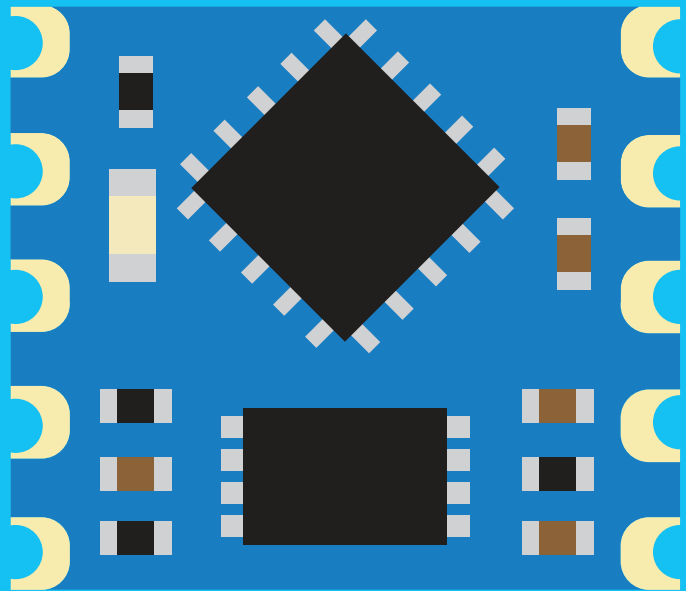


OEM-ORPTM

Embedded ORP Circuit

Reads	ORP
Range	-1019.9mV – 1019.9mV
Accuracy	+/- 1mV
Response time	1 reading every 420ms
Supported probes	Any type & brand
Calibration	Single point
Temp compensation	N/A
Data protocol	SMBus/I²C
Default I ² C address	0x66
Operating voltage	3.0V – 5.5V
Data format	ASCII



PATENT PROTECTED



STOP

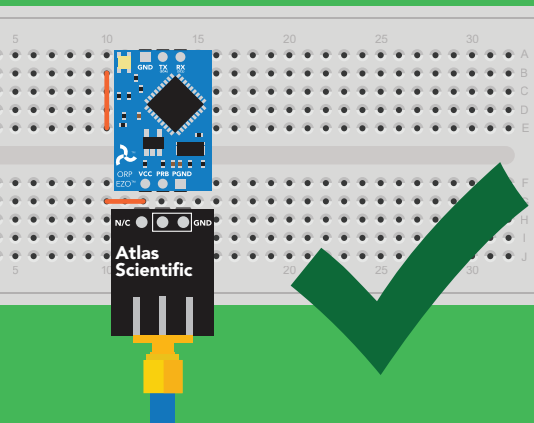
SOLDERING THIS DEVICE VOIDS YOUR WARRANTY.

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

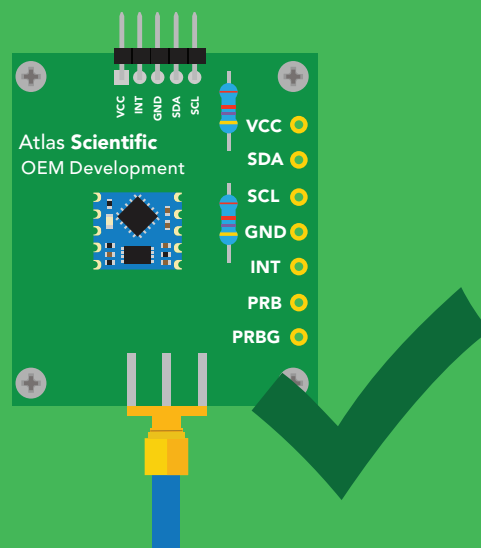
This device is designed for electrical engineers who are familiar with embedded systems design and programming. If you, or your engineering team are not familiar with embedded systems design and programming, Atlas Scientific does not recommend buying this product.

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

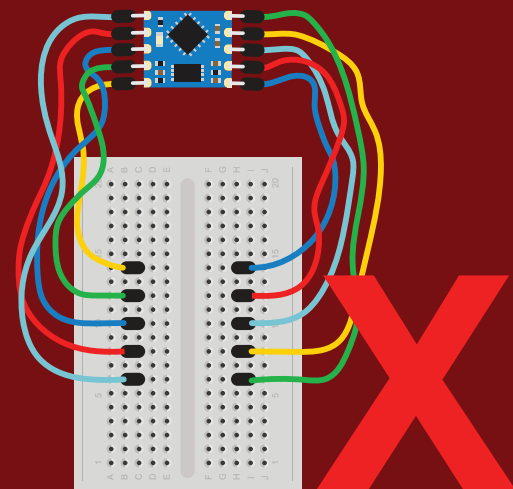
It's much easier to use, and
provides a good working
reference.

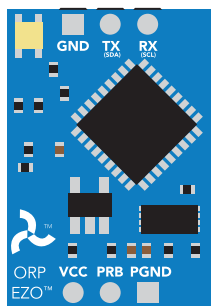


Get this device working in our
OEM Development board first!



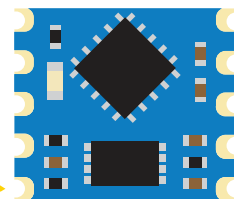
Do not solder wires
to this device.





EZO-ORP

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



ORP-OEM

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

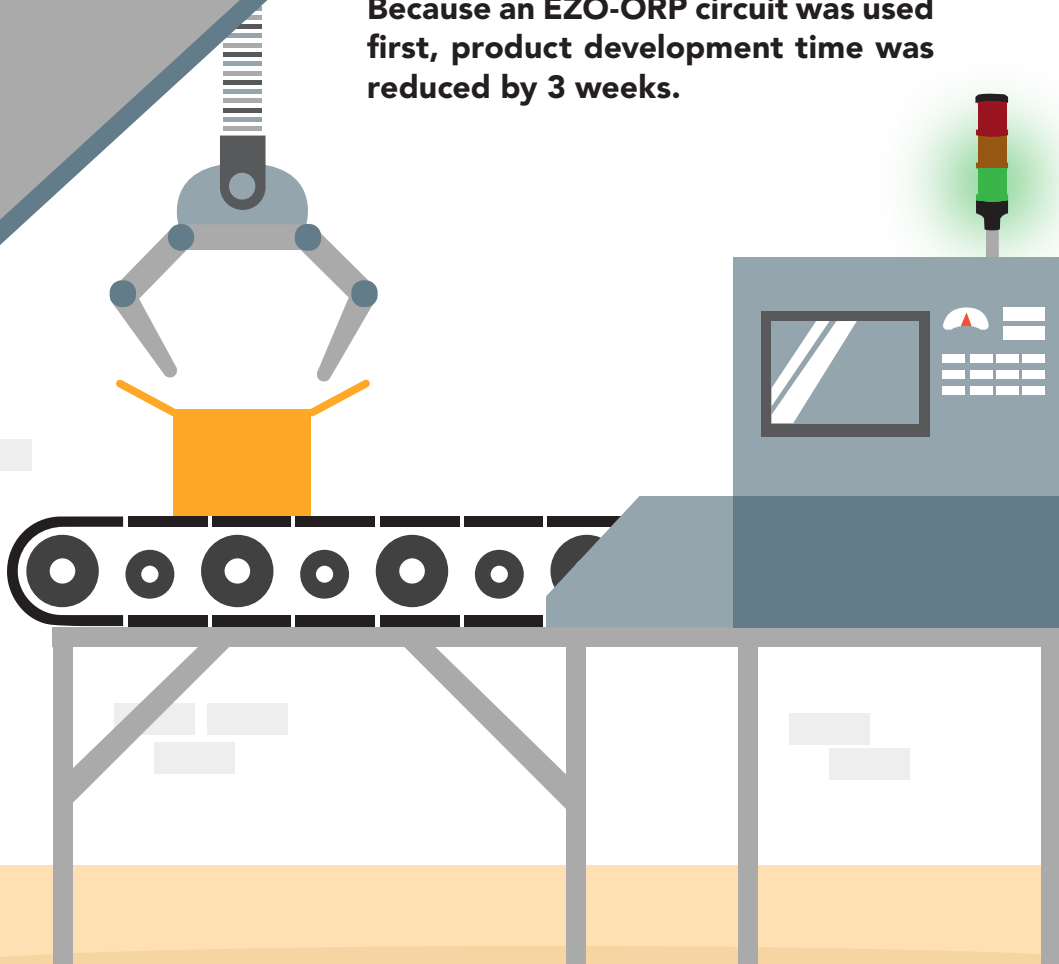


Table of contents

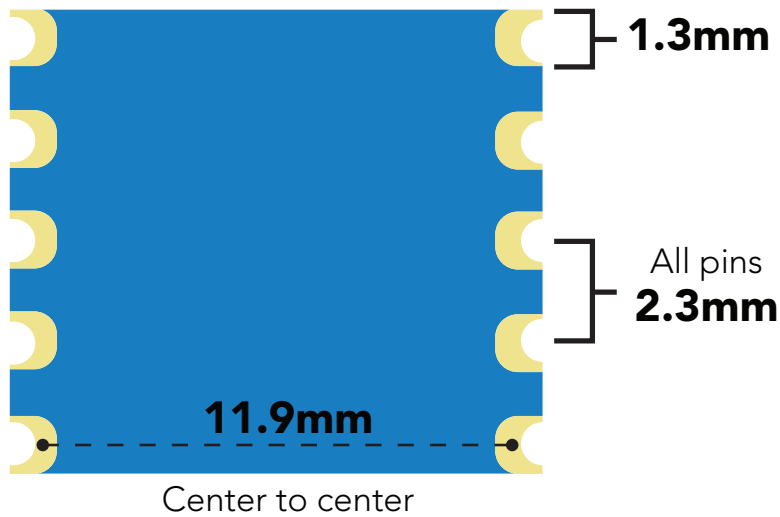
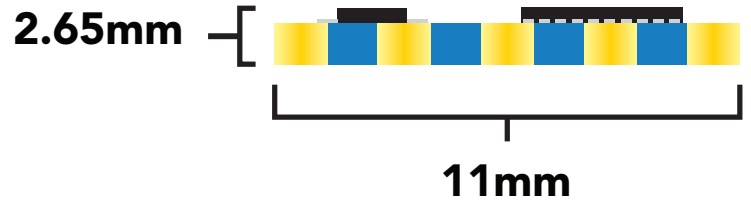
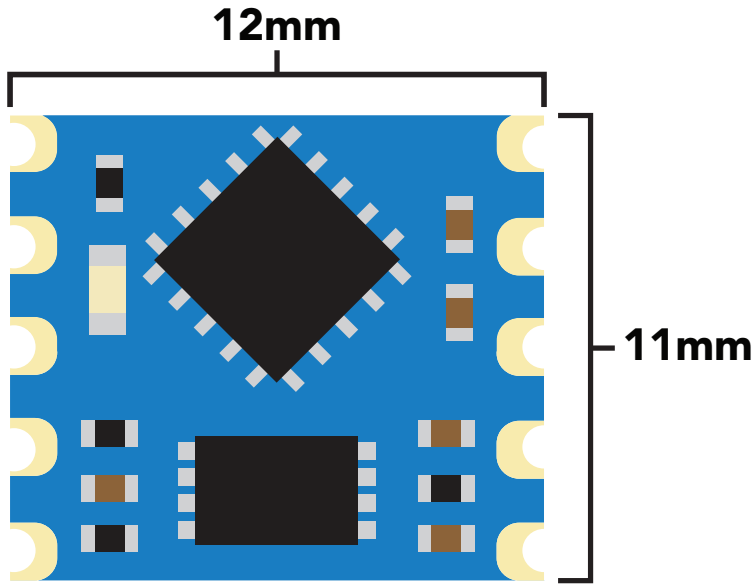
OEM circuit dimensions	5	System overview	7
Power consumption	5	Reading register values	8
Absolute max ratings	5	Writing register values	9
Pin out	6	Sending floating point numbers	10
Resolution	6	Receiving floating point numbers	11
Power on/start up	6		

