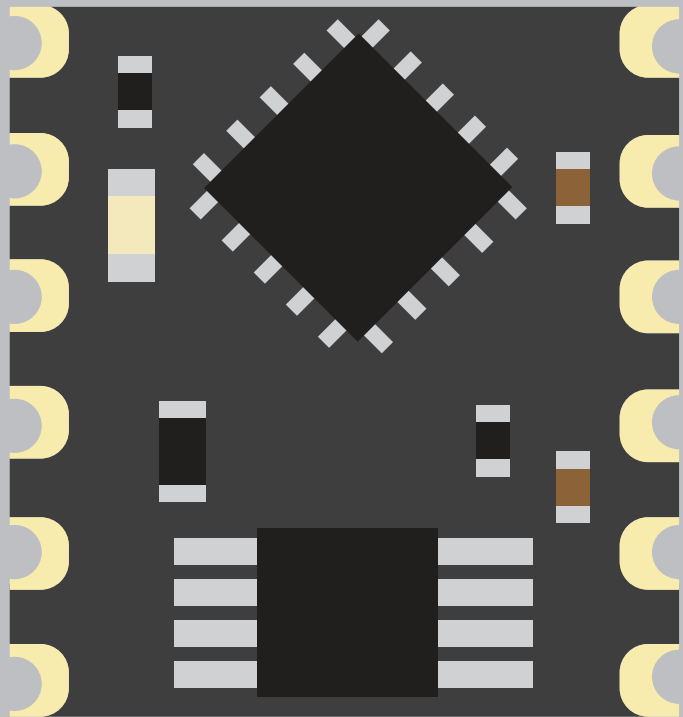


OEM-RTDTM

4 Wire – Embedded Temperature Circuit

Reads	Temperature in °C
Range	-126.000 °C – 1254 °C
Resolution	0.001
Accuracy	+/- (0.1 + 0.0017 x °C)
Response time	1 reading every 420ms
Supported probes	Any PT-100 or PT-1000 RTD
Supported configuration	2 wire, 3 wire or 4 wire RTD
Calibration	Single point
Data protocol	SMBus/I²C
Default I ² C address	0x68
Operating voltage	3.0V – 3.6V
Data format	ASCII





STOP

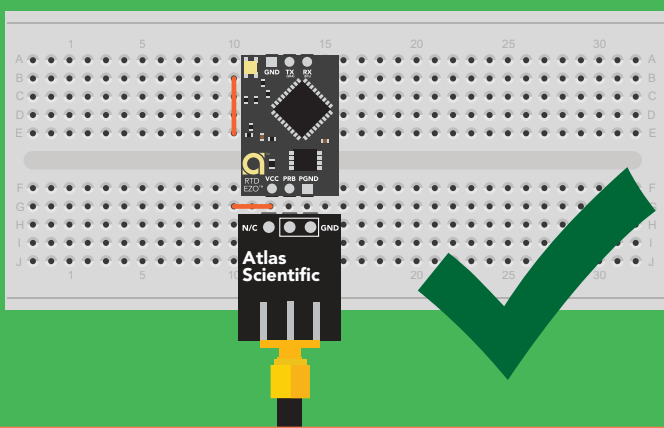
SOLDERING THIS DEVICE VOIDS YOUR WARRANTY.

Before purchasing the RTD OEM™ read this data sheet in its entirety. This product is designed to be surface mounted to a PCB of your own design.

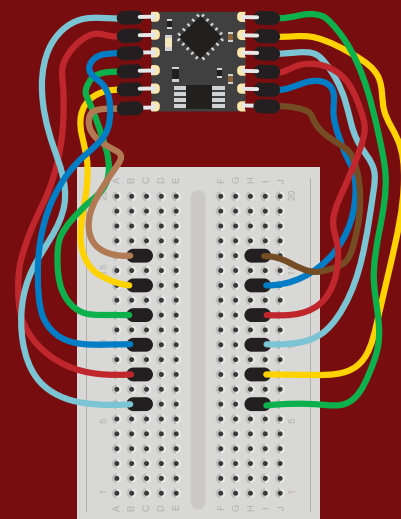
This device is designed for electrical engineers who are familiar with embedded systems design and programming. If you, or your engineering team are not familiar with embedded systems design and programming, Atlas Scientific does not recommend buying this product.

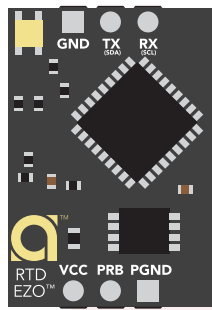
Unfamiliar with RTD sensing?
Try our EZO™ RTD circuit first.

It's much easier to use, and
provides a good working
reference.



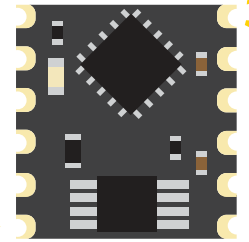
Do not solder wires to this device.





EZO-RTD

Getting an EZO-RTD circuit working first will significantly speed up OEM development. It will act as a working reference model; making it easy to debug OEM issues.



RTD-OEM

Because an EZO-RTD circuit was used first, product development time was reduced by 3 weeks.

