AtlasScientific™
Environmental Robotics

ORP Circuit

EZO™

EZO™ class embedded ORP circuit

V 2.9
This is an evolving document
check back for updates.

Features

Reads

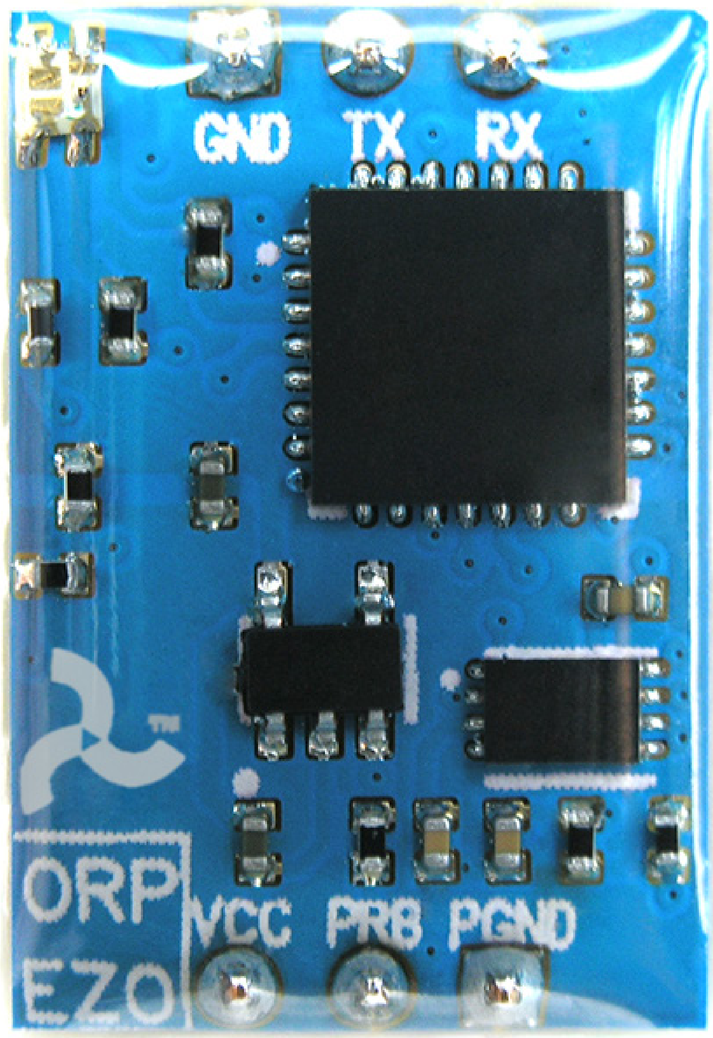
- Wide range ORP readings from -1019.9mV to +1019.9mV
- Accurate ORP readings down to the tenths place **(+/- 1mV)**
- Flexible calibration protocol supports single point calibration to any value
- Calibration required only once per year with
- Atlas Scientific ORP probe
- Single reading or continuous reading modes
- **Data format is ASCII**

Two data protocols

- UART asynchronous serial connectivity
- (RX/TX voltage swing 0-VCC)
- I^2C (default I^2C address 0x62)
- Compatible with any microprocessor that supports UART, or I^2C protocol
- Operating voltage: 3.3V to 5V
- Works with any off-the-shelf ORP probe

Sleep mode power consumption

- 0.995mA at 3.3V



Patent pending

Description

The Atlas Scientific™ EZO™ class embedded ORP circuit, is our 6th generation embedded ORP circuit. This EZO class ORP circuit, offers the highest level of stability and accuracy. With proper configuration the EZO class ORP circuit, can meet, or exceed the accuracy and precision found in most bench top laboratory grade ORP meters. The ORP-EZO™ ORP circuit, can work with any off-the-shelf ORP probe/sensor/electrode. This device reads ORP from an ORP probe/sensor/electrode. This device does not include an ORP probe/sensor/electrode.

Atlas**Scientific**™
Environmental Robotics

ORP Circuit

EZO™

STOP

This is sensitive electronic equipment. Get this device working in a solderless breadboard first. Once this device has been soldered it is no longer covered by our warranty.

This device has been designed to be soldered and can be soldered at any time. Once that decision has been made, Atlas Scientific no longer assumes responsibility for the device's continued operation. The embedded systems engineer is now the responsible party.

Atlas Scientific
Environmental Robotics

ORP Circuit

EZO™

Contents

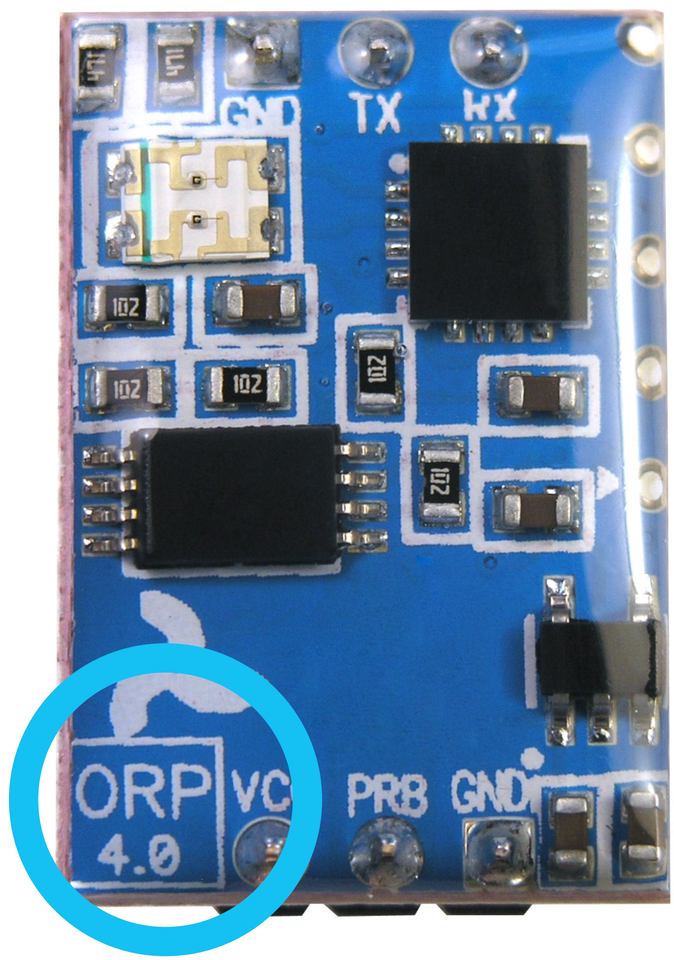
UART Mode

I²C Mode

Circuit identification

EZO™ Class Circuit

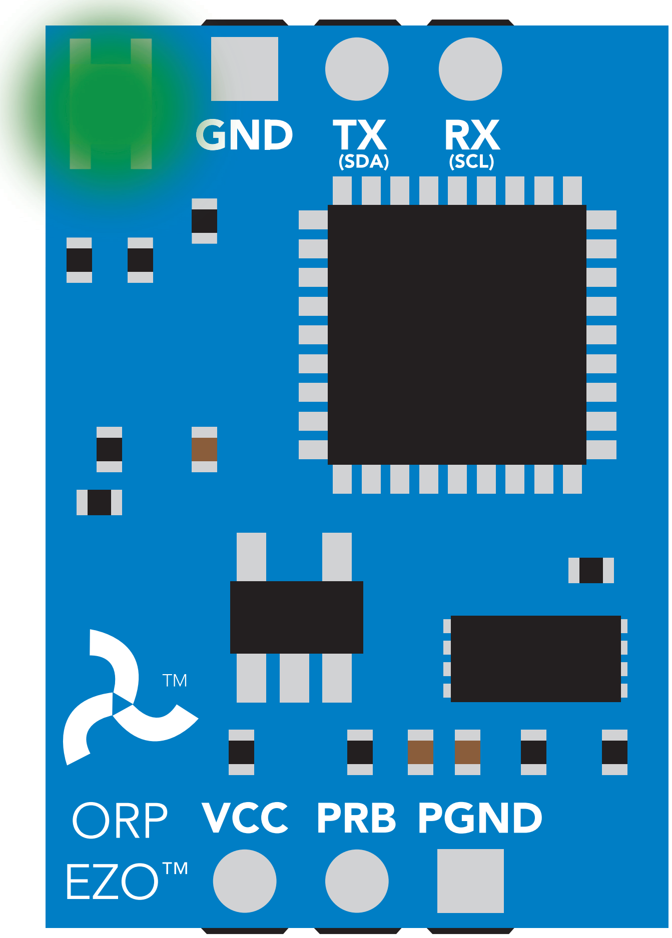
If your Atlas Scientific™ ORP Circuit says "ORP EZO" you are viewing the correct datasheet.



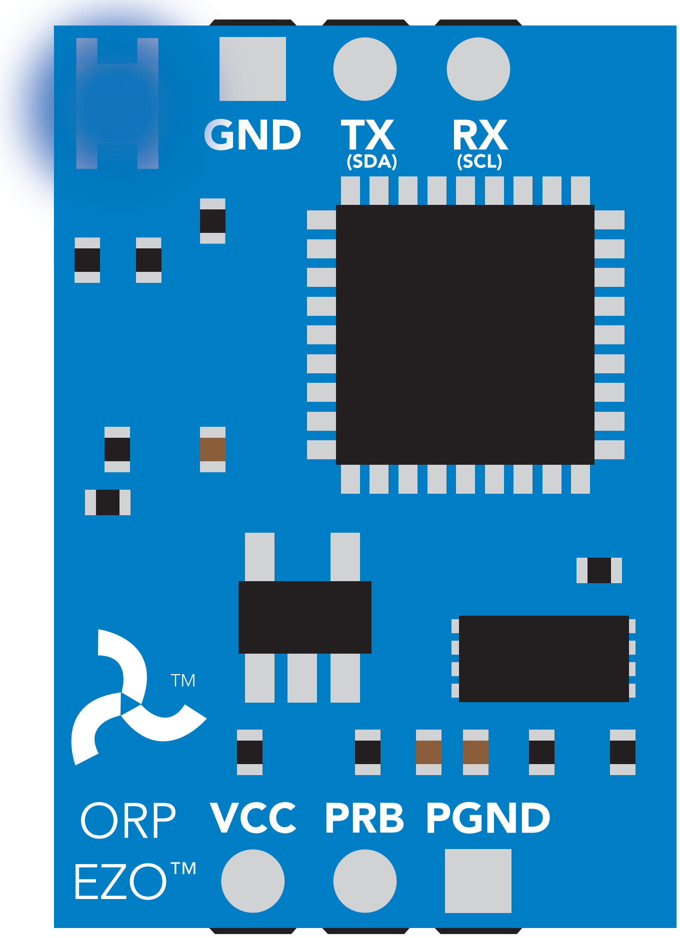
Legacy Circuit

If your Atlas Scientific™ ORP Circuit says "ORP 2.0, 3.0, or 4.0," you are viewing the *incorrect datasheet*. Many functions will not will not work on legacy circuits.

To view the legacy datasheet **click here**.



UART Mode



I^2C Mode

System overview

The EZO™ class ORP circuit, is a small footprint computer system that is specifically designed to be used in robotics applications where the embedded systems engineer requires accurate and precise measurements of the oxidation reduction potential. The ORP circuit will output readings from -1019.9mV to +1019.9mV.

The EZO™ class ORP circuit, is capable of reading ORP down to the tenths place.

Example:

ORP=124.7

ORP is a complex measurement and should not be compared to straight-forward pH measurement. Microscopic manufacturing difference in OPR probes, monomolecular oxide layers forming on the sensor and interferences from organics, sulphides, and bromide make it likely that two ORP probes will not provide the same measurement results in similar samples.

Power consumption

	LED	MAX	STANDBY	SLEEP
5V	ON	18.3 mA	16 mA	1.16 mA
	OFF	13.8 mA	13.8 mA	
3.3V	ON	14.5 mA	13.9 mA	0.995 mA
	OFF	13.3 mA	13.3 mA	

Absolute maximum ratings*

Parameter	MIN	TYP	MAX
Storage temperature (EZO™ ORP circuit)	-65 °C		125 °C
Operational temperature (EZO™ ORP circuit)	-40 °C	25 °C	85 °C
VCC	3.3V	3.3V	5.5V

***Note:** Stresses above those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. Exposure to maximum rating conditions for extended periods may affect device reliability.