REGISTERS

0x00 Device type register	13
0x01 Firmware version register	13
0x02 Address lock/unlock register	14
0x03 Address register	15
0x04 Interrupt control register	16
0x05 LED control register	18
0x06 Active/hibernate register	18
0x07 New reading available register	19
0x08 – 0x0B Calibration registers	20
0x0C Calibration request register	21
0x0D – Calibration confirmation register	21
0x0E – 0x11 ORP reading registers	22

OEM electrical isolation	23
Designing your product	24
Designing your PCB	26
Recommended pad layout	30
IC tube measurements	30
Recommended reflow soldering profile	31
Pick and place usage	32
Datasheet change log	32
Firmware updates	33

OEM circuit dimensions



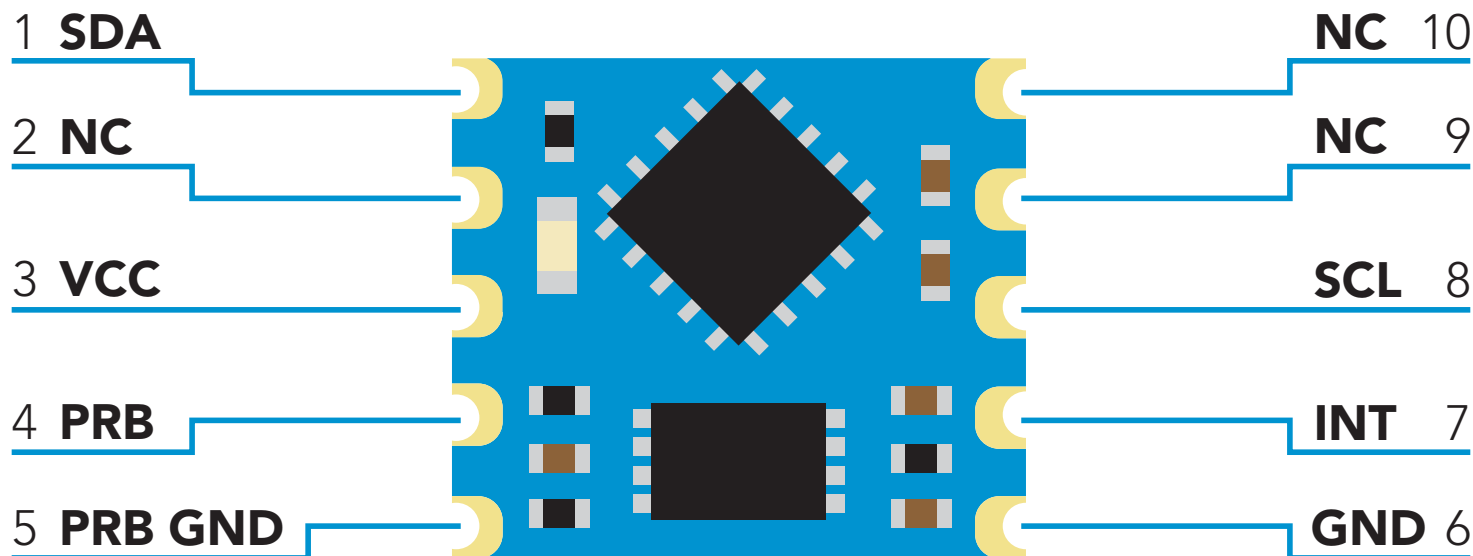
Power consumption

	LED	OPERATIONAL	HIBERNATION
3.3V	ON	3.46 mA	3.43 mA
	OFF	3.03 mA	3.0 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	5.5V

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™ ORP OEM™ will always produce a reading with a resolution of one decimal place.

Example

1.2 mV
-190.6 mV

Power on/start up

Once the Atlas Scientific™ ORP OEM™ is powered on it will be ready to receive commands and take readings after 1ms. 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

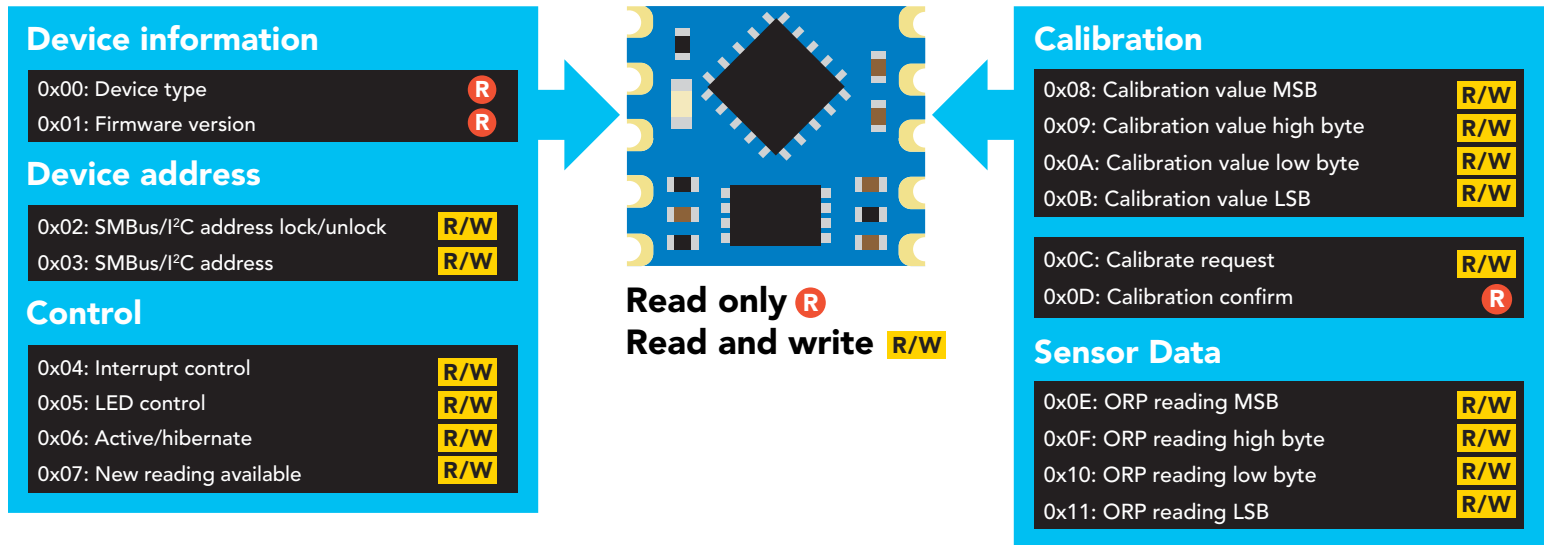
Active/Hibernation mode
LED control
Interrupt control

System overview

The Atlas Scientific ORP OEM™ Class Embedded ORP Circuit is the core electronics needed to read the ORP of water from any off the shelf ORP probe. The ORP OEM™ Embedded Circuit will meet, or exceed the capabilities and accuracy found in all models of bench top laboratory grade ORP meters.

The ORP 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 **0x66**
This address can be changed.

**Each ORP reading
takes 420ms**

Reading register values

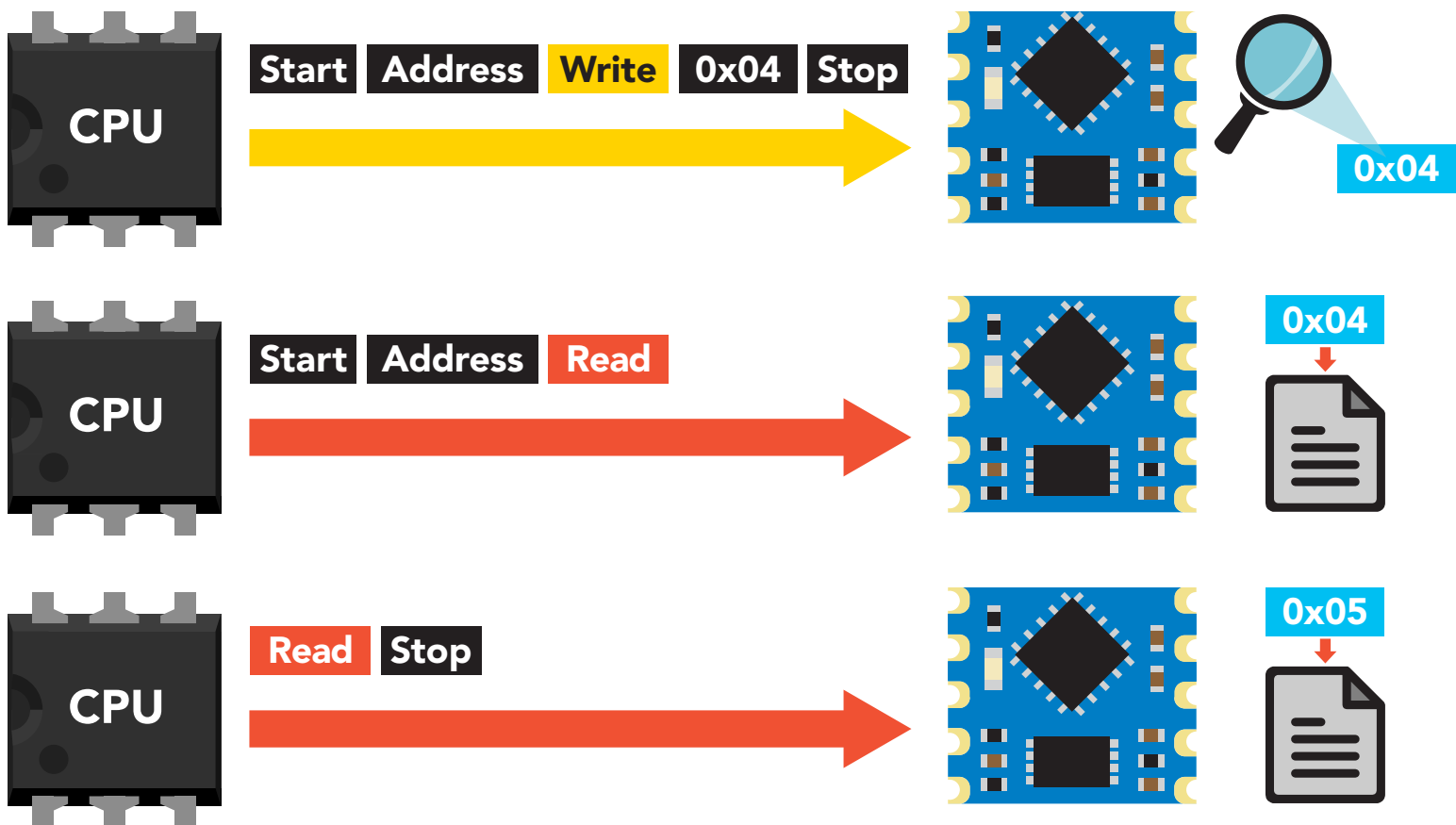
To read one or more registers, issue a write command and transmit the register address that should be read from, followed by a stop command. Then issue a read command, the data read will be the value that is stored in that register. Issuing another read command will automatically read the value in the 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.