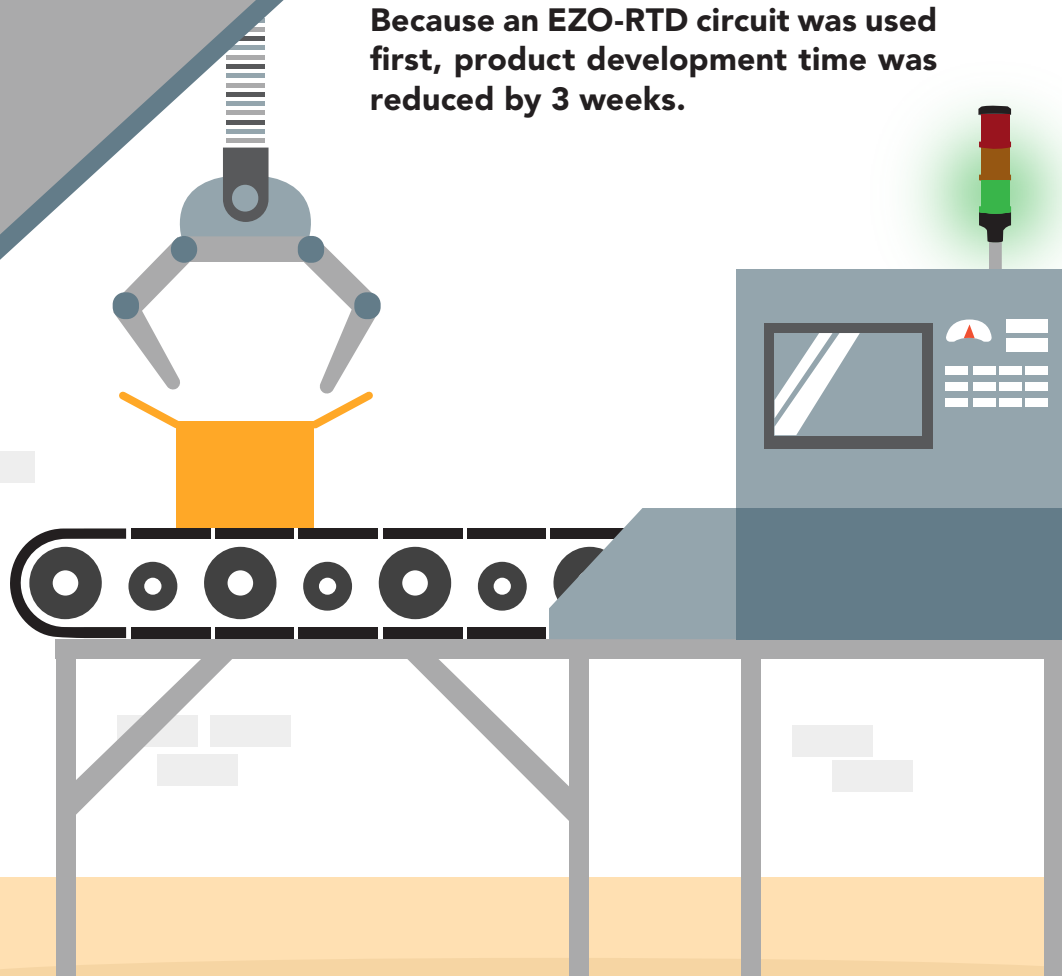


Table of contents

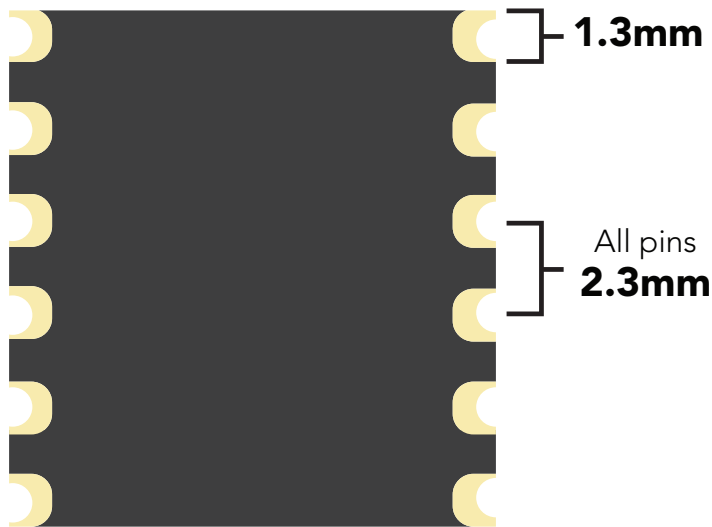
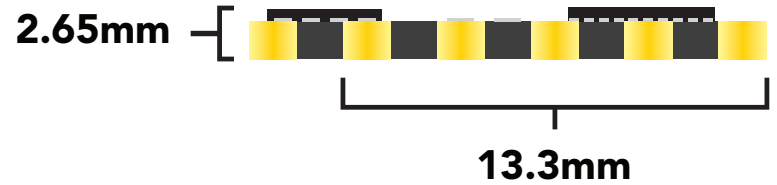
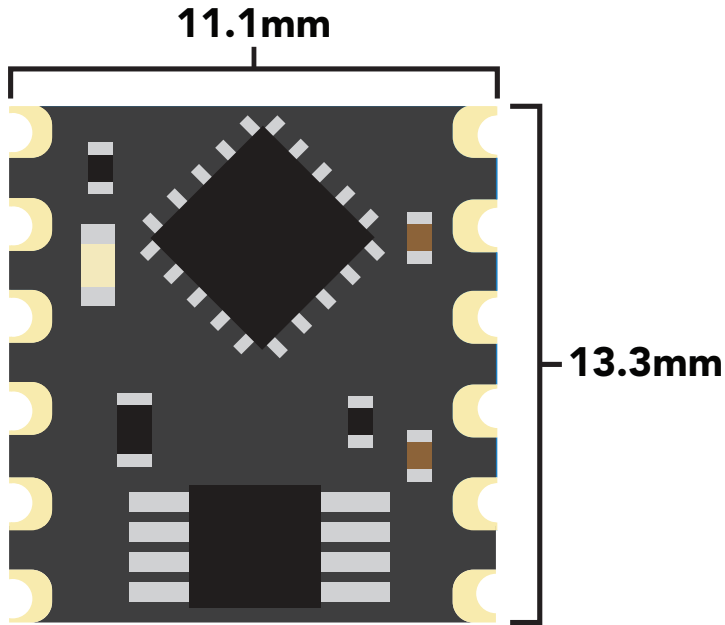
OEM circuit dimensions	5	RTD connection	7
Power consumption	5	System overview	8
Absolute max ratings	5	Reading register values	9
Pin out	6	Writing register values	10
Resolution	6	Sending floating point numbers	11
Power on/start up	6	Receiving floating point numbers	12

REGISTERS

0x00 Device type register	14
0x01 Firmware version register	14
0x02 Address lock/unlock register	15
0x03 Address register	16
0x04 Interrupt control register	17
0x05 LED control register	19
0x06 Active/hibernate register	19
0x07 New reading available register	20
0x08 – 0x0B Calibration registers	21
0x0C Calibration request register	22
0x0D – Calibration confirmation register	22
0x0E – 0x11 RTD reading registers	23

Designing your product	24
Designing your PCB	26
Recommended pad layout	27
IC tube measurements	27
Recommended reflow soldering profile	28
Pick and place usage	29
Datasheet change log	30
Firmware updates	31

OEM circuit dimensions



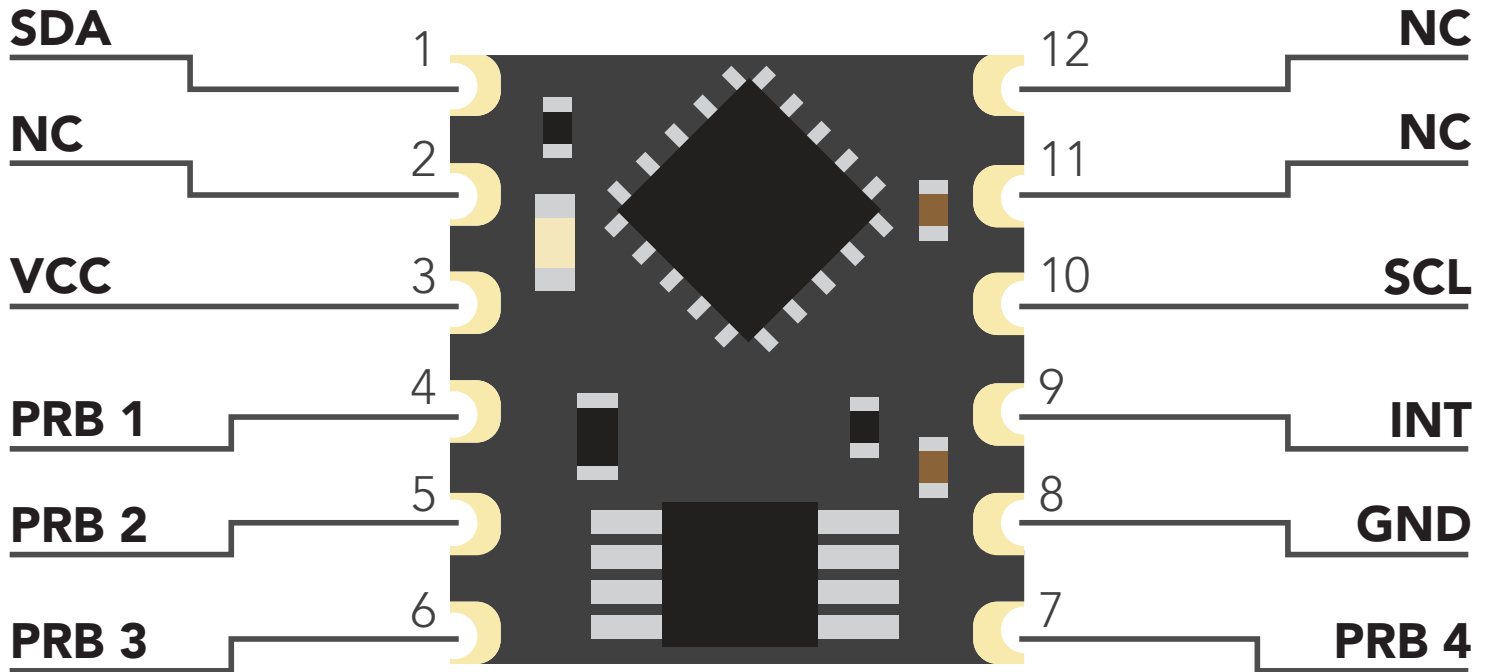
Power consumption

	LED	OPERATIONAL	HIBERNATION
3.3V	ON	4.2 mA	2.9 mA
	OFF	3.7 mA	2.3 mA

Absolute max ratings

Parameter	MIN	TYP	MAX
Storage temperature	-60 °C		150 °C
Operational temperature	-40 °C	25 °C	125 °C
VCC	3.0V	3.3V	4.0V

Pin out



Resolution

The resolution of a sensor is the smallest change it can detect in the quantity that it is measuring. The Atlas Scientific™ RTD OEM™ will always produce a reading with a resolution of three decimal places.

Example

100.123 °C
-76.000 °C

Power on/start up

Once the Atlas Scientific™ RTD OEM™ is powered on it will be ready to receive commands and take readings after 1 ms. Communication is done using the SMBus/I²C protocol at speeds of 10 – 100 kHz.

Settings that are retained if power is cut

Calibration
I²C address

Settings that are **NOT** retained if power is cut

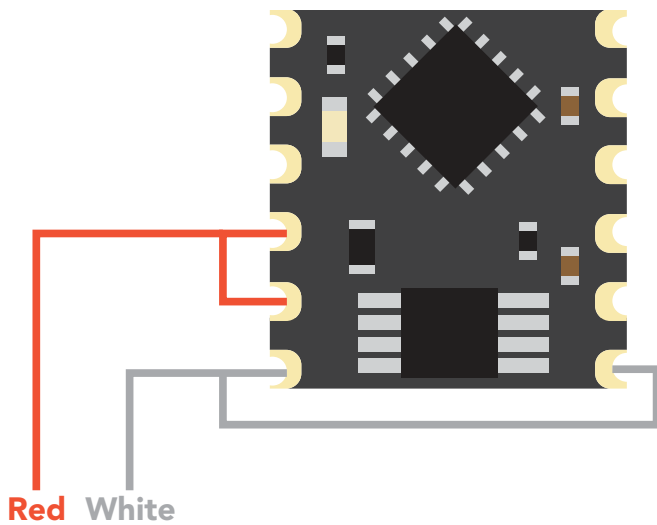
Active/Hibernation mode
LED control
Interrupt control

RTD connection

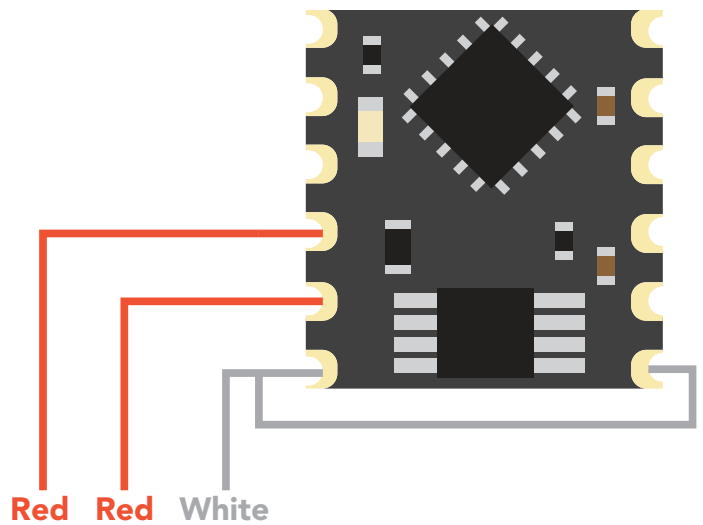
The Atlas Scientific™ RTD OEM™ will automatically detect if the attached probe is a **PT-100** or **PT-1000 probe**. The device will also automatically configure itself to read from an attached 2, 3, or 4 wire RTD probe. There are no settings to adjust, simply connect the probe type that you are using.

Keep in mind that PT-100 / PT-1000 probes have no polarity. It's not possible to connect the leads to the probe in reverse.