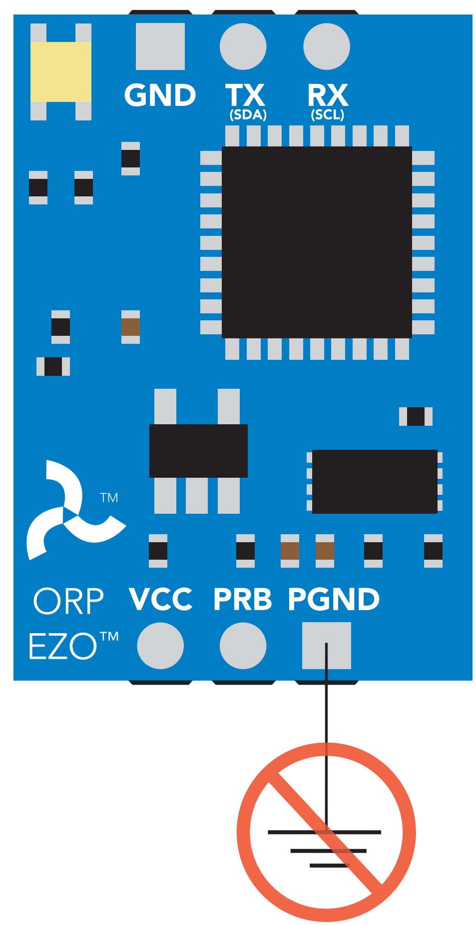
Pin Out

GND Return for the DC power supply

Vcc Operates on 3.3V – 5.5V

TX / SDA All EZO™ class circuits can operate in either UART mode, or I^2C mode

The default state is UART mode.
In UART mode, this pin acts as the transmit (TX) line. The default baud rate is 9600, 8 bits, no parity, no flow control, one stop bit. If standard RS232 voltage levels are desired, connect an RS232 converter such as a MAX232. If the devices is in I^2C mode, this pin acts as the Serial Data Line (SDA). The I^2C protocol requires an external pull up resistor on the SDA line (resistor not included).



RX / SCL All EZO™ class circuits can operate in either UART mode, or I^2C mode.

The default state is UART mode. In UART mode, this pin acts as the receive (RX) line. If the devices is in I^2C mode, this pin acts as the Serial Clock Line (SCL). The I^2C protocol requires an external pull up resistor on the SCL line (resistor not included).

PRB This pin connects to the output lead of a ORP probe/sensor/electrode

PGND This pin connects to the ground lead of a ORP probe/sensor/electrode

This pin is not ground.
Do not tie this pin to system ground

Device operation

When an EZO™ class circuit is first powered up the boot sequence will begin. This is indicated by the LED moving from **Red** to **Green** to **Blue**. The boot up sequence takes 1 second. Once the device has booted up the circuit will output:

*RS<CR>
*RE<CR>
Indicating the device is ready for operation.

The LED will enter its default blink pattern *(see page 10)* indicating the device is operational and actively taking readings.

Default state

Mode
UART

Baud rate
9600 bps
8 data bits
1 stop bit
no parity
no flow control

Reading time
1 reading every second

Probe type
Any off the shelf single, or double junction ORP probe/sensor/electrode

LEDs:
Enabled
Steady **Green**= Power on/ standby
Red double blink = Command received and not understood
Green double blink per data packet = Continuous data streaming
Cyan = taking a reading

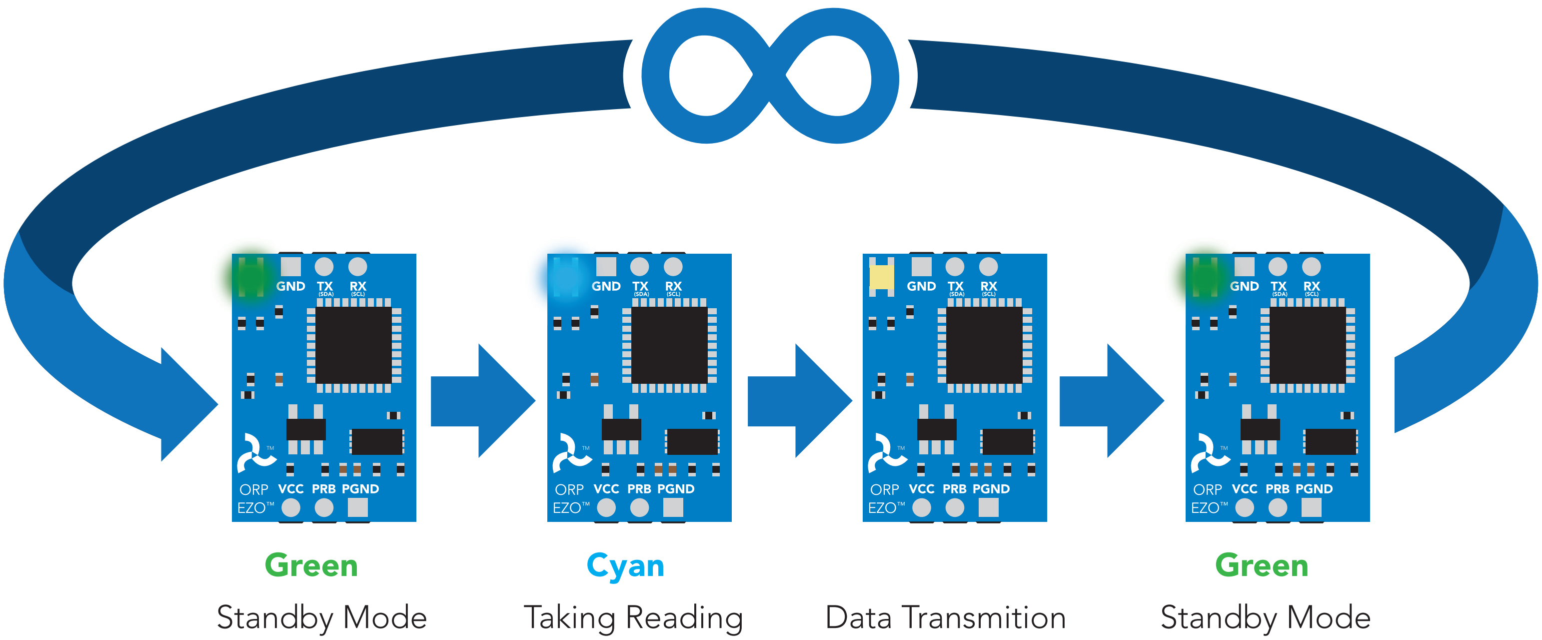
Data output
ORP

Units	Data Type	Format
mV	Floating point	String

Encoding
ASCII characters followed by a carriage return <CR>
Maximum string length: 10 characters

If the response code is enabled the EZO™ class circuit will respond "*OK<CR>" after a command is acknowledged. If an unknown command is sent the ORP Circuit will respond "*ER<CR>" this will happen whether or not response codes are enabled.

Default LED blink pattern



This is the LED pattern for Continous Mode (which is the default state)

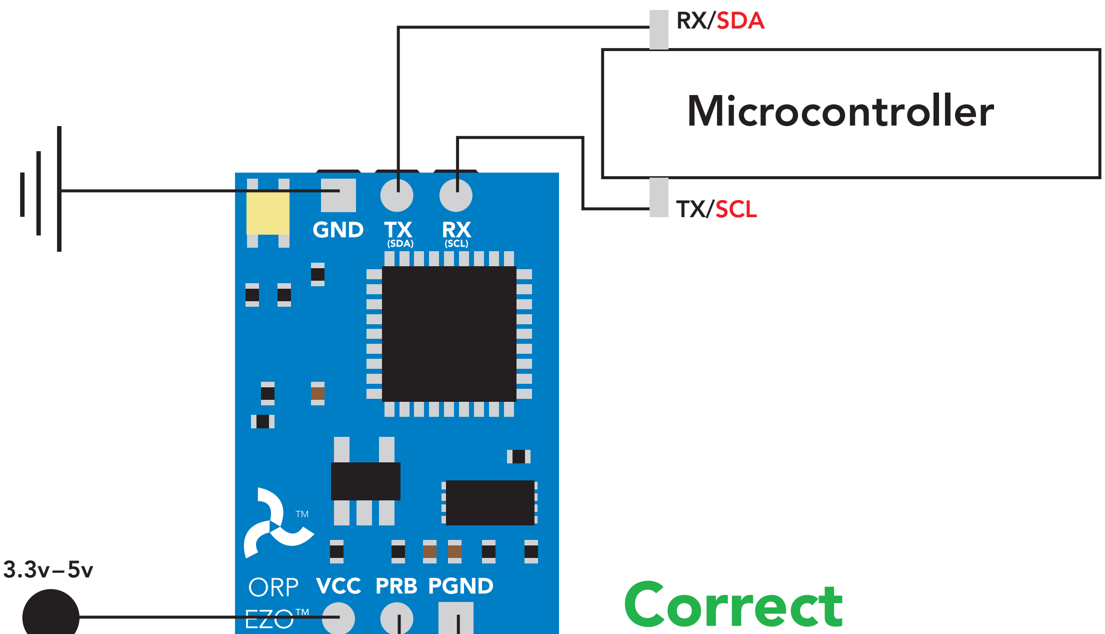
Calibration theory

The Atlas Scientific EZO™ class ORP circuit has a flexible calibration protocol, allowing single point calibration to any off the shelf calibration solution.

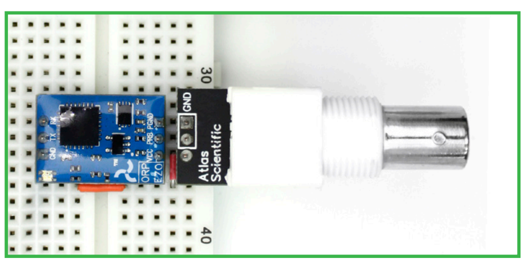
If the EZO™ class ORP circuit is being used with an Atlas Scientific ORP probe calibration can typically be done once per year. If the ORP that is being read is continuously on the extremes of the scale (around -900mV or +900mV) calibration may have to be done more often. The exact frequency of calibration will have to be determined by your engineering team.

Wiring diagram

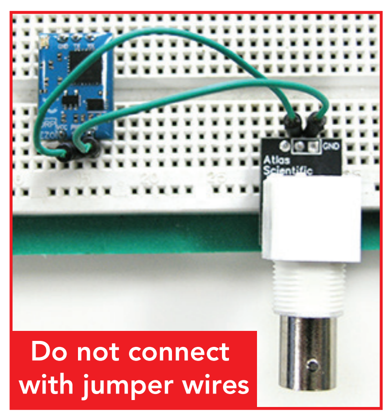
- To connect the Circuit to your microcontroller, follow the diagram below.
- Make sure your Circuit and microcontroller share a common ground.
- TX on your Circuit connects to RX on your microcontroller.
- If in I²C mode connect SDA to SDA and SCL to SCL
- *4.7k pull up resistor on SDA and SCL may be required