The default device address is **0x66**
This address can be changed.

Example

Start reading at register 0x04 and read 2 times.



Example code reading two registers

```
byte i2c_device_address=0x66;
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();
```

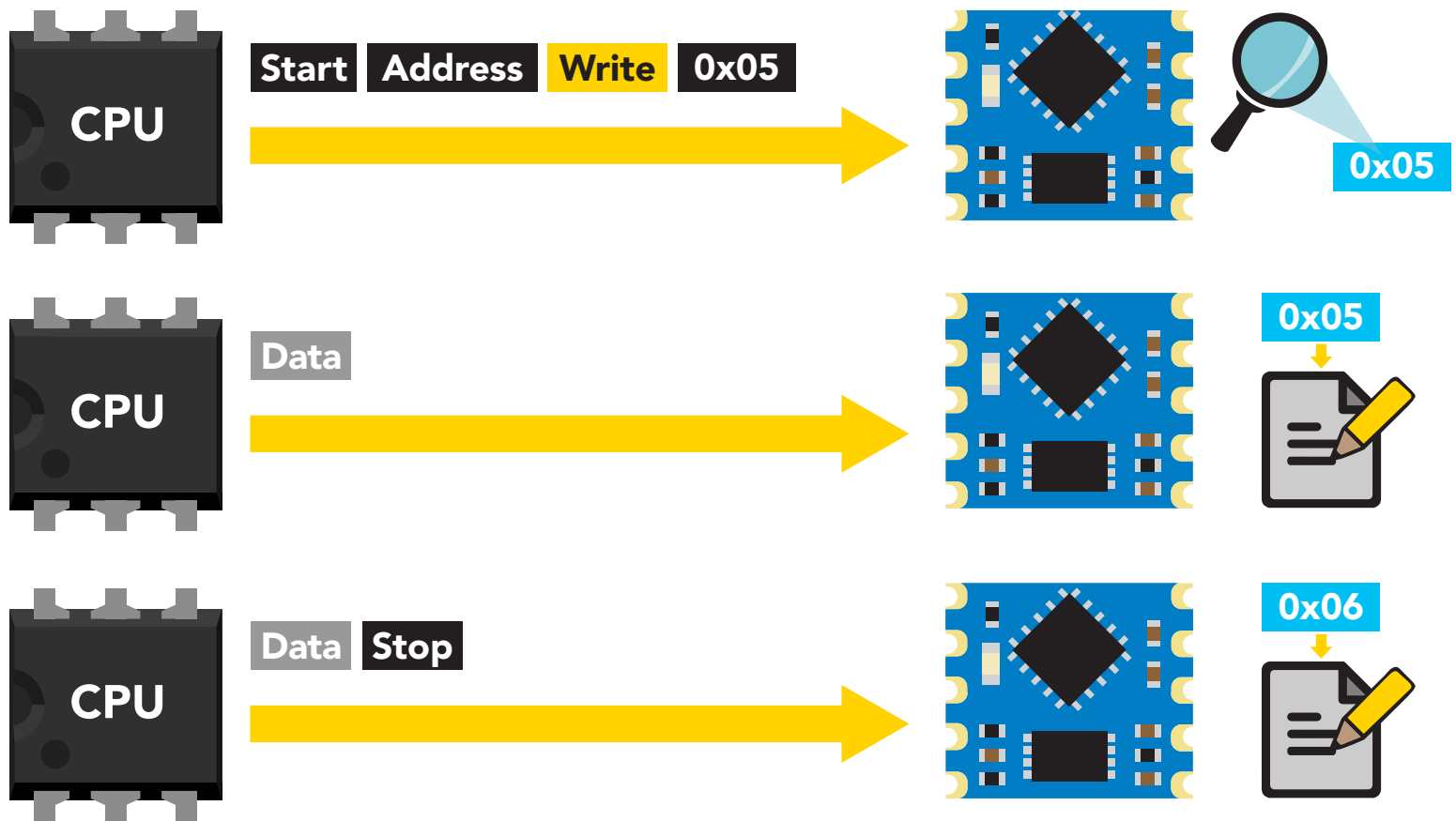

Writing register values

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=0x66;  
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 10. This would have the effect of removing the floating point. Internally the ORP OEM™ will divide the number by 10, converting it back into a floating point number.

Example

Setting an ORP calibration value of: 125.6

$$125.6 \times 10 = 1256$$

Transmit the number 1256 to the Calibration value registers

Setting an ORP calibration value of: -80

$$-80 \times 10 = -800$$

Transmit the number -800 to the Calibration value registers

When reading back a value stored in the calibration value registers, the value must be divided by 10 to return it to its originally intended value.

Receiving floating point numbers

After receiving a value from the ORP reading registers, the number must be divided by 10 to convert it back into a floating point number.

Example

Reading an ORP value of 14.5

Value received = 145

$145 / 10 = 14.5$

Reading an ORP value of -281.3

Value received = -2813

$-2813 / 10 = -281.3$

Registers

Device information

0x00: Device type

R

0x01: Firmware version

R

0x00 – Device type register

1 unsigned byte

Read only value = 2

2 = ORP

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=0x66;  
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();
```



0x00

0x01

0x02

0x03

0x04

0x05

0x06

0x07

0x08

0x09

0x0A

0x0B

0x0C

0x0D

0x0E

0x0F

0x10

0x11

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

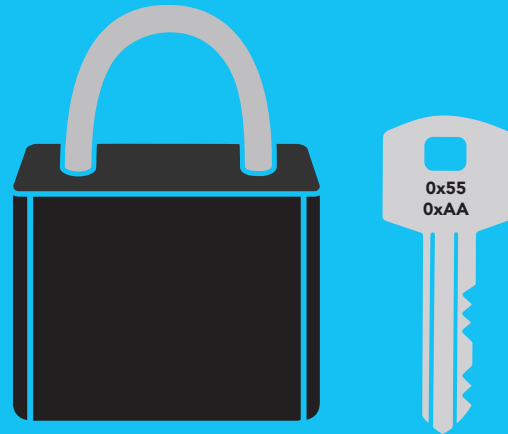
0 = **unlocked**

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=0x66;  
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 = **0x66**

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=0x66;  
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
0x05: LED control
0x06: Active/hibernate
0x07: New reading available

R/W
R/W
R/W
R/W

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

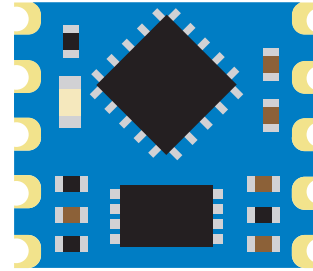


0x04 – Interrupt control register

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)



Pin 7

The Interrupt control register adjusts the function of pin 7 (the interrupt output pin).

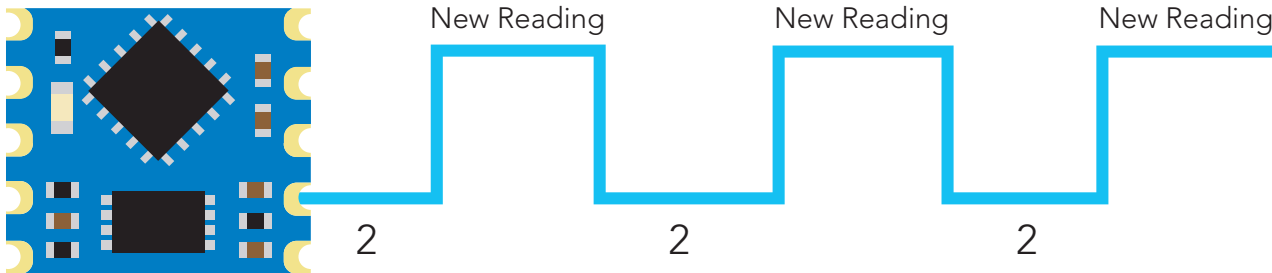


Settings to this register are **not** retained if the power is cut.

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 7) 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

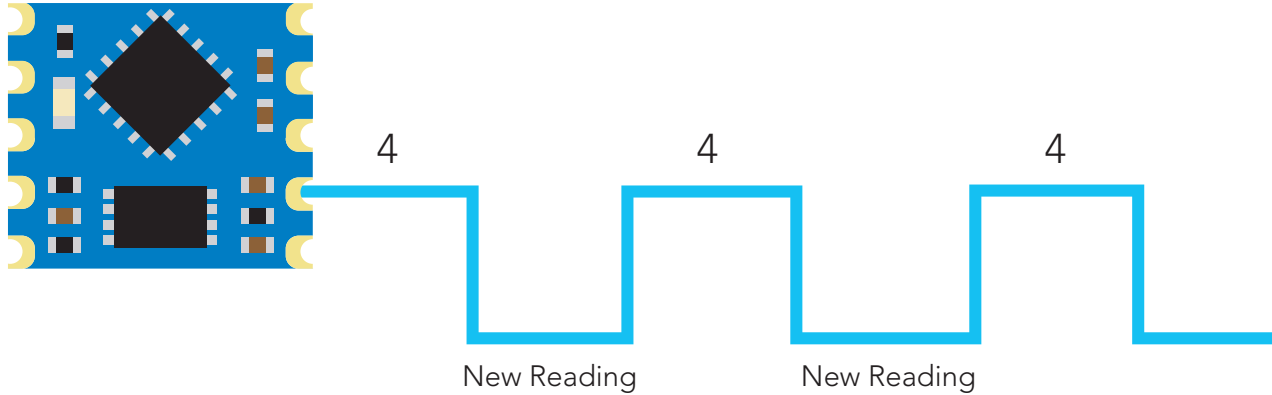
Setting pin high on new reading

```
byte i2c_device_address=0x66;  
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 7) 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