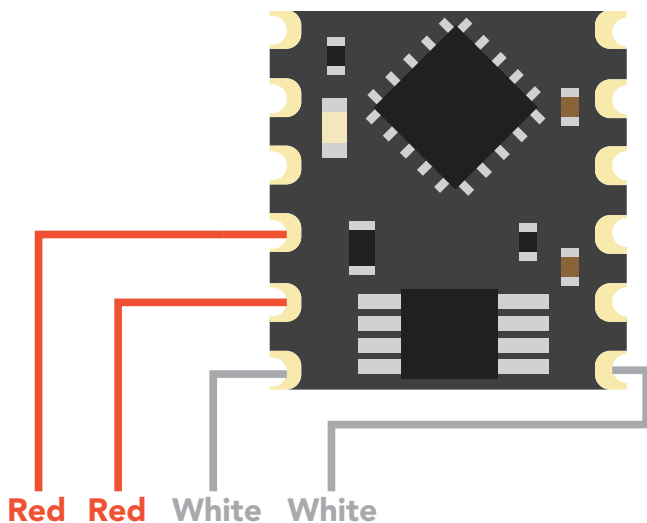
2 wire



3 wire



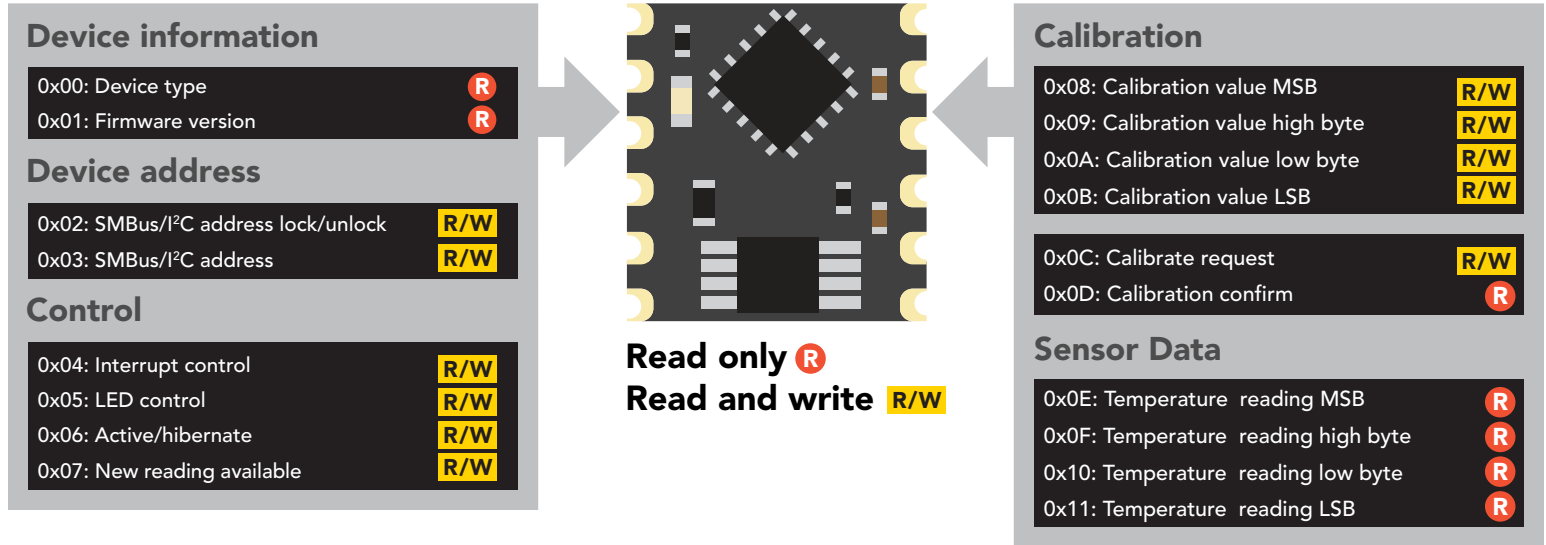
4 wire



System overview

The Atlas Scientific™ RTD OEM™ Class Embedded Circuit is the core electronics needed to read temperature from any brand of PT-100 or PT-1000 RTD temperature probe. The RTD OEM™ is an SMBus/I²C slave device that communicates to a master device at a speed of 10 –100 kHz. Read and write operations are done by accessing **18** different 8 bit registers.

Accessible registers



The default device address is **0x68**
This address can be changed.

**Each RTD reading
takes 420ms**

Reading register values

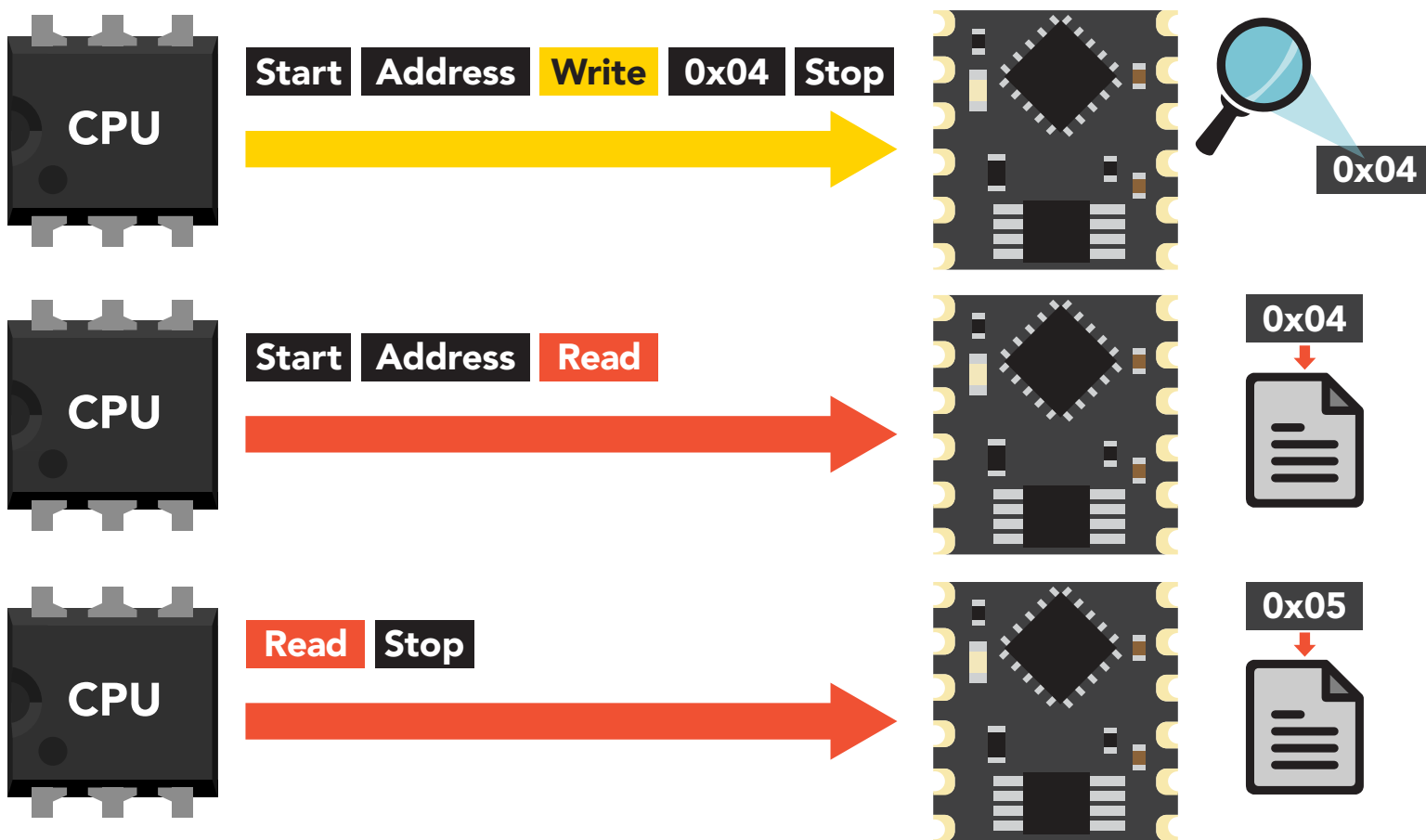
To read one or more registers, issue a write command and transmit the register address that should be read from, followed by a stop command. Then issue a read command; the data read will be the value that is stored in that register. Issuing another read command will automatically read the value in the next register. This can go on until all registers have been read. After reading the last register, additional read commands will return 0xFF. Issuing a stop command will terminate the read event.

Issuing a stop command will terminate the read event.

The default device address is **0x68**
This address can be changed.

Example

Start reading at register 0x04 and read 2 times.



Example code reading two registers

```
byte i2c_device_address=0x68;  
byte reg_4, reg_5;  
  
Wire.beginTransmission(i2c_device_address);  
Wire.write(0x04);  
Wire.endTransmission();  
  
Wire.requestFrom(i2c_device_address,2);  
reg_4=Wire.read();  
reg_5=Wire.read();  
Wire.endTransmission();
```