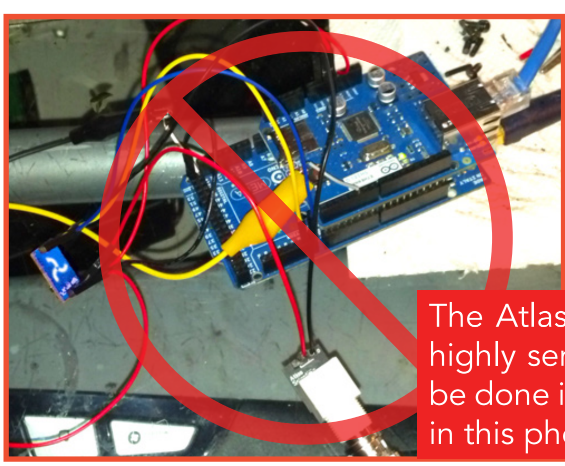


Correct

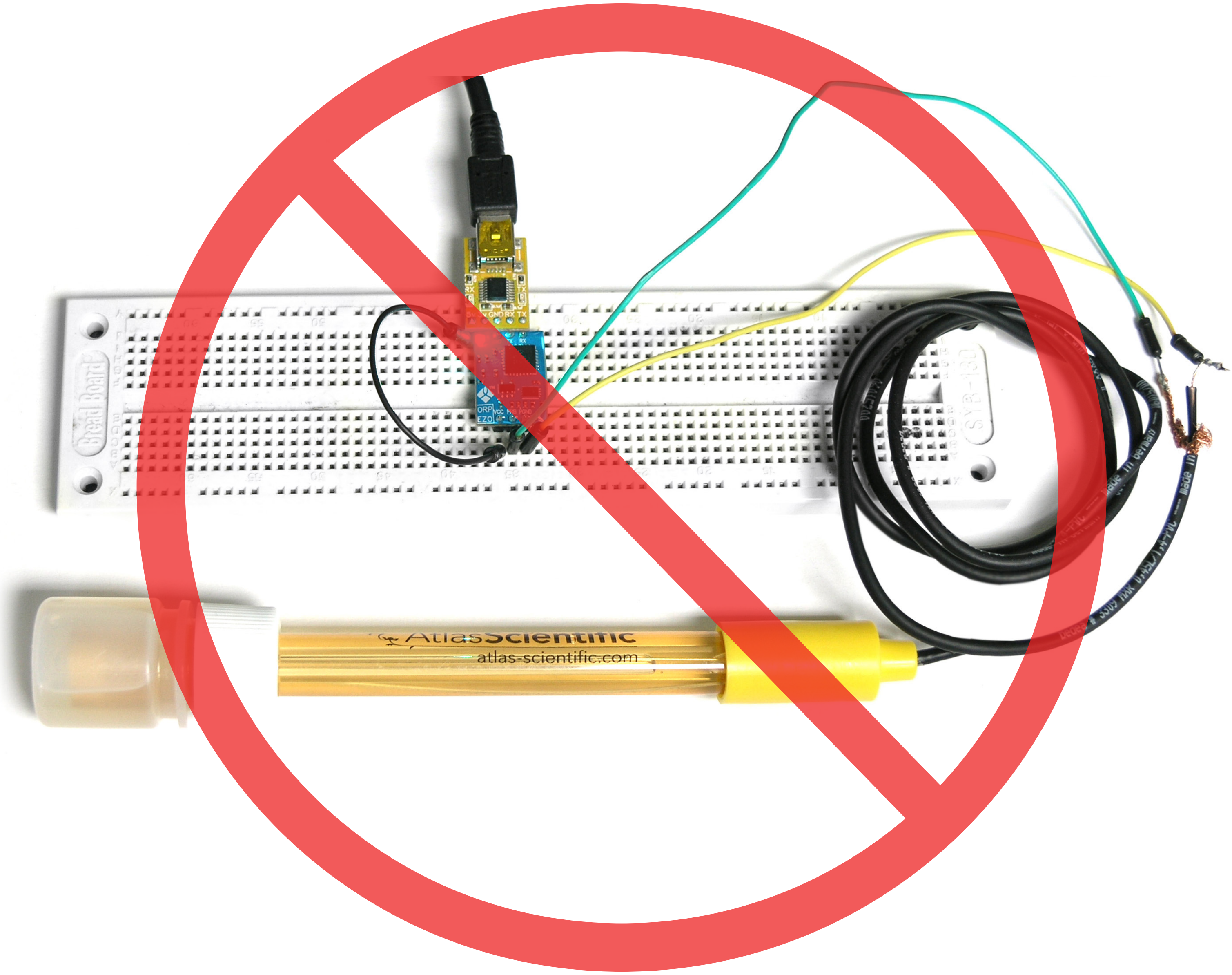


Incorrect



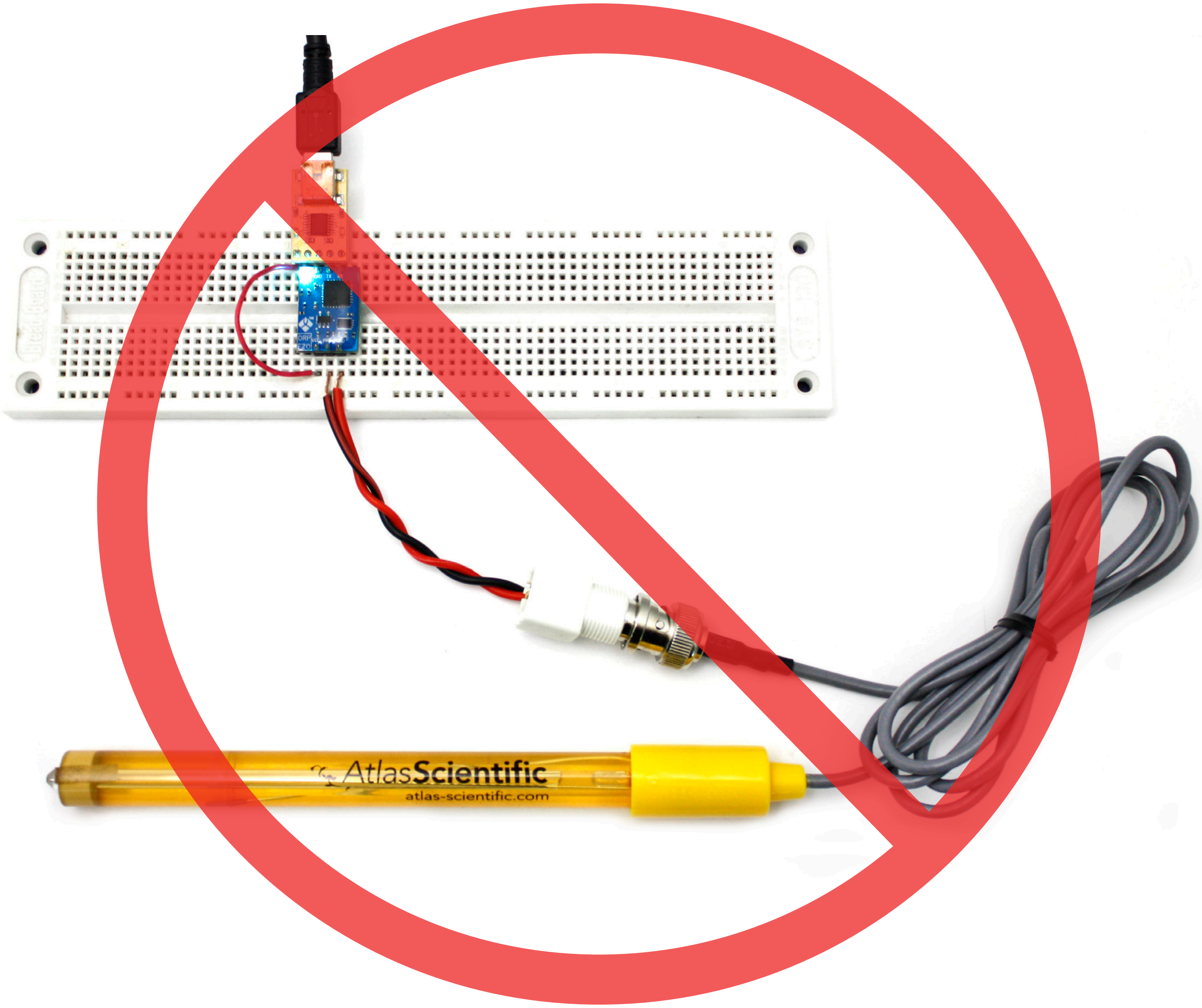


The Atlas Scientific™ EZO™ class ORP circuit is highly sensitive equipment. Debugging should be done in a bread board; Not like what is show in this photo.



DO NOT CUT THE CABLE WITHOUT REFERING TO THIS DOCUMENT!

NEVER EXTEND THE CABLE WITH CHEAP JUMPER WIRES.



DO NOT MAKE YOUR OWN UNSHIELDED CABLES REFERING TO THIS DOCUMENT!

NEVER EXTEND THE CABLE WITH CHEAP JUMPER WIRES.
ONLY USE SHIELDED CABLES

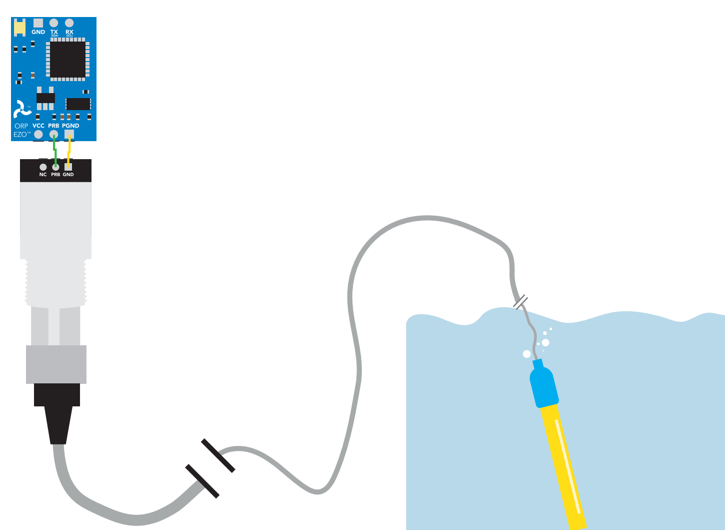
Design considerations

The Atlas Scientific EZO™ ORP circuit is a micro-computer system that is specifically designed to be embedded into a larger system. The EZO™ ORP circuit is not a completed product. The embedded systems engineer is responsible for building a completed working product.

Power and data isolation

The Atlas Scientific EZO™ ORP circuit is a very sensitive device. This sensitivity is what gives the ORP circuit its accuracy. This also means that the ORP circuit is capable of reading micro-voltages that are bleeding into the water from unnatural sources such as pumps, solenoid valves or other sensors.

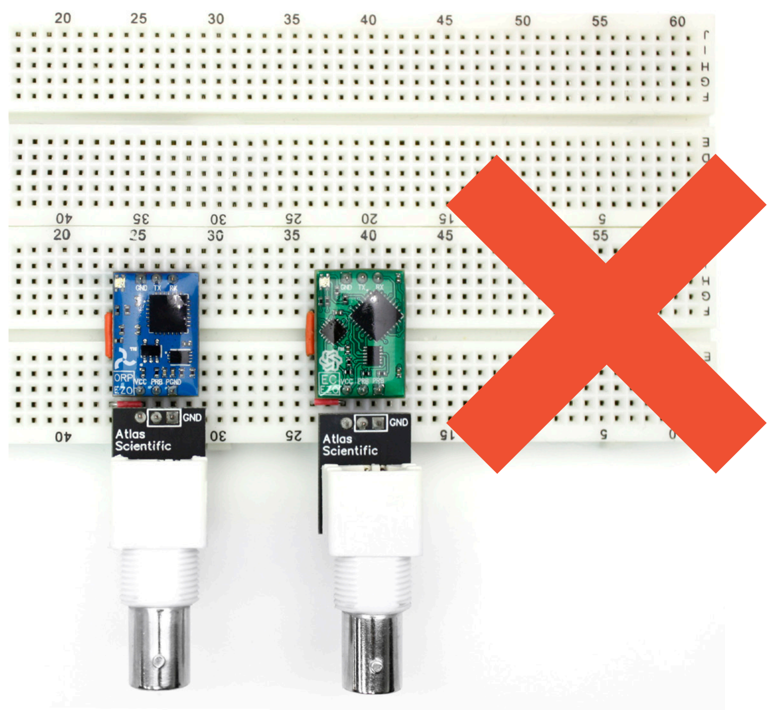
When electrical noise is interfering with the ORP readings it is common to see rapidly fluctuating readings or readings that are consistently off. To verify that electrical noise is causing inaccurate readings place the ORP probe in a cup of water by itself. The readings should stabilize quickly, confirming that electrical noise was the issue.



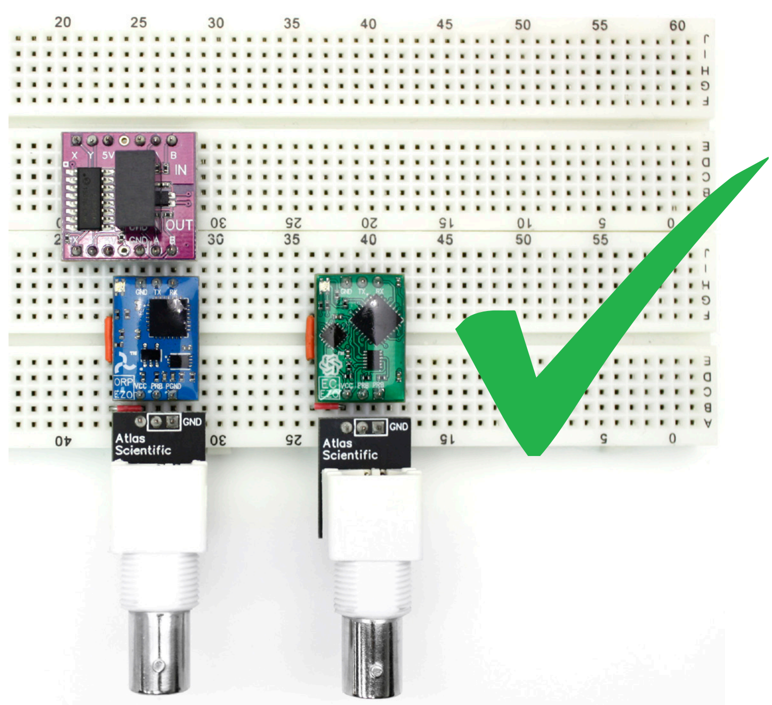
When reading ORP and Conductivity together, it is strongly recommended that the EZO™ ORP circuit is electrically isolated from the EZO™ Conductivity circuit.