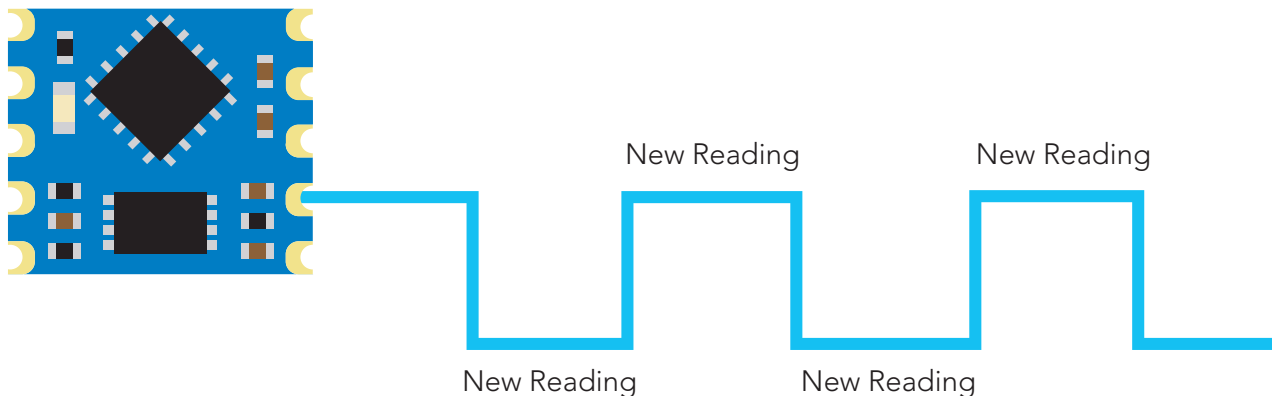
Setting pin low on new reading

```
byte I2C_device_address=0x66;  
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 7) 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=0x66;  
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=0x66;  
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.

0x00

0x01

0x02

0x03

0x04

0x05

0x06

0x07

0x08

0x09

0x0A

0x0B

0x0C

0x0D

0x0E

0x0F

0x10

0x11

0x06 – Active/hibernate register

1 unsigned byte

To wake the device

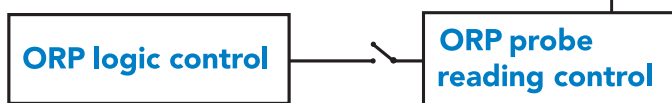
Transmit a 0x01 to register 0x06

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.

Hibernation



Active mode



Example code

Activate ORP readings

```
byte i2c_device_address=0x66;  
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.**

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=0x66;
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_ORP();
  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
 0x09: Calibration value high byte
 0x0A: Calibration value low byte
 0x0B: Calibration value LSB

R/W
 R/W
 R/W
 R/W

0x08 – 0x0B Calibration registers

Signed long
 0x08 = MSB
 0x0B = LSB
 Units = mV

A calibration point can be a signed whole number, or signed floating point number with one decimal place.

Example

225.0
 -12.5

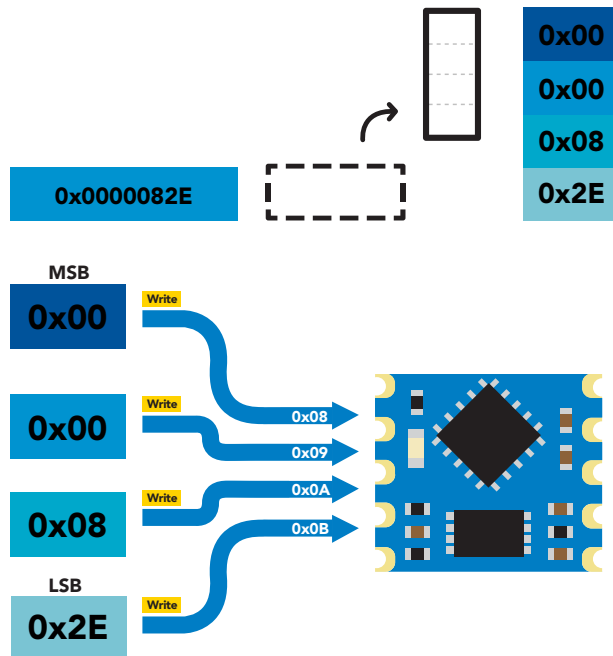
After sending a value to this register block, calibration is **not** complete. The calibration request register must be set after loading a calibration value into this register block.

To send a new calibration value to the ORP OEM™ the value of the calibration solution must be multiplied by 10 and then transmitted to the ORP OEM™. *(The calibration value will be divided by 10 internally).* Move the value from a float to a signed long. Break up the signed long into its 4 individual bytes. Send the bytes (MSB to LSB) to registers 0x08, 0x09, 0x0A and 0x0B.

Example

calibrating to an ORP of 209.4
 calibration value = 209.4
 $209.4 \times 10 = 2094$
 2094 to HEX = 0x0000082E

calibration MSB Register = 0x00
 calibration high byte Register = 0x00
 calibration low byte Register = 0x08
 calibration LSB Register = 0x2E



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 ORP 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: ORP reading MSB	R/W
0x0F: ORP reading high byte	R/W
0x10: ORP reading low byte	R/W
0x11: ORP reading LSB	R/W

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

0x0E – 0x11 ORP reading registers

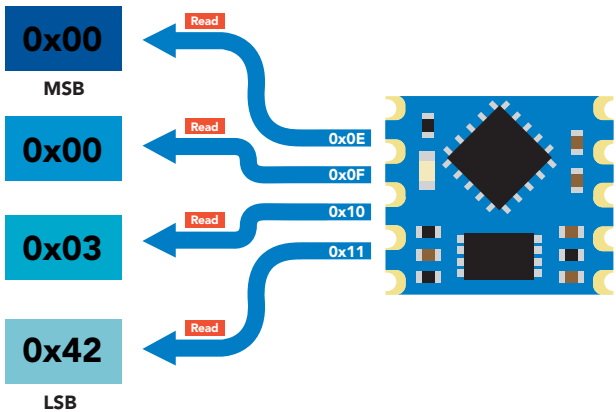
Signed long
0x0E = MSB
0x11 = LSB
Units = mV

The last ORP 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 10.

Example

Reading an ORP of 83.4 mV

Step 1 read 4 bytes



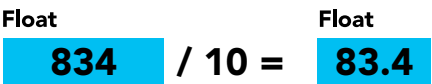
Step 2 read unsigned long



Step 3 cast unsigned long to a float



Step 4 divide by 10



OEM electrical isolation

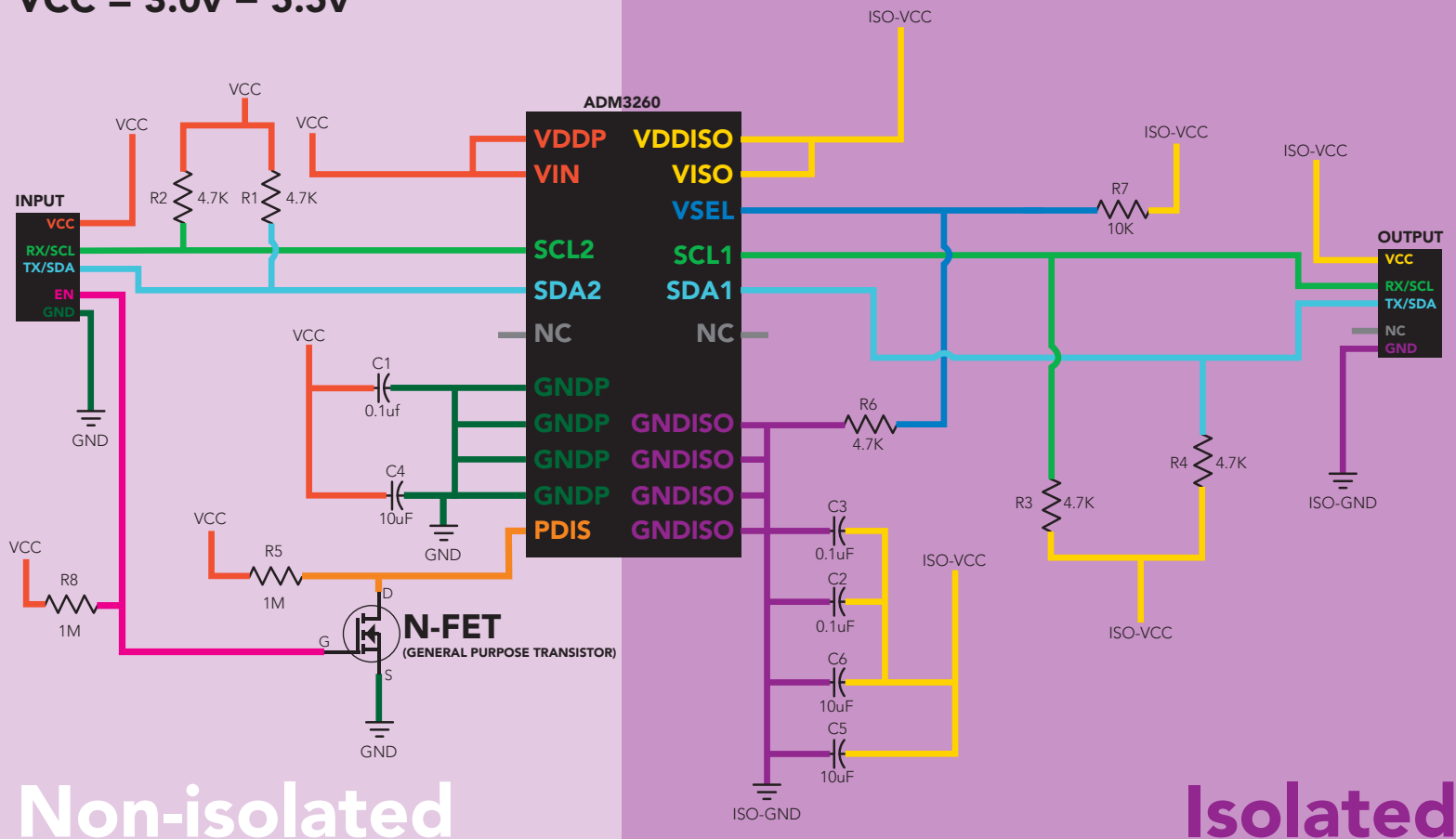
If the ORP OEM™ Class Embedded Circuit is going to be used in consumer, industrial, or scientific/medical applications electrical isolation is strongly recommended. Electrically isolating the device will insure that the readings are accurate, the ORP probe does not interfere with other sensors and that outside electrical noise does not affect the device.

The goal of electrically isolating the ORP OEM™ device is to insure that the device no longer shares a common ground with the master CPU, other sensors and other devices that are can be traced back to a common ground. It is important to keep in mind that simply isolating the power and ground is not enough. Both data lines (SDA, SCL) and the INT pin must also be isolated.

This technology works by using tiny transformers to induce the voltage across an air gap. PCB layout requires special attention for EMI/EMC and RF Control, having proper ground planes and keeping the capacitors as close to the chip as possible are crucial for proper performance. The two data channels have a 4.7kΩ pull up resistor on both the isolated and non-isolated lines (R1, R2, R3, and R4) The output voltage is set using a voltage divider (R6 and R7) this produces a voltage of 3.9V regardless of your input voltage.

Isolated ground is different from non-isolated ground, these two lines should not be connected together.