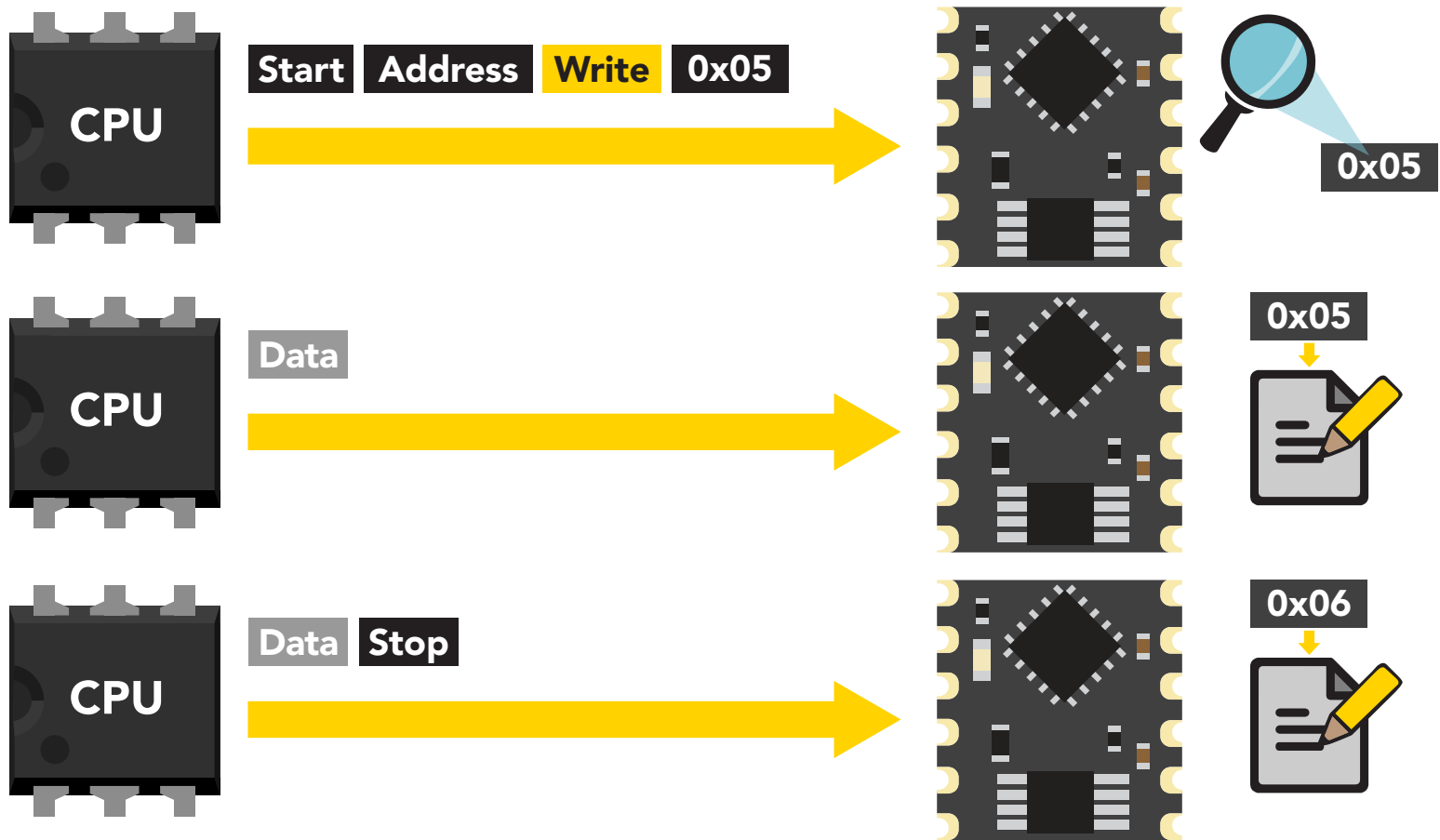
Writing register values

All registers can be read, but only registers marked read/write can be written to.

To write to one (or more) registers, issue a write command and transmit the register address that should be written to, followed by the data byte to be written. Issuing another write command will automatically write the value in the next register. This can go on until all registers have been written to. **After writing to the last register, additional write commands will do nothing.**

Example

Start writing at address 0x05 and write 2 values.



Example code

writing the number 1
in register 0x05 – 0x06

```
byte i2c_device_address=0x68;  
byte starting_register=0x05  
byte data=1;
```

```
Wire.beginTransmission(i2c_device_address);  
Wire.write(starting_register);  
Wire.write(data);  
Wire.write(data);  
Wire.endTransmission();
```

Sending floating point numbers

For ease of understanding we are calling fixed decimal numbers “floating point numbers.” We are aware they are not technically floating point numbers.

It is not possible to send/receive a floating (fixed decimal) point number over the SMBus/I²C data protocol. Therefore, a multiplier/divider is used to remove the decimal point. Do not transmit a floating point number without property formatting the number first.

When transmitting a floating point number to the calibration value registers, the number must first be multiplied by 1,000. This would have the effect of removing the floating point. Internally the RTD OEM™ will divide the number by 1,000; converting it back into a floating point number.

Example

Setting an RTD calibration value of: 100.123 °C

$$100.123 \times 1,000 = 100,123$$

Transmit the number 100,123 to the Calibration value registers.

Setting an RTD calibration value of: -76 °C

$$-76 \times 1,000 = -76,000$$

Transmit the number -76,000 to the Calibration value registers.

When reading back a value stored in the calibration value registers, the value must be divided by 1,000 to return it to its originally intended value.

Receiving floating point numbers

After receiving a value from the temperature reading registers, the number must be divided by 1,000 to convert it back into a floating point number.

Example

Reading a temperature value of 34.786

Value received = 34,786

$34,786 / 1,000 = 34.786$

Reading an temperature value of -98.335

Value received = -98,335

$-98,335 / 1,000 = -98.335$

Registers

Device information



0x00

0x01

0x02

0x03

0x04

0x05

0x06

0x07

0x08

0x09

0x0A

0x0B

0x0C

0x0D

0x0E

0x0F

0x10

0x11

0x00: Device type

R

0x01: Firmware version

R

0x00 – Device type register

1 unsigned byte

Read only value = 5

5 = RTD

This register contains a number indicating what type of OEM device it is.

0x01 – Firmware version register

1 unsigned byte

Read only value = 2

2 = firmware version

This register contains a number indicating the firmware version of the OEM device.

Example code

reading device type and device version registers

```
byte i2c_device_address=0x68;  
byte starting_register=0x00  
byte device_type;  
byte version_number;
```

```
Wire.beginTransmission(i2c_device_address);  
Wire.write(starting_register);  
Wire.endTransmission();
```

```
Wire.requestFrom(i2c_device_address,(byte)2);  
device_type = Wire.read();  
version_number = Wire.read();  
Wire.endTransmission();
```

Changing I²C address

0x02: SMBus/I²C address lock/unlock

R/W

0x03: SMBus/I²C address

R/W



0x00

0x01

0x02

0x03

0x04

0x05

0x06

0x07

0x08

0x09

0x0A

0x0B

0x0C

0x0D

0x0E

0x0F

0x10

0x11

This is a 2 step procedure

To change the I²C address, an unlock command must first be issued.

Step 1

Issue unlock command

0x02 – I²C address unlock register

1 unsigned byte

Read only value = 0 or 1

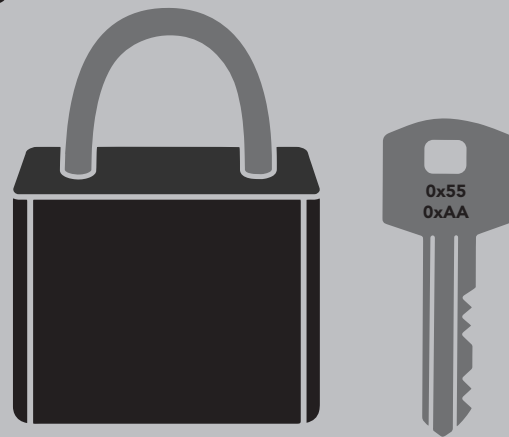
0 = **unlocked**

1 = **locked**

To unlock this register it must be written to twice.

Start **unlock register** **0x55** **Stop**

Start **unlock register** **0xAA** **Stop**



The two unlock commands must be sent back to back in immediate succession. No other write, or read event can occur. Once the register is unlocked it will equal 0x00 (unlocked).

To lock the register

Write any value to the register other than 0x55;
or, change the address in the Device Address Register.

Example code address unlock

```
byte i2c_device_address=0x68;  
byte unlock_register=0x02;
```

```
Wire.beginTransmission(bus_address);  
Wire.write(unlock_register);  
Wire.write(0x55);  
Wire.endTransmission();
```

```
Wire.beginTransmission(bus_address);  
Wire.write(unlock_register);  
Wire.write(0xAA);  
Wire.endTransmission();
```

Step 2

Change address

0x03 – I²C address register

1 unsigned byte

Default value = **0x68**

Address can be changed **0x01 – 0x7F (1–127)**

Address changes outside of the possible range **0x01 – 0x7F (1–127)** will be ignored.

After a new address has been sent to the device the Address lock/unlock register will lock and the new address will take hold. It will no longer be possible to communicate with the device using the old address.



Settings to this register are retained if the power is cut.

Example code changing device address

```
byte i2c_device_address=0x68;  
byte new_i2c_device_address=0x60;  
byte address_reg=0x03;
```

```
Wire.beginTransmission(bus_address);  
Wire.write(address_reg);  
Wire.write(new_i2c_device_address);  
Wire.endTransmission();
```

0x00

0x01

0x02

0x03

0x04

0x05

0x06

0x07

0x08

0x09

0x0A

0x0B

0x0C

0x0D

0x0E

0x0F

0x10

0x11

Control registers

0x04: Interrupt control

R/W

0x05: LED control

R/W

0x06: Active/hibernate

R/W

0x07: New reading available

R/W

0x00

0x01

0x02

0x03

0x04

0x05

0x06

0x07

0x08

0x09

0x0A

0x0B

0x0C

0x0D

0x0E

0x0F

0x10

0x11

0x04 – Interrupt control register

1 unsigned byte

Default value = 0 (disabled)

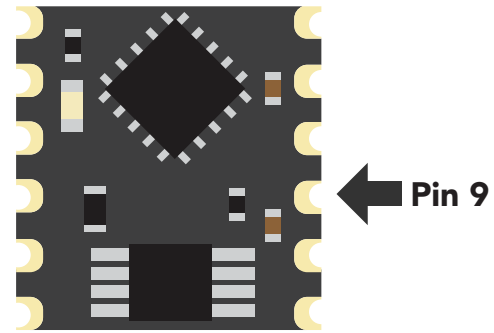
Command values

0 = disabled

2 = pin high on new reading (manually reset)

4 = pin low on new reading (manually reset)

8 = invert state on new reading (automatically reset)



The Interrupt control register adjusts the function of pin 9 (the interrupt output pin).

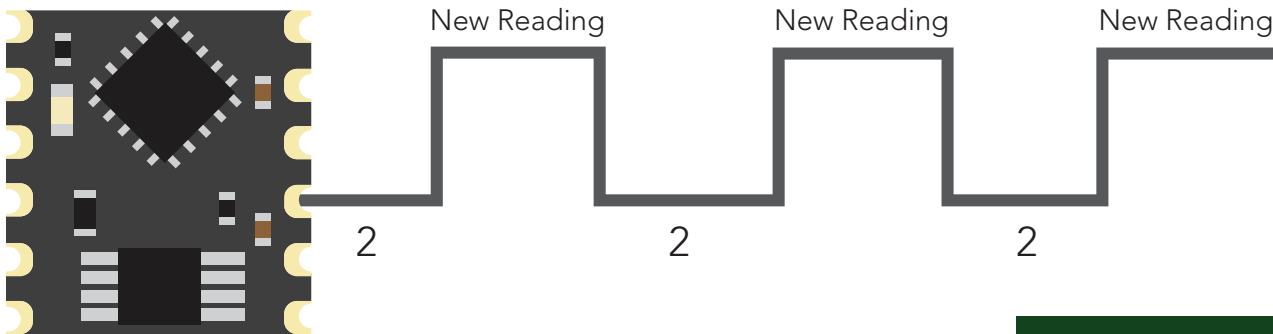


Settings to this register are **not** retained if the power is cut.