Without isolation, Conductivity readings will effect ORP accuracy.

Incorrect



Correct



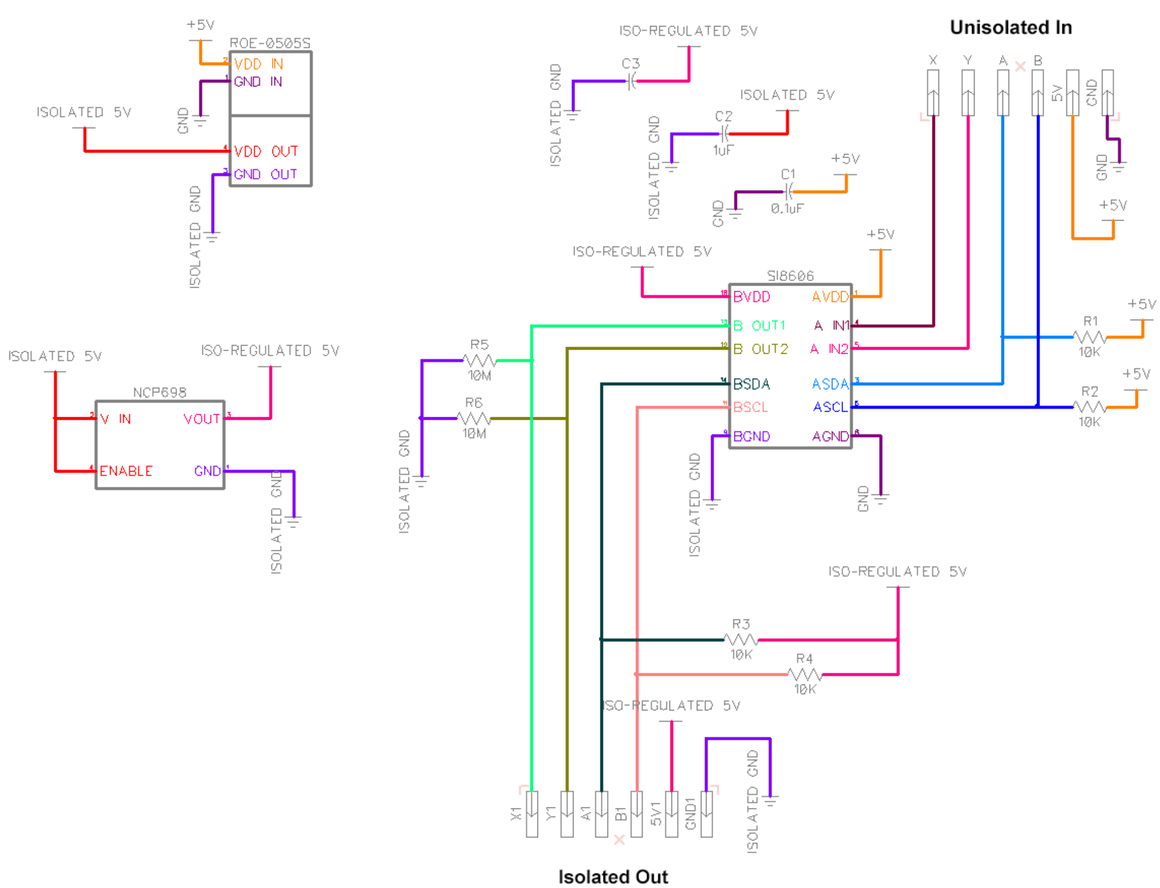
To correct this problem the power and data lines need to be electrically isolated. There is no one single method of doing this. This is just one of many ways to do so.

This schematic shows exactly how we isolate data and power using two parts, the data isolator part # SI8606, and the Power isolator part # ROE-0505S.

The SI8606 is a digital isolator with two bidirectional channels, which makes it excellent for use with I²C and UART protocols. This Part requires isolated power and pull ups on both channels on the isolated and non-isolated inputs. Pull up resistors can be anything from 3k to 10k.

The ROE-0505s is an isolated DC/DC converter that can handle 5V @ 1W. This part uses a Transformer that provides a 1:1 ratio (5V in and 5v out) however we have seen that 5V in produces 5.4V out and we recommend using a 5V regulator on its output. We use part# NCP698SQ50T1G.

Note: the Isolated Ground is different from the non-isolated Ground, these two lines should not be connected together.



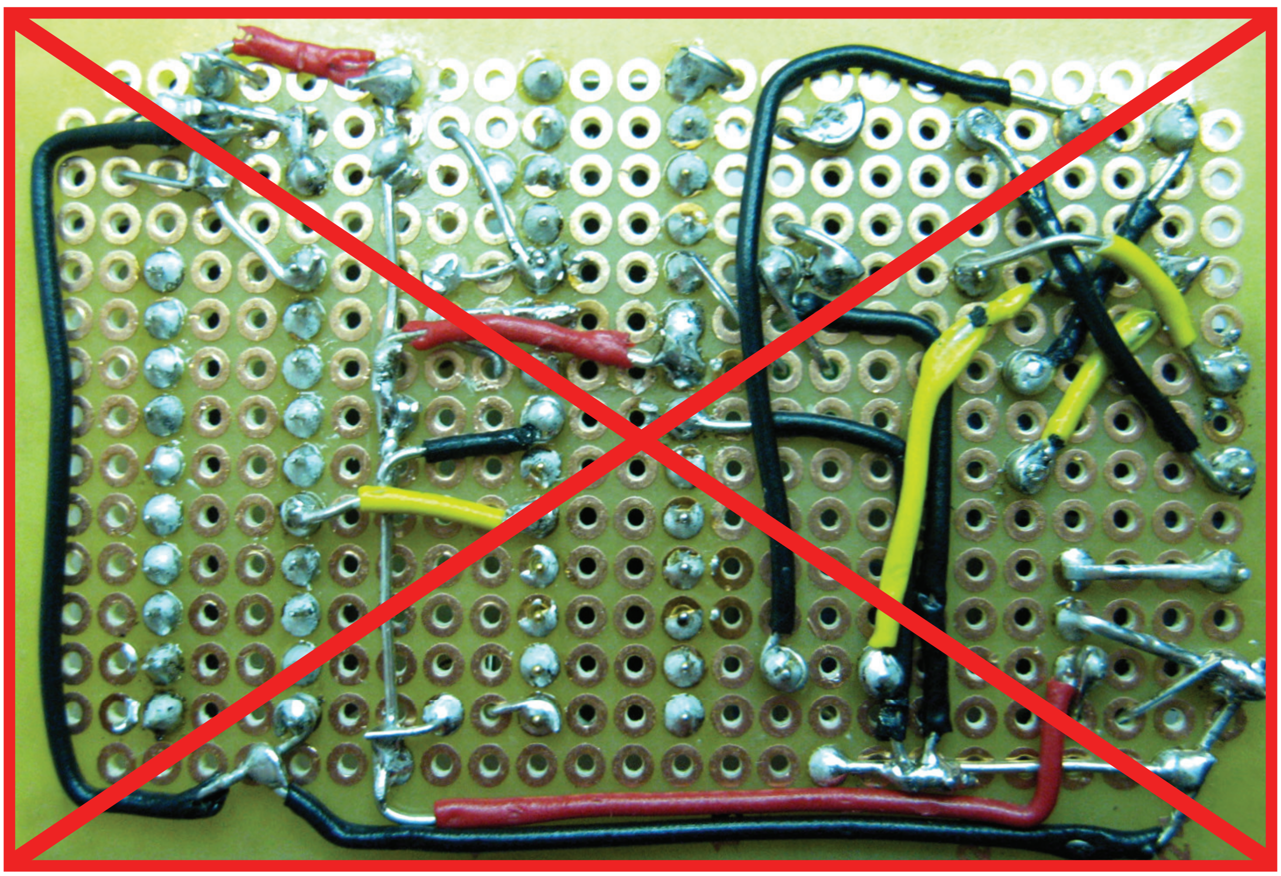
Board mounting

The Atlas Scientific EZO™ ORP circuit should be tested in a **bread board** with different colored jumper wires connecting to each pin of the EZO™ ORP circuit.

The EZO™ ORP circuit should not have wires for other devices in your system laying on top of it.

If long term use is desired a PCB should be made to hold the device.

Perfboards *(sometimes called Protoboards)* should never be used.



Micro-shorts and bleeding voltages are very common when using such boards. Achieving stable reading can be quite difficult or impossible.

Perfboards *(sometimes called Protoboards)* will void your devices warranty. No support will be given.

AtlasScientific™
Environmental Robotics

ORP Circuit
EZO™

UART Mode

™

UART mode command quick reference

There are a total of 13 different commands that can be given to the EZO™ class ORP circuit.

All commands are ASCII strings or single ASCII characters

Command	Function	Default state
C	Enable / Disable or Query continuous readings (pg.21)	Enabled
Cal	Performs calibration (pg.23)	User must calibrate
Factory	Factory reset (pg.29)	N/A
I	Device information (pg.24)	N/A
I2C	Sets the I²C ID number (pg.30)	Not set
L	Enable / Disable or Query the LEDs (pg.20)	LEDs Enabled
Name	Set or Query the name of the device (pg.24)	Not set
Plock	Enables / Disables the protocol lock feature (pg.32)	Disabled
R	Returns a single reading (pg.22)	N/A
Response	Enable / Disable or Query response code (pg.25)	Enabled
Serial	Set the baud rate (pg.28)	9600
Sleep	Enter low power sleep mode (pg.27)	N/A
Status	Retrieve status information (pg.26)	N/A

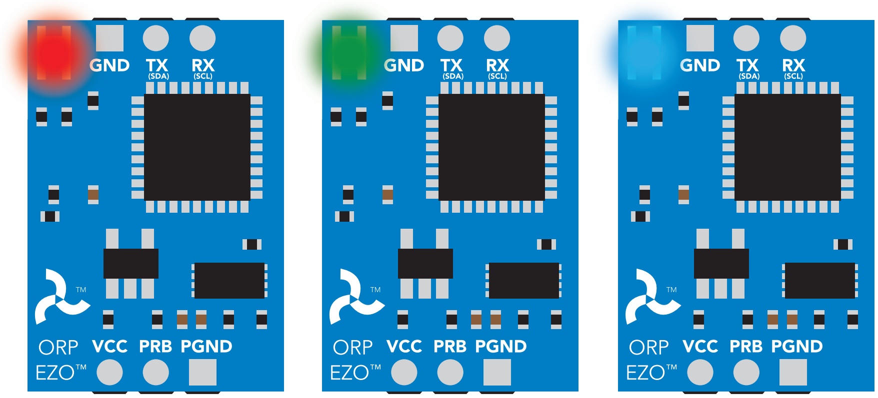
UART command definitions

<CR> represents a carriage return (ASCII 13). The user does not transmit the literal string "<CR>".
Commands are not case sensitive.

LED control

All EZO™ class circuits have a tri-color LED, used to indicate device operation.

UART mode LED color definitions:
Steady **Green**= Power on/ standby
Red double blink = Command received and not understood
Green blink=Data transmission sent
Cyan= taking a reading



Command syntax

L,1<CR> LED enable
L,0<CR> LED disable
L,? <CR> Query the LED

Device response

L,1 <CR>
(If the response code is enabled, the EZO™ class circuit will respond "*OK<CR>")
The Led will be enabled and the green power on/ standby LED will turn on

L,0 <CR>
(If the response code is enabled, the EZO™ class circuit will respond "*OK<CR>")
The Led will be disabled

L,? <CR>
(If the response code is enabled, the EZO™ class circuit will respond "*OK<CR>")
?L,1<CR> if the LED is enabled
?L,0<CR> if the LED is disabled

<CR> represents a carriage return (ASCII 13). The user does not transmit the literal string "<CR>". Commands are not case sensitive.

Continuous reading mode

All EZO™ class circuits are capable of continuous mode operation. In continuous mode, the device will output its readings, one after the other continuously until the continuous mode disable command has been issued. All EZO™ class circuits are defaulted to operate in continuous mode. If the LEDs are enabled, each time a data transmission occurs, the green LED will blink.