VCC = 3.0v – 5.5v

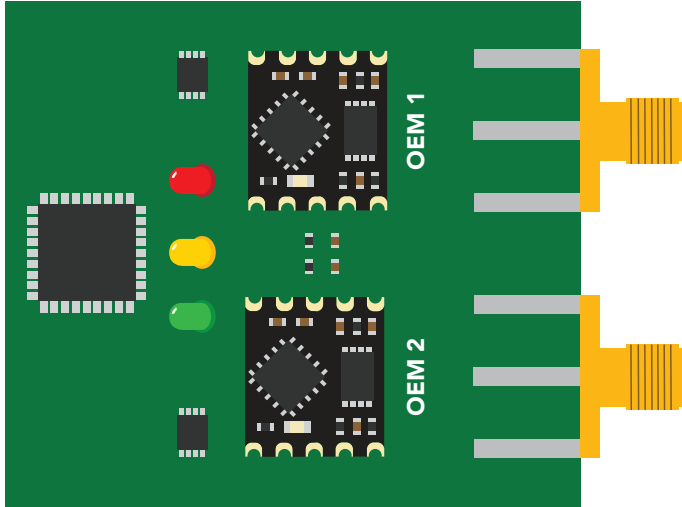


Designing your product

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

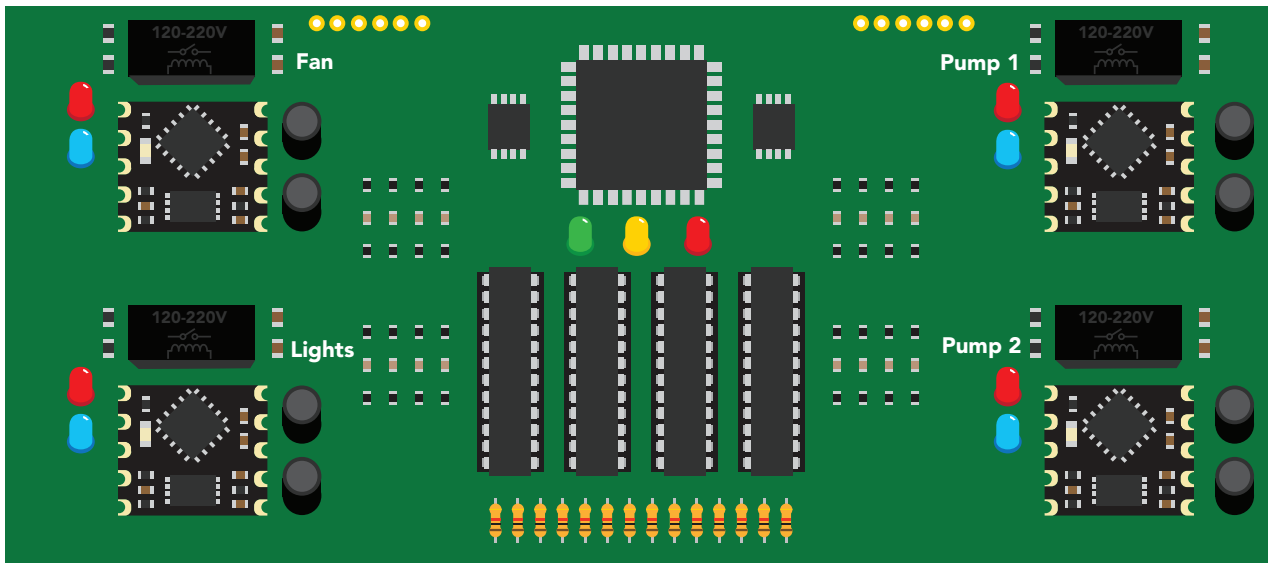
Simple design

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.



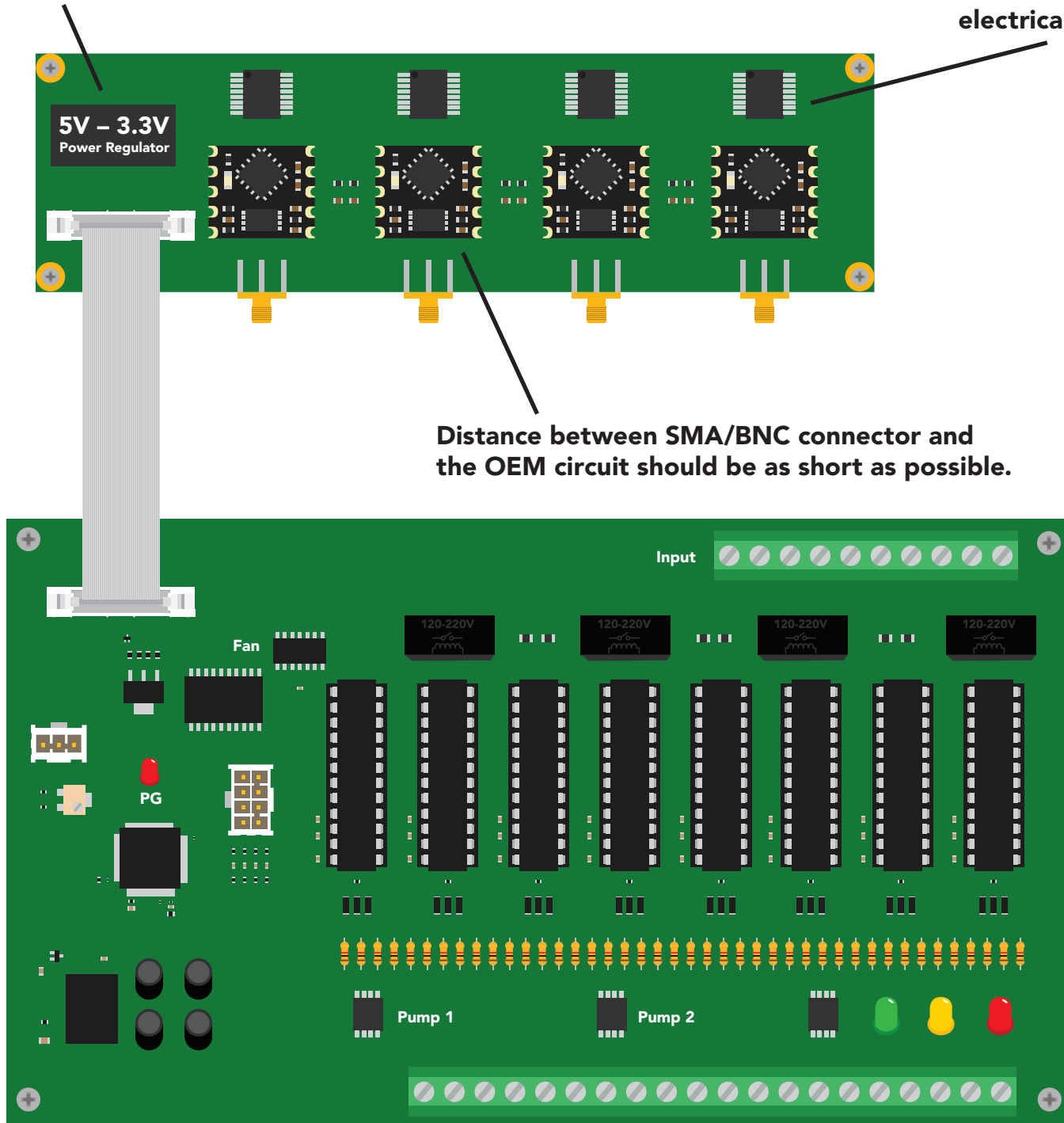
How to add chemical sensing to a complex computer system

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.

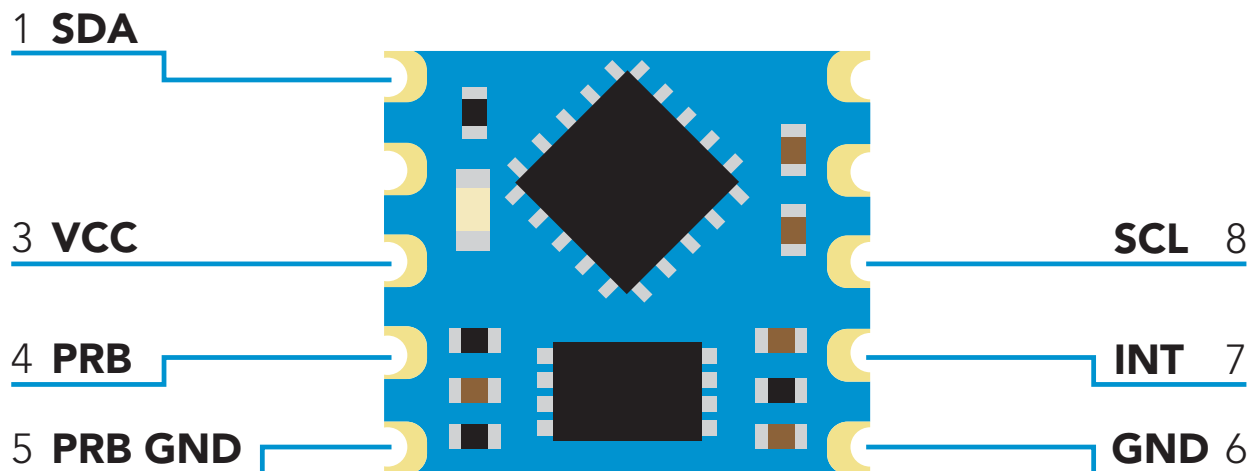
Target customers will experience accurate, stable and repeatable readings for the life of your product.

The sensor board should have it's own power regulator.

All sensors should be electrically isolated.

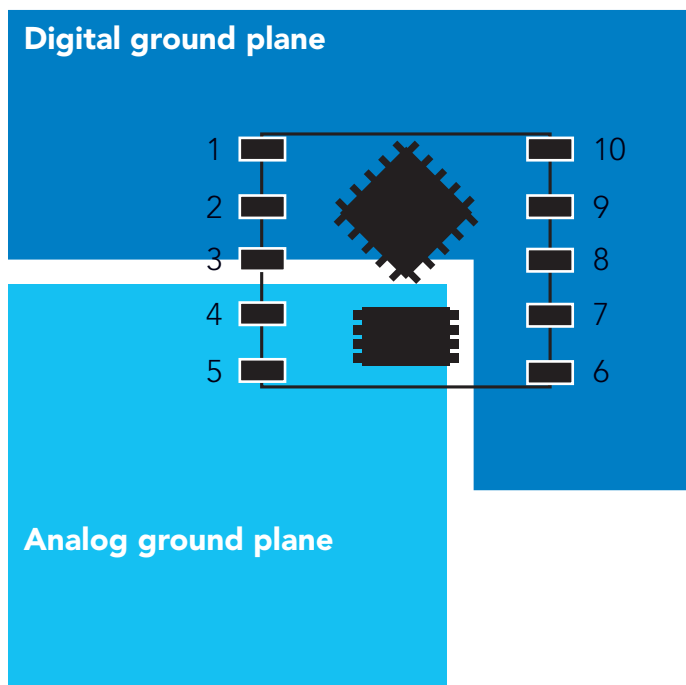


Designing your PCB

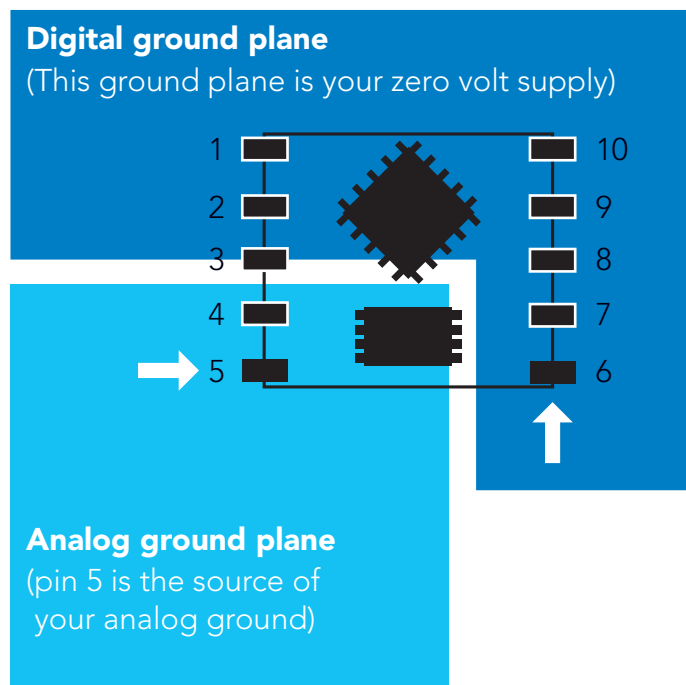


The ORP OEM™ circuit requires two separate ground planes to operate properly. One ground plane is for the digital section of the device, the other is for the analog section.