Pin high on new reading

Command value = 2

By setting the interrupt control register to 2 the pin will go to a low state (0 volts). Each time a new reading is available the INT pin (pin 9) will be set and output the same voltage that is on the VCC pin.



The pin will not auto reset. 2 must be written to the interrupt control register after each transition from low to high.

Example code

Setting pin high on new reading

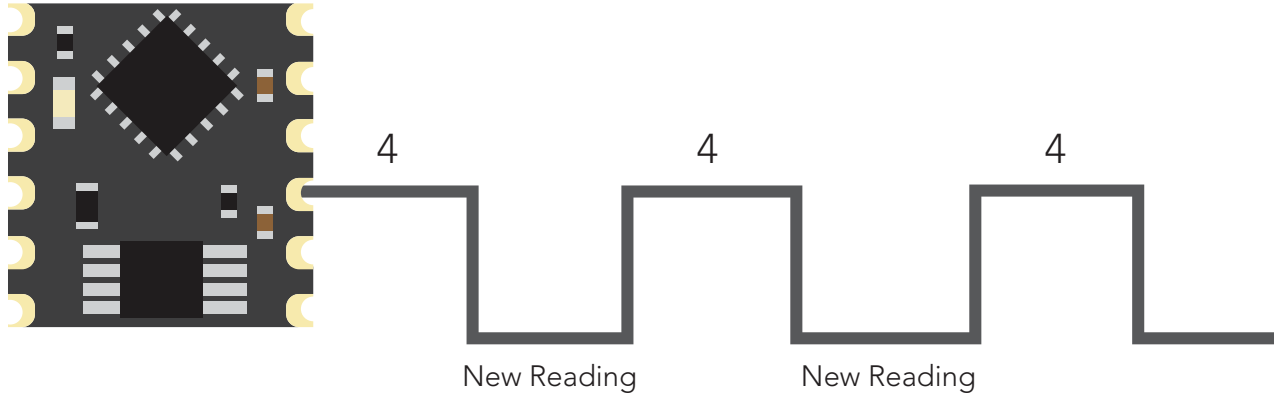
```
byte i2c_device_address=0x68;  
byte int_control=0x04;
```

```
Wire.beginTransmission(i2c_device_address);  
Wire.write(int_control);  
Wire.write(0x02);  
Wire.endTransmission();
```

Pin low on new reading

Command value = 4

By setting the interrupt control register to 4 the pin will go to a high state (VCC). Each time a new reading is available the INT pin (pin 9) will be reset and the pin will be at 0 volts.



The pin will not auto set. 4 must be written to the interrupt control register after each transition from high to low.

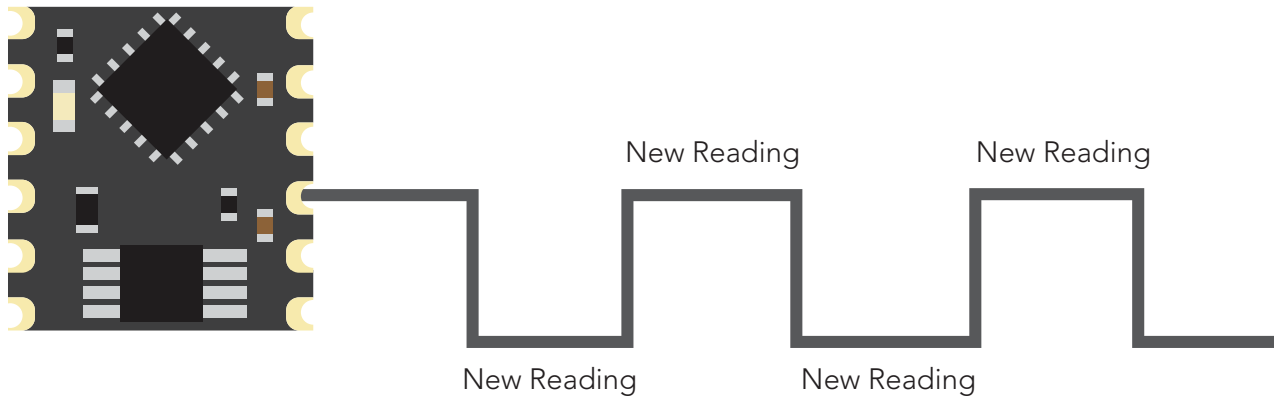
Example code Setting pin low on new reading

```
byte I2C_device_address=0x68;  
byte int_control=0x04;  
  
Wire.beginTransmission(I2C_device_address);  
Wire.write(int_control);  
Wire.write(0x04);  
Wire.endTransmission();
```

Invert state on new reading

Command value = 8

By setting the interrupt control register to 8 the pin will remain in whatever state it is in. Each time a new reading is available the INT pin (pin 9) will invert its state.



The pin will automatically invert its state each time a new reading is available. This setting has been specifically designed for a master device that can use an interrupt on change function.

Example code Inverting state on new reading

```
byte i2c_device_address=0x68;  
byte int_control=0x04;  
  
Wire.beginTransmission(i2c_device_address);  
Wire.write(int_control);  
Wire.write(0x08);  
Wire.endTransmission();
```

- 0x00
- 0x01
- 0x02
- 0x03
- 0x04
- 0x05
- 0x06
- 0x07
- 0x08
- 0x09
- 0x0A
- 0x0B
- 0x0C
- 0x0D
- 0x0E
- 0x0F
- 0x10
- 0x11

0x05 – LED control register

1 unsigned byte

Command values

1 = Blink each time a reading is taken
0 = Off

The LED control register adjusts the function of the on board LED. By default the LED is set to blink each time a reading is taken.

Example code Turning off LED

```
byte i2c_device_address=0x68;  
byte led_reg=0x05;  
  
Wire.beginTransmission(i2c_device_address);  
Wire.write(led_reg);  
Wire.write(0x00);  
Wire.endTransmission();
```



Settings to this register are **not** retained if the power is cut.

0x06 – Active/hibernate register

1 unsigned byte

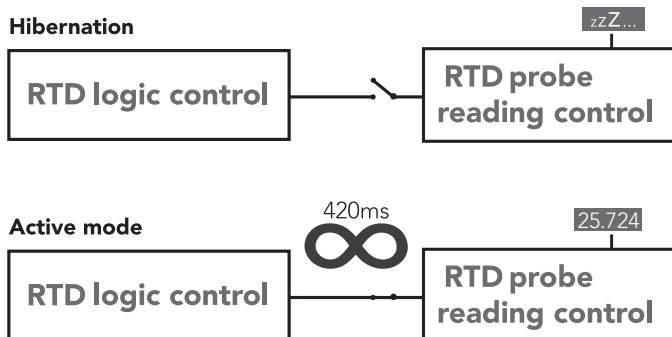
To wake the device

Transmit a 0x01 to register 0x06

To hibernate the device

Transmit a 0x00 to register 0x06

This register is used to activate, or hibernate the sensing subsystem of the OEM device.



Example code Activate RTD readings

```
byte i2c_device_address=0x68;  
byte active_reg=0x06;  
  
Wire.beginTransmission(i2c_device_address);  
Wire.write(active_reg);  
Wire.write(0x01);  
Wire.endTransmission();
```

Once the device has been woken up it will continuously take readings every 420ms. **Waking the device is the only way to take a reading. Hibernating the device is the only way to stop taking readings.**

0x00

0x01

0x02

0x03

0x04

0x05

0x06

0x07

0x08

0x09

0x0A

0x0B

0x0C

0x0D

0x0E

0x0F

0x10

0x11

0x07 – New reading available register

1 unsigned byte

Default value = 0 (no new reading)

New reading available = 1

Command values

0 = reset register

This register is for applications where the interrupt output pin cannot be used and continuously polling the device would be the preferred method of identifying when a new reading is available.

When the device is powered on, the New Reading Available Register will equal 0. Once the device is placed into active mode and a reading has been taken, the New Reading Available Register will move from 0 to 1.

This register will never automatically reset itself to 0. The master must reset the register back to 0 each time.

Example code

Polling new reading available register

```
byte i2c_device_address=0x68;  
byte new_reading_available=0;  
byte nra=0x07;
```

```
while(new_reading_available==0){  
Wire.beginTransmission(i2c_device_address);  
Wire.write(nra);  
Wire.endTransmission();
```

```
Wire.requestFrom(i2c_device_address,(byte)1);  
new_reading_available = Wire.read();  
Wire.endTransmission();  
delay(10);  
}
```

```
if(new_reading_available==1){  
call read_RTD();  
Wire.beginTransmission(i2c_device_address);  
Wire.write(nra);  
Wire.write(0x00);  
Wire.endTransmission();  
}
```

0x00

0x01

0x02

0x03

0x04

0x05

0x06

0x07

0x08

0x09

0x0A

0x0B

0x0C

0x0D

0x0E

0x0F

0x10

0x11

Calibration

0x08: Calibration value MSB	R/W
0x09: Calibration value high byte	R/W
0x0A: Calibration value low byte	R/W
0x0B: Calibration value LSB	R/W

0x08 – 0x0B Calibration registers

Signed long
 0x08 = MSB
 0x0B = LSB
 Units = °C

A calibration point can be a single whole number, or single floating point number up to three decimal place.