Command syntax

C,1<CR> Continuous mode enable
C,0<CR> Continuous mode disable
C,?<CR> Query continuous mode

Device response

C,1 <CR>
(If the response code is enabled, the EZO™ class circuit will respond "*OK<CR>")
The EZO™ class ORP circuit, will output a numeric string containing the ORP once per second

ORP<CR> (1 second)
ORP<CR> (2 seconds)
ORP<CR> (n* seconds)

C,0 <CR>
(If the response code is enabled, the EZO™ class circuit will respond "*OK<CR>")
Continuous data transmission will cease.

C,? <CR>
(If the response code is enabled, the EZO™ class circuit will respond "*OK<CR>")
?C,1<CR> if continuous mode is enabled.
?C,0<CR> if continuous mode is disabled.

<CR> represents a carriage return (ASCII 13). The user does not transmit the literal string "<CR>". Commands are not case sensitive.

Single reading mode

All EZO™ class circuits are capable of taking a single reading upon request. If the LEDs are enabled, each time a data transmission occurs, the green LED will blink.

Command syntax

R<CR> Returns a single reading

Device response

(If the response code is enabled, the EZO™ class circuit will respond "*OK<CR>")
The EZO™ class ORP circuit, will output a single string containing a ORP reading 1 second after the command was issued.

ORP<CR> (1 second)

<CR> represents a carriage return (ASCII 13). The user does not transmit the literal string "<CR>". Commands are not case sensitive.

Calibration

The EZO™ class ORP circuit can be calibrated to any known ORP value.

Command syntax

Cal,clear<CR>	Clears all calibration data
Cal,nnn<CR>	Calibrates the ORP circuit to the correct value Where nnn is any integer or floating point value
Cal,? <CR>	Query the calibration

Device response

Cal,clear<CR>
(If the response code is enabled, the EZO™ class circuit will respond "*OK<CR>")
There is no other output associated output with this command.

Cal,nnn<CR>
(If the response code is enabled, the EZO™ class circuit will respond "*OK<CR>")
The LED will turn **Cyan** during the calibration.

Cal,?<CR>
(If the response code is enabled, the EZO™ class circuit will respond "*OK<CR>")

If not calibrated:	?CAL,0
If calibrated:	?CAL,1

<CR> represents a carriage return (ASCII 13). The user does not transmit the literal string "<CR>". Commands are not case sensitive.

Device Identification

All EZO™ class circuits are capable of being assigned a name. This is a simple way to identify the device in a system that consists of multiple EZO™ class circuits. A name can consist of any combination of ASCII characters, with a length of 1 to 16 characters long, ***no blank spaces***.

Command syntax

NAME,nnn<CR> Sets the device name, where nnn is the given name.
NAME,?<CR> Query the device name

Device response

NAME,DEVICE_1<CR>
(If the response code is enabled, the EZO™ class circuit will respond "*OK<CR>")
There is no other output associated output with this command.

NAME,?<CR>
(If the response code is enabled, the EZO™ class circuit will respond "*OK<CR>")
?NAME, DEVICE_1<CR>

Device information

The EZO™ class circuit can identify itself by device type and firmware version.
This is done by transmitting the "I" command.

Command syntax

I<CR> Device information

Device response

?I,ORP,1.0<CR>
(If the response code is enabled, the EZO™ class circuit will respond "*OK<CR>")

Where ORP = device type
1.0 = firmware version number

<CR> represents a carriage return (ASCII 13). The user does not transmit the literal string "<CR>". Commands are not case sensitive.

Response codes

The Atlas Scientific EZO™ class circuits, have 7 response codes to help the user understand how the device is operating, and to aid in the construction of a state machine to control the EZO™ class circuit. All EZO™ class devices indicate a response code has been triggered, by transmitting a string with the prefix "*" and ending with a carriage return <CR>.

A list of response codes

***ER**	An unknown command has been sent
***OV**	The circuit is being overvolted (VCC>=5.5V)
***UV**	The circuit is being undervolted (VCC<=3.1V)
***RS**	The circuit has reset
***RE**	The circuit has completed boot up
***SL**	The circuit has been put to sleep
***WA**	The circuit has woken up from sleep

Only the response code "*OK" can be disabled.
Disabling this response code is done using the "response" command.

Command syntax

RESPONSE,1<CR>	Enable response code (default)
RESPONSE,0<CR>	Disable response code
RESPONSE,?<CR>	Query the response code

Device response

RESPONSE,1<CR>
EZO™ class circuit will respond "*OK<CR>"

RESPONSE,0<CR>
There is no response to this command

RESPONSE,?<CR>

?RESPONSE,1<CR> If the response code is enabled
?RESPONSE,0<CR> If the response code is disabled

<CR> represents a carriage return (ASCII 13). The user does not transmit the literal string "<CR>". Commands are not case sensitive.

Reading the status of the device

The Atlas Scientific™ EZO™ class circuit, is able to report its voltage at the VCC pin and reason the device was last restarted.

Restart codes

P power on reset
S software reset
B brown out reset
W watchdog reset
U unknown

Command syntax

STATUS<CR>

Device response

(If the response code is enabled, the EZO™ class circuit will respond "*OK<CR>")

?STATUS,P,5.038<CR>

Where: P is the reason for the last reset event
Where: 5.038 is the its voltage at the VCC

<CR> represents a carriage return (ASCII 13). The user does not transmit the literal string "<CR>". Commands are not case sensitive.

Low power state

To conserve energy in between readings, the Atlas Scientific™ EZO™ class circuit, can be put into a low power sleep state. This will turn off the LEDs and shut down almost all of the internal workings of the EZO™ class circuit. The power consumption will be reduced to 1.16 mA at 5V and 0.995 mA at 3.3V. **To wake the EZO™ class circuit, send it any character.**

After the device is woken up, **4** consecutive readings should be taken before the readings are considered valid.

Command syntax

SLEEP<CR> Enter low power sleep state

Device response

(If the response code is enabled, the EZO™ class circuit will respond "*OK<CR>")
*SL<CR>

Device response to wake up:
*WA<CR>

<CR> represents a carriage return (ASCII 13). The user does not transmit the literal string "<CR>". Commands are not case sensitive.

Change baud rate

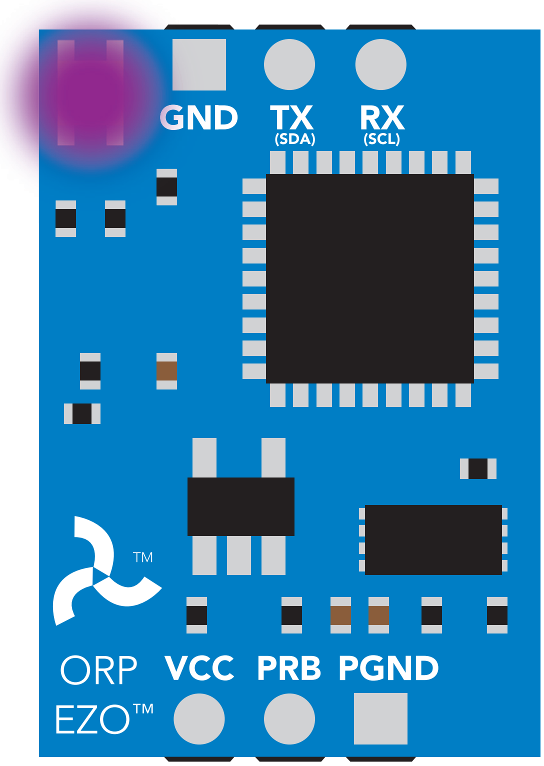
The Atlas Scientific EZO™ class circuit, has 8 possible baud rates it can operate at.
The default baud rate is

9600 bps
8 data bits
1 stop bit
no parity
no flow control

Baud rate changes will be retained even if power is cut.

Data bits, stop bits, parity and flow control are fixed and cannot be changed.

1. 300 bps
2. 1200 bps
3. 2400 bps
4. 9600 bps
5. 19200 bps
6. 38400 bps
7. 57600 bps
8. 115200 bps



Command syntax

(Using an example baud rate of 38400)
SERIAL,38400<CR>

Device response

(If the response code is enabled, the EZO™ class circuit will respond "*OK<CR>") The EZO™ class circuit will respond with a **Purple** LED double blink. The EZO™ class circuit will then restart at the new baud rate.

The LED blink will happen even if the LEDs are disabled.

<CR> represents a carriage return (ASCII 13). The user does not transmit the literal string "<CR>". Commands are not case sensitive.

Factory reset

All EZO™ class circuits, are capable of resetting themselves to the original factory settings. Issuing a factory reset will:

Reset the calibration back to factory default
Set debugging LED to on
Enable response codes

This command will not change the set baud rate.

Command syntax

Factory<CR> Factory reset

Device response

(If the response code is enabled, the EZO™ class circuit will respond "*OK<CR>")
The EZO™ class circuit, will respond: *RE<CR>

<CR> represents a carriage return (ASCII 13). The user does not transmit the literal string "<CR>". Commands are not case sensitive.

Switch from UART mode to I^{2}C mode

Transmitting the command I^{2}C,[n] will set the EZO™ class circuit into I^{2}C mode from UART mode. **Where [n] represents any number from 1-127.** The I^{2}C address is sent in decimal ASCII form. Do not send the address in hexadecimal ASCII form.

Command syntax

(Using as example an I^{2}C ID number of 98)
I2C,98<CR>

Device response

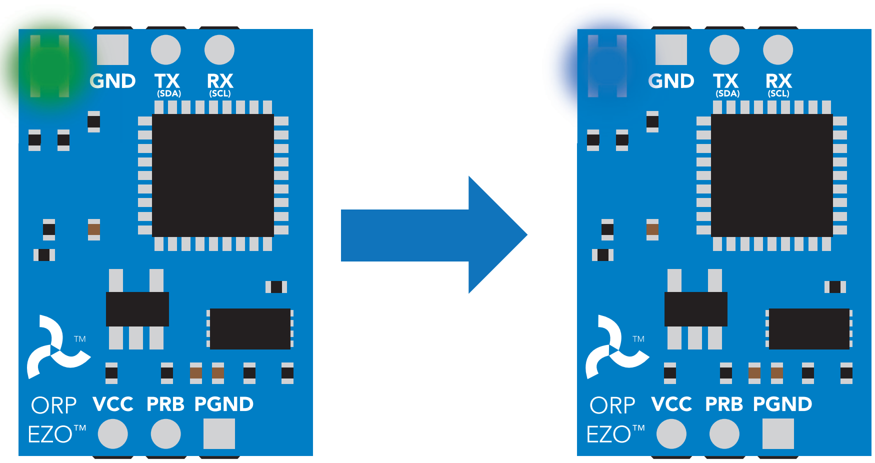
If an address > 127 is given

*ER Indicating an error has occurred

If an address >0 and <128 is given
(If the response code is enabled, the EZO™ class circuit will respond "*OK<CR>")

*RS<CR> The device will restart in I^{2}C mode

The **Green** LED used to indicate that the device is powered and awaiting an instruction will now change to **Blue**.