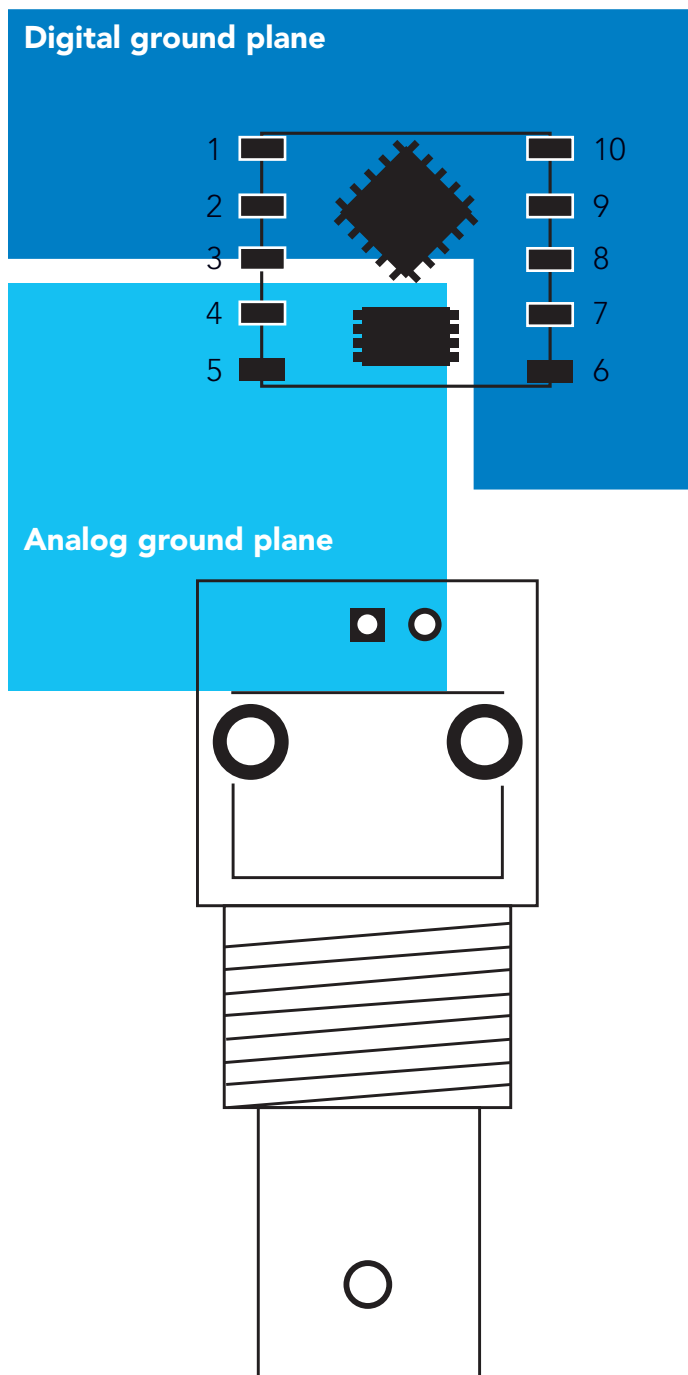
1 Create two double-sided ground planes, just like the image below.



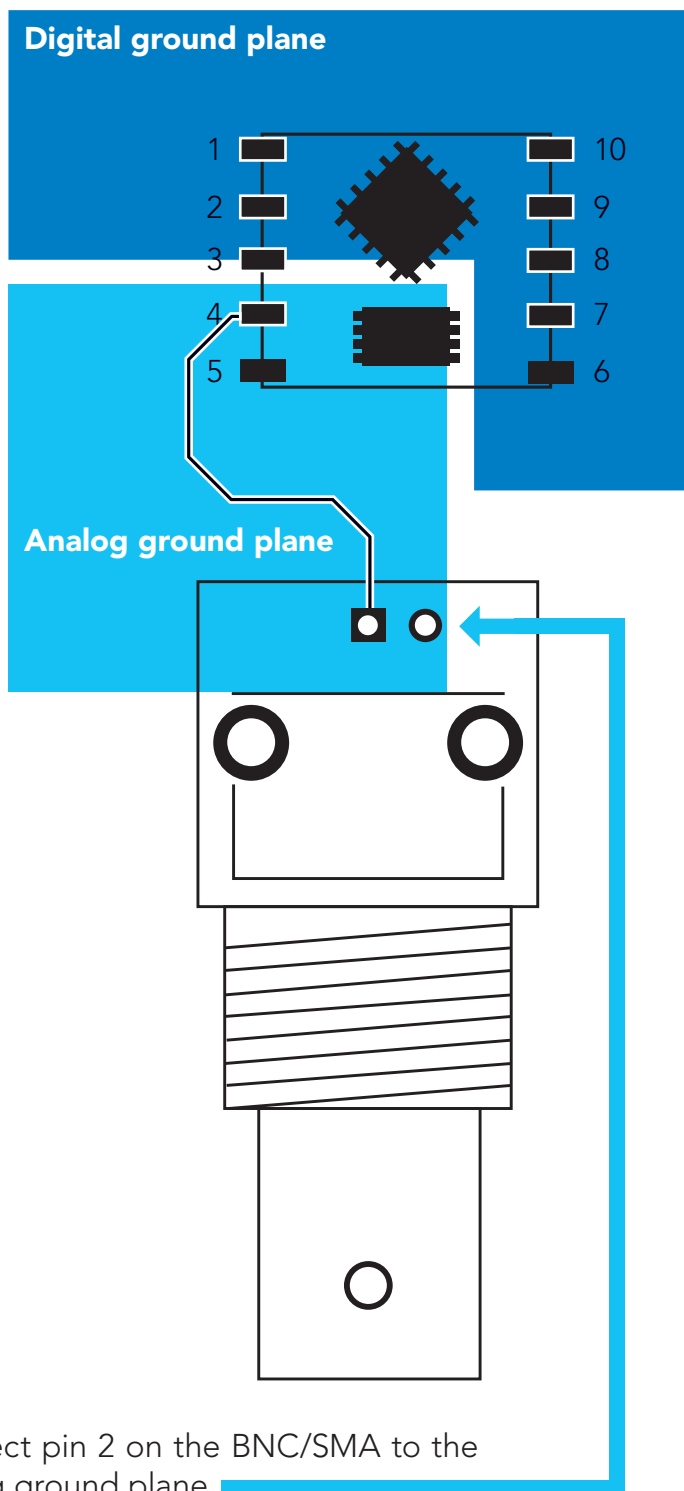
2 Connect pin 5 to the analog ground plane, and pin 6 to the digital ground plane.



- 3** Place the probe connector (BNC/SMA) close to the ORP OEM™ circuit.

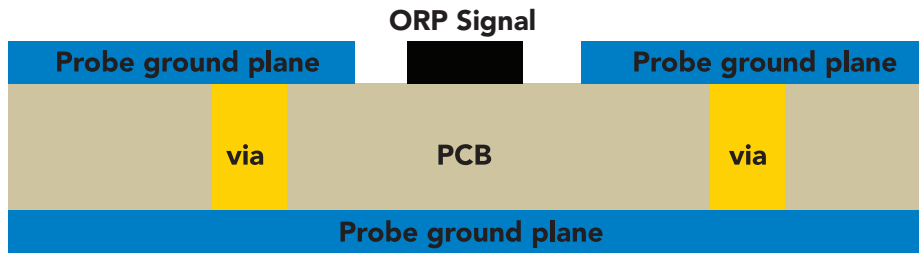


- 4** Using a 0.4mm trace width connect pin 4 (PRB) to pin 1 on the BNC/SMA. Keep this trace as short as possible. This trace is the ORP signal path.



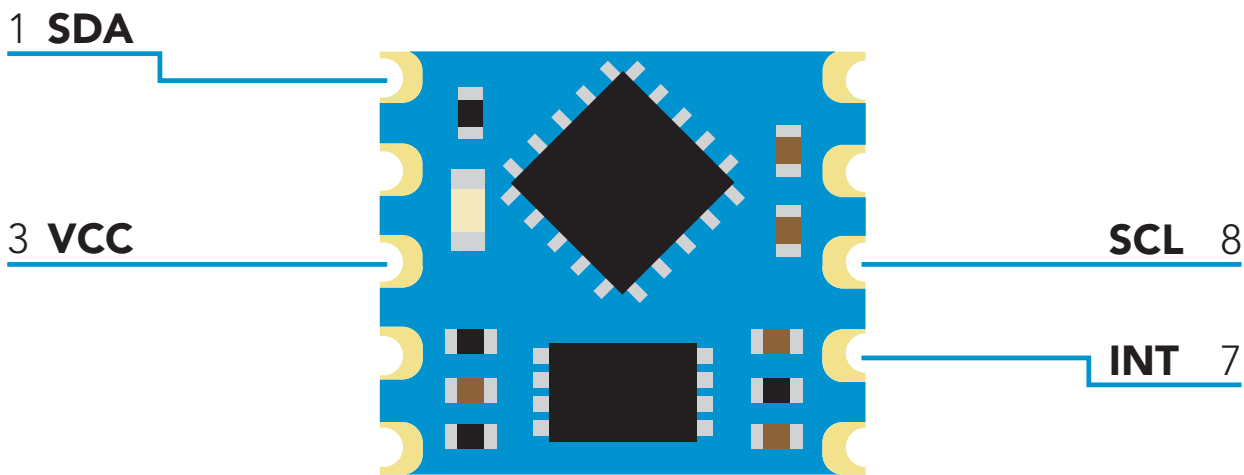
Connect pin 2 on the BNC/SMA to the analog ground plane