Example

100
 -21.4
 49.613

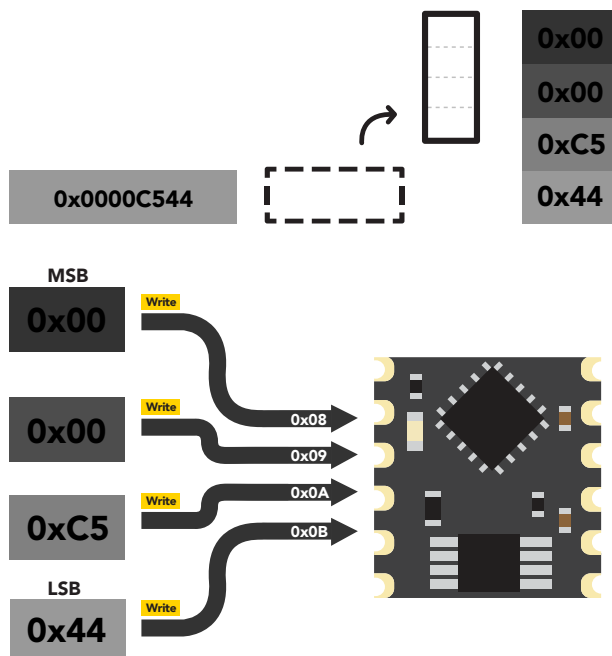
After sending a value to this register block, calibration is **not** complete. The calibration request register must be set after loading a calibration value into this register block.

When sending a calibration temperature to the RTD OEM™ the value of the calibration temperature must be multiplied by 1,000 and then transmitted to the RTD OEM™.

Example

Calibrating to a temperature of 50.5
 calibration value = 50.5
 $50.5 \times 1,000 = 50,500$
 50500 to HEX = 0x0000C544

calibration MSB Register = 0x00
 calibration high byte Register = 0x00
 calibration low byte Register = 0xC5
 calibration LSB Register = 0x44



0x00
0x01
0x02
0x03
0x04
0x05
0x06
0x07
0x08
0x09
0x0A
0x0B
0x0C
0x0D
0x0E
0x0F
0x10
0x11

0x0C – Calibration request register

1 unsigned byte

Command values

1 = Clear calibration (delete all calibration data)

2 = Single point calibration

By default this register will read 0x00. When a calibration request command has been sent and a stop command has been issued, the RTD OEM™ will perform that calibration requested. Once the calibration has been done the Calibration Request Registers value will return to 0x00.

0x0D – Calibration confirmation register

1 unsigned byte

Command values

0 = no calibration

1 = calibration

After a calibration event has been successfully carried out, the calibration confirmation register will reflect what that calibration has been done.



Settings to this register are retained if the power is cut.

0x00

0x01

0x02

0x03

0x04

0x05

0x06

0x07

0x08

0x09

0x0A

0x0B

0x0C

0x0D

0x0E

0x0F

0x10

0x11

Sensor data

0x0E: Temperature reading MSB

R

0x0F: Temperature reading high byte

R

0x10: Temperature reading low byte

R

0x11: Temperature reading LSB

R

0x00

0x01

0x02

0x03

0x04

0x05

0x06

0x07

0x08

0x09

0x0A

0x0B

0x0C

0x0D

0x0E

0x0F

0x10

0x11

0x0E – 0x11 RTD reading registers

Signed long

0x0E = MSB

0x11 = LSB

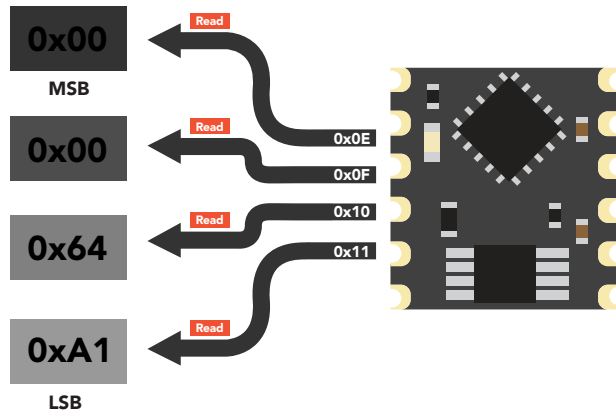
Units = °C

The last temperature reading taken is stored in these four registers. To read the value in this register, read the bytes MSB to LSB and assign them to a signed long, cast to a float. Divide that number by 1,000.

Example

Reading an temperature of 25.761 °C

Step 1 read 4 bytes



Step 2 read signed long



Step 3 cast signed long to a float



Step 4 divide by 1,000

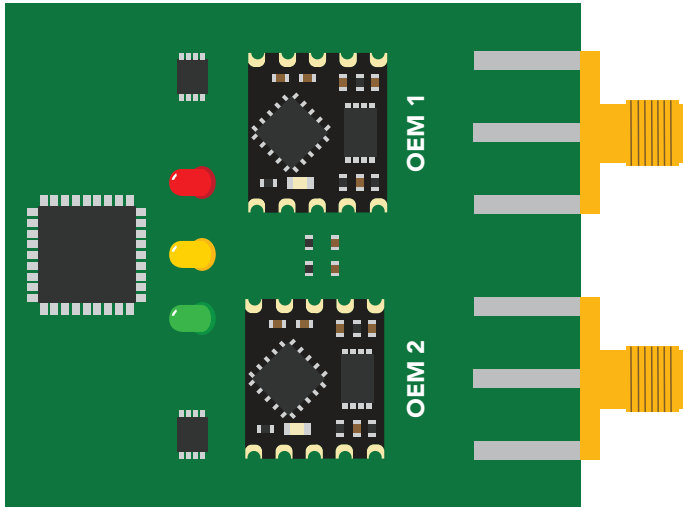


Designing your product

The RTD OEM™ circuit is a sensitive device. Special care **MUST** be taken to ensure your Temperature readings are accurate.

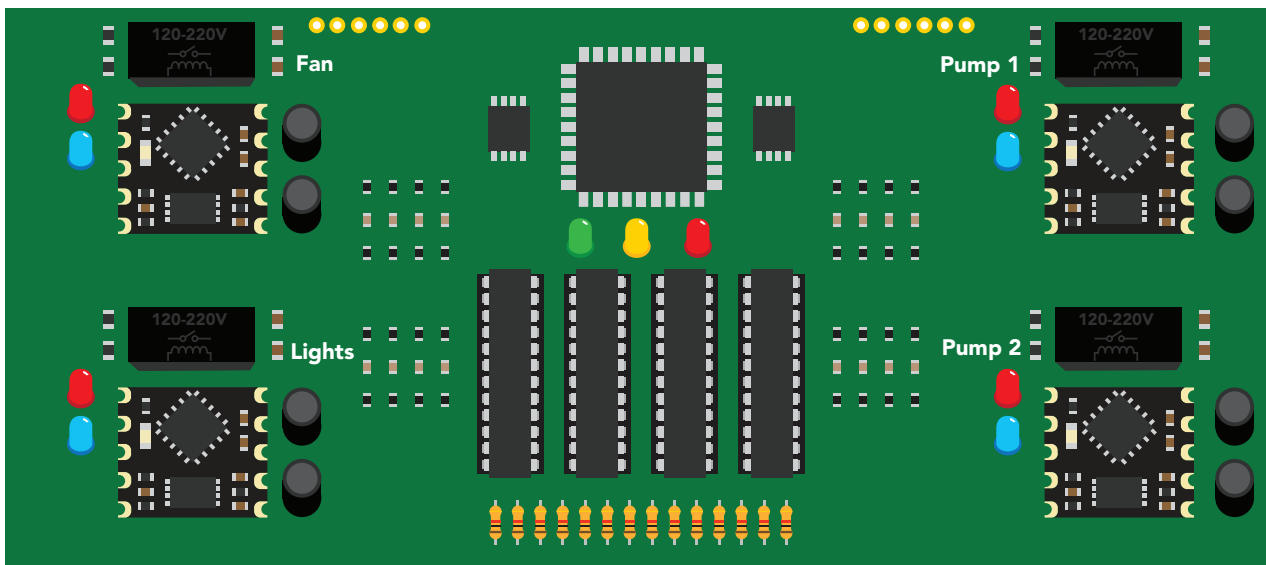
Simple design

Simple low voltage computer systems experience little to no problems during development and have no reported issues from the target customer.



Complex design

Complex computer systems with multiple voltages and switching, can lead to extended and unnecessary debugging time. Target customers can experience frequent accuracy issues.