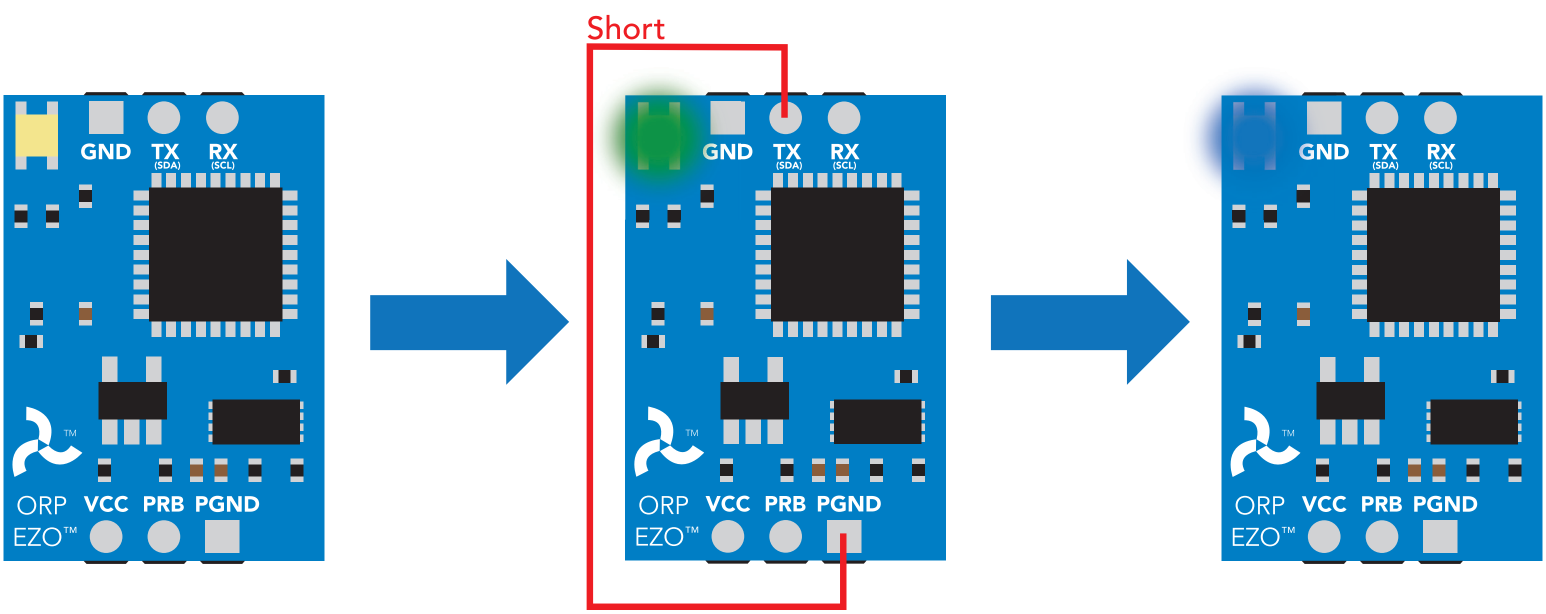


<CR> represents a carriage return (ASCII 13). The user does not transmit the literal string "<CR>". Commands are not case sensitive.

Manual switching to I²C mode

All EZO™ class circuits can be manually switched from UART mode, to I²C mode. **If this is done the EZO™ class ORP circuit, will set its I²C address to 98 (0x62).**

1. Cut the power to the device
2. Disconnect any jumper wires going from TX and RX to the master micro controller
3. Short the PGND pin to the TX pin
4. Power the device
5. Wait for LED to change from **Green** to **Blue**
6. Remove the short from the probe pin to the TX pin
7. Power cycle the device
8. The device is now I²C mode



<CR> represents a carriage return (ASCII 13). The user does not transmit the literal string "<CR>". Commands are not case sensitive.

Protocol lock

This feature is available on All EZO™ class circuits running firmware version 1.95 or higher.

When the protocol lock feature is enabled all changes to the communication protocol are blocked. This means that whatever communication mode the device is in (I^2C or UART); that communication protocol cannot be changed by any means. Furthermore, changes to the devices baud rate or I^2C address also cannot be changed.

By default the protocol lock is: **DISABLED**
Changes to this setting are retained even if the power is cut.

Command syntax

PLOCK,1<CR>	Enables the protocol lock feature
PLOCK,0<CR>	Disables the protocol lock feature
PLOCK,?<CR>	Query the state of the lock

Device response

PLOCK,1<CR>
(If the response code is enabled, the EZO™ class circuit will respond "*OK<CR>")
There is no other output associated output with this command.

PLOCK,0<CR>
(If the response code is enabled, the EZO™ class circuit will respond "*OK<CR>")
There is no other output associated output with this command.

PLOCK,?<CR>
(If the response code is enabled, the EZO™ class circuit will respond "*OK<CR>")

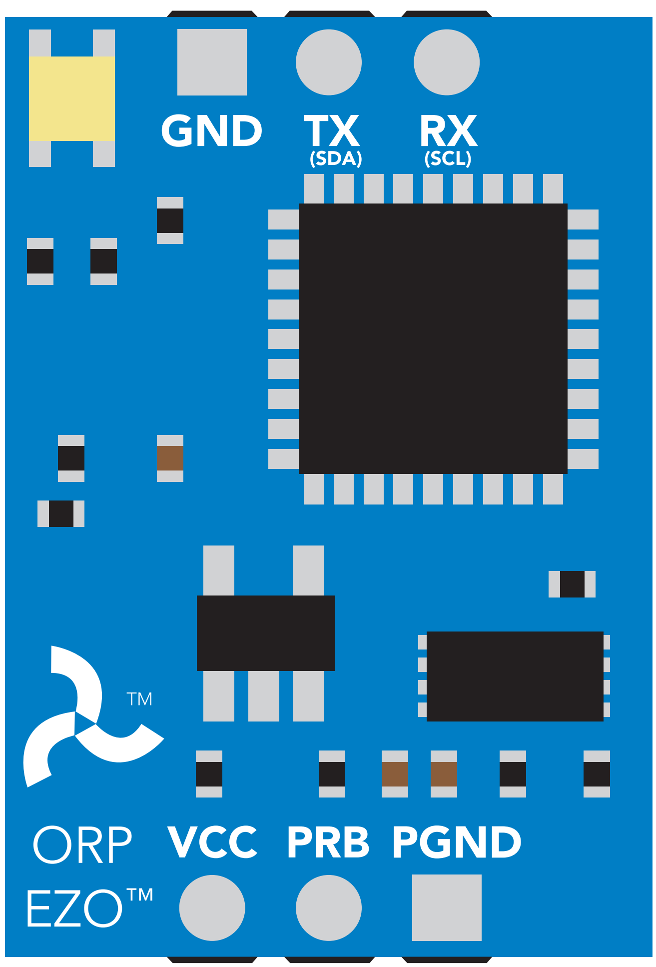
?PLOCK,1<CR>	if the lock in enabled
?PLOCK,0<CR>	if the lock in disabled

<CR> represents a carriage return (ASCII 13). The user does not transmit the literal string "<CR>". Commands are not case sensitive.

Once the protocol lock is enable the following commands / actions will no longer work

Manual switching to I^{2}C or UART mode
Software switching from I^{2}C or UART mode
UART baud rate change
I^{2}C address change

If the protocol lock is enabled attempting to manually switch to UART or I^{2}C mode will have no effect. If any of the software commands are issued to switch mode, baud rate or I^{2}C address the EZO class device will return *ER<CR>



AtlasScientific™
Environmental Robotics

ORP Circuit
EZO™

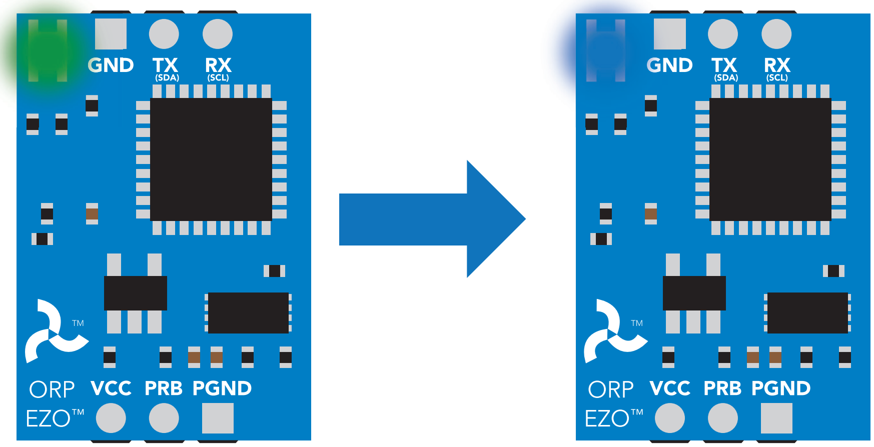
I²C Mode

™

I²C mode

An I²C address can be any number from 1-127. If the EZO™ Class ORP circuit was put into I²C mode by jumping PRB to TX, the I²C address is 98(0x62).

Once an EZO™ class device has been put into I²C mode the **Green** power LED that was used in UART mode will now switch to a **Blue** LED. This indicates the device is now in I²C mode.



The I²C protocol is considerably more complex than the UART (RS-232) protocol. Atlas Scientific assumes the embedded systems engineer understands this protocol.

Communication to the EZO™ class device is controlled by the master. The EZO™ class device as an I²C slave. The slave device is not able to initiate any data transmissions.

An I²C write event is defined as such

start | write command to device address | instruction | stop

In order to get the response from device, it is necessary to initiate a read command. The I²C protocol does not permit the slave device to initiate any data transmissions.

An I²C read event is defined as such

start | read command to device address | data byte | data byte | data byte | stop

Data from a read back event

The first byte of the data read back, is the response code. This byte informs the master of the status of the data about to be read back. For all commands, the first byte of the read data is the response code, which is defined as

Value	Meaning
255	**No Data** – there is no pending request, so there is no data to return from the circuit
254	**Pending** – the request is still being processed. Ensure that you have waited the minimum time to guarantee a response
2	**Failed** – the request failed
1	**Success** – the requested information is ready for transmission. There may be more bytes following this which are returned data

The bytes transmitted after that, will be the requested data. When all the data has been transmitted each additional byte will be a NULL.

Example

A read request when no command has been given.

255 | null | (every byte read after the first byte will be NULL) | stop

All I²C mode responses are in ASCII format however, they do not terminate with a <CR> rather, they terminate with a NULL. The Null termination makes data manipulation easier once it has been received.

Example
EZO™ class device responds to a request for a reading

12.34 ≠ float	12.34 =byte[7]	
	Byte[0]= 1	(decimal 1)
	byte[1]= "1"	(ASCII 49)
	byte[2]= "2"	(ASCII 50)
	byte[3]= "."	(ASCII 46)
	byte[4]= "3"	(ASCII 51)
	byte[5]= "4"	(ASCII 52)
	byte[6]= NULL	(ASCII 0)

I²C timing

When a command is issued to the EZO™ class device, a certain amount of time must be allowed to pass before the data is ready to be read. Each command specifies the delay needed before the data can be read back. EZO™ class devices do not support I²C clock stretching. All commands are sent to the EZO™ class device in the same ASCII format as in UART mode however, there is no <CR> sent at the end of the transmission.

I²C command quick reference

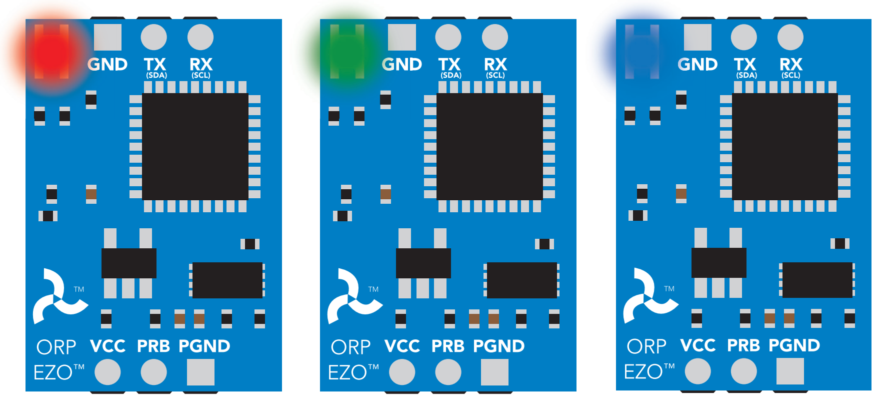
There are a total of 9 different commands that can be given to the EZO™ class ORP circuit.

Command	Function
Cal	Performs calibration (pg.41)
Factory	Factory reset (pg.47)
I	Device information (pg.42)
L	Enable / Disable or Query the LEDs (pg.39)
Plock	Enables / Disables the protocol lock feature (pg.49)
R	Returns a single reading (pg.40)
Serial	Switch back to UART mode (pg.46)
Sleep	Enter low power sleep mode (pg.45)
Status	Retrieve status information (pg.43)

I²C LED control

All EZO™ class circuits have a tri-color LED used to indicate device operation.