Cross section of the ORP signal path

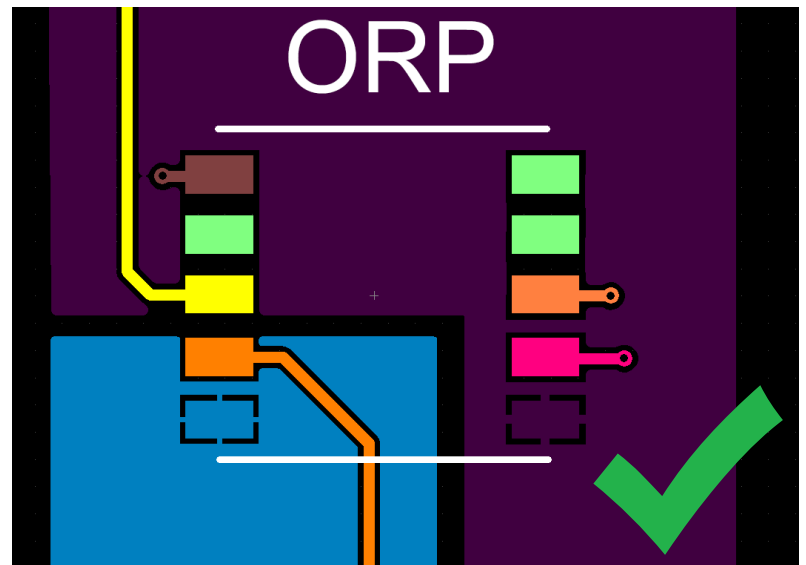
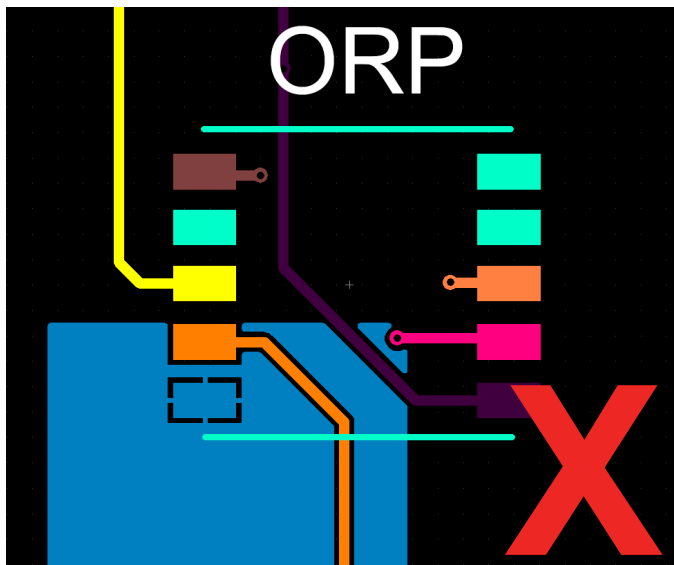


This cross section is an example of how the analog ground plane protects the ORP signal. The analog ground should surround the ORP signal, on both the top and bottom layers.

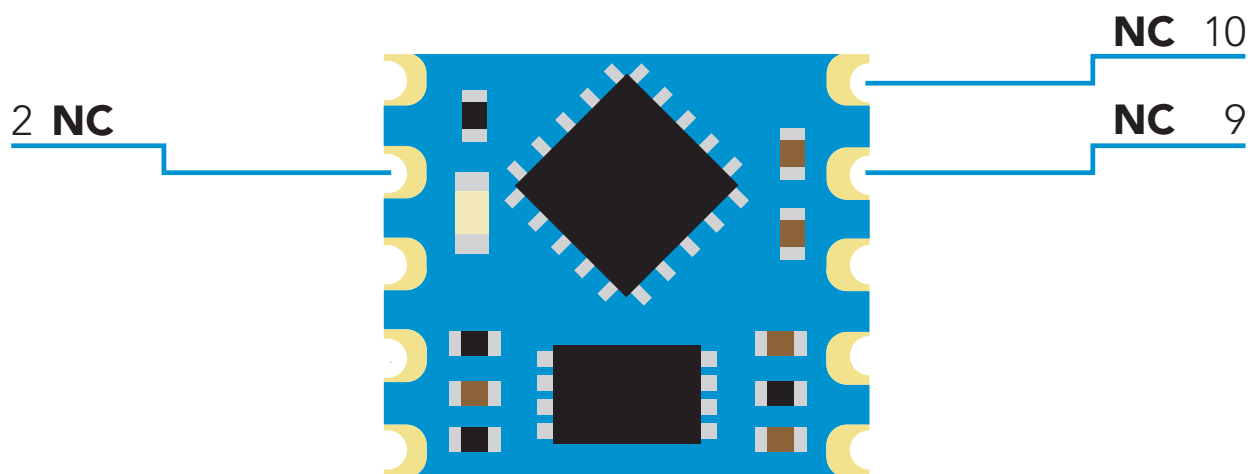
- 5** Rout the other traces as you see fit. If pin 7(INT) is unused leave it floating, *do not* connect pin 7 to VCC or ground.



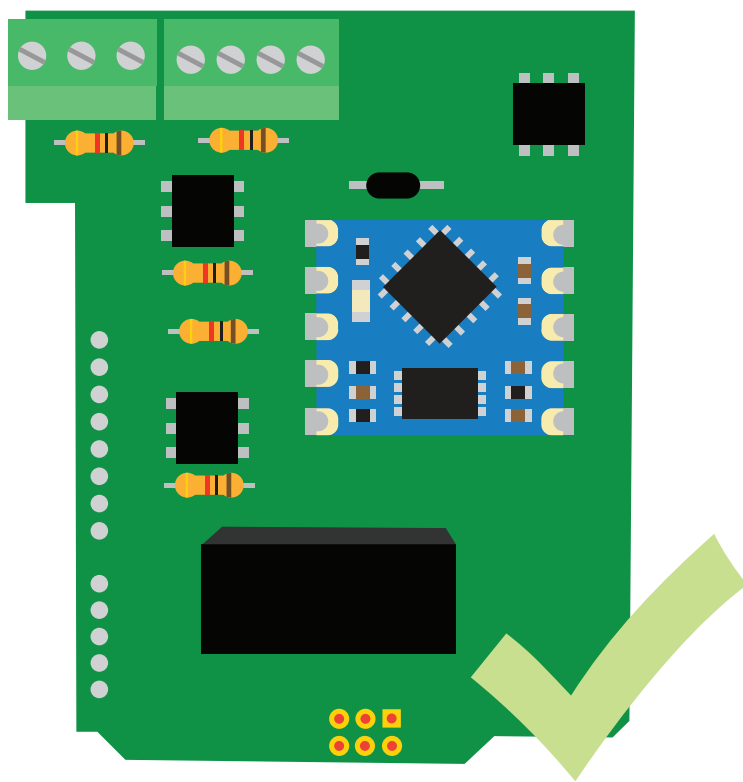
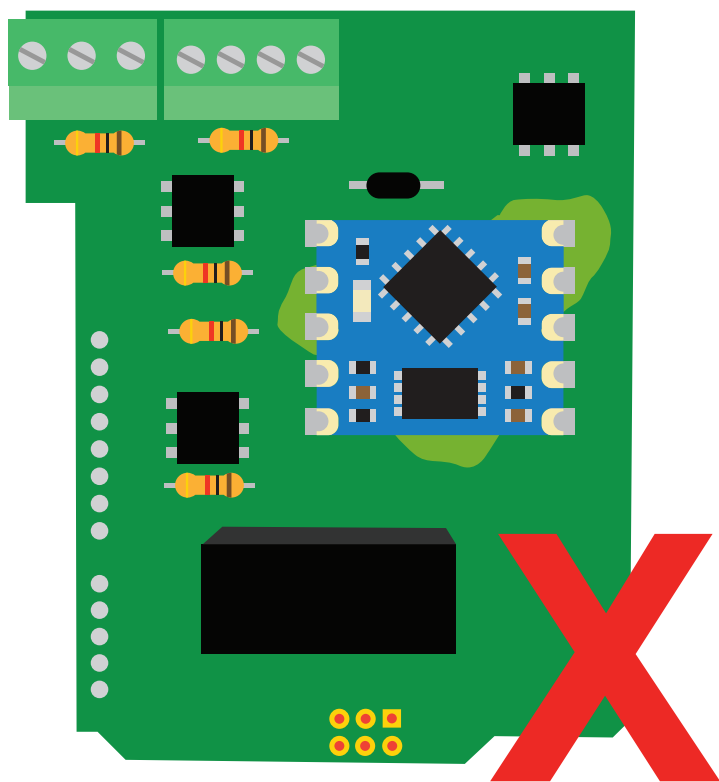
NEVER place vias under the OEM footprint.



- 6** Pins marked NC (No Connect) must be left floating. **NEVER** connect pins marked NC to VCC or ground.



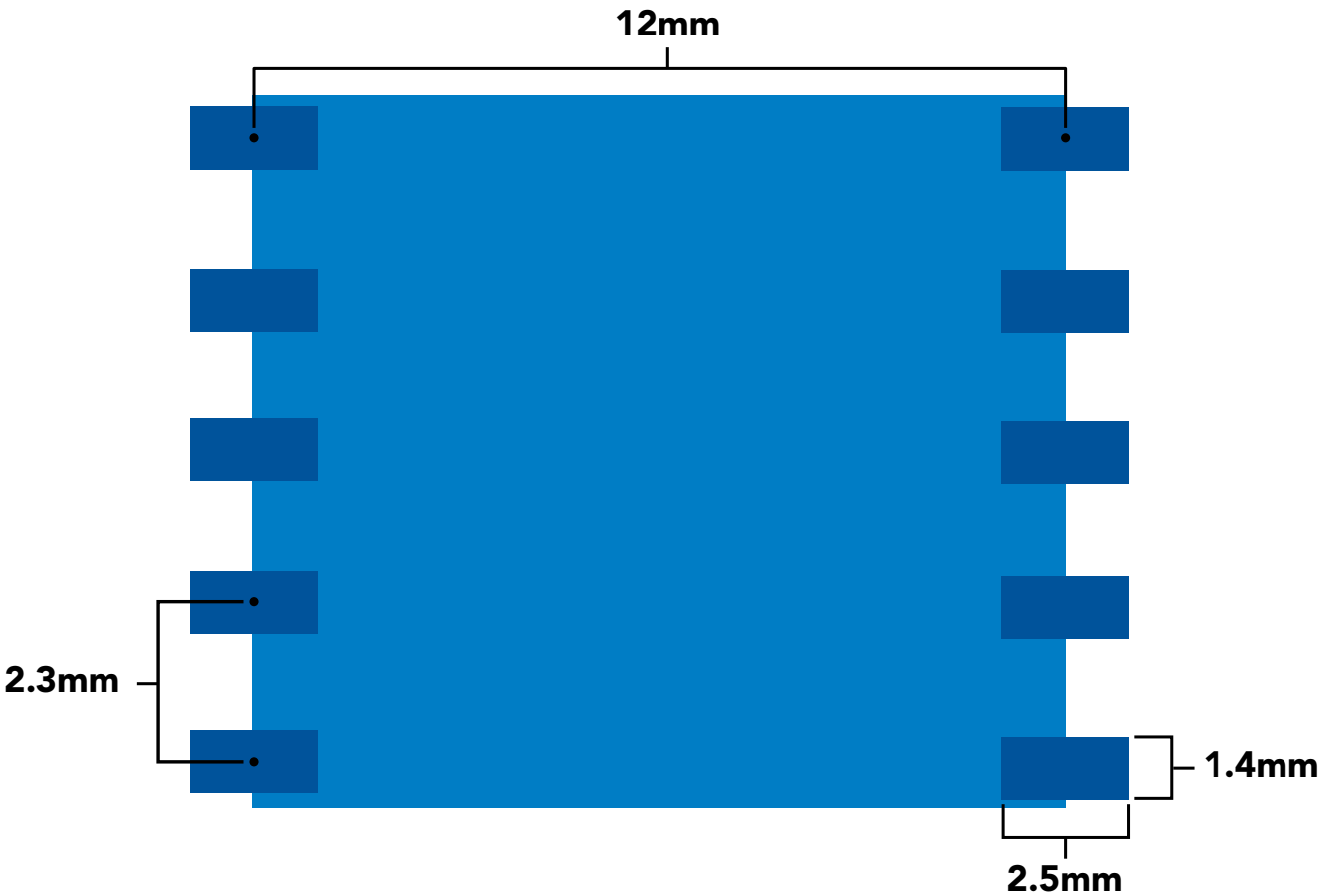
- 7** If the ORP OEM™ circuit is going to be hand soldered, avoid using rosin core solder. Use as little flux as possible. Do not let liquid flux seep under the ORP OEM™ circuit. After the ORP OEM™ circuit has been soldered to the PCB all flux residue **MUST** be removed. Failure to do so will result in poor quality readings.