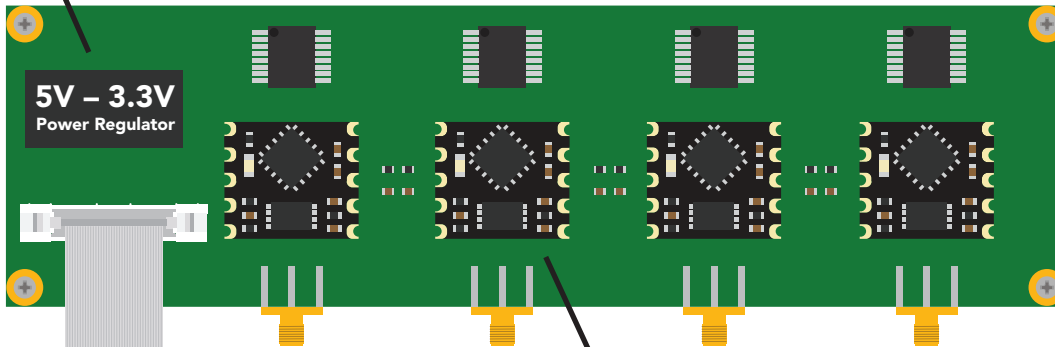


How to add chemical sensing to a complex computer system

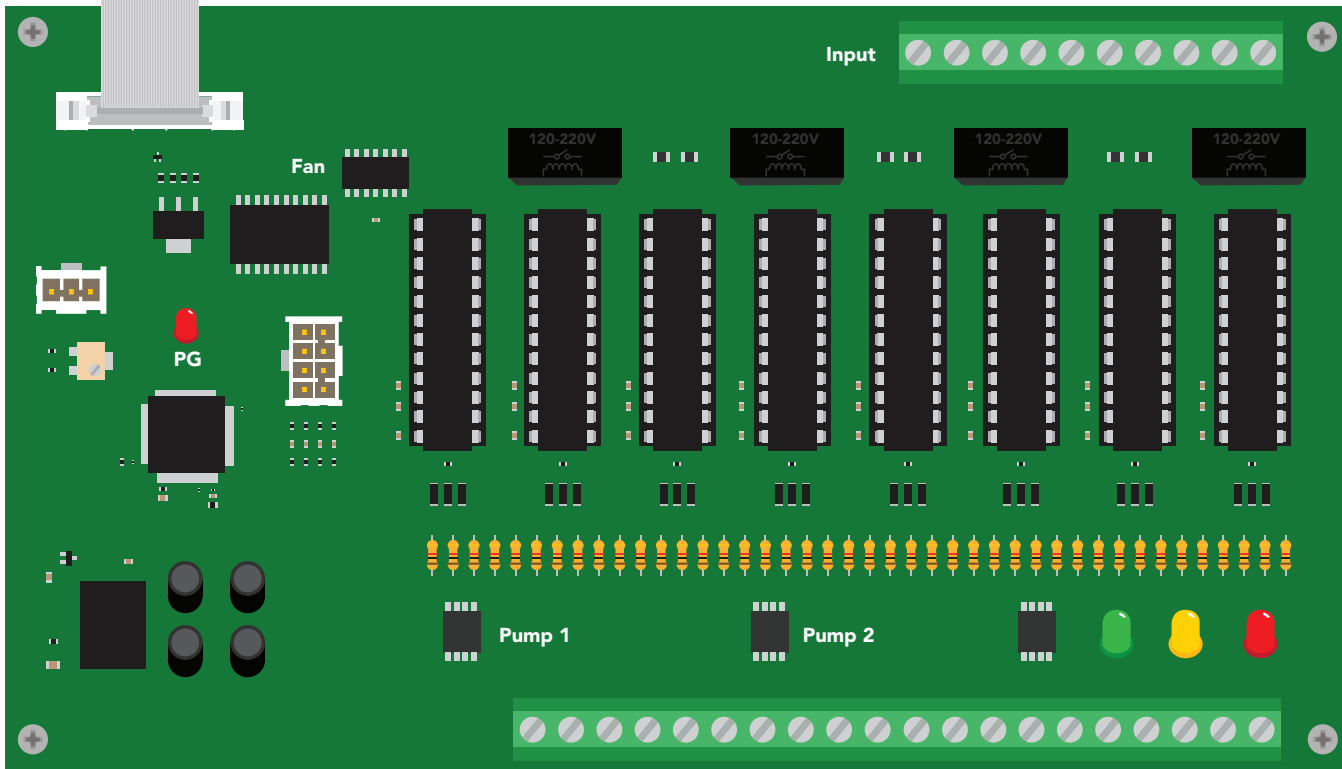
Placing the OEM™ circuits onto their own board is **strongly recommended**; Not only does this help keep the design layout simple and easy to follow, it also significantly reduces debugging and development time.

Target customers will experience accurate, stable and repeatable readings for the life of your product.

The sensor board should have its own power regulator.



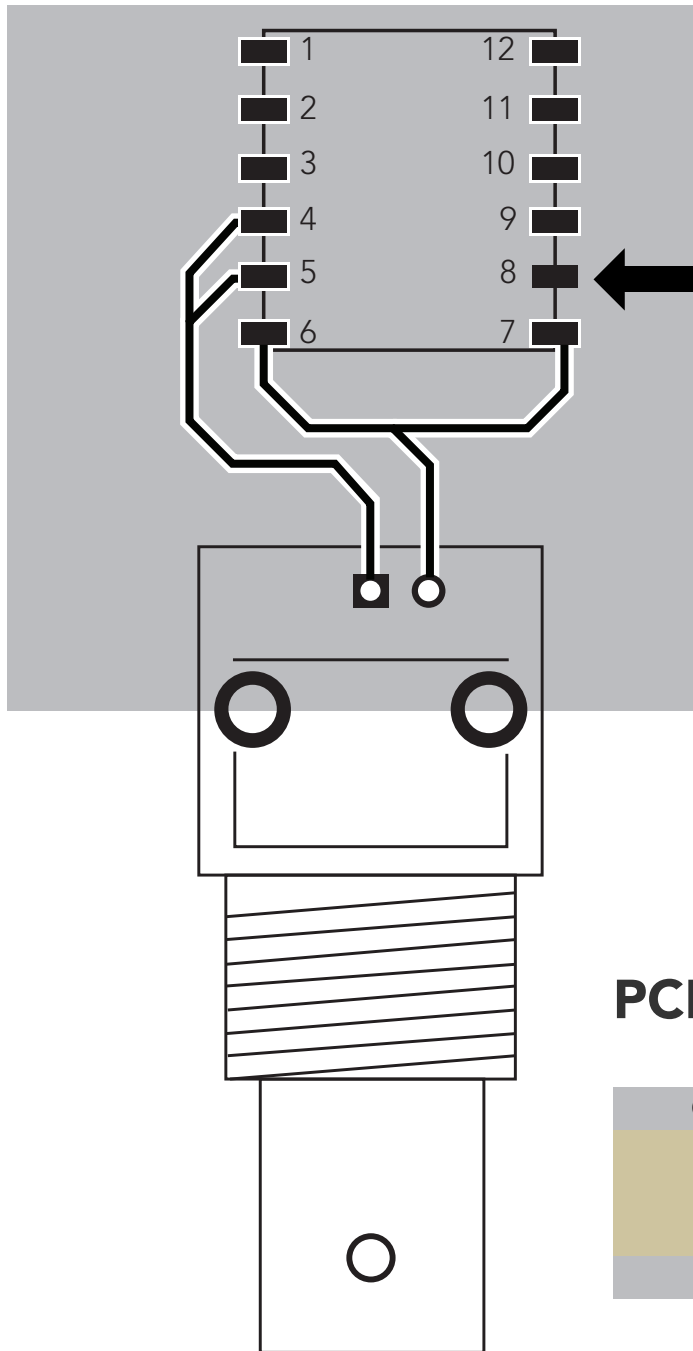
Distance between SMA/BNC connector and the OEM circuit should be as short as possible.



Designing your PCB

Create the traces as short as possible from the RTD OEM™ to your probe connection. Keep the traces on your top layer, keep a distance of 1mm for any other trace, use 0.4mm trace width. Use a ground plane underneath the traces and probe connection.

Ground Plane



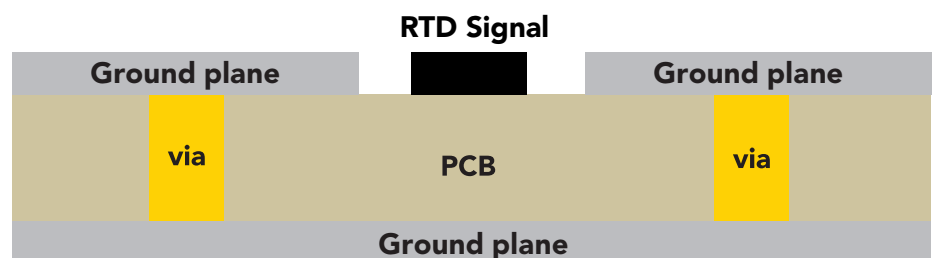
Connect pin 8 to the ground plane.

Make sure there are no vias or exposed metal underneath the RTD OEM™ circuit.

If pin 9(INT) is unused leave it floating, do not connect pin 9 to VCC or ground.

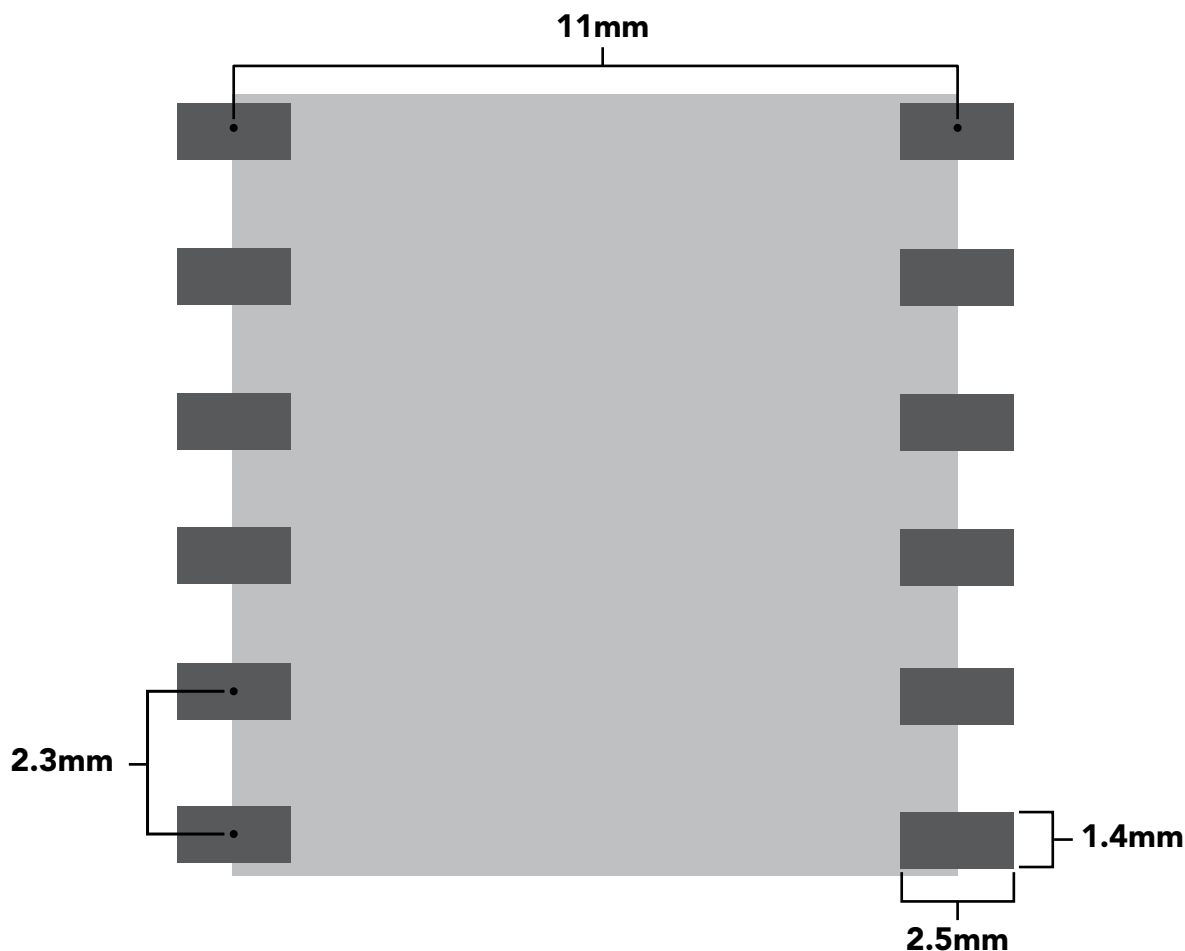
Keep the traces for both probe and probe ground as short as possible.