I²C mode LED color definitions:
Steady **Blue** = Power on/ standby
Red double blink = Command received and not understood
Blue blink = Data transmission sent
Green = taking a reading



Command syntax

L,1 LED enable
L,0 LED disable
L,? Query the LED

Device response

L,1
The Led will be enabled and the blue power on/ standby LED turn on.
After 300ms, an I²C read command can be issued to get the response code. A decimal 1 would indicate the command has been successfully processed.

| 1 | null |

L,0
The Led will be disabled
After 300ms, an I²C read command can be issued to get the response code. A decimal 1 would indicate the command has been successfully processed.

| 1 | null |

L,?
After 300ms, an I²C read command can be issued to get the response code.

| 1 | ? | L | , | 1 | null | (?L,1) if the LED is enabled |
| 1 | ? | L | , | 0 | null | (?L,0) if the LED is disabled |

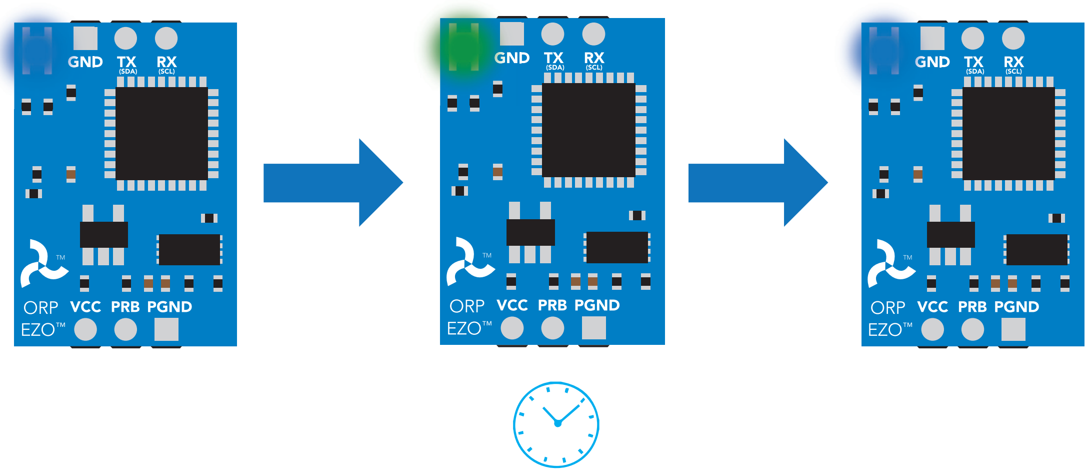
I²C take reading

When a reading is taken, the LED (if enabled) will turn **Green**, indicating that a reading is being taken. Once the reading has been taken, the LED will turn back to **Blue**.

Command syntax

R Returns a single reading

Time until instruction is processed: 1 second



1 Second time has passed

Device response

After 1 second, an I²C read command can be issued to get the response:

ORP represents many bytes.

The string will be no longer than 8 bytes.

I²C Calibration

The EZO™ class ORP circuit can be calibrated using a just a single point.
Any off the shelf calibration solution can be used.

Command syntax

Cal,clear	Clears all calibration data Time until instruction is processed: 300ms
Cal,nnn	Calibrates the ORP circuit to the correct value Where nnn is any integer or floating point value Time until instruction is processed: 1.3s
Cal,?	Query the calibration Time until instruction is processed: 300ms

Device response

Cal,clear
The LED will turn **Cyan** during the calibration.
After 300ms, an I²C read command can be issued to get the response code.
A decimal 1 would indicate the command has been successfully processed.

1	null

Cal,nnn
The LED will turn **Cyan** during the calibration.
After 1.3 seconds, an I²C read command can be issued to get the response code.
A decimal 1 would indicate the command has been successfully processed.

1	null

Cal,?
After 300ms, an I²C read command can be issued to get the response code.

If not calibrated

(?CAL,0)

If calibrated

(?CAL,1)

I²C Device Info

The EZO™ class circuit, can identify itself by device type and firmware version. This is done by transmitting the "I" command.

Command syntax
I Device information

Time until instruction is processed 300 ms

Device response:
After 300ms, an I²C read command can be issued to get the response:

?I,ORP,1.0

Where ORP = device type
1.0 = firmware version number

Reading the status of the device in I²C mode

The Atlas Scientific™ EZO™ class circuit, is able to report its voltage at the VCC pin and the reason the device was last restarted.

Restart codes

P power on reset
S software reset
B brown out reset
W watchdog reset
U unknown

Command syntax

STATUS
Time until instruction is processed, 300ms

Device response

After 300ms, an I²C read command can be issued, to get the response

?STATUS,P,5.038

Where: P is the reason for the last reset event
Where: 5.038 is the its voltage at the VCC

I²C Address change

Transmitting the command I²C,[n] while the EZO™ class circuit is already in I²C mode will change the devices I²C address. **Where [n] represents any number from 1-127.**

Warning!

After changing the I²C address the EZO™ class circuit will no longer be able respond to any commands from the master device until its code has been updated with the new I²C address

Command syntax

I2c,[n]

Device response

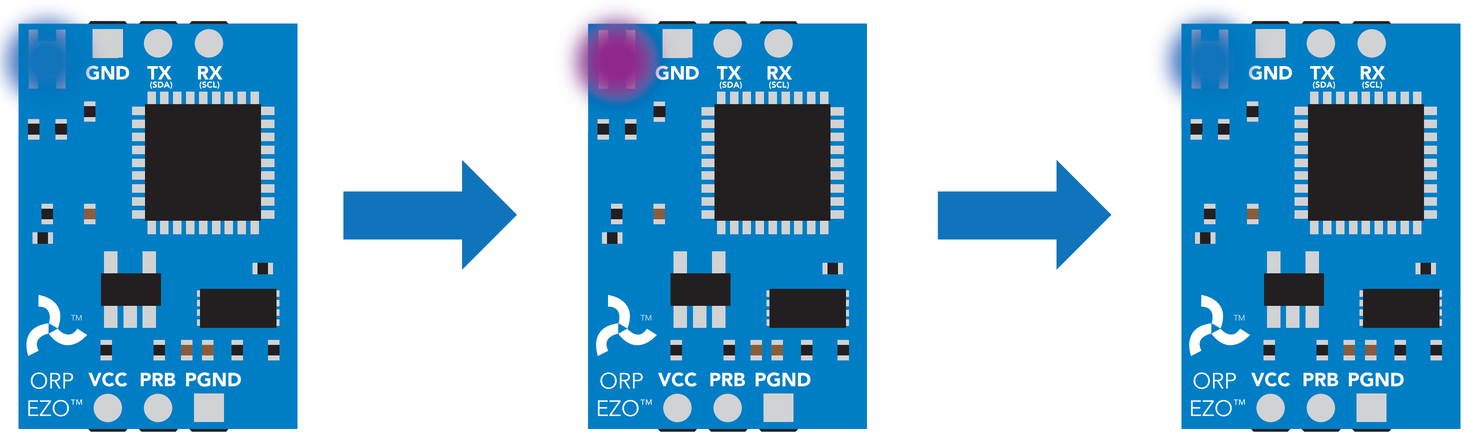
If an address >0 and <128 is given

1 null

If an address of 0 or and address of > 127 is given EZO™ class circuit will issue an error response and not change the I²C address.

The blue led used to indicate the device is in I²C mode will turn purple then the device will restart using its new I²C address.

No calibration information will be lost by changing the I²C address



I²C Low power state

To conserve energy in between readings, the Atlas Scientific ORP EZO™ class circuit can be put into a low power sleep state. This will turn off the LEDs and shut down almost all of the internal workings of the EZO™ class circuit. The power consumption will be reduced to 1.16 mA at 5V and 0.995 mA at 3.3V. **To wake the EZO™ class circuit, send it any command.**

After the device is woken up, **4** consecutive readings should be taken before the readings are considered valid.

Command syntax

SLEEP Enter low power sleep state
Time until instruction is processed, 300ms

Device response

If the LEDs are enabled, the **Blue** LED will blink and then turn off.
There is no other output associated with this command.

Switch from I²C mode to UART mode

Transmitting the command serial,<n> will set the EZO™ class circuit into UART mode from I²C mode. **Where [n] represents any of one the 8 available baud rates.**

Command syntax

(Using as example a baud rate of 9600)

SERIAL,9600

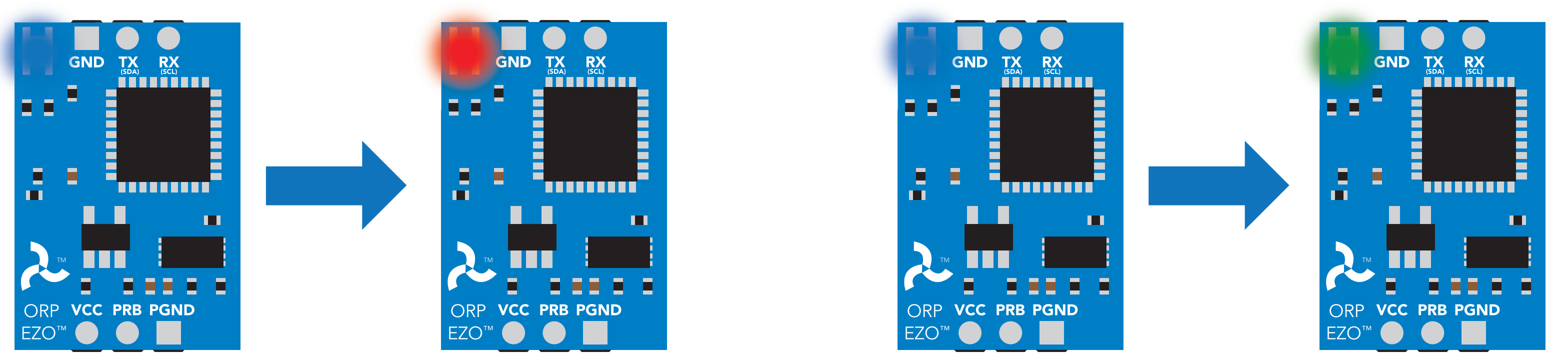
Device response

If an incorrect baud rate is sent the device will not switch into UART mode and the **Red** LED will flash.

If a correct baud rate is given:
The **Blue** LED used to indicate that the device is powered and awaiting an instruction will now change to **Green**.

Incorrect

Correct



Factory reset

All EZO™ class circuits, are capable of resetting themselves to the original factory settings.
Issuing a factory reset will:

Reset the calibration back to factory default
Set debugging LED to on.
Enable response codes

This command will not change the set I²C address

Command syntax

Factory Factory reset

Device response

After 300ms the STATUS command can be issued to see that the device was reset.

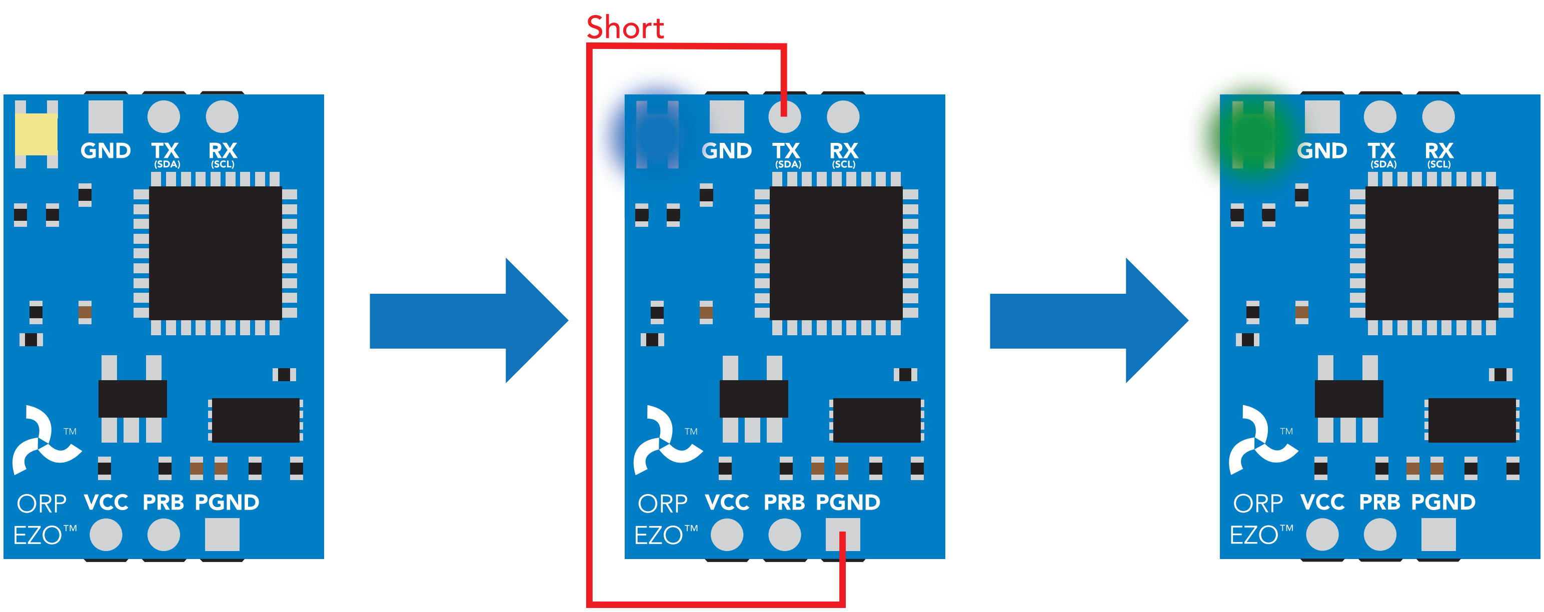
?STATUS,S,5.038

Where: S is the reason for the last reset event (software reset)
Where: 5.038 is the its voltage at the VCC

Manual switching to UART mode

All EZO™ class circuits, can be manually switched from I²C mode to UART mode.
If this is done, the EZO™ class ORP circuit, will set its baud rate to 9600.

