient temperature high 8 bits Temperature = (D_1+D_2×256)×0.1°C	The D2 highest bit is a sign bit, the sign bit is 1, it indicates the temperature is negative
2	Read the version	0x1F	D_1: Version low 8 bits D_2: Version high 8 bits	For example, if the return value is 0x0101, the version is V1.01
3	Obtain the thermocouple type	0x28	D_1 (bit3~bit0): Thermocouple type 000: K type thermocouple 001: N type thermocouple 010: E type thermocouple 011: J type thermocouple 100: R type thermocouple D2: Register high 8 bits, default is 0x00	

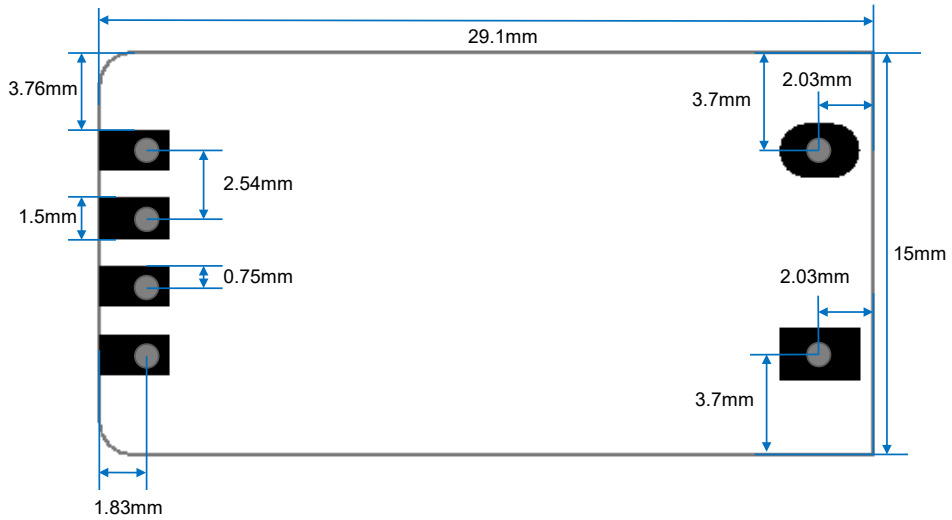
Application Circuit



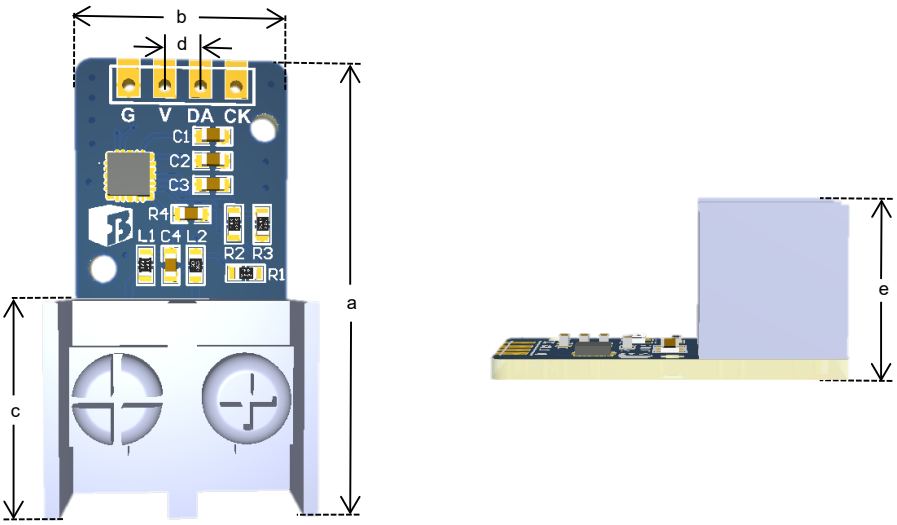
Note: If higher accuracy and anti-interference capability are required, it is recommended to keep 0.1μF and 47μF capacitors. If the cost is a main concern, the 47μF capacitor can be omitted.

Layout Description

PCB Footprint



Dimensions



Symbol \ Unit	mm	inch
a	29.1	11.46
b	15.0	5.91
c	12.3	4.84
d	2.54	1
e	14.2	5.60

Reference Information

Revision History

Data	Author	Issue	Modification Information
2024.03.01	彭玉斌	V1.00	First Version

Related document

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