PCB cross section of the signal path



This cross section is an example of how the ground plane protects the RTD signal. The ground plane should surround the RTD signal, on the top layer as well as the bottom layer.

Recommended pad layout

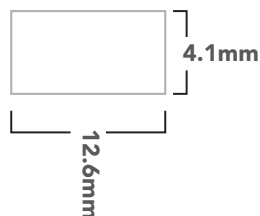


IC tube measurements

Top View



Side View

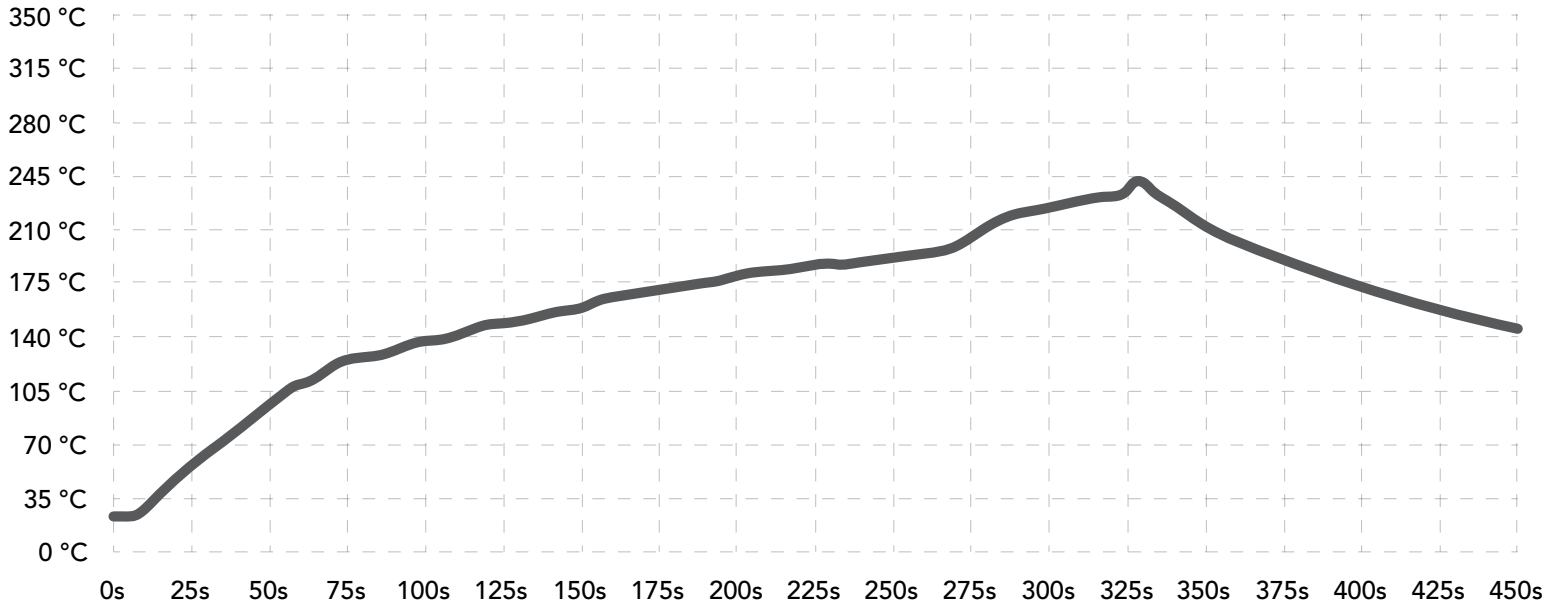


Fits 23 RTD OEM™ circuits

	inside dimensions	outside dimensions
L	325mm	325mm
W	11.6mm	12.6mm
H	3.1mm	4.1mm

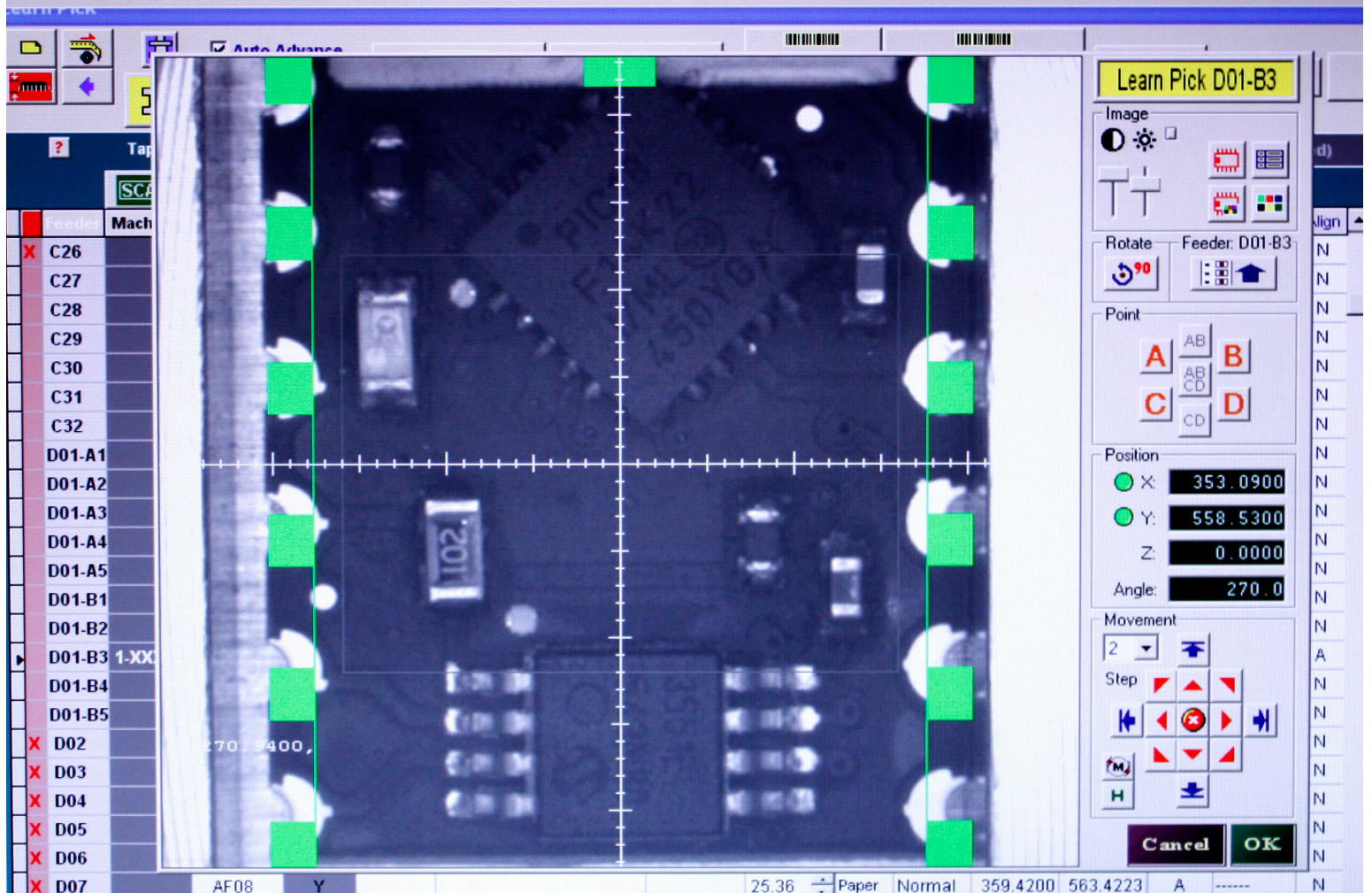
plastic thickness 0.5mm

Recommended reflow soldering profile



#	Temp	Sec	#	Temp	Sec	#	Temp	Sec	#	Temp	Sec
1	30	15	11	163	10	21	182	10	31	100	25
2	90	20	12	165	10	22	183	10	32	80	30
3	110	8	13	167	10	23	185	10	33	30	30
4	130	5	14	170	10	24	187	10	34	0	15
5	135	5	15	172	10	25	220	30			
6	140	5	16	174	10	26	225	20			
7	155	8	17	176	10	27	230	20			
8	156	10	18	178	10	28	235	8			
9	158	10	19	180	10	29	170	20			
10	160	10	20	181	10	30	130	20			

Pick and place usage



Datasheet change log

Datasheet V 1.9

Added new graphic on pg 3.

Datasheet V 1.8

Revised operating voltages on pages 1 & 4.

Datasheet V 1.7

Revised artwork on pg 8.

Datasheet V 1.6

Added "Designing you product" on pg 23.

Datasheet V 1.5

Revised information about *designing your own RTD board* on pg. 23

Datasheet V 1.4

Firmware update.

Datasheet V 1.3

Changed registers 0x0D, 0x0E, 0x0F, 0x10 and 0x11 from R/W to R.

Datasheet V 1.2

Changed "Max rate" to "Response time" on cover page.

Datasheet V 1.1

Revised pinout illustration on pg. 5

Datasheet V 1.0

New datasheet

Firmware updates

V4.0 – Initial release (June, 28 2017)

V5.0 – (November 27, 2018)

- Fixed a bug where the calibration status didn't load correctly on power up.