1. Cut the power to the device
2. Disconnect any jumper wires going from TX and RX to the master micro controller
3. Short the PGND pin to the TX pin
4. Power the device
5. Wait for LED to change from **Blue** to **Green**
6. Remove the short from the probe pin to the TX pin
7. Power cycle the device
8. The device is now UART mode



Protocol lock

This feature is available on All EZO™ class circuits running firmware version 1.95 or higher.

When the protocol lock feature is enabled all changes to the communication protocol are blocked. This means that whatever communication mode the device is in (I^2C or UART); that communication protocol cannot be changed by any means. Furthermore, changes to the devices baud rate or I^2C address also cannot be changed.

By default the protocol lock is: **DISABLED**
Changes to this setting are retained even if the power is cut.

Command syntax

PLOCK,1	Enables the protocol lock feature
PLOCK,0	Disables the protocol lock feature
PLOCK,?	Query the state of the lock

Device response

PLOCK,1
After 300ms, an I^2C read command can be issued to get the response code.
A decimal 1 would indicate the command has been successfully processed.

| 1 | null |

PLOCK,0
After 300ms, an I^2C read command can be issued to get the response code.
A decimal 1 would indicate the command has been successfully processed.

| 1 | null |

PLOCK,?
After 300ms, an I^2C read command can be issued to get the response code.

If locked

| ? | P | L | O | C | K | , | 1 | null |

(?PLOCK,1)

If unlocked

?	P	L	O	C	K	,	0	null

(?PLOCK,0)

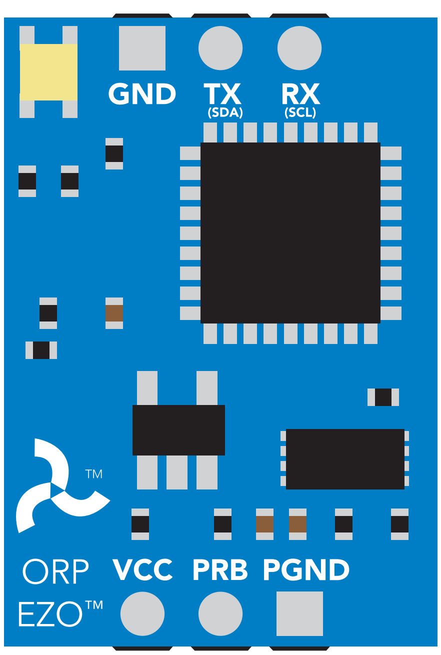
Once the protocol lock is enable the following commands / actions will no longer work

Manual switching to I²C or UART mode
Software switching from I²C or UART mode
UART baud rate change
I²C address change

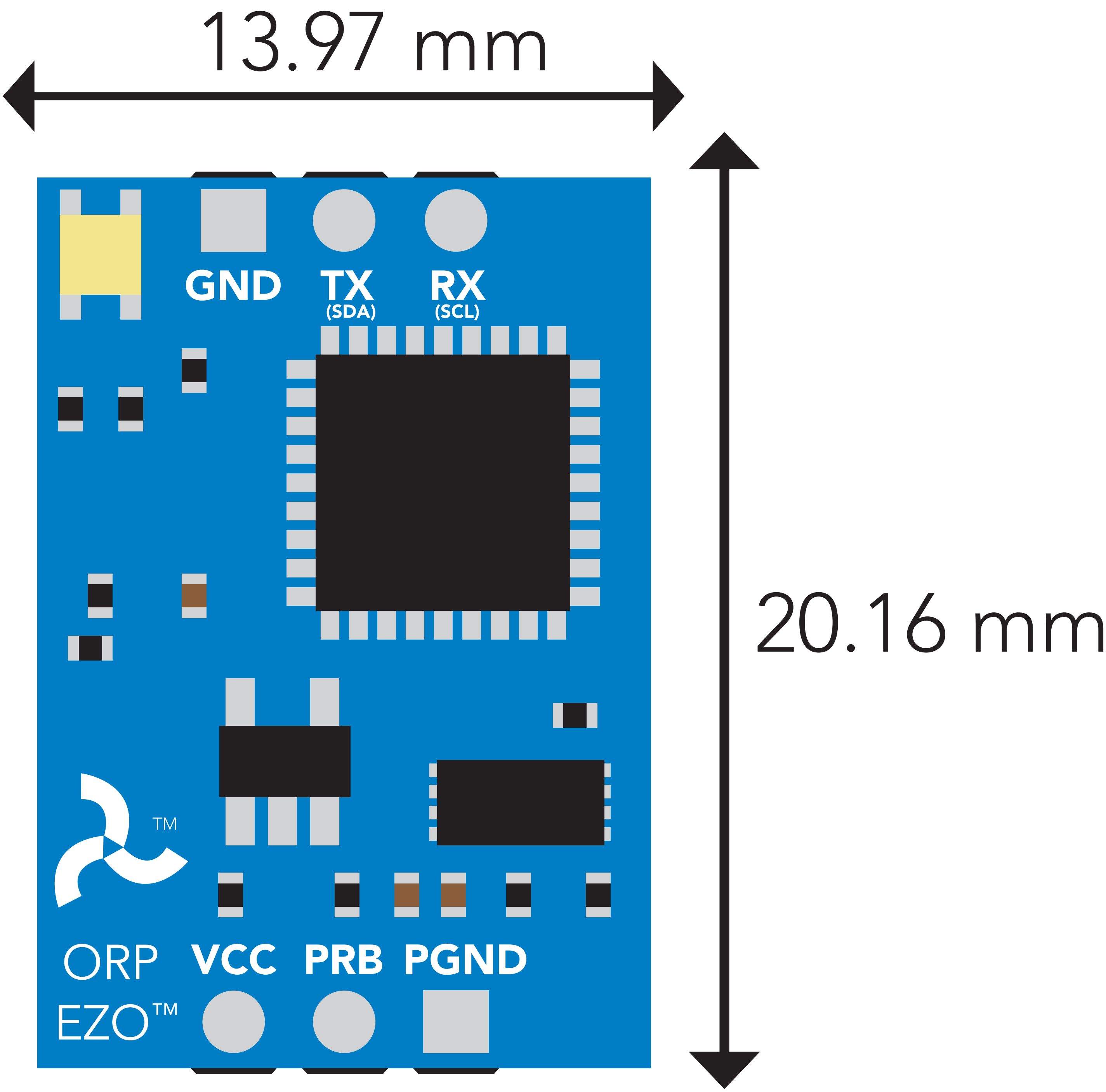
If the protocol lock is enabled attempting to manually switch to UART or I²C mode will have no effect. If any of the software commands are issued to switch mode, baud rate or I²C address the EZO class device will return:

2	null

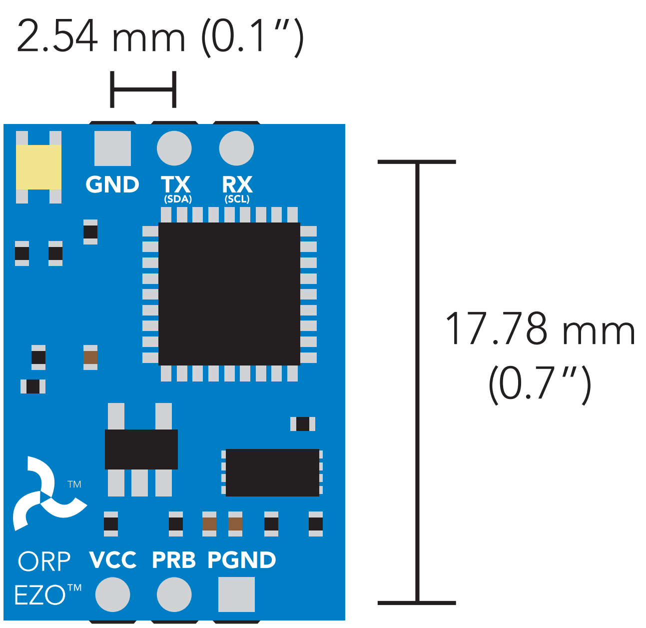
Indicating that the request failed.



Circuit dimensions

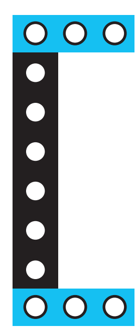


How to make a footprint for the Atlas Scientific™ EZO™ ORP circuit

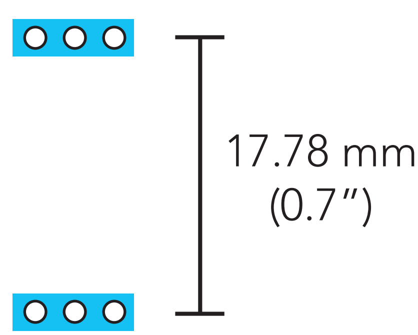


1. In your CAD software place an 8 position header.

2. Place a 3 position header at both top and bottom of the 8 position header as shown.



3. Once this is done, you can delete the 8 position header. Make sure that the two 3 position headers are 17.78mm (0.7") apart from each other.



Datasheet change log

Datasheet V 2.9

Added Protocol Lock function on pages 32 and 49.

Datasheet V 2.8

Revised warning on pages 12 and 13.

Datasheet V 2.7

Revised photos on pages 11 and 15.

Datasheet V 2.6

Added I^{2}C address change command on pg 42.

Datasheet V 2.5

Moved wiring diagram to pg 10

Datasheet V 2.4

Added

"After the device is woken up, 4 consecutive readings should be taken before the readings are considered valid." to pages 21 and 36

"Circuit identification" on page 4.

Replaced

"X" command to "Factory"

Datasheet change log

ORP circuit firmware changes

V1.0 – Initial release (Aug 22, 2014)

V1.5 – Baud rate change (Nov 6, 2014)
- Change default baud rate to 9600

V1.6 – I2C bug (Dec 1, 2014)
- Fix I2C bug where the circuit may inappropriately respond when other I^2C devices are connected.

V1.7 – Factory (April 14, 2015)
- Changed "X" command to "Factory"

Warranty

Atlas Scientific™ Warranties the EZO™ class ORP circuit to be free of defect during the debugging phase of device implementation, or 30 days after receiving the EZO™class ORP circuit (which ever comes first).

The debugging phase

The debugging phase as defined by Atlas Scientific™, is the time period when the EZO™ class ORP circuit is inserted into a bread board, or shield, and is connected to a microcontroller according to the wiring diagram on pg. 42. Reference this wiring diagram for a connection to USB debugging device, or if a shield is being used, when it is connected to its carrier board.

If the EZO™ class ORP circuit is being debugged in a bread board, the bread board must be devoid of other components. If the EZO™ class ORP circuit is being connected to a microcontroller, the microcontroller must be running code that has been designed to drive the EZO™ class ORP circuit exclusively and output the EZO™ class ORP circuit data as a serial string.

It is important for the embedded systems engineer to keep in mind that the following activities will void the EZO™ class ORP circuit warranty:

- **Soldering any part of the EZO™ class ORP circuit**
- **Running any code, that does not exclusively drive the EZO™ class ORP circuit and output its data in a serial string**
- **Embedding the EZO™ class ORP circuit into a custom made device**
- **Removing any potting compound**

Reasoning behind this warranty

Because Atlas Scientific™ does not sell consumer electronics; once the device has been embedded into a custom made system, Atlas Scientific™ cannot possibly warranty the EZO™ class ORP circuit, against the thousands of possible variables that may cause the EZO™ class ORP circuit to no longer function properly.
Please keep this in mind:

1. All Atlas Scientific™ devices have been designed to be embedded into a custom made system by you, the embedded systems engineer.
2. All Atlas Scientific™ devices have been designed to run indefinitely without failure in the field.
3. All Atlas Scientific™ devices can be soldered into place, however you do so at your own risk.

Atlas Scientific™ is simply stating that once the device is being used in your application, Atlas Scientific™ can no longer take responsibility for the EZO™ class ORP circuits continued operation. This is because that would be equivalent to Atlas Scientific™ taking responsibility over the correct operation of your entire device.

TM

TM