DO NOT SKIP THIS STEP

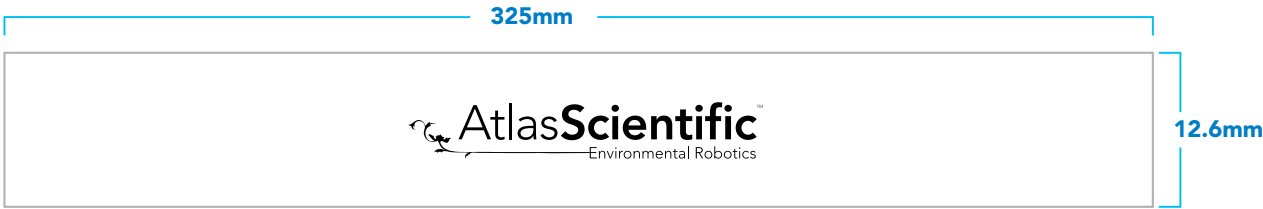
The PCB must be washed with an ultrasonic cleaner, OR cleaned with a commercial flux removing chemical, OR soaked in alcohol for ~20 minutes.

Recommended pad layout

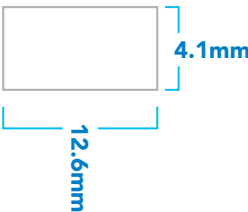


IC tube measurements

Top View



Side View

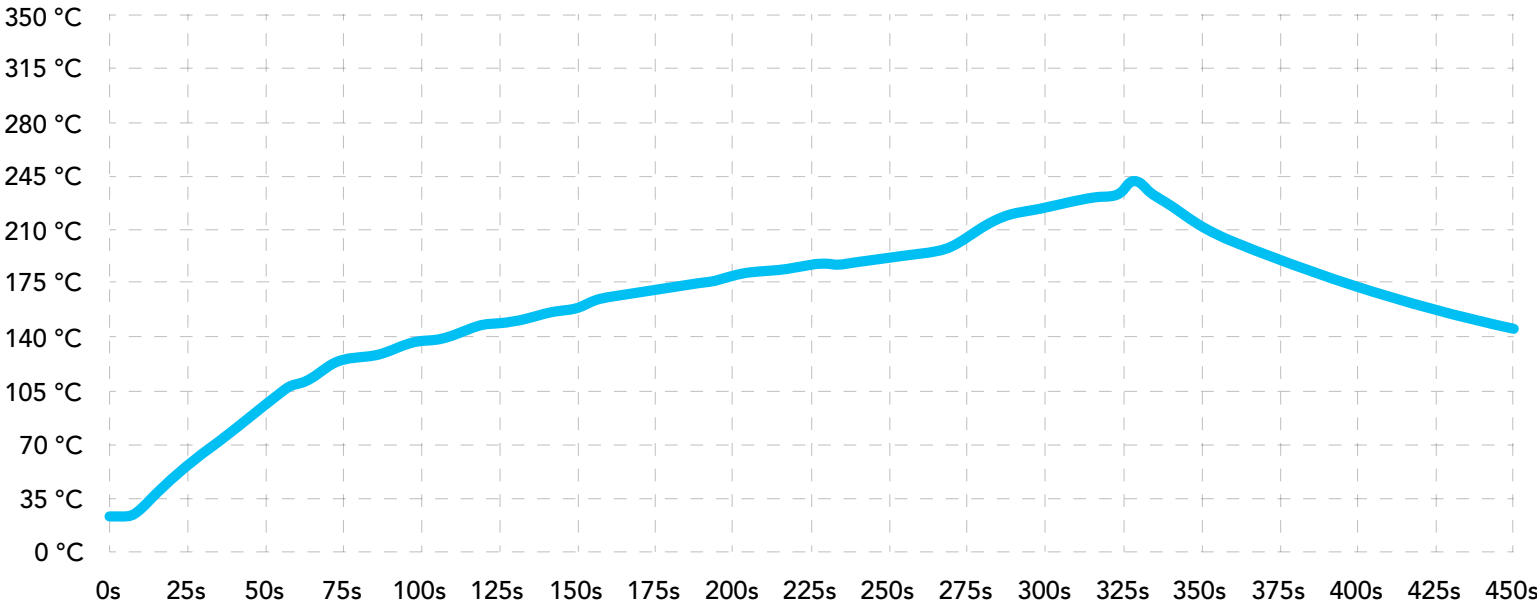


Fits 25 ORP OEM™ circuits

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

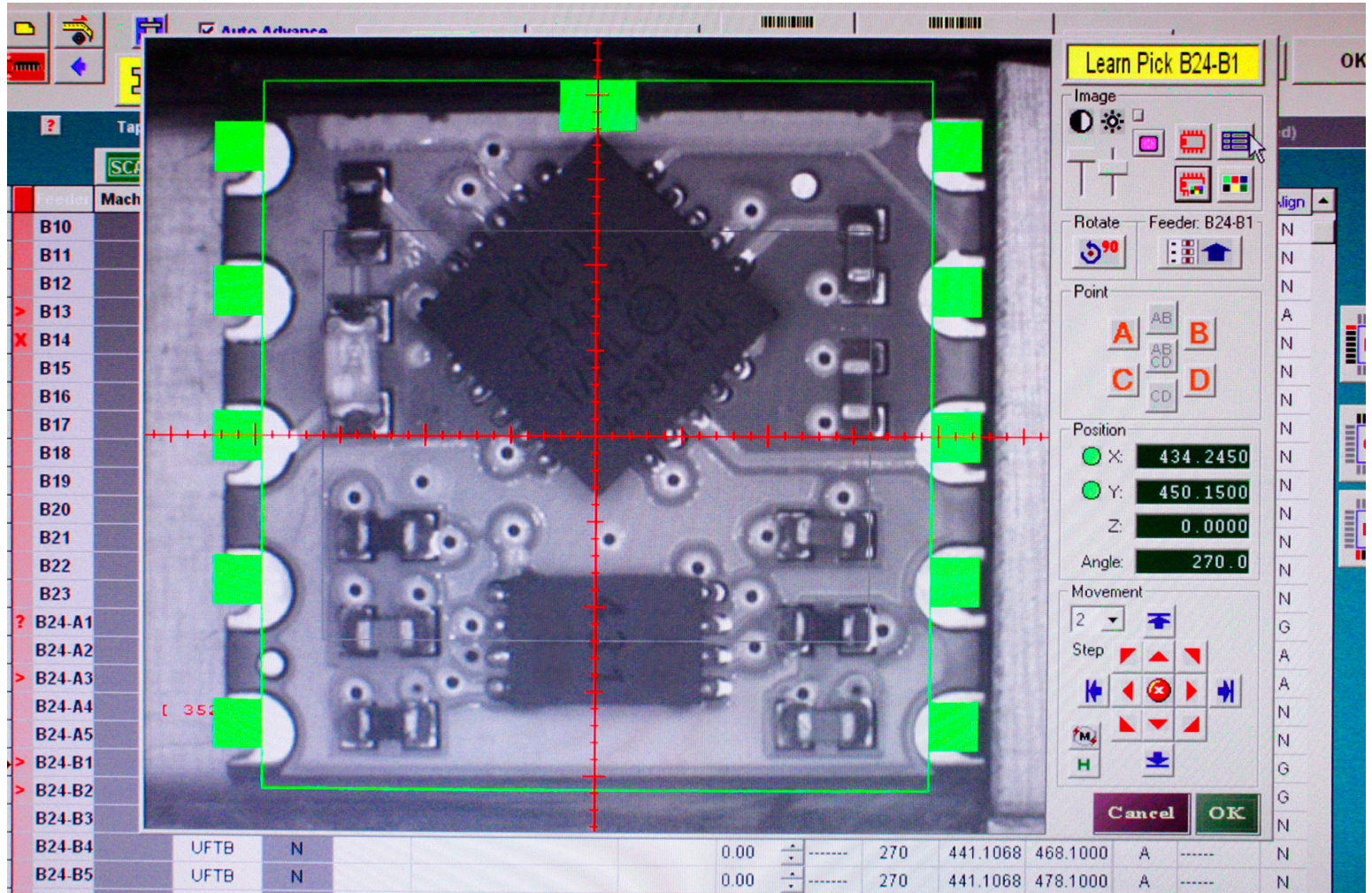
plastic thickness 0.5mm

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 3.0

Added new graphic on pg 3.

Datasheet V 2.9

Revised operating voltages on pages 1 & 4.

Datasheet V 2.8

Revised artwork on pg 7.

Datasheet V 2.7

Added "Designing you product" on pg 23.

Datasheet V 2.6

Changed Calibration Confrim register 0x0D from R/W to R.

Datasheet V 2.5

Expanded upon the "Designing your PCB" section of datasheet, pg. 23

Datasheet V 2.4

Firmware update.

Datasheet V 2.3

Revised isolation schematic on pg. 22

Datasheet V 2.2

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

Datasheet V 2.1

Corrected max rate reading on cover page.

Datasheet V 2.0

Revised entire datasheet

Firmware updates

V4.0 – Initial release (Feb 14, 2016)

V5.0 – (November 27, 2018